Cascadia

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How does geology control where you find and how you use water?

Water and geology

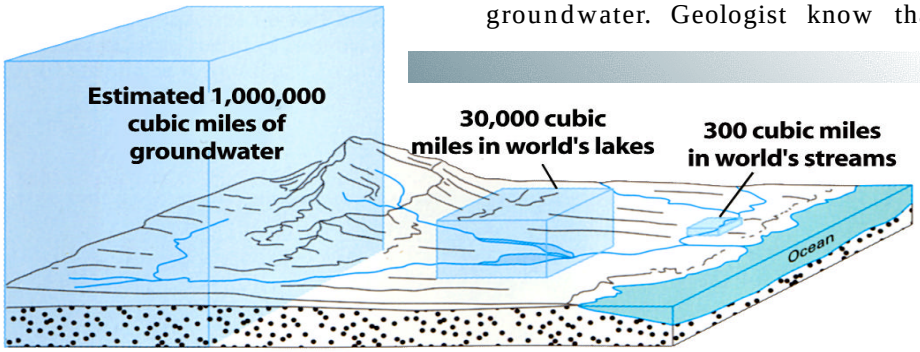
By James Roddey

Water is an unusual resource. It has some characteristics of renewable resources like forests and some of non-renewable resources like minerals. But finding, using and managing water resources, especially groundwater resources in arid parts of Oregon, can be a frustrating task – witness the evolving difficulties in the Klamath Basin this past year. In fact, seventeen counties had drought declarations in 2001, causing serious economic, social, and environmental problems across the state.

The problems with our water supply are not going to go away and how we find and use water has become one of the most critical questions to the future of our state.

When geologists look at water, they see an entirely different picture that policies and politics don't affect. They see rocks below the earth's surface controlling the water – a natural system that stores and transmits water (groundwater) and connects it to rivers (surface water). They see the geology of an area controlling the behavior of water – in the streams, where groundwater is found, and in the interaction of these streams with groundwater. Geologist know that understanding an area's geology is often critical for coordinated management of groundwater and surface water to help prevent the problems we've seen in the past year.

Groundwater can be essential for agricultural production. Understanding where to find it can be critical in managing this unusual natural resource.



Comparison of the amount of fresh water in storage on the earth. It is only in recent decades that scientists and engineers have learned how to estimate how much groundwater is stored underground. (graphic courtesy USGS)

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Who manages Oregon's water is another question with no easy answer. Many state and local agencies are charged with looking after various parts of Oregon's water supply (see page 4).

Although the Oregon Department of Geology and Mineral Industries (DOGAMI) is not the lead state agency for water policy or water management, it has an important role to play because of its knowledge of the relationship between water and rocks. DOGAMI *is* the lead agency for geologic mapping in the state and is the source and coordinator of much of the geologic information needed to help craft successful groundwater and surface water strategies.

As you will see throughout this issue of **Cascadia**, this expertise from DOGAMI can contribute to cost-effective and innovative water management programs at both state and local levels. DOGAMI can also help forge strategic partnerships with federal, state and local stakeholders that bring benefits to all users.

(continued on the next page)

Through the eyes of the State Geologist

by John D. Beaulieu, Oregon State Geologist

The first use of geology in all cultures was to find or record mineral resources. This has led to an unfortunate bias. Most people today have come to associate geologic maps with mineral deposits and little else.

Yet a properly constructed geology map of the earth is more like a blueprint than it is a treasure map to locate metals alone. It highlights other resources – land stability, engineering properties, geologic hazards, and the flow of water.

Yes, the flow of water. Rocks beneath the surface of the earth control the flow of water. They control where it is, how long it stays, how fast it flows, how much can be stored, and how easy it is to get it out of the ground. Rocks control the very abundance and occurrence of ground water. If someone wants to manage the ground water in an area, they must understand the geology.

Rocks also control streams and rivers. Streams are wedded to the sediments they carry and to the floodplains which they flow over. The Columbia and Willamette Rivers, are where they are today because of geology. Some rivers like the Snake River fight the geology and even carve valleys through growing mountain ranges, but even there the processes are controlled by the geology.

Beyond the geology, if one wants to understand why streams do what they do, one must study a branch of science that looks at the landforms associated with rivers and streams and the processes that form them called fluvial geomorphology. On a grand scale, failure to understand this relationship doomed the ancient civilizations of the Tigris-Euphrates, the Indus, and the Nile rivers.

On a smaller scale we see similar examples in Oregon every day. We see an earlier failure to understand the geologic processes in challenges to the Oregon Plan in the Rogue River, at Confluence Island in Eugene (see page 9), and in flooding problems in Tillamook County. On some scale we see it every time we try to manage our affairs in or near the pathway of rivers.

Fluvial geomorphology: the branch of science that studies the landforms associated with river channels and the processes that form them.

DOGAMI has grown beyond its first mission of helping society find minerals. The agency, as the Geologic Survey for the state, now increasingly turns its attention to the state's need for geologic perspective in meeting the groundwater and surface water demands of its people. What is the proper niche for DOGAMI in this arena?

On October 17, 2001 the Governing Board of DOGAMI adopted a position paper to help guide some of the future water-related activities of the agency. This issue of **Cascadia** explores some of the aspects of this new use of geologic information in Oregon.

