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Geohydrologic Monograph 5

PRINCIPAL AQUIFERS AND WELL YIELDS IN WASHINGTON

By
Dee Molenaar, Peder Grimstad, and Kenneth L. Walters

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DEPARTMENT OF ECOLOGY

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INTRODUCTION

The accompanying map designates the principal aquifers presently supplying water to wells in the State of Washington and indicates the general range in yields of wells tapping each aquifer. On the map, the State is divided into 21 regions that correspond roughly to the physiographic areas, drainage basins, or groups of drainage basins. Although geologic and hydrologic conditions, well yields, and degrees of ground-water development differ considerably within regions, an attempt was made to regionalize the State so that valid generalizations could be made.

Because of areal differences in availability of and demand for ground water throughout the State, the significance of well yields shown on the map varies greatly from region to region. For example, in the San Juan region an aquifer capable of providing well yields of 100 gal/min (gallons per minute) is of great significance. Elsewhere, in much of the Columbia Basin region an aquifer capable of yielding only 100 gal/min to individual wells is not considered significant, for much larger yields generally are available from other aquifers here.

Most information on principal aquifers tapped by wells is based on reports (see Selected References) that describe the geology and ground-water resources of various parts of the State. These reports were published by the U.S. Geological Survey and the State of Washington Department of Ecology (and its predecessor agencies, the Division of Water Resources and Department of Water Resources) as part of a State-Federal cooperative program. The areas covered by the reports include principal river basins, counties, and geohydrologic subareas; a few describe smaller areas that had a need for definition of local ground-water conditions.

PRINCIPAL AQUIFERS

The principal aquifers supplying water to wells in Washington are divided into four broad categories that are defined from oldest to youngest as follows:

Basalt (Tb)

The basalt aquifers include lava flows and some interbedded sedimentary rocks of the Columbia River Basalt Group. Of Miocene age, these rocks are extensive and in great thickness beneath the Columbia Plateau (includes the Columbia Basin region) in eastern Washington. They decrease in thickness and extent in parts of southern and southwestern Washington adjacent to the Columbia River. Ground water in these aquifers occurs mostly in fractures, rubble zones, and interbedded sand and gravel at the tops and bottoms of the flow units.

Recharge to the basalt aquifers from direct precipitation is generally small, but in some areas additional recharge comes from seepage from streams draining adjacent mountains, or from irrigation water imported from surface sources, as in the Columbia Basin Irrigation Project area.

The ground water moves laterally along interflow zones and, to a lesser extent, vertically between flows. Movement of the water is partly and locally controlled by fractures and joints, and regionally by folds and faults in the basalt.

The most productive wells in the basalt aquifers usually penetrate several water-bearing zones, and yields of 1,000 to more than 3,000 gal/min are common in parts of the Columbia Basin. However, because the potentiometric head is lowered by large-scale withdrawals for irrigation, and recharge to the aquifers is limited by scant precipitation, obtaining such large yields in some areas requires drilling to deeper zones—or lowering pumps in wells.

Sedimentary Deposits (QTg)

These aquifers comprise partially consolidated sand and gravel deposits and some silt and clay of Pliocene and early Pleistocene age. The deposits include terrace gravel along the western and southern lowlands of the Olympic Peninsula and northwestern Willapa region, the Pliocene Troutdale Formation of the Lewis region, the Miocene Ellensburg Formation underlying the lowlands of the Yakima region, and older valley-fill sand and gravel underlying the Walla Walla valley. Wells finished in these aquifers yield a few gallons per minute (for domestic supplies) in many areas but more than 1,000 gal/min (for industrial and municipal supplies) from the upper part of the Troutdale Formation in the Vancouver area.

Glacial Drift (Qd)

The glacial drift comprises unconsolidated sand, gravel, silt, and clay, and partially consolidated till ("hardpan" to well drillers). These were deposited either directly by the ice (as with the till) or by melt-water streams issuing from lobes of the Cordilleran Ice Sheet that covered the lowlands of western and northeastern Washington during the Pleistocene Ice Age. The sand and gravel units in the drift form the principal aquifers. In the Puget Sound region, these aquifers—along with local alluvial aquifers—provide most of the water used for municipal, industrial, domestic, and some irrigation supplies. In general, these aquifers receive ample recharge from the heavy precipitation characteristic of western Washington. In eastern Washington, the drift includes the coarse sand and gravel deposited locally by the water of the catastrophic Spokane Flood of late Pleistocene time.

