Fact Sheet

Aquifer Sensitivity Analysis: State of Oregon's Source Drinking Water Assessment Procedures

Background

In Oregon, the "sensitivity" of a groundwater drinking water source (aquifer) to become contaminated is evaluated from several perspectives. "Sensitivity" of an aquifer refers to how readily contaminants can migrate from the land surface or near surface to the aquifer. Factors that are considered include:

- Monitoring history (a contamination detection indicates a pathway exists between a contaminant source and the aquifer);
- Aquifer characteristics (e.g., shallow or less than 100 feet, unconfined, cobbles and gravel, etc.);
- Well construction (primarily based on the placement and construction of the casing seal); and
- Ease in which water, carrying contaminants, can move to the aquifer.

While the first two bullets above are self-explanatory, the third and fourth require further explanation.

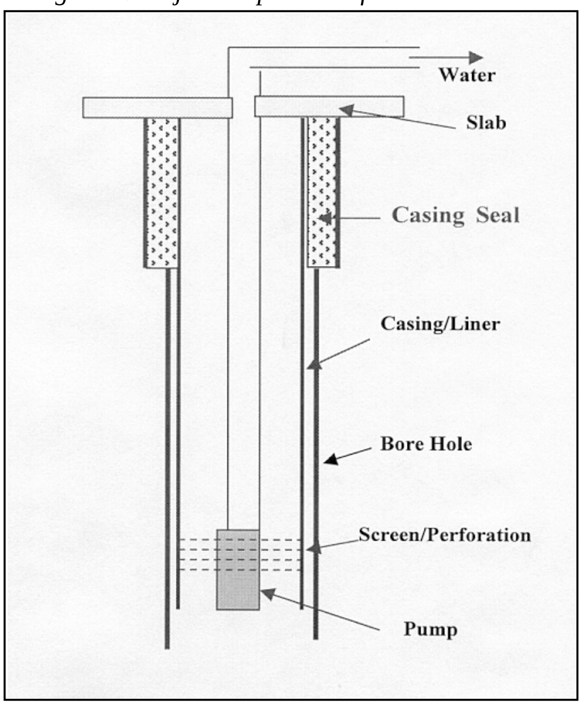
Well construction

Wells are drilled in the ground for the main purpose of extracting water for beneficial uses such as drinking water and irrigation water. However, if the well is not constructed properly, it can become a conduit for contaminants to reach the aquifer. It can also lead to commingling of two separate aquifers, which is generally detrimental to one aquifer or the other, from either a water quality or water quantity perspective.

Figure 1 (at right) identifies the major components of a well: the bore hole, casing, cement slab, pump, perforations or screen, and casing seal.

- The bore hole, of course, is the hole drilled by the well constructor from the surface into the aquifer below ground;
- The casing is the metal or plastic pipe that is placed in the hole by the well constructor for the primary purpose of preventing the sides of the bore hole from caving into the well bore;
- The cement slab at the surface prevents surface water from pooling around the casing at the surface and seeping into the subsurface;
- The pump extracts groundwater from the aquifer and delivers it through the piping to the user of the water;
- The perforations or screen allow easy access of the groundwater into the cased borehole
- The casing seal prevents the well from allowing contaminants from the surface or from a shallow aquifer to migrate to the aquifer that the well is drawing water from.

Figure 1: Major components of a well



The Oregon Water Resources Department regulates well construction in the state and has specific requirements for the casing seal. The casing seal must be a minimum of 18 feet deep or, if appropriate, extend to a depth that adequately separates a shallow aquifer from a deeper aquifer. When constructing the casing seal, the well constructor generally has to oversize the bore hole to a diameter of at least four inches greater than the diameter of the casing that will be placed in the hole.

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After the casing is placed in the hole, the ring-shaped spacing between the casing and the bore hole walls must be filled with cement or expanding clay (bentonite). This prevents water from migrating along the side of the casing between aquifers or from the surface down to the aquifer. The casing itself does not provide an adequate seal for the well.

