10 Regulatory Challenges

Although many regulators are receptive to advanced site characterization information and newer characterization tools, some may not be comfortable with the departure from standard site characterization practices. For regulatory agency personnel who have been operating under what may now be considered outdated CSMs for subsurface contamination, there is a clear challenge to incorporate the newer views of contaminant behavior in fractured rock systems into ongoing cleanups. This chapter discusses some of the potential regulatory acceptance issues associated with the fractured rock site characterization methods. Issues include understanding new tools and technologies used to develop a more representative CSM, the types of analyses, decisions, and responses associated with the various types of data collection (which vary depending on site and project circumstances), and reconciling the advancements in site characterization with current regulatory expectations and requirements.

10.1 Measuring Groundwater Flow Rate and Direction

Regulations are developed to cover a wide range of situations. Regulations intended to prevent a particular problem from occurring may impede characterization and remediation efforts. An example of one such rule is Minnesota Rule 4725.2050. Use of Wells or Borings for Disposal or Injection Prohibited:

> *A well or boring must not be used for disposal or injection of surface water, groundwater, or any other liquid, gas, or chemical, except for groundwater thermal exchange devices, drilling fluids, vertical turbine prelubrication water, treatment chemicals, priming water, water used for hydrofracturing, and water used for disinfection in accordance with parts 4725.1831, 4725.2950, 4725.3250, 4725.3725, 4725.5050, 4725.5475, and 4725.5550.*

Compliance with this rule prevents the injection of dye-tracing chemicals, nutrients, organisms, or other materials for groundwater contamination remediation in a well or boring. However, the regulatory authority may grant a variance to the rule for these purposes in certain circumstances.

There are also situations when regulations are prescriptive or were written at a time when the complexities associated with fractured rock groundwater flow and contaminant transport were not well understood or addressed. In these situations, meeting the regulatory requirements and technical needs of a project can be contradictory. An example is the following requirement, which is cited in the California Code of Regulations for RCR-Permitted sites (Title 22, section 66264.97):

> *In addition to the water quality sampling conducted pursuant to the requirements of this article, the owner or operator shall measure the water level in each well and determine groundwater flow rate and direction in the uppermost aquifer and in any zones of perched water and in any additional aquifers monitored pursuant to subsection (b)(1) of this section at least quarterly, including the times of expected highest and lowest elevations of the water levels in the wells.*

This requirement, like others around the nation, does not account for the complexities of fracture flow and contaminant transport. In this specific example, groundwater flow rates and directions simply calculated from water levels from wells at a fractured rock site, as required, could result in directions and rates that are not accurate. Although regulatory requirements need to be met, the usefulness of the results from meeting these requirements should always be considered and documented, especially when meeting the requirements create results that are inaccurate or inconsistent with the CSM.

10.2 Design of the Investigation

Regulatory actions typically start when regulators are notified of the presence of contamination. This is usually the result of either real estate transactions or other discovery of contaminants, often in drinking water wells. The design of the initial investigations is often based on traditional investigations that likely have not been designed using the principles described in this guidance. Regulators must decide how to use the data provided and may not have the authority to, for example, require monitoring wells to be redrilled if the screen monitored interval is not likely to be representative of the fractured rock condition.

10.3 Investigation and Monitoring Well Design

Monitoring well design may be constrained by regulatory guidance requiring specific screen vertical interval lengths (such as10 feet), and well spacing intervals (often up to 500 feet). Conventionally, solid waste programs have interpreted USEPA guidance indicating wells should be spaced no more than 500 feet apart as not allowing regulators to routinely require more closely spaced wells, even when there may be good fracture-based reasons for requiring wells in some areas of a facility to be much more closely spaced and others to be more widely spaced.

Existing drinking water wells can be potential contaminant flow pathways. Most environmental regulators are unlikely to have the authority to require such wells to be closed or modified, and health departments that may have that authority may be reluctant to require drinking water well closure or modification unless an alternate water supply is available. Bedrock well construction and closure may be under the authority of a separate entity and closure requirements may not adequately prevent contaminant migration. For example, Virginia Department of Health requirements for well closure currently only specify that bedrock wells closed in rock below the groundwater table be backfilled “with clean fill” to the water table and grouted or bentonite filled until five feet from the surface. Furthermore, some states have requirements for drinking water well construction that may be applied to monitoring wells. For example, requirements for well casings to be constructed to particular depths, or particular depths into bedrock, may appear to restrict construction of monitoring wells at the upper bedrock transition zone that is often a significant zone of groundwater movement and storage.

