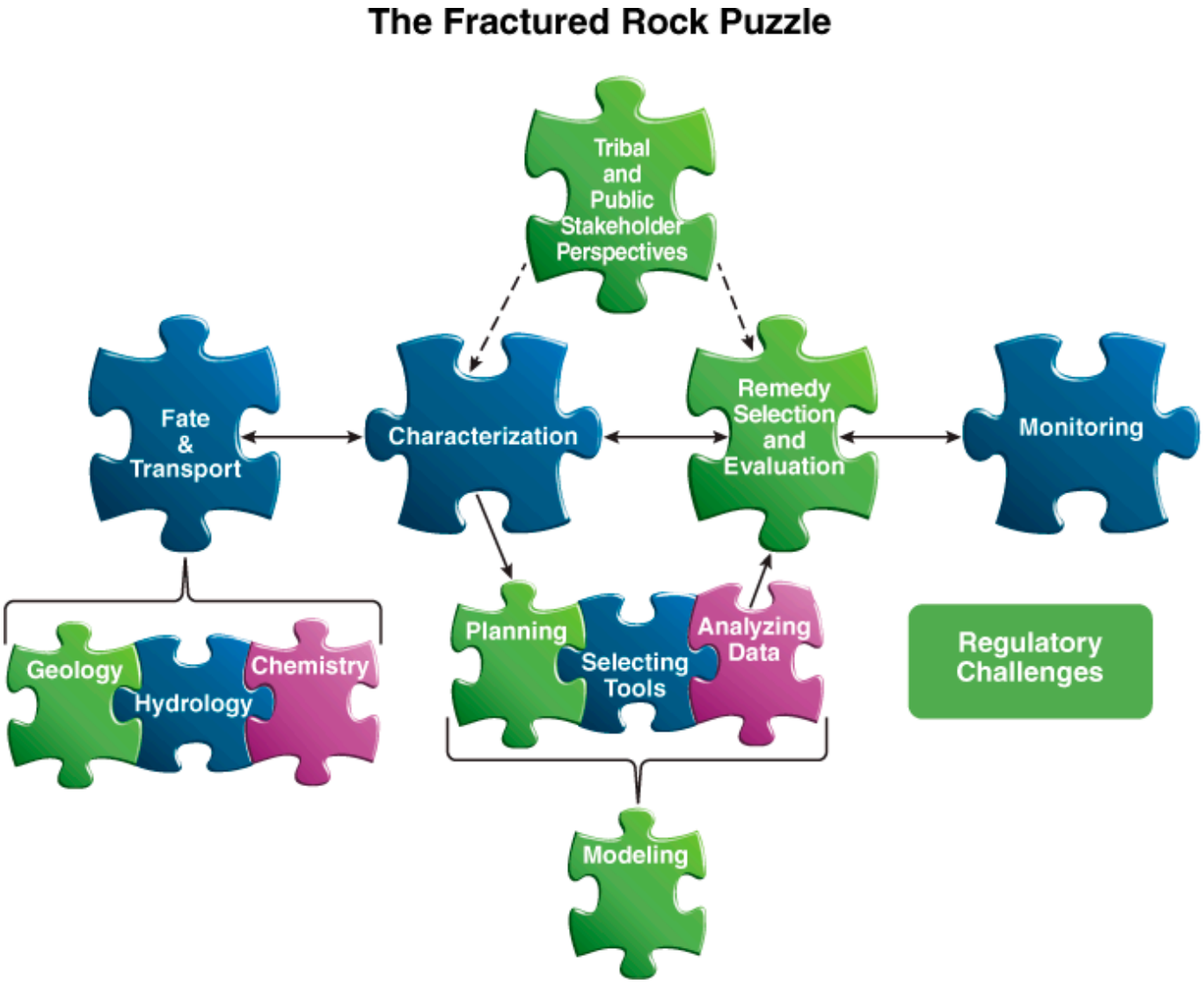

Overview

This guidance (ITRC FracRx-1) explains the processes controlling contaminant fate and transport in fractured rock, as well as innovative approaches to managing these sites. Additionally, this guidance describes how to develop a useful conceptual site model (CSM) and how to identify strategies to remediate contamination in fractured rock. This document is part of a series of ITRC documents that present an integrated strategy to characterize, remediate, and manage contaminated sites:

- *Mass Flux and Mass Discharge* (ITRC 2010)
- *Integrated DNAPL Site Strategy* (ITRC 2011)
- *Integrated DNAPL Site Characterization and Tools Selection* (ITRC 2015b)

Contaminated fractured rock sites have often been considered too complex to be remediated, so site managers often default to simply containing the contamination. This guidance provides a high-level introduction to the unique puzzle faced when investigating and remediating fractured rock sites. With the new strategies and technologies presented here, fractured bedrock challenges that may have prevented site remediation in the past are now surmountable.

The guidance begins with a general discussion of fractured rock characteristics and a comparison of fractured rock and porous media CSMs. The guidance further introduces the parameters necessary for developing a fractured rock CSM and stresses the need for an experienced multidisciplinary team. The 21-Compartment Model is also introduced. This model is an adaptation of the 14-Compartment Model (Sale 2011) for unconsolidated materials. This model helps its users to visualize and understand contaminant storage, flux, and flow pathways in fractured rock.

Understanding contaminant fate and transport in fractured rock allows site managers to develop a robust CSM that can guide remediation. Specific geology and lithology and structure control the unique mechanics of fluid flow in fractured rock. In addition to these physical properties, chemical properties affect fate and transport and are equally important in developing the CSM.

This guidance details specific steps in solving the puzzle of fractured rock contaminant fate and transport, including:

- reviewing and refining the CSM
- defining the characterization problem
- identifying significant data gaps
- defining data collection objectives
- identifying potential tools for data collection
- developing and implementing the work plan
- managing, interpreting, and presenting the data

A downloadable and searchable Tools Selection Worksheet is provided , which was initially used in ISC-1 (ITRC 2015b). The Tools Selection Worksheet allows users to screen for tools to address specific data needs and collect qualitative, semiquantitative or quantitative data as needed. The Tools Selection Worksheet links to detailed descriptions of all the tools and to references for further information. The guidance describes how data can be managed, interpreted, and displayed. Table 5-5 presents valuable lessons learned from real-world fractured rock characterization and remediation projects.

As a CSM nears completion, the guidance offers direction for developing remedial objectives and strategies. A table shows how to assess the different remedial strategies that may address mass stored in the compartments described in the 21-Compartment Model.

Strategies for monitoring contamination for compliance, system operation, and performance are also provided. The guidance explains how to design a monitoring well network that will provide the data needed to understand site conditions, remedy performance, and compliance.

When applied properly, mathematical models are powerful tools for understanding contaminant flow. Chapter 8 describes various model types, proper application, data needs, calibration, sensitivity, and limitations.

Finally, a discussion on stakeholder and regulatory considerations are presented, followed by a collection of case studies that demonstrate practical application of the concepts presented throughout the guidance.

Publication Date: December 2017