Construction deficiencies that can significantly compromise the effectiveness of the casing seal include:

- A casing seal of insufficient diameter (less than four inches greater than the casing, unless specific approved construction methods are used);
- The casing seal is not placed to a sufficient depth; and
- Insufficient sealant is used to completely fill the annular space

Movement of contaminants to the aquifer

The State of Oregon evaluated this characteristic in relative rather than quantitative terms through the use of two matrices to evaluate the potential of [1] water migrating from the surface to the aquifer (Traverse Potential) and [2] the availability of infiltrating water to transport contaminants to the aquifer (Infiltration Potential). At this stage, it is assumed that the contaminants behave conservatively (i.e., move directly with the downward percolating water). Individual chemicals can be evaluated using two additional matrices that consider chemical persistence and sorption potential (not used for aquifer sensitivity). In each matrix, two parameters are plotted. Their intersection within the matrix yields a score from 1 to 10. The higher the score, the greater the potential that these parameters will contribute to aquifer sensitivity.

1. Traverse potential

This matrix (next page) assesses the ability of the unsaturated zone to transmit water to aquifer. Considered are the depth to the aquifer and the weighted hydraulic conductivity of the vadose zone. Absent site-specific data, water-saturated horizontal hydraulic conductivity values were assumed, representing worst-case scenario. Shallow wells with high hydraulic conductivity have the higher scores (i.e. >7). The matrix score is assigned as the traverse potential which is carried to the next matrix.

2. Infiltration potential

This matrix (next page) assesses the combination of the traverse potential and the availability of water at the surface. It plots the traverse potential against the hydraulic surplus, equal to rainfall + irrigation - evapotranspiration - runoff. These data are not always available, so methods of estimation are provided. The score produced by the intersection of the hydraulic surplus and the traverse potential is assigned to the infiltration potential.

The infiltration potential can be used as a general estimate of the sensitivity of the aquifer.

Alternative formats

Alternative formats (Braille, large type) of this document can be made available. Contact DEQ’s Office of Communications & Outreach, Portland, at (503) 229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696

TRAVERSE POTENTIAL*1

(Hydrogeologic characteristics related to water movement to the aquifer)

Depth (feet) to Aquifer												
		<50	50	100	150	200	250	300	350	400	450	500
Kw *2	**1000**	10	10	10	10	10	10	10	10	10	10	10
	100	10	10	9	9	8	8	8	7	7	7	7
	10	8	7	6	6	5	5	5	5	5	4	4
	1	5	4	3	3	3	2	2	2	2	2	1
	0.1	2	1	1	1	1	1	1	1	1	1	1

*1. A traverse potential of 1 = low potential for water movement, 10 = high

*2. Kw = Z (total)/[(Z1/K1) + (Z2/K2) + ...(Zn/Kn)], where Z(total) = total thickness of n layers, Z1, Z2......Zn represent individual thickness of layers 1 through n, and K1, K2....Kn represent permeability of layers 1 through n. Permeability should be in compatible units to thickness, i.e. ft/sec if thickness is in feet. Final values should be converted to gallons/day/ft^2 for use in the matrix as Kw. For example, if thickness is in feet, permeability in ft/sec, multiply the result from the formula above by 646,340 to convert to gal/day/ft^2.

INFILTRATION POTENTIAL*1

(Relating water availability to traverse potential)

Hydraulic Surplus (inches) *2									
		5	10	15	20	25	30	35	40
TP	**1**	1	2	2	3	5	6	7	7
	2	1	2	3	4	6	7	7	7
	3	2	3	5	6	6	7	7	8
	4	2	4	5	6	7	7	8	8
	5	3	5	6	7	7	8	8	8
	6	3	5	6	7	8	8	8	9
	7	4	6	7	7	8	8	9	9
	8	4	6	7	8	8	9	9	10
	9	5	7	8	8	9	10	10	10
	10	5	7	9	9	10	10	10	10

*1. An infiltration potential of 10 indicates a high probability that the combined availability of water (hydraulic surplus) and geologic conditions (traverse potential) will lead to water from the surface reaching the aquifer. A score of 1 indicates a low probability.

*2. Hydraulic surplus is the amount of water that is available to infiltrate to the aquifer. It is based on rainfall, irrigation amount and method, and evapotranspiration.