In 1999, DOGAMI cooperated with the Oregon Water Resources Department to drill the 1,005-foot Lorella Deep Well in Klamath County. DOGAMI was able to identify and map subsurface layers, leading to an increased understanding of the regional water resources.

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Water problems – drought, flooding, pollution – will never go away, and the questions of how best to use this most critical of all natural resources will always be an ongoing challenge. But knowing how the natural system works that controls the water is a fundamental step in learning to manage the resource wisely.

By concentrating in key areas with geologic mapping, and studying and coordinating information on stream geology, DOGAMI can bring a professional understanding and expertise to what can be a frustrating problem. The result is a well managed renewable natural resource for future generations.

Special note

This will be the last issue of Cascadia mailed to subscribers of this publication and Oregon Geology. Cascadia will, however, continue to be available free on the DOGAMI website at: http://www.OregonGeology.com

What is groundwater?

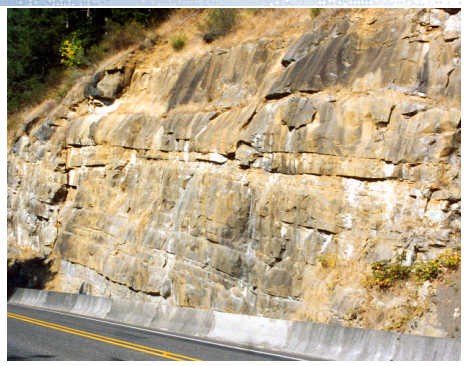
When rain falls to the ground, the water does not stop moving. Some of it flows along the surface in streams or lakes, some of it is used by plants, some evaporates and returns to the atmosphere, and some sinks into the ground.

Groundwater is water that is found underground in cracks and spaces in soil, sand and rocks. The area where water fills these spaces is called the **saturated zone**. The top of this zone is called the **water table** and it may be only a foot below the ground's surface or it may be hundreds of feet down.

Groundwater can be found almost everywhere. The water table may be deep or shallow; and may rise or fall depending on many factors. Groundwater is stored in – and moves slowly through – layers of soil, sand and rocks called **aquifers**. The speed at which groundwater flows depends on the size of the spaces in the soil or rock and how well the spaces are connected.

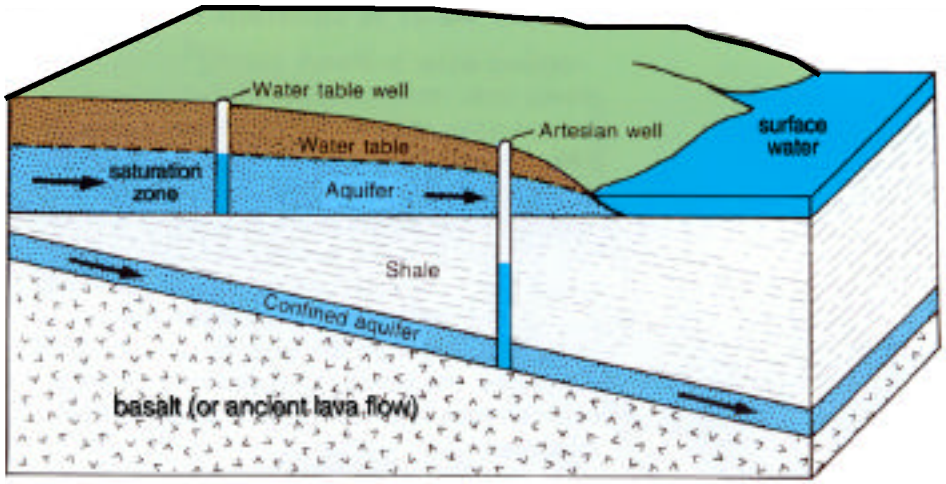
Aquifers typically consist of gravel, sand, sandstone, or fractured rock, like limestone or basalt. These materials are permeable because they have large connected spaces that allow water to flow through. Water in aquifers is brought to the surface naturally through a spring or can be discharged into lakes and streams. This water can also be extracted through a well drilled into the aquifer. Some wells, called artesian wells, do not need a pump because of natural pressures that force the water up and out of the well.

Groundwater supplies are replenished, or recharged, by rain and snow melt. Groundwater is used for drinking water by more than 50% of the people in the United States, including almost everyone who lives in rural areas, and the largest use for groundwater is to irrigate crops.



A close look at the rocks exposed in road cuts can show the types of openings in which groundwater can occur. The gaps between the layers can contain water that percolates into these spaces.

To learn more about groundwater, go to http://water.usgs.gov/ogw/ or http://www.groundwater.org



(graphic courtesy USGS)