The regulatory process typically requires samples to be taken at regular time intervals. This approach may not allow samples to be taken at the most high risk times (such as during high rainfall or low rainfall periods) and may not reflect the relatively rapid groundwater and contaminant flow velocity in some fractured rock aquifers.

10.4 Protecting Multiple Flow Zones in Fractured Aquifers

Characterizing a site across confining layers may be subject to state rules that may prohibit the interconnection of aquifers and have specific definitions of what is considered confining layer in bedrock and unconsolidated materials. The interconnection of wells or borings completed in different aquifers through piping manifolds or other means, such as with a flexible liner, may be prohibited. In these cases, the local regulatory authority may require wells or borings through a confining layer to have an outer casing driven or grouted into the confining layer and an inner casing installed through the confining layers with the annular space filled with grout. It is important to work closely with the local regulatory authority and understand rules that may affect the characterization procedures.

Issues may arise because an alternative to short screen wells with one monitoring zone per well is long-interval wells that are separated into multiple hydraulically isolated zones with either inflatable packers or FLUTe liner systems. These multiple-zone wells offer valuable information and operational opportunities (described below) if they are constructed and maintained without allowing cross contamination or cross flows between separate fractures and portions of the fracture network. Emplacement of individual wells with access to multiple isolated intervals requires a team effort for planning, coordination, and on-site expertise and decision-making. Appropriate drilling (+/- coring) methods may be considered on a case-by-case basis that allow drilling but prevent establishing preferential flow paths.

Strings of removable inflatable packers (inflated with compressed gas or with water) or FLUTe liners are installed as soon as possible after drilling and well logging are completed. Information from logs (especially caliper, televiewer, combined temperature-resistivity-gamma, heat-pulse flow meter) and water samples during or immediately after drilling, guide the selection of zone intervals and packer placement locations. Multiple-zone isolation systems of packers or FLUTe liners are known to be reliable if properly sized, installed, and monitored for air or water pressure. Multiple-zone isolation systems of packers or FLUTe liners can be (1) permanent; (2) modular and thus modified in configuration, or replaced if needed; or (3) converted in place from temporary to permanent.

High value information and operational opportunities from individual wells with access to multiple isolated intervals include:

- Information can be obtained, such as 1D vertical profiles per well (and collectively providing 3D information in a volume of interest when several such wells are used) for water sampling, hydraulic head measurements, and periodic monitoring prior to, during and after in situ remediation. 3D characterization can also be obtained to determine or estimate hydraulic parameter distributions of both fractures and rock matrix, and fracture connectivity (hydraulic tomography, and/or hydraulic tests at individual zones, and tracer tests using multiple wells +/- multiple configurations). Local rules may prohibit the injection of dye tracing materials, organisms, nutrients or oxidation compounds, but in certain circumstances a variance from the rules may be granted.
- Operational opportunities available during remediation include 3D in situ remediation with many possible configurations for simultaneous injection, withdrawal, hydraulic control, and monitoring using multiple zones in

multiple wells.

Alternative configurations of multiple individual single-zone wells cannot realistically provide the information and operational opportunities of wells with access to multiple isolated intervals each because of the cost and logistics of having a cluster of perhaps 4 to10 or more individual wells for every individual well with access to multiple isolated intervals.

10.5 Decision making

Regulations have traditionally been written based on an understanding that data are taken from grab samples, either or soil or rock, or from relatively long-screen monitoring wells. For example, in petroleum programs, corrective action requires removal of free product to a thickness of 0.01 feet or the maximum extent practicable. Regulations may not allow flexibility in addressing data from samples taken from discrete sample intervals, or from specific intervals in a core sample that may be elevated compared to a groundwater sample averaged over a longer interval.

10.6 Stakeholders

Most state environmental agencies have been designated by legislatures as the entity tasked with protecting the citizen's interests related to environmental protection and contamination. While some states have specific processes to form and engage independent stakeholder groups actively in remediation decisions, many do not. Most regulatory programs have specific processes for citizens to comment on active cases and help regulators make better decisions, but the authority for those decisions still lies with the regulatory agency. Regulators might find it helpful to offer guidance on how best to engage stakeholders specifically for fractured rock sites (for example, guidance on how best to present a CSM and discuss uncertainty).