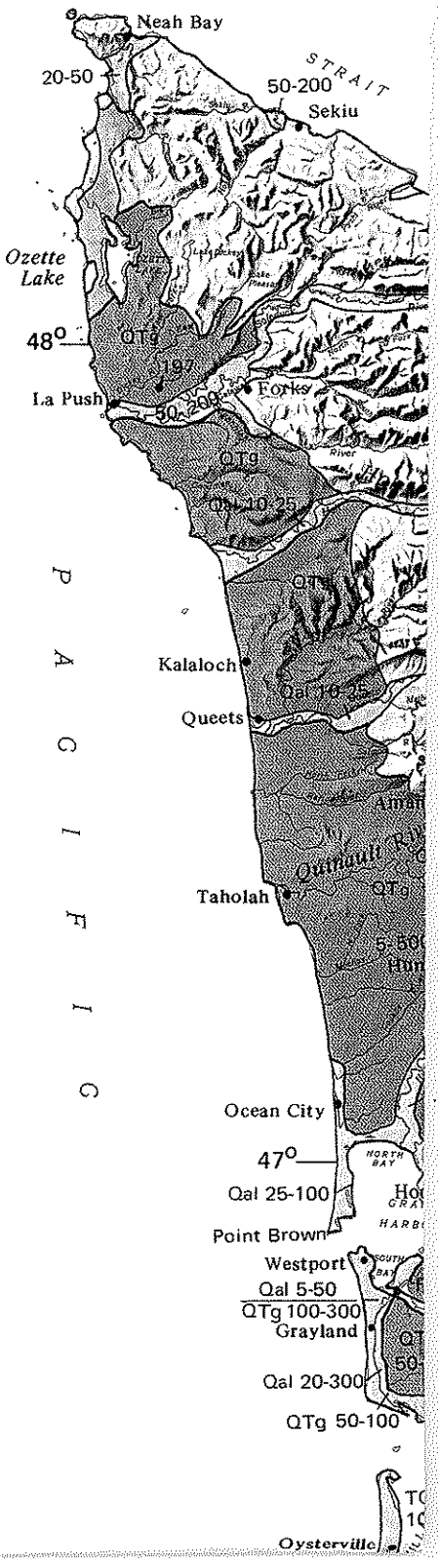
Owing to various modes of deposition—by glacial melt-water streams, in ice-dammed lakes, and beneath the advancing ice itself—the drift in the Puget Sound region varies greatly in composition and, correspondingly, in water-yielding capability. Wells tapping thick, saturated layers of highly permeable gravel and coarse sand yield more than 1,000 gal/min, whereas wells tapping silt, clay, or till generally yield only enough water for domestic supplies.

Locally, in valley areas adjacent to glacial drift plains, flowing artesian wells tap saturated sand and gravel zones confined beneath poorly permeable silt, clay, or till. The artesian pressure results from water in the area of recharge being at a higher altitude than the point at which the well was completed. Some municipal- and industrial-supply wells drilled to depths between 500 and 1,000 feet, or even deeper, in the lowland valleys yield 1,000 gal/min or more.

Coarse sand and gravel of the glacial drift in some areas are the most productive aquifers in the State. For example, in the Spokane Valley between Spokane and the Idaho state line, these aquifers provide 500 to 2,000 gal/min to wells. These materials have been designated as a "Sole Source Aquifer" by the Environmental Protection Agency (1978), indicating their importance as the only source of a good-quality water supply. Similarly, in the North Fork Green River valley in the Puget Sound region, deposits of coarse gravel are among the most productive aquifers in the United States; some wells drilled here for the City of Tacoma municipal supply yield as much as 10,000 gal/min.

Alluvium (Qal)

For the purpose of this report, alluvial aquifers are defined as (1) unconsolidated sand, gravel, silt, and



bles deposited by more turbulent streams in mountain valleys; and (3) sand deposited along coastal beaches.

Alluvial deposits occur along most stream valleys in western Washington, along coastal areas of southwestern Washington, and along the flood plains of the Columbia, Okanogan, Methow, Wenatchee, Yakima, and Walla Walla Rivers. On the map, these may be included with the glacial drift (Qd).

The alluvium is recharged generally by precipitation and infrequently by seepage from adjacent streams; its upper saturated section is usually in hydraulic connection with the stream. Wells obtain water at shallow depth along the streams and are mostly used for domestic and stock supplies. Along coastal beaches, small-diameter (2-inch) driven wells are commonly used to obtain domestic supplies, but in some coastal areas larger diameter wells commonly yield 50 to 200 gal/min for municipal and industrial supplies (mostly seafood processing and canning).

AREAL DISTRIBUTION OF AQUIFERS AND WELL YIELDS

Most of the more densely populated parts of Washington are in lowland areas and stream valleys where ground water is usually available to wells tapping relatively shallow aquifers in unconsolidated sand and gravel. These aquifers include (1) alluvium along the main stream valleys, (2) glacial drift beneath the Puget Sound lowland, (3) dune sand and terrace materials in some coastal areas, and (4) valley-fill deposits underlying inland basins. Many large municipal and industrial wells and thousands of domestic wells are completed in these aquifers. They provide ample water supplies with little depletion of the ground water in storage.

In some parts of semiarid eastern Washington, particularly in areas distant from significant streams and alluvial aquifers, most ground water is obtained from deep wells tapping basalt aquifers. In such places, several water-bearing zones in the basalt, and in associated interbeds of sand and gravel, are usually penetrated to obtain quantities of water adequate for municipal, irrigation, and industrial supplies.