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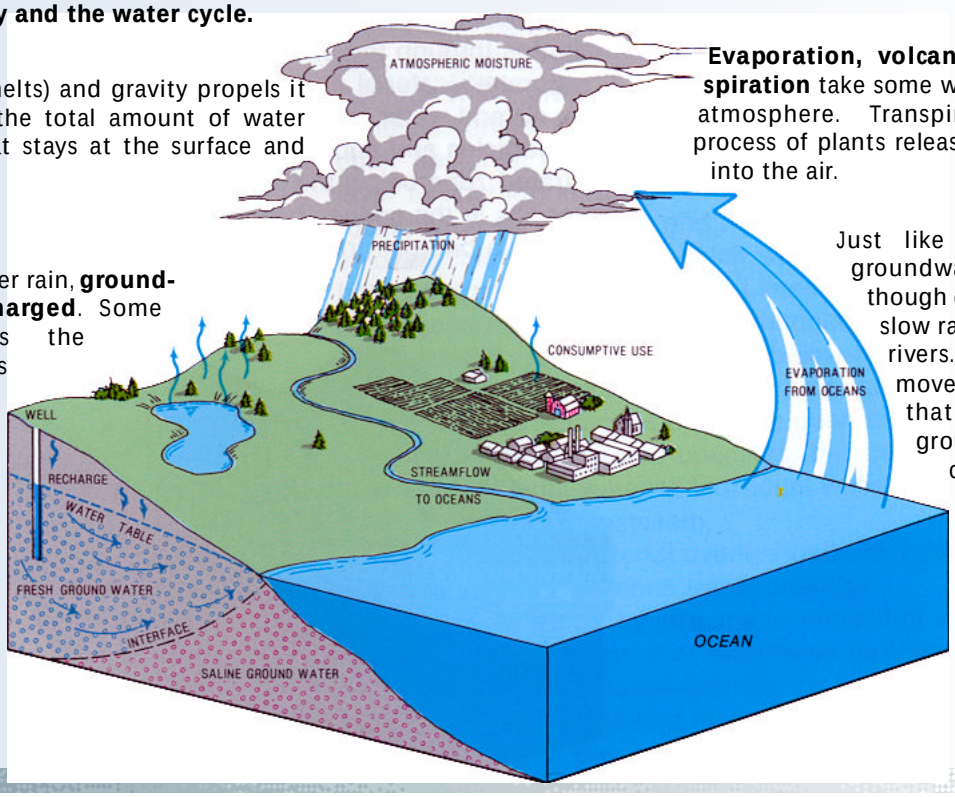
Geology and groundwater

Geologists can help describe the earth's plumbing system: the conduits through which water flows. To efficiently find and use groundwater, you must understand the regional geology and the water cycle.

Rain falls (or snow melts) and gravity propels it downhill. **Runoff** is the total amount of water after a rainstorm that stays at the surface and ends up in streams.

Just as rivers grow after rain, **groundwater** can be **recharged**. Some moisture infiltrates the ground where it is trapped below the water table and becomes part of the **aquifer**. An aquifer is an underground source of water that can be tapped by wells. Like other geologic features, aquifers can be mapped.



Evaporation, volcanoes, and **transpiration** take some water back to the atmosphere. Transpiration is the process of plants releasing water vapor into the air.

Just like surface water, groundwater also **flows**, though obviously at very slow rates compared to rivers. Because of this movement, pollutants that enter the ground at one point can contaminate many wells, even an entire aquifer. **(graphic courtesy USGS)**

Who owns and manages Oregon's water?

By law, all surface and groundwater in Oregon belongs to the public, but there are many groups that have a hand in its management.

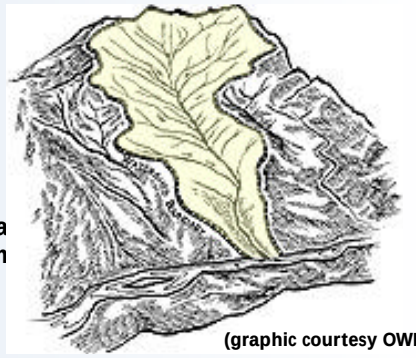
On a statewide basis, it is the job of the Oregon Water Resources Department (OWRD) to manage the use of Oregon's public water to ensure a sufficient supply to sustain its growing economy, quality of life, and natural heritage. That means preserving an equitable balance between public and private uses of water. OWRD protects existing uses of water while trying to maintain adequate levels in waterways to support fish, wildlife, water quality, and recreation.

OWRD staff monitor water levels at hundreds of gaging stations, map and study underground aquifers and help design long-term water plans for Oregon's river basins. OWRD, like DOGAMI, supplies local governments and citizen groups with information and technical assistance to make and carry out their own water programs.

The Oregon Watershed Enhancement Board (OWEB) is another state agency that promotes and funds voluntary actions related to Oregon's watersheds. OWEB's programs support Oregon's efforts to restore salmon runs, improve water quality, and strengthen ecosystems that are critical to healthy watersheds and sustainable communities. OWEB administers a grant program that awards more than $20 million

WHAT IS A WATERSHED?

The term "watershed" describes an area of land that drains downslope to the lowest point. The water moves through a network of drainage pathways that may be underground or on the surface. Generally, these pathways converge into a stream and river system that becomes progressively larger a the water moves downstream. Every stream tributary, or river has an associated watershed, and small watersheds aggregate together to become larger watersheds.



(graphic courtesy OWEB)

annually to support these voluntary efforts.

On a local management level, watershed councils in Oregon are voluntary, non-regulatory groups established to improve the condition of watersheds in their local area. There are dozens of watershed councils in the state – some, like the Harney County Watershed Council, cover a huge area, others may cover only a small creek's watershed. Through the councils, partnerships between residents, local, state and federal agency staff, and others can be developed.

Other state organizations have a hand in water management as well. The Department of Agriculture's Natural Resources Division provides support to 45 Soil and Water Conservation Districts that interface with local and state groups to promote watershed health. The Division of State Lands, the Department of Forestry, and the Department of Fish and Wildlife also play a part in how Oregon's groundwater and surface water are used.

