Ground-Water Hydrology of the Willamette Basin, Oregon

By Terrence D. Conlon, Karl C. Wozniak, Douglas Woodcock, Nora B. Herrera, Bruce J. Fisher, David S. Morgan, Karl K. Lee, and Stephen R. Hinkle

Prepared in cooperation with the Oregon Water Resources Department

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Contents

Plate [in pocket]

Figures

Tables

Conversion Factors

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

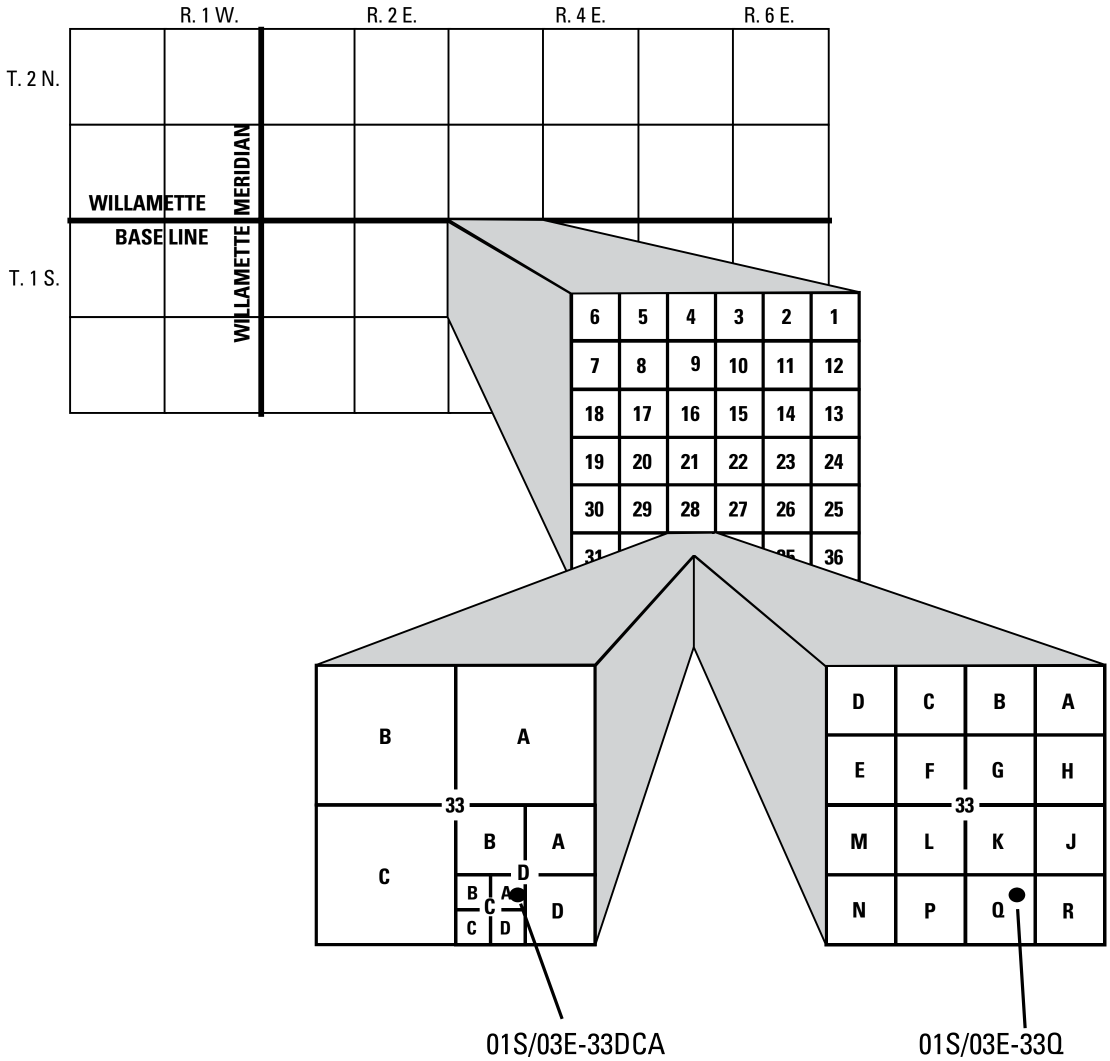
°C=(°F-32)/1.8

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29)."

Altitude, as used in this report, refers to distance above the vertical datum.

Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Base map composited from U.S. Geological Survey digital line graphs and other digital information. Universal Transverse Mercator projection, zone 10 1927 North American Datum. Longitude of Central Meridian: -123.000000. Latitude of Projection Origin: 0.000000. False Easting: 500000.000000. False Northing: 0.000000.



