Groundwater under the Direct Influence of Surface Water
Flow Chart Explanation

Objective of Procedure: To develop a step-wise procedure that would identify systems that are vulnerable to direct surface water influence and that would yield information that the system would be able to apply to other programs.

A vulnerability assessment with respect to groundwater under the direct influence of surface water (GWSWI) comprises the two traditional steps: is the contaminant present and is the aquifer susceptible to contamination? While the presence of the contaminant will likely rely on a particulate analysis, the susceptibility analysis will be accomplished through a determination of whether or not the aquifer is in hydraulic connection (through natural or induced infiltration) with a surface water body. The confirmation of a hydraulic connection has implications not only with respect to susceptibility to contamination by *Giardia*, but also other contaminants that may be in the water. Systems with such susceptibility need to have this information for proper management of their resource (e.g. under the wellhead protection program).

Procedure:

1. **State Level Review:** The first step in determining those sources that are potentially vulnerable to GWSWI was to identify those systems with groundwater sources that are within 500 feet of a surface water source. The next step was to evaluate those systems in terms of a history of coliform bacteria in the source. Monitoring data and information from the most recent sanitary survey were used in this process. Systems that currently disinfect are considered to be doing so because of source problems unless demonstrated otherwise.

Wells

The well logs of those wells within 500 feet of surface water, but without obvious problems with coliform bacteria in the source were reviewed to determine whether or not the grout seal was emplaced in a manner that affords adequate protection from surface or near-surface water gaining access to the well bore. In general an adequate seal was considered to be one that was emplaced into a low permeability layer that is at least five feet thick.

Those wells that have neither source-related bacteria problems nor inadequate seals were not considered further. However, for systems where either source-related coliforms were suspect or the seal adequacy is questionable, further study is required. The system is responsible for this study. As indicated in the accompanying flowchart, two options exist. The first involves a detailed hydrogeologic assessment that addresses the potential of surface water migrating to the aquifer. The second option entails an evaluation of water quality parameters over a period of 12 months.

Springs

Though there are obvious construction standard differences between well and spring

development, the standards for developing the aquifer are virtually the same. For instance, where a casing grout seal is used to prevent surface water from entering a well, an impervious backfill is used as a barrier over the collection pipe for spring construction. Both methods achieve the same goal of aquifer protection from surface water influence through different aspects of construction.

Infiltration Galleries

By virtue of the reasonable assumption that infiltration galleries are constructed to enhance a hydraulic connection, these sources must be evaluated with the Division on a case by case basis.

2. **Hydrogeologic Assessment.** This option will allow the system to arrive at a determination concerning whether or not they should be classified as under direct surface water influence in a relatively short period of time. It requires the assessment of hydrogeologic factors (see below) and will require the services of a professional geologist or hydrogeologist.

The factors of concern include, but are not limited to, the following:

Well Characteristics:
- Well Depth
- Screened/Perforated Interval
- Grout Seal

Aquifer Characteristics:
- Thickness of the Unsaturated Zone
- Hydraulic Conductivities of the Unsaturated Zone and Aquifer
- Presence of Low Permeability Zones in the Unsaturated Zone
- Degree of Connection Between the Surface Water Source and the Aquifer (i.e. does the surface water body penetrate the aquifer?)

Hydraulic Gradient:
- Vertical Gradient under Pumping Conditions
- Horizontal Gradient between the Aquifer and the Surface Water Source under Pumping Conditions
- Variation of Static Water Level and Surface Water Level with Time

Groundwater Flow:

- Does the Well's Steady State Capture Zone intersect the surface water source?
- What is the Estimated Time of Travel for Water between the Surface Water Source and the Well?

If the hydrogeologic assessment indicates in OHD's opinion that the aquifer supplying the system's well is not in hydraulic connection with surface water, the system will not be required to perform any further analysis. If the hydrogeologic assessment indicates the potential for hydraulic connection, the system will be required to initiate a water quality assessment.

3. **Water Quality Assessment:** This option requires a more lengthy period of data collection and stresses water quality measurements. The data can be collected by water system staff.

Although exceptions do occur, groundwater that is not in a short term connection to surface water generally exhibits only minor variations in chemical and physical parameters. Surface water, on the other hand, tends to undergo more substantial variations as a function of season, or rainfall or snowmelt events. If groundwater is hydraulically connected to such surface water, then that groundwater should vary sympathetically with surface water.

The procedure that has been developed in Oregon requires frequent and simultaneous measurement of water quality parameters in ground water and nearby surface water. Because of some finite amount of travel time from surface water to the groundwater source, we should not expect the variations in these two water sources to be precisely at the same time. However, weekly measurements over a year's time should establish similar variation patterns if the two are in hydraulic connection. Recording the weekly rainfall during this time will also help interpret spikes or patterns in the data.

As an example, data collected from a small perennial stream in west Texas is compared to water collected from a monitoring well (M/Well in Fig. 1) completed within the adjacent alluvium. It is evident from figure 1 that the groundwater and surface water undergo very similar, though not exact, variations with time.

Note that the compositions of the groundwater and surface water in figure 1 are not the same. This is to be expected given the potential of chemical and biological reactions that can take place within a few feet of travel through soil or stream bed deposits. The key factor indicating hydraulic connection is the similar pattern of compositional variation.

OHD is requiring a minimum of weekly monitoring of rainfall, temperature, and an additional parameter in both the groundwater and surface water over a one year period (see Water Quality Assessment protocol). Procedures for intermittent surface sources are discussed in the following section.

It is important that the surface water measurement be consistently taken. Water temperature should be measured at the same time of day each time. Measurement of well water should be accomplished after the well has been on long enough for the temperature to stabilize (normally 3 to 5 well volumes). The measurement of surface water should be taken at a depth of approximately one foot or more. A simple rainfall gage can be used to measure the cumulative rainfall for each week.

The system may choose from a number of parameters to be monitored along with temperature, such as pH, conductivity, dissolved oxygen, hardness, or other dissolved constituents. Previous data has shown that turbidity is not a good indicator of hydraulic connection and will therefore not be used.

If a system appears to be in hydraulic connection based on water quality data, a detailed evaluation of well construction (or source development) should be undertaken to determine its role in producing the variability. The rainfall data will be very useful here. It is possible that a poorly constructed source may be allowing inflow of rainfall or runoff into the aquifer. Although clearly a water quality problem, this may not mean that the system is in hydraulic connection to the surface water body.

4. **Particulate Analysis**. Either the hydrogeologic or water quality assessments may end up with a determination that the source's characteristics indicate that the aquifer is in hydraulic connection with surface water. Whether or not the source is also under the direct influence of surface water will depend on the results of the particulate analysis.

The EPA has published a detailed technical document on methods for using particulate analysis for establishing direct surface water influence (EPA 910/9-92-029: Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)).

OHD is recommending that a minimum of two samples be taken during a one year period. Actual sampling times should be dictated by the results of water quality monitoring. In other words, MPA should be accomplished at those periods when the water quality data indicate the greatest probability that surface water is impacting groundwater.

EPA's technical document states that since groundwater under the direct influence of surface water is indicated by the <u>significant</u> occurrence of "...insects, algae or other large-diameter pathogens...", the MPA can not be used as a presence or absence criterion. The document arrives at a risk factor based on the number of the various bio-indicators per 100 gallons of water, i.e. *Giardia*, coccidia, diatoms, algae, insects/larvae, rotifers and plant debris. If a hydraulic connection is established by hydrogeologic and/or water quality evaluations, the determination of whether or not the source is under the direct influence of surface water will likely be based on a threshold value of the cumulative risk factors associated with the identified abundances of the surface water indicators.