Even federal agencies impact water management in Oregon. They include the U.S. Army Corps of Engineers, the Bureau of Land Management, the USDA Forest Service and the National Marine Fisheries Service.

DOGAMI, while not involved in water management, works with all of these agencies to craft successful groundwater and surface water strategies and is responsible for making geologic maps that include critical groundwater information.

Who owns the water has a simple answer. Who manages this resource is a question that often times has no simple answer. But finding the water to use in many cases is the first big step, and knowing that geology controls where you find water at least gives this question a solution.

2 good sources of information on water management in Oregon are the OWRD website (www.wrd.state.or.us), and the OWEB website (www.oweb.state.or.us).

Recent geologic efforts related to water

For almost 20 years DOGAMI has been working with state, federal, and local organizations to provide expertise in groundwater management issues throughout Oregon. Collectively, these efforts have enabled the agency to define a unique and key role in the state's efforts to deal with groundwater and surface water problems.

Beginning in the early 1990's DOGAMI began including groundwater information in the geologic maps it produced. Other major efforts include:

- In 1994 DOGAMI geologists worked in the field with the Oregon Water Resource Department in the Bend area as they developed a groundwater model to assist in managing water resources.
- In 1995 DOGAMI Mined Land Reclamation (MLR) specialists initiated a process to coordinate stakeholder efforts in the Confluence Island areas north of Eugene and the Applegate Watershed in Jackson County.
- In 1997, DOGAMI helped design the Klamath Project in coordination with OWRD, US Geologic Survey (USGS), US Bureau of Land Management (BLM), USDA Forest Service, and local consultants to define geologic controls on ground and surface water in the Klamath Basin. Also in 1997, staff geologists mapped and analyzed groundwater and geology in the Grande Ronde Basin for the state, local watershed councils, and other water managers. MLR staff helped coordinate stakeholder efforts in the lower Rogue River of Jackson County.
- In 1999, under contract with the US Bureau of Reclamation, DOGAMI cooperated with OWRD to drill the 1,005-foot Lorella Deep Well in Klamath County, a dual-completion, long-term monitoring well. DOGAMI was able to identify and map subsurface layers, leading to an increased understanding of the regional water resources.
- In 2000, DOGAMI personnel participated in Core and Implementation Team discussions, and provided

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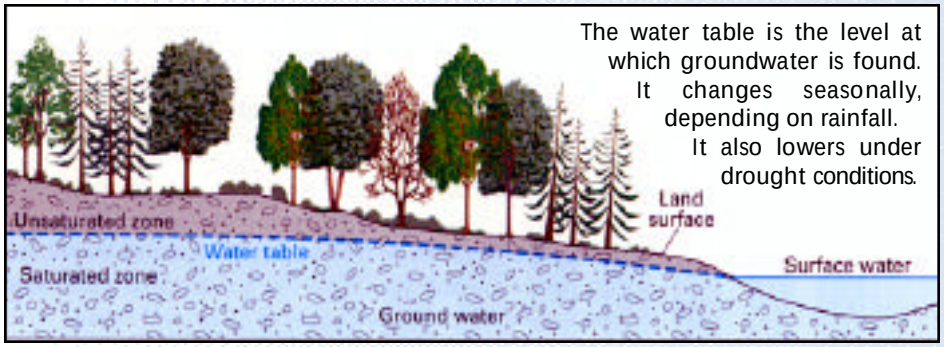
More than 98% of the Earth's fresh water is groundwater.

Groundwater and streams (surface water) are intricately tied together. They are part of a single hydrologic system.



Using wells to pump out groundwater can permanently lower the water table, making the wells useless. This happens when the recharge rate (addition of new water) exceeds water usage. Determining recharge paths requires understanding the geology of an entire watershed. **(graphic courtesy USGS)**

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leadership in efforts to link the Oregon Plan with the State of the Environment Report. Staff geologists also began a cooperative effort with OWRD, Illinois Valley Soil and Water Conservation District, and OWEB to investigate geologic controls on groundwater resources and groundwater/surface water interaction in the Illinois Valley in southeast Oregon.

The agency also worked in an advisory capacity on the multi-agency Tillamook County Flood modeling project. The goal of the effort was to implement ecosystem restoration and flood damage reduction measures.

■ In 2001 DOGAMI continued water related efforts on many fronts, including mapping efforts in the Klamath Basin area and participating in groundwater problem solving in the declared disaster area of Klamath County. Staffers were active in the Oregon Plan and MLR continued to help mining operators across the state develop new strategies for storm water control to help protect streams, wetlands and groundwater.

In the Klamath Basin, DOGAMI has worked with many groups to better define how geology influences the vital water resources of that watershed.

As DOGAMI's role in water related issues continues to evolve, the department approaches the future with the knowledge that water resources are critical to Oregon's future. Core strategies, as outlined in the new strategic plan, include developing, maintaining and sharing vital geologic information related to groundwater and surface water management while forging strong, beneficial partnerships.

