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5 Site Characterization

This chapter presents the components of the characterization process that are unique to fractured rock. Characterizing a fractured rock site follows the Integrated Site Characterization Process described in Figure 4-1 of ITRC's ISC-1, integrated site characterization, guidance (ITRC 2015b). The process is generic and applicable to both fractured rock and unconsolidated media. Most contaminated fractured rock sites have unconsolidated media or weathered material above the bedrock that also require characterization and remediation. Different SMART characterization objectives can be developed for both media using different tools and techniques, but the CSM includes both components. For the unconsolidated media, the ISC-1 guidance and the ITRC DNAPL site strategy guidance (ITRC 2011) describe the unconsolidated component of the site.

Compared to unconsolidated media, intrusive fractured rock investigations can be costly and time consuming; however, these investigations are needed to test assumptions developed during the desktop research and surface investigations. Extensive geologic literature is available, ranging from topographic maps, aerial photographs, satellite imagery, and other geologic and geotechnical investigations to nonpublished reports. To refine the initial site assessment, surface field reconnaissance and outcrop mapping should be completed to project rock type and structures into the subsurface. In addition, subsurface investigations should consider surface geophysical tools to test the assumptions and subsurface projections from the desktop research and surface investigations. Having team members experienced in the geology and hydrology is necessary to select on-site borehole locations, where the information can be gathered to test assumptions made from earlier investigations. Multiple interpretations of the subsurface geology and hydrology should be made and peer-reviewed prior to drilling (Link Appendix C) boreholes. Objectives-based data collection and interpretation are especially important in fractured rock settings, where boreholes are few and expensive.

To illustrate the process described in the ISC-1, (ITRC 2015b) Figure 4-1, a hypothetical dissolved VOC contaminated example site is included in Table 5-1. Sections in Chapter 5 will refer to this example to illustrate several points for clarity and application.

The Investigation Process

1. Research easily available sources of existing information, such as topographic maps, geologic maps, logs for nearby well, information on nearby bedrock outcrops, and information on other nearby sites.

2. Develop preliminary CSM.

3. Perform appropriate and relevant surface geophysical testing, such as electromagnetic, or VLF.

4. Drill bedrock boreholes targeting surface geophysical anomalies.

5. Conduct appropriate and relevant borehole geophysical logging.

6. Test boreholes for hydrologic characteristics and contaminant distribution (with techniques such as packer testing/packer sampling, heat pulse flow meter, and multiwell aquifer pump testing).

7. Identify significant data gaps.

8. Repeat previous steps as needed to define the horizontal and vertical extent of the groundwater contamination. The CSM should be updated to reflect the results of any newly generated data.

Unconsolidated source material has been remediated. A dissolved plume in fractured rock was previously assumed to pose no immediate threat to off-site receptors. A detection has been confirmed in one off-site well, which is known to be screened at a lower elevation than the elevation of the known plume.	
Section 5.1. Review and Refine Existing CSM	Assess if detection identified at lower elevation can be explained with existing CSM, or is plausible within the degree of uncertainty of the existing CSM
Section 5.2. Define the Problem, Define Characterization Objective	Problem: The vertical contaminant distribution and/or rate of plume expansion/migration are inadequately understood. Objective: Delineate the vertical and lateral extent of the plume, then develop strategies for the protection of deep off-site receptors.
Section 5.3. Identify Significant Data Gaps	• maximum depth of contamination exceeding criteria • maximum lateral distance (from the source) of contamination exceeding criteria • direction in which the deepest/farthest contamination is flowing • rate at which the deepest and farthest contamination is flowing
Section 5.4. Define Data Collection Objectives and Design Data Collection Process	• discrete samples from deep fractures • orientation of deep fractures • connectivity among deep fractures • gradient within interconnected, deep fractures • transmissivities within interconnected, deep fractures

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Section 5.5. Select Tools/Techniques	• Use borehole televiewer, caliper, temperature and HPFM logs to identify potential water-bearing fractures at each location. • Use borehole televiewer log to assess fracture orientation at each location • Use borehole packer sampling to collect groundwater samples from discrete water-bearing fractures and provide vertical profile of contamination and of hydraulic conductivity of fractures at individual borehole. • Measure head changes in adjacent wells during drilling and packer testing to assess fracture connectivity. • Conduct transmissivity profiling of boreholes. • Install wells to monitor deep water-bearing fractures identified. • Measure water level in wells to assess horizontal and vertical gradients. • Perform tracer testing to assess fracture connectivity and groundwater velocity. • Perform pumping tests to evaluate transmissivity, fracture connectivity, and anisotropy.
Section 5.6. Develop and Implement Work Plan	Prepare and implement a work plan for characterization activities.
Section 5.7. Manage, Interpret, and Present Data	Manage and interpret data to refine CSM and communicate findings and CSM. Refine CSM and assess if characterization objective is met or significant data gaps remain (return to steps at beginning of this table).

Many sites have existing information from previous site investigations. Most sites will have an existing CSM and this model should serve as the beginning of any investigation.