The thickness and permeability of any one aquifer may vary greatly in some areas, and yields of wells vary accordingly. For the purpose of this map the range of well yields noted represents those reported for roughly 80 to 90 percent of the wells in the area; 5 to 10 percent might have considerably higher yields, and 5 to 10 percent might have considerably lower yields. The yields noted on the map can be defined quantitatively according to the following general classifications:

1. 1-20 gal/min: small yield, adequate only for domestic supplies, including some stock water and lawn and garden irrigation;
2. 20-100 gal/min: moderate yield, adequate for small community supply and irrigation of a few acres;
3. 100-500 gal/min: moderately large yield, adequate for large-community and some industrial supplies, and for irrigation of 10 to 50 acres;
4. 500-2,000 gal/min: large yield, for municipal, industrial, and large irrigation supplies; and
5. More than 2,000 gal/min: very large yield, for municipal, industrial, and large irrigation supplies.

Grays-Elochoman Region

Domestic and small irrigation supplies are obtained from aquifers in valley-bottom alluvium, from wells capable of yielding 25 to 250 gal/min. Domestic supplies in the upland areas are obtained from the basalt aquifer, which locally has provided yields as high as 500 gal/min.

Willapa Region

The principal aquifers in this region are in beach sand of the coastal areas, alluvium of the interior valley bottoms, and older sand and gravel terrace deposits underlying the lowlands between the coast and hills. Most of the wells are situated on the North Beach Peninsula. The wells tapping the beach-sand aquifer in these areas are 15 to 30 feet deep and provide adequate domestic supplies, but they are capable locally of yielding 50 to 2,000 gal/min. Several wells as much as 250 feet deep obtain water from the underlying older terrace gravel and have yields of 100 to 300 gal/min. In a small area on the east side of Willapa Bay, wells about 500 feet deep in the gravel tap artesian water that flows at land surface and can be pumped at rates as high as 1,000 gal/min.

Most ground-water development has been for individual household use, a few community supplies, irrigation, seafood processing and canning, and temperature protection of cranberries, the principal crop of the region.

Chehalis Region

Ground water, used mostly for domestic and stock supplies, is obtained principally from alluvial sand and gravel deposits underlying the lowland stream valleys and from glacial drift in the area between Centralia and Grand Mound. Most wells tapping the alluvial deposits are less than 300 feet deep, and most yields range from 50 to 600 gal/min; a maximum of 3,000 gal/min has been obtained from a deeper well in the alluvium in the lower Chehalis River valley.

In the Newaukum River valley, several wells ranging in depth from 75 to 545 feet tap an aquifer in sedimentary rocks of Tertiary age that locally provide artesian flows as much as 600 gal/min.

Olympic Peninsula Region

The principal aquifers in this region are in beach sand of the Point Brown peninsula (extending south from near Ocean City), alluvium in the major stream valleys, glacial drift in the Port Angeles-Sequim area, and older terrace gravel that underlies areas between the coast and mountainous interior. From wells generally less than 50 feet deep, the beach-sand deposits yield 25 to 100 gal/min and the valley alluvium yields 25 to 200 gal/min. From wells 50 to 100 feet deep, the drift yields 5 to 300 gal/min and the terrace gravel yields 5 to 200 gal/min. Most of the ground-water development has been for domestic and small community supplies. In the Sequim area, there has also been development for irrigation.

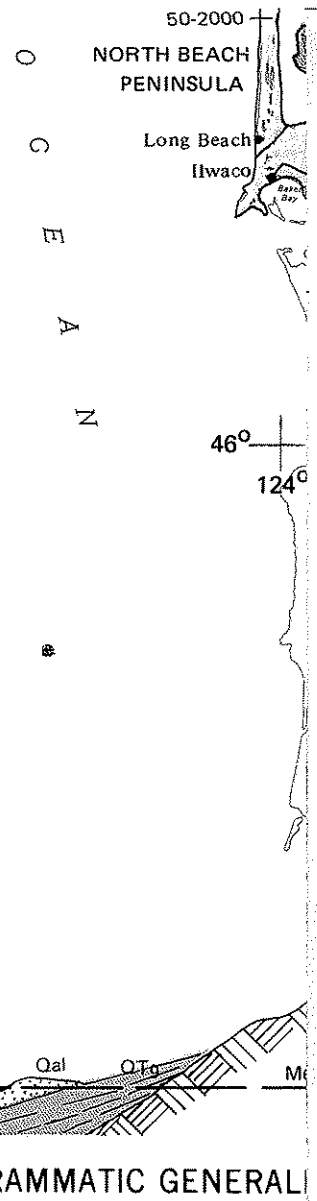
San Juan Region

The San Juan region is underlain mostly by bedrock of low permeability. Some ground water occurs in the region, but it is principally in localized deposits of unconsolidated glacial drift. Some wells developed in sand and gravel units of the drift may be capable of producing 100 gal/min or more, but the aquifer extent and thickness are small, and most wells are adequate only for domestic and small-community supplies.