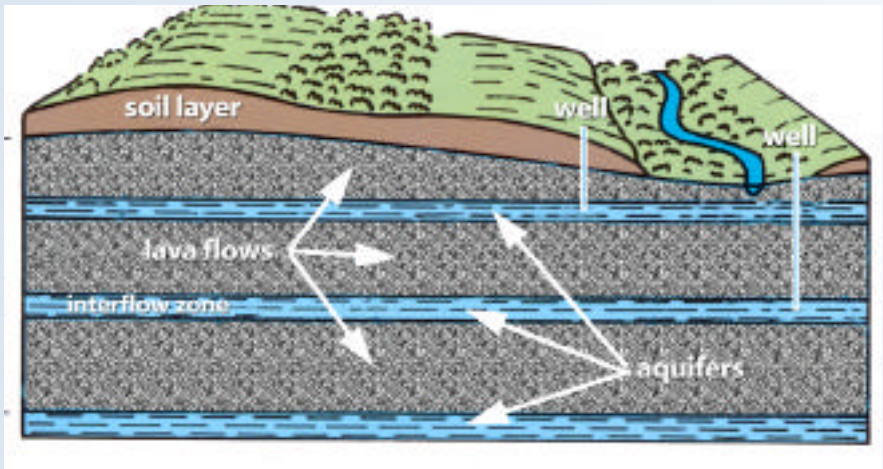
Supporting the Oregon Plan and other local watershed related initiatives, and continuing to improve our understanding of river behavior and forms (fluvial geomorphology) are also important core strategies to carry the department into the future.

To learn more, review DOGAMI's position paper on water and geology at www.OregonGeology.com

A special thanks to the USGS,the Oregon Water Resources Department (OWRD),and the Oregon Water Enhancement Board (OWEB) for helping with this issue of Cascadia.

Types of aquifers

In Oregon, most aquifers are either found in sand and gravel deposits from river systems, or in rock fractures.



In Oregon, many aquifers are inside ancient lava flows. Wells in lava flows tend to produce high quantities of water. Many wells drilled in Columbia River basalt can produce 1,000 to 2,000 gallons per minute.

It might seem odd to have a source of water that is mostly solid rock, but that is actually the reason these wells produce so much water.

Groundwater cannot flow through the dense basalt. It can only move in the layers between flows and through fractures in the rock. A well will not produce water until it hits one of these **interflow zones**.

One problem with rock aquifers is recharge. The same qualities that force water into small flow zones can make it difficult to replace water once it has been removed by wells. Several areas in the state with this type of aquifer have been designated critical groundwater areas, and no new wells are permitted. **(adapted from a USGS graphic)**

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from the Oregon Department of Geology and Mineral Industries

A groundwater case study:

Catherine Creek and the Upper Grande Ronde Valley

In the Upper Grande Ronde River basin in Northeast Oregon, there are proposals to increase the amount of water flowing in Catherine Creek, one of Oregon's few remaining wild salmon spawning streams, by using groundwater (instead of surface water) for irrigation.

The plan sounds simple – pump water out of the ground to protect the amount of water flowing in Catherine Creek. But without a detailed understanding of the geology in the area, knowing where to find the groundwater to make this possible could mean spending hundreds of thousands of dollars drilling dry holes.

The Grande Ronde Valley is a large basin situated along the east flank of the Blue Mountains. La Grande is at the west end of the valley, Hot Lake and Union are to the south and Summerville and Imbler border the valley to the north. The valley floor is a broad and flat alluvial plain – an area generally covered with a mixture of clays, silts, sands and gravels deposited by streams as they come out of the mountains.

At first glance, it might appear there should be plentiful water in relatively shallow aquifers, but that is not always the case. The more permeable underground layers that make the best aquifers in the Grande Ronde Valley occur at two different levels.

Relatively shallow aquifers can be found in the areas that extend beneath the Grande Ronde River and Catherine Creek where they come out of the mountains flow toward the alluvial plain. These shallow aquifers are generally cold-water and require pumping.

Deeper volcanic aquifers can also be found in the area and are generally warmer water systems that may not require pumping. However, for about 60% of the valley, to produce significant flows from these deeper volcanic aquifers, wells would probably need to be drilled about 2,000 feet – a very costly enterprise.

A closer look at the geology of three different rock units in and under the Grande Ronde Valley can give you an idea of how complicated the mapping process can be and how the geology of the area controls each area's potential for usable water.

Alluvial plain deposits

These thin, fine-grained silt and clay deposits that cover much of the valley came from marshlands, shallow lakes, and low terraces scoured by wind. They extend north from Hot Lake and dominate the southwest end of the valley. This layer close to the surface has little potential as an aquifer.

Fan deposits near the mouths of mountain valleys

Alluvial fans, deposits of gravel, sand, and silt, have formed where perennial streams (the Grande Ronde River, Ladd Creek, Mill Creek, and Catherine Creek) enter the valley. The different make-up of each fan suggests different grades of aquifers.

The **Grande Ronde fan** is a relatively good to very good aquifer. Wells drilled into the edges of the fan yield as much as 2475 gallons per minute.

The **Catherine Creek fan** may also be a good aquifer. Residential wells at Union, where the fan deposits at least 300 feet thick, typically yield only about 10-20 gallons per minute. But irrigation wells drilled in the edge of the fan reportedly yield 500-950 gallons per minute.

The **Ladd and Mill Creek fans** probably have a lower permeability, which results in lower water yields.