Well- and Spring-Location System

The system used for locating wells and springs in this report is based on the rectangular system for subdivision of public land. The State is divided into 36 square-mile townships numbered according to their location relative to the east-west Willamette baseline and a north-south Willamette meridian. The position of a township is given by its north-south "Township" position relative to the baseline and its east-west "Range" position relative to the meridian. Each township is divided into 36 sections approximately 1 square mile (640-acre) in area and numbered from 1 to 36. For example, a well designated as 01S/03E-33DCA is located in Township 1 south, Range 3 east, section 33. The letters following the section number correspond to the location within the section; the first letter (D) identifies the quarter section (160 acres), the second letter (C) identifies the quarter-quarter section (40 acres), and the third letter (A) identifies the quarter-quarter-quarter section (10 acres). Thus, well 33DCA is located in the NE quarter of the SW quarter of the SE quarter of section 33. When more than one designated well occurs in the quarter-quarter-quarter section, a serial number is appended. For some wells that were field located during previous USGS and OWRD studies, a different system of letters following the section number was used for the location within the section. This system assigns a letter to one of 16 quarter-quarter sections (40 acres) that divide the section. The location 33DCA would correspond to the location 33Q. When more than one designated well occurs in the quarter-quarter section, a serial number is appended.

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Abstract

The Willamette Basin encompasses a drainage of 12,000 square miles and is home to approximately 70 percent of Oregon's population. Agriculture and population are concentrated in the lowland, a broad, relatively flat area between the Coast and Cascade Ranges. Annual rainfall is high, with about 80 percent of precipitation falling from October through March and less than 5 percent falling in July and August, the peak growing season. Population growth and an increase in cultivation of crops needing irrigation have produced a growing seasonal demand for water. Because many streams are administratively closed to new appropriations in summer, ground water is the most likely source for meeting future water demand. This report describes the current understanding of the regional ground-water flow system, and addresses the effects of ground-water development.

This study defines seven regional hydrogeologic units in the Willamette Basin. The highly permeable High Cascade unit consists of young volcanic material found at the surface along the crest of the Cascade Range. Four sedimentary hydrogeologic units fill the lowland between the Cascade and Coast Ranges. Young, highly permeable coarse-grained sediments of the upper sedimentary unit have a limited extent in the floodplains of the major streams and in part of the Portland Basin. Extending over much of the lowland where the upper sedimentary unit does not occur, silts and clays of the Willamette silt unit act as a confining unit. The middle sedimentary unit, consisting of permeable coarse-grained material, occurs beneath the Willamette silt and upper sedimentary units and at the surface as terraces in the lowland. Beneath these units is the lower sedimentary unit, which consists of predominantly fine-grained sediments. In the northern part of the basin, lavas of the Columbia River basalt unit occur at the surface in uplands and beneath the basin-fill sedimentary units. The Columbia River basalt unit contains multiple productive water-bearing zones. A basement confining unit of older marine and volcanic rocks of low permeability underlies the basin and occurs at land surface in the Coast Range and western part of the Cascade Range.

Most recharge in the basin is from infiltration of precipitation, and the spatial distribution of recharge mimics the distribution of precipitation, which increases with elevation. Basinwide annual mean recharge is estimated to be 22 inches. Rain and snowmelt easily recharge into the permeable High Cascade unit and discharge within the High Cascade area. Most recharge in the Coast Range and western part of the Cascade Range follows short flowpaths through the upper part of the low permeability material and discharges to streams within the mountains. Consequently, recharge in the Coast and Cascade Ranges is not available as lateral ground-water flow into the lowland, where most ground-water use occurs. Within the lowland, annual mean recharge is 16 inches and most recharge occurs from November to April, when rainfall is large and evapotranspiration is small. From May to October recharge is negligible because precipitation is small and evapotranspiration is large.

Discharge of ground water is mainly to streams. Ground-water discharge is a relatively large component of flow in streams that drain the High Cascade unit and parts of the Portland Basin where permeable units are at the surface. In streams that do not head in the High Cascade area, streamflow is generally dominated by runoff of precipitation. Ground-water in the permeable units in the lowland discharges to the major streams where there is a good hydraulic connection between aquifers and streams. Ground-water discharge to smaller streams, which flow on the less permeable Willamette silt unit, is small and mostly from the Willamette silt unit.

Most ground-water withdrawals occur within the lowland. Irrigation is the largest use of ground water, accounting for 240,000 acre feet of withdrawals, or 81 percent of annual ground-water withdrawals. Most withdrawals for irrigation occur from March to October and are largely from the upper and middle sedimentary unit in the central Willamette and southern Willamette Basins. Lesser amounts of ground water are withdrawn from the Columbia River basalt and lower sedimentary units. Withdrawals from the basement confining unit are a small percentage of total withdrawals. No significant water is withdrawn from the Willamette silt unit.

The effect of ground-water withdrawals on streamflow in the lowland is small for many streams because there is a poor hydraulic connection between streams that flow on the less permeable Willamette silt unit and the productive middle sedimentary unit. Withdrawals from wells open to the middle and upper sedimentary units capture ground water that would otherwise discharge to the large streams that have an efficient hydraulic connection to the upper sedimentary unit.

In the lowland, average annual water levels and the direction of ground-water flow are unchanged from predevelopment conditions in 1935. Seasonal water-level fluctuations outside the central Willamette Basin are similar to predevelopment fluctuations. In the central Willamette Basin, seasonal water-level fluctuations have increased by as much as 55 feet because of increased summer pumpage, but in most areas, the

water levels return to their historic winter high levels. In some areas, water levels vary on a decadal scale in response to climatic trends, but these changes are small compared to seasonal fluctuations.

Long-term water-level declines are observed in wells open to the Columbia River basalt unit in areas with concentrated pumping. Declines as great as 6 feet per year have occurred in some areas.