Puget Sound Region

The principal aquifers in this region are in glacial drift, which, along with finer grained interglacial sediments, underlies the basin lowland to depths of more than 1,000 feet, and in alluvial deposits that underlie the major valleys of the lowland and mountain valleys. The water-yielding capability of the sand and gravel units of the drift ranges from a few gallons per minute to more than 5,000 gal/min. The alluvial deposits also vary widely in water-yielding capability, depending on the proportions of silt, sand, and gravel present. Yields greater than 2,000 gal/min have been obtained from the valley alluvium underlying some lowland flood plains and from the coarser alluvium underlying mountain valley bottoms.

The principal source of supply for the city of Olympia, in the southern part of the region, is a large spring that discharges between 15 and 25 cubic feet per second (6,750 and 11,300 gal/min) from glacial-drift deposits. Wells drilled to depths of 100 to 200 feet in alluvium and glacial drift underlying the lower Nisqually River flood plain generally have artesian flows of 200 to 350 gal/min; some flows are even greater.



DIAGRAMMATIC GENERALI

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to 250 feet deep yield 150 to 1,700 gal/min, t
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Glacial drift and alluvial deposits underlying
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In the west-central part of the region, betwee
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The principal aquifer in this region is alluviu
Longview-Kelso area along the Columbia River
200 gal/min, most of the water being used
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The principal aquifers are alluvial deposits, wh
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Most ground-water development has been
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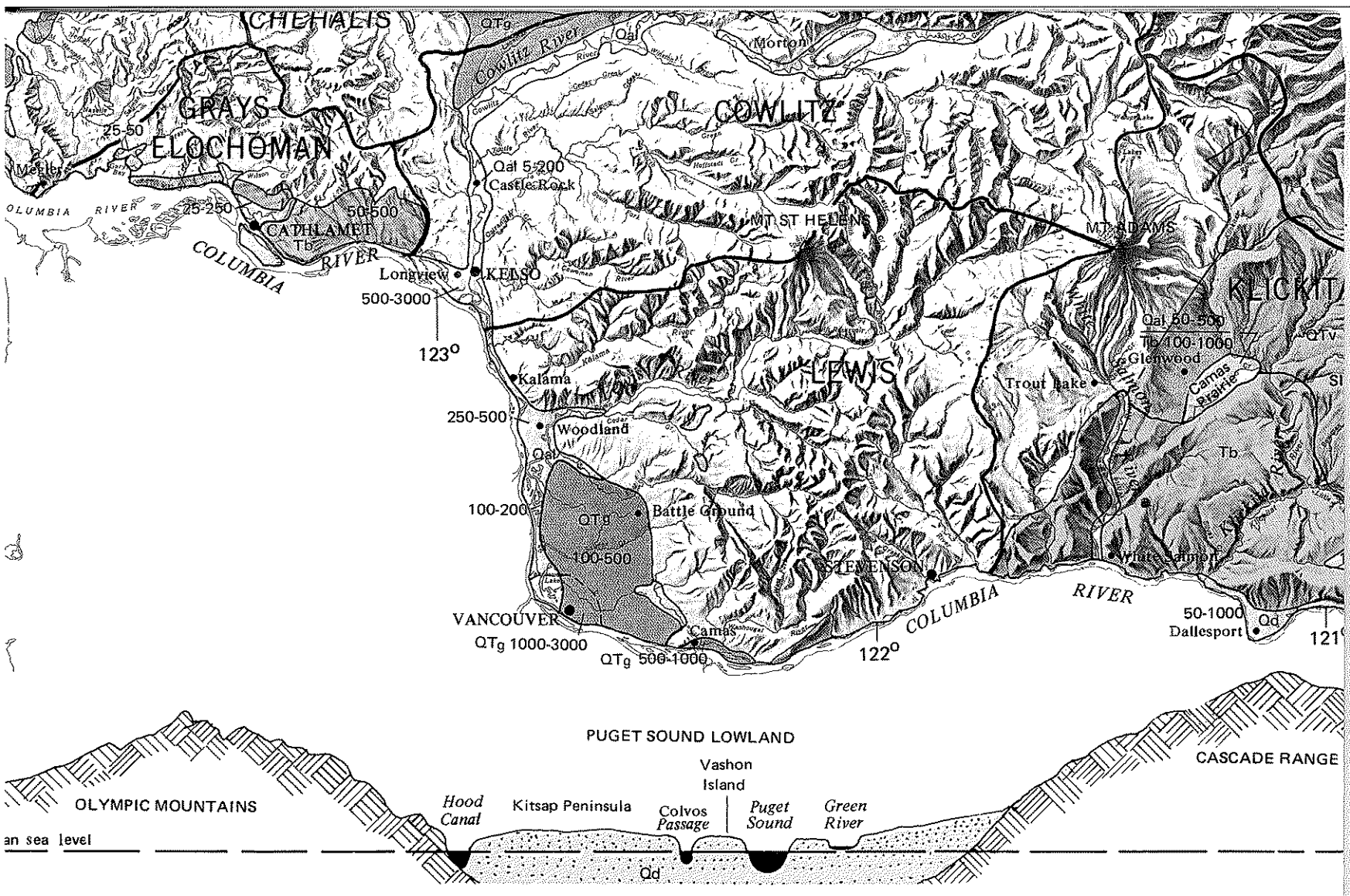