Grande Ronde Basalt

Although it may seem strange, the thick, impermeable lava flows that make up the basement of the Grande Ronde Valley make excellent aquifers. Groundwater is forced into

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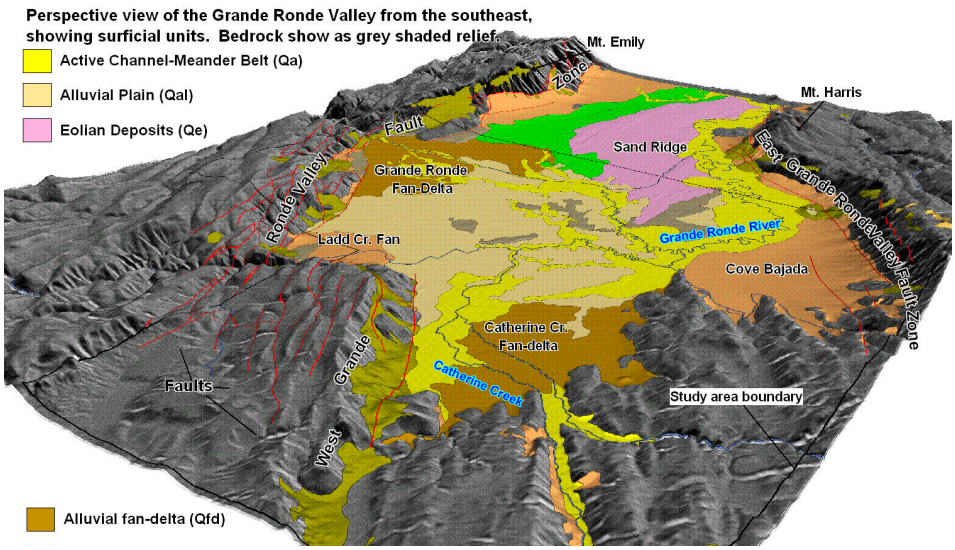

This 3 dimensional map of Catherine Creek and the Upper Grand Ronde Valley has been generated by using data from the completed geologic map. It is another way to show what type of deposits are found on the surface of the area and where you might look for potential aquifers underneath the surface.

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the large cracks and edges between the many different lava flows where the rock is permeable and porous. This is the most extensive aquifer in the valley, in places providing artesian flows of more than 2,000 gallons per minute. Municipal wells at La Grande, Imbler, and Union, as well as about a half-dozen irrigation wells tap this deep aquifer across the valley.

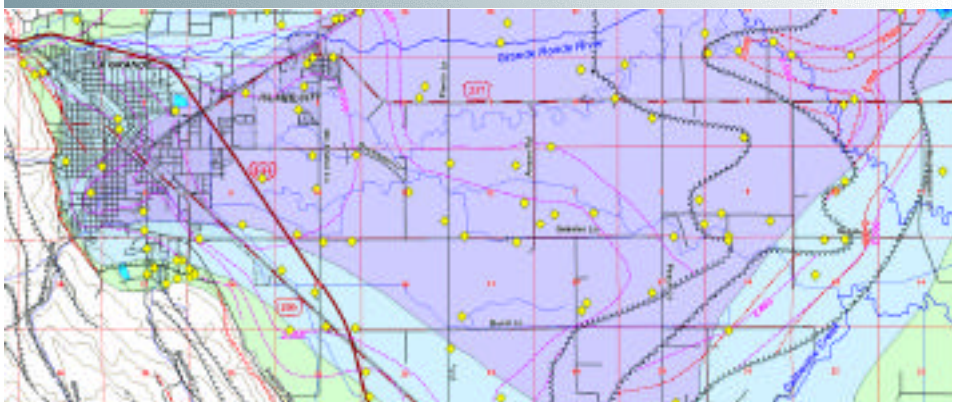
Even though the aquifer has great potential for lots of water very quickly, once a well is drilled, long-term production in some areas of the valley may not be possible because of the long time it takes to recharge, or refill, these aquifers.

Understanding the geology of the Upper Grande Ronde River basin provides the first step in making this evaluation and is the initial key to successful water management.

Farmers, ranchers and local governments will be able to take this information and decide if the idea of using groundwater to help keep Catherine Creek flowing will work.

This information can also be used in many other ways. Most importantly, local governments can develop long-term strategies for providing this essential natural resource to their communities.

Open File Report O–02–02, **Geology of the Surface and Subsurface of the Southern Grande Ronde Valley and Lower Catherine Creek Drainage** is available from the Nature of the Northwest Information Center. See page 11 for details.



This map of the Catherine Creek - La Grande area looks below the surface to help identify the location of aquifers. The yellow diamonds are well sites which DOGAMI geologists studied to help characterize the subsurface geology.