ZED WEST-TO-EAST GEOLOGIC SECTION ACROSS WASHINGTON, SHOWING STRATIGRAPHIC RELATIONS OF PRIN

been obtained from municipal-supply wells 130 to 1,100
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similar deposits and also obtain artesian flows; some
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wells yield 1,000 to 9,000 gal/min from coarse gravel
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ve yielded 8,000 to 10,000 gal/min to individual wells.
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litz Region

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Well yields in the Cowlitz River valley range from 5 to
or domestic supplies. In the Longview-Kelso area,
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is Region

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itat Region

Columbia River Basalt Group, but the northern part of
ks of Pliocene and Pleistocene age. Alluvium under-
s of the White Salmon River valley and lower Klickitat

y relatively shallow wells (less than 80 ft deep) for
from the alluvium vary, but as much as 500 gal/min
d from wells completed in the underlying basalt, to depths ranging generally from 300 to 1000 feet. Pumping tests of some wells in the basalt indicate that yields of 1,000 gal/min or more can be obtained from deep wells.

Horse Heaven Region

Basalt underlies this entire region and is the principal aquifer tapped, by mostly domestic wells and a few community-supply wells. Deposits of alluvial sand and gravel along the Columbia River locally provide water for some domestic and community supplies. Irrigation water is obtained from wells generally less than 150 feet deep which tap the valley-fill alluvium in the Swale Creek basin southwest of Goldendale and in the upper Glade Creek basin near the crest of the Horse Heaven Hills. At Dallesport and near Plymouth, yields of 50 to 1,000 gal/min are obtained from 30- to 150-foot wells that tap the alluvial gravel aquifer near river level.

Larger yields are obtained from several deep irrigation wells tapping basalt beneath the area. Some of the 700- to 1000-foot wells have artesian flows of 2,000 to 2,500 gal/min. Elsewhere, adequate domestic and stock supplies are obtained from wells that range in depth from 150 to 1,100 feet.

Yakima Region

The principal aquifers in this region include those in the basalt that underlies most of the area, in alluvium along major stream valleys, and in older unconsolidated deposits that underlie the lowlands of several basins formed by structural deformation of the basalt. The basalt aquifers vary in their water-yielding character, and well yields range generally from 100 gal/min to 2,000 gal/min. Artesian flows of 300 to 2,000 gal/min have been obtained from several wells tapping basalt aquifers between the depths of 600 and 1,100 feet in the structurally downwarped Cold Creek valley northwest of the Hanford Department of Energy facility. Also, flows of 200 to 875 gal/min have been obtained from 900- to 1,326-foot wells in the vicinity of Moxee City. A 2,760-foot well in the Ahtanum Creek valley reportedly had a flow of 2,000 gal/min upon completion years ago. In the northern part of the Kittitas Valley a well drilled 600 feet into the basalt had an artesian flow of 2,100 gal/min in 1975.

The aquifer composed of the older unconsolidated deposits provides water to domestic and stock-supply wells in some parts of the region. It is important to irrigation in the Wenas Creek valley and to the food-processing and canning industry in the Kittitas Valley near Ellensburg. Well yields of 500 to 1,000 gal/min have been reported from wells 200 to 1,000 feet deep in the Ellensburg area.

Entiat-Wenatchee Region

Glacial-drift aquifers underlying the bottoms of the major valleys are the principal source of ground water for industrial, irrigation, public, and domestic supplies. Well depths range from about 30 to 120 feet. Most wells yield 250 to 500 gal/min, but 1,000 gal/min has been obtained from some wells.

Chelan Region

The principal aquifers in this mostly mountainous area are composed of coarse alluvium and glacial drift that occur in the lower parts of most valleys tributary to Lake Chelan. Ground-water development is limited almost entirely to domestic supplies obtained from glacial deposits that form the terraces along the lower 15-mile reach of the lake. Yields of 10 to 100 gal/min are common from wells tapping these deposits, which are locally as thick as 100 feet. At the town of Stehekin near the head of Lake Chelan, an 80-foot-deep community-supply well produces about 100 gal/min from gravel and cobbles