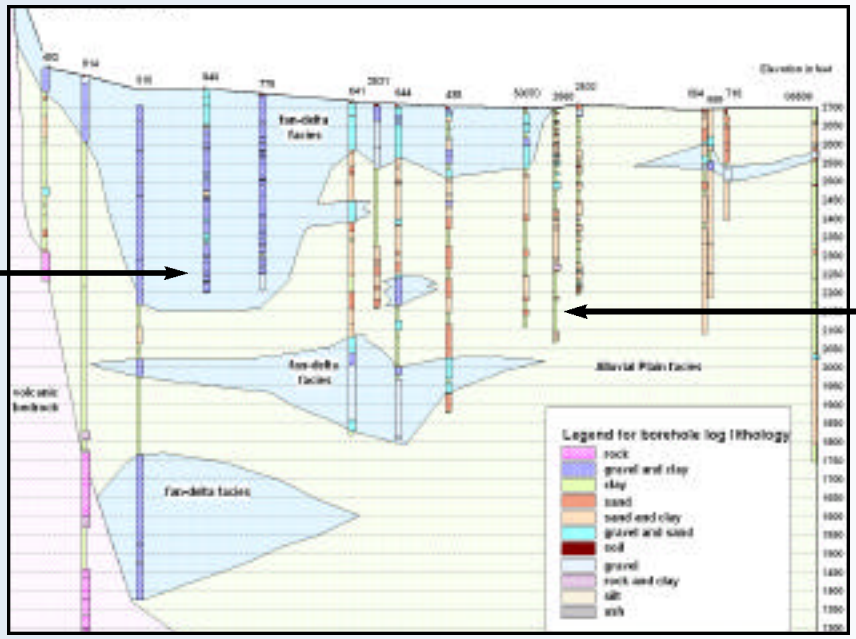
To learn more, contact Mark Ferns or Vicki McConnell in the Baker City Field Office at (541) 523-3133.

Mapping aquifers

Wells situated near each other might produce very different amounts of water. They might be drawing water from different aquifers like this example from the Catherine Creek/Southern Grande Ronde Valley.

The importance of water for residential, commercial, industrial and agriculture purposes cannot be overstated. Because of the expense of drilling new wells or deepening old wells that have run dry, mapping the subsurface geology can be very cost-effective.

A well drawing from a layer of sand and gravel can produce a strong, steady source of water.



A nearby well tapping into a different layer, one of sand mixed with clay, might produce water on a more intermittent basis.

A surface water case study:

McKenzie–Willamette River Confluence Project

Water issues don't necessarily just involve managing water supplies. In the Eugene area, the McKenzie Watershed Council and DOGAMI are facilitating a collaborative process with landowners, government agencies and other key stakeholders to protect and restore fish and wildlife habitat and provide flood protection for a variety of land uses.

The Confluence Area of the McKenzie and Willamette Rivers is 11,123 acres, encompassing the river channel, riparian, floodplain, and upland habitats within about 1/2-mile of the river. The area supports a variety of land uses, including aggregate production, urban/suburban areas, recreation, and farmlands.

Significantly, the Confluence Area is the largest contiguous area of mined lands in Western Oregon, with current reserves anticipated to last about another 50 years. These floodplain excavations are also some of the deepest in the state, reaching depths of 120 feet below the surface. Four major sand and gravel companies operate in this area.

Historically, the area around the confluence of the McKenzie and Willamette Rivers had some of the most productive and complex fish and wildlife habitat in the Willamette River Basin, including critical rearing habitat for spring chinook salmon.

Recent studies have shown that the quality of fish and wildlife habitat in the area has degraded over time, but studies have also shown that the Confluence Area has some of the most extensive intact habitats remaining in the Willamette River Basin, including side channels and floodplain forests.

The impetus for developing local solutions for flood protection and habitat enhancement in the Confluence Area actually began a few years ago. In 1996 the area experienced a flood that resulted in the need to address significant stream bank erosion and flood protection for the sand and gravel operations and other urban and rural development. Also in 1998 and 2000, the Willamette River Basin's bull trout and spring chinook salmon, were listed as "threatened" species according to the Endangered Species Act.

Today, the mine operations in the area have significant portions that are currently exempt from regulation or were permitted by county, state and federal agencies at a time of less awareness of environmental concerns. Natural resource management approaches for most of the Confluence Area were developed in the 1970's when these sites were shallow drag-line pits and the plans approved by the government agencies did not anticipate the potential consequences of deeper mining in close proximity to the river channel.

The Confluence Area's current and historic river channels and surrounding floodplain habitats provide an outstanding opportunity to restore critical habitats while promoting continued economic activity.

Confluence Area mine operators felt that by participating with a group of stakeholders and government regulatory agencies, they could solve the flooding problems they had experienced in the past, ease the permitting process, and achieve lasting economic and environmental benefits. Since there was recognition that any plan would need to consider all lands in the Confluence Area and not just the aggregate operations, key landowners, governmental officials, including Mined Land Reclamation specialists from DOGAMI, and the McKenzie Watershed Council agreed in 1999 to work cooperatively to address the issues.

Through a consensus-oriented approach, the group has developed

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The flooding of gravel mining operations in the Confluence Island area near Eugene in 1996 was the original impetus behind a collaborative effort that aims at developing a long-term approach to resource management.

Field notes

Jan Durflinger, Office Specialist in the Baker City Field Office has been named employee of the year for 2001. Jan has worked for DOGAMI for 19 years and shares the office with regional geologist Mark Ferns and field geologist Vicki McConnell. She was cited in her nomination for her leadership, professionalism, and attention to detail as well as making a positive first impression on the people who drop by the office to purchase a map or ask a geology related question.

Recently, Jan was responsible for organizing and overseeing the highly successful La Grande workshop (see **Cascadia** Summer 2001). As Mark Ferns noted in his nomination letter, "Jan's part in the success of the workshop will lead to better communications and networking between private parties, local government, and state and federal personnel. Her professionalism and competence gives these people the confidence to use her as a first contact." Congratulations Jan!

Employee of the year Jan Durflinger (left) with Baker City field office geologists Mark Ferns and Vicki McConnell.