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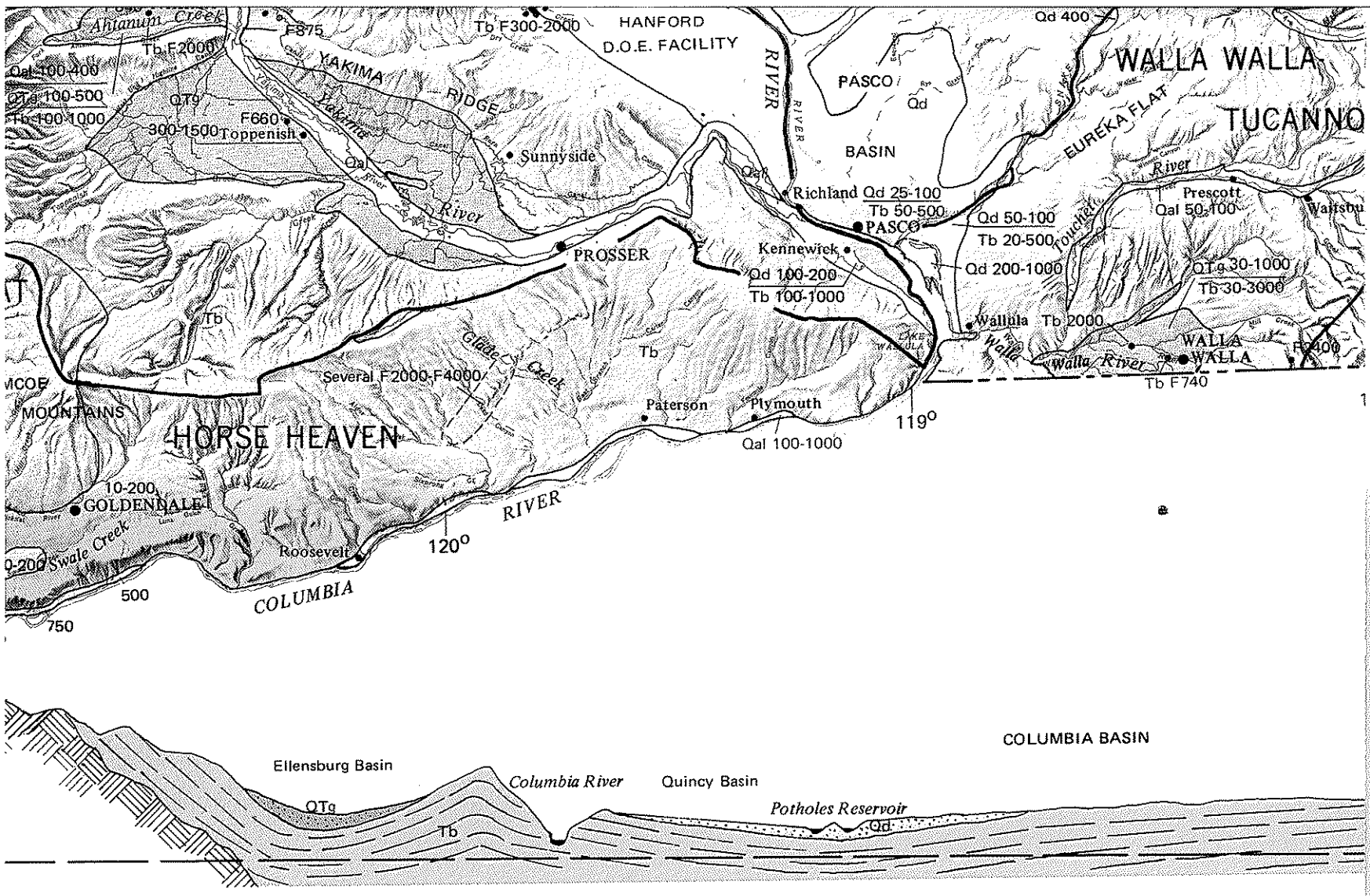


CIPAL AQUIFERS

of a talus slope that underlies part of the community.

Methow Region

n underlying the lower parts of the major valleys of this region is the principal aquifer. Well ıe from a few feet to 200 feet, and well yields generally range from 100 to 1,300 gal/min. The ɜed mostly for domestic and community supplies, but some are for industrial supplies.

Okanogan Region

: deposits of sand and gravel as much as several hundred feet in thickness are the prin-rs in the Okanogan River valley and several tributary valleys. By far the greatest use of ər in the region is for irrigation. Wells tapping these deposits yield 10 to 1,000 gal/min. In the wells are less than 60 feet deep.

Northeastern Region

the Okanogan region, alluvium and glacial drift underlying the major valleys and basins ıcipal aquifers providing water to wells, mostly for domestic and stock supplies, but for tion. Most well yields range from 50 to 250 gal/min, although 1,700 gal/min has been ɔm the 212-foot City of Colville municipal well, which had an artesian flow of 300 gal/min ɨ in 1954.

Spokane Region

al aquifer in this region is glacial drift—coarse sand and gravel alluvium—underlying the ver valley east of Spokane. As thick as 800 feet in some places, the gravel provides yields 2,000 gal/min to most wells, which are used for municipal, industrial, irrigation, and ıpplies. Wells tapping these deposits in the Chamokane Creek valley and in the Spokane , for short distances above and below the junction of the two streams, yield 100 to 500 gal/ for irrigation. Yields as great as 5,000 gal/min have been obtained from similar drift the area north of Spokane. Wells in the basalt aquifer underlying the southwestern part of in an area between Medical Lake and Spokane, yield 100 to 500 gal/min.

Palouse Region

stream-valley alluvium provide water to relatively shallow domestic and stock-supply yields have been obtained locally. However, the principal aquifer underlying the region is e Columbia River Basalt Group.

pply development from the basalt aquifer is concentrated most heavily in the Pullman ɣ for municipal supply at Pullman, which includes water for Washington State University. completed to depths as great as 950 feet yield more than 1,000 gal/min. Many wells tap-aquifers initially flowed, but extensive pumping during the past 60 years has appreciably ɜ artesian head.

nicipal-supply wells in the region have obtained large artesian flows from wells tapping 106-foot City of Colfax well (situated in the floor of the North Fork Palouse River valley, 6 east of Colfax) had an artesian flow of 1,550 gal/min when drilled in 1927. However, the ad and flow rate have declined over the years.

Columbia Basin Region

The entire region is underlain by the Columbia River Basalt Group. In some are alluvial gravel and sand overlying the basalt provide local water supplies, but yi min are obtained from wells tapping the basalt aquifer nearly everywhere in the exceptions are in some marginal parts of the plateau where the basalt thins ar accordingly. In some areas, as in the scabland areas characterized by numero aquifers are undeveloped because the soil is too thin to support agriculture.

The basalt aquifers provide water for irrigation in Moses Coulee, along upp areas around Almira, Harrington, and Lind. Well yields of 500 to 800 gal/min ar Moses Coulee, and as much as 2000 gal/min is obtained in the Odessa-Lind

In the Quincy Basin and in an elongate area between Ephrata and Moses La aquifer is locally capable of yielding as much as 700 gal/min to wells; however, for domestic supplies. According to pumping-test data, wells completed in this yielding 200 to 800 gal/min in the lower Crab Creek valley, 800 gal/min in Wahluke Slope, along the Columbia River, and 25 to 100 gal/min near Pasco.

Walla Walla-Tucannon Region

This region is underlain by basalt aquifers and locally by aquifers in alluvium. C in gravel bars principally along the Snake and Columbia Rivers, and alluvi Touchet and Tucannon Rivers. The agriculturally developed lowland of the lo valley is a structurally depressed basin in basalt, which is filled to depths as sedimentary deposits of silt, clay, sand, and gravel.

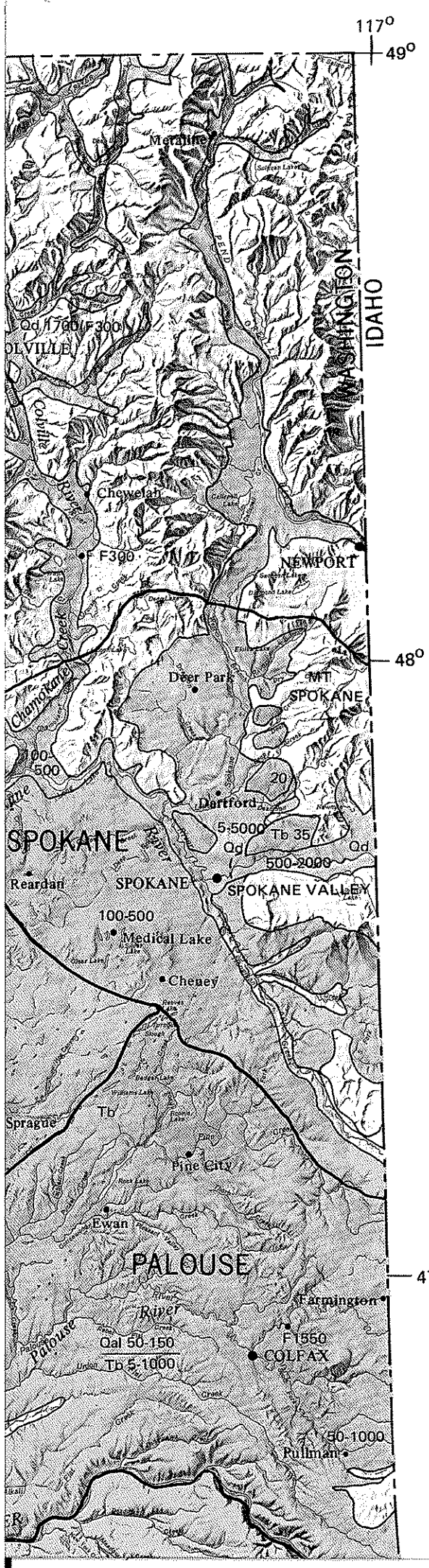
Saturated gravel units in the sedimentary deposits, which are the source of c water in the Walla Walla area, yield 30 to 1,000 gal/min to wells which range gen feet to 300 feet. Water in the underlying basalt also is tapped by irrigation an and at depths generally between 100 and 2,000 feet wells yield 30 to 3,000 gal/ wells had artesian flows when first drilled. The most productive well in the Walla deep and taps the basalt aquifer upslope from an apparent fault in the easterr well had an artesian flow of nearly 2,400 gal/min when drilled in 1945.