(continued from page 9)

the foundation of good communication, mutual trust, plus pursued the scientific information necessary to develop a long-term approach to resource management in the Confluence Area.

To date, the group has already had some success with their partnership. They have completed a hydrologic analysis of flood and erosion hazards (aggregate industry funded) and an assessment of fish and wildlife habitat (OWEB funded). These studies have provided detailed and site-specific information on habitat features, fish and wildlife population status, water quality, hydraulic conditions, and habitat enhancement and flood protection opportunities.

The group has produced a set of guidelines that provide a framework for evaluating proposed actions and these guidelines outline a realistic vision for long-term habitat enhancement and economic sustain ability.

OWEB is also funding 5 fish and wildlife habitat restoration projects with a cost of $151,781. These projects, all on aggregate company lands, focus on improving salmonid and pond turtle habitats.

There are significant opportunities for habitat enhancement in the Confluence Area. Over the short term, riparian areas and aquatic features can be improved. Over the long-term, as the aggregate operators move to different sites, there are significant opportunities to restore the historic river meander areas and reconnect blocked channel areas. The group has developed principles for enhancing fish and wildlife habitat and identified areas for short-term (1 to 6 years) and long-term (more than 50 years) habitat enhancement actions.

The group has made significant progress in developing and implementing a local approach that integrates habitat restoration while supporting a healthy economy. While these beginning stages have seen some success, there is also a great deal more that needs to be done to develop a durable and long lasting partnership.

If this process is successful, DOGAMI believes it will be a model for sustaining economic development while protecting and enhancing critical floodplain, riparian, and river habitat. Ideally the Confluence Area project could be a blueprint for a locally based and outcome-directed partnership – a framework where coordinated federal, state and local government agencies are able to work with area mining companies to cut through red tape while all the parties in the partnership continue to work on long term habitat restoration.

Participants in the Confluence Area partnership include:

The McKenzie Watershed Council
The Oregon Department of Geology and Mineral Industries
Eugene Sand & Gravel
Wildish Sand & Gravel
Delta Sand & Gravel
Green Island Farm
Riveridge Golf Course
McKenzie Flyfishers
The McKenzie River Land Trust
Lane County Land Management
National Marine Fisheries Service
The Oregon Division of State Lands
The Oregon Department of Fish and Wildlife
The U.S. Army Corps of Engineers

To learn more about restoring and protecting Oregon's watersheds through locally-driven, voluntary, cooperative efforts log on to: http://www.oregon-plan.org/

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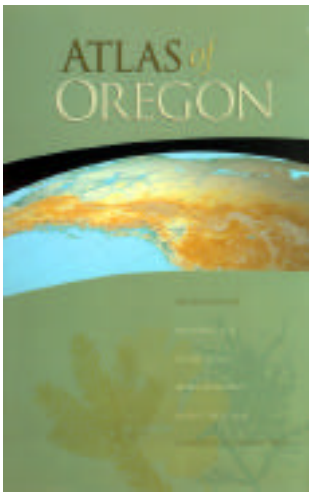

The Atlas of Oregon is much more than a collection of maps in the common sense – it is a portrait of the state, from its place on our globe to the growth of downtown Portland through time, from its geologic beginnings hundreds of millions of years ago to currently protected wild and scenic areas, and much more. Interspersed are short essays that help to keep the detailed information in perspective.

The Atlas of Oregon is available in both hardcover ($100) and softcover ($60) editions. It has 301 pages and is approximately 10x14 inches in size.

Open File Report O–02–02 Geology of the Surface and Subsurface of the Southern Grande Ronde Valley and Lower Catherine Creek Drainage, Union County, Oregon, By Mark L. Ferns, Ian P. Madin, and Vicki S. McConnell, Oregon Department of Geology and Mineral Industries, and J. Johnson, U.S. Geological Survey, Hawaiian Volcano Observatory. $10 (see article on page 7)

RMS-1, Reconnaissance Geologic Map of the La Grande 30' x 60' Quadrangle, Baker, Grant, Umatilla, and Union Counties, Oregon by Mark L. Ferns and Ian P. Madin, Oregon Department of Geology and Mineral Industries, and William H. Taubeneck, Professor Emeritus, Oregon State University. $10

Highlights include a geologic history of the area that contains some of the oldest rocks in Oregon. Water and mineral resources, geothermal energy, fossil fuels and where to look for semi-precious gemstones are included in the map. Natural hazards on the map include earthquake faults and landslides.

IMS-20, Earthquake Hazard Maps and Seismic Risk Assessment for Klamath County, Oregon by Zhenming Wang and Yumei Wang. $10

This release on CD-ROM contains 3 earthquake maps , a seismic risk assessment for the county and a HAZUS99 inventory of almost 1,000 buildings, critical facilities and lifelines.

This 53 page publication from the American Geological Institute is an excellent introduction to groundwater issues. $6.50

A complete list of DOGAMI publications can be found online at: www.OregonGeology.com.

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Oregon Watershed Council Boundaries

Watershed councils in Oregon are locally organized, voluntary, non-regulatory groups established to improve the condition of watersheds in their local area. DOGAMI works with watershed councils throughout the state to help them manage their water wisely. To find which watershed you live in, log on to the Environmental Protection Agency website at http://cfpub.epa.gov/surf/locate/index.cfm (graphic courtesy of OWEB)

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