Water levels in the basalt aquifers beneath the Eureka Flat area are gene below land surface, and the well yields are limited to domestic supplies of 10 domestic supplies are obtained from shallower wells tapping gravel that overl

Coarse gravel in glacial drift that occurs locally along the Columbia and Snak 1,000 gal/min to relatively shallow wells. Aquifers in alluvial sand, silt, and gra and Tucannon Rivers yield quantities of water adequate for domestic supplies tion.

Blue Mountains Region

This region, underlain by the Columbia River Basalt Group, is relatively undevel ged topography. Principal ground-water development is for public and dom Clarkston-Asotin area along the Snake River. In the upland areas a few d hundred feet deep tap aquifers in basalt and associated sedimentary interbeds to 100 gal/min.



EXPLANATION

Qal	Alluvium of Holocene age
Qd	Glacial drift of Pleistocene age
QTg	Sedimentary deposits of early Pleistocene to Miocene age
QTv	Volcanic rocks of Pleistocene and late Pliocene age; probably an aquifer, but well data lacking
Tb	Basalt and interbedded sedimentary deposits of Columbia River Basalt Group of Miocene age
	Consolidated igneous, sedimentary, and metamorphic rocks of Pleistocene to pre-Cambrian age; as mapped includes mostly mountainous areas of little or no ground-water development
	Boundary between regions

WELL YIELDS

(values in gallons per minute)

20-50	Range of yields of most wells tapping aquifer in the area
• 3000	Large yield and approximate well location
• F2000	Large artesian flow and approximate well location
Qd 50 100 Tb 100 500	Overlying and underlying aquifers and ranges of well yields
50	Area of specified well yield

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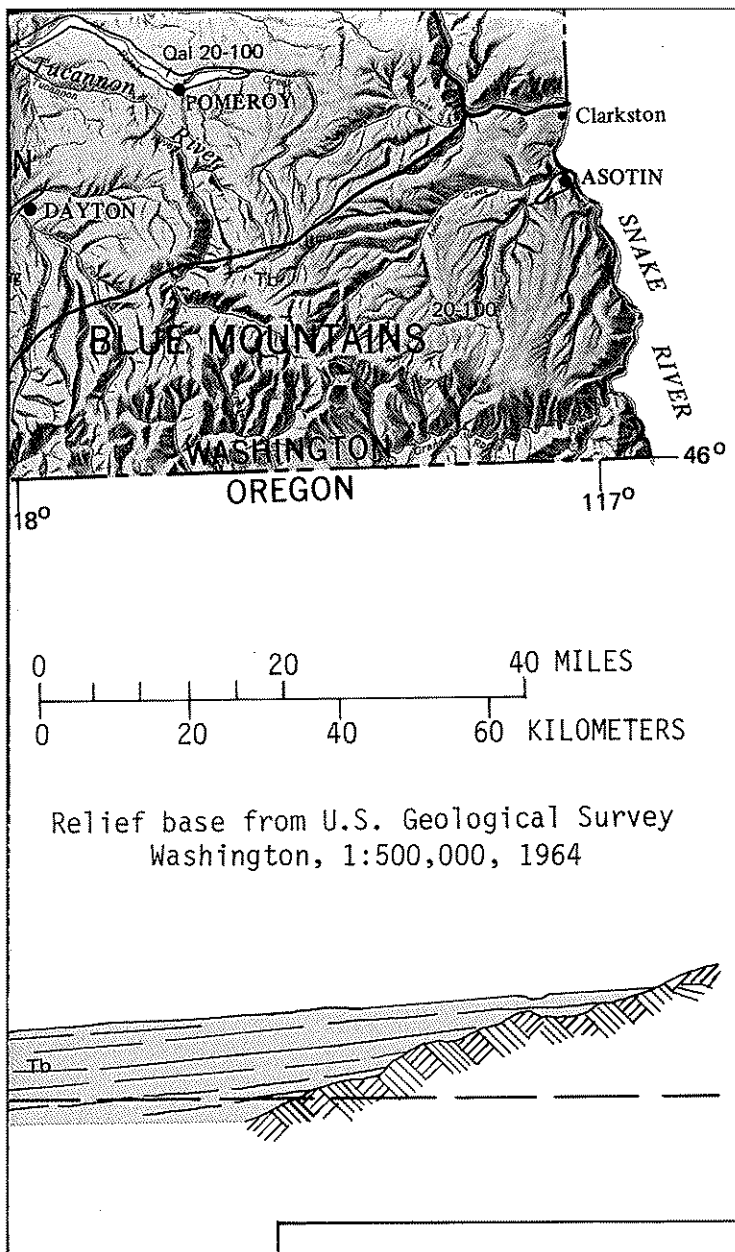

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PRINCIPAL AQUIFERS AND WELL YIELDS IN WASHINGTON

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1980