Table FR-1. Summary information for LNAPL investigation tools applicable in fractured bedrock

Investigative Category / Specific Tools	Applicability Rock Types (1 to 4)				LNAPL in Fractured Rock Commentary	Web link
	T1	T2	T3	T4		
Geologic Literature and Map Review	T1	T2	T3	T4	Understanding of regional fracture features provides indication of LNAPL preferential flow pathways.	Fractured Rock Guidance Table
Surface Reconnaissance	T1	T2	T3	T4	Understanding of local fracture features and observation of surficial LNAPL seeps.	Fractured Rock Guidance Table
Surface Geophysics	T1	T2	T3	T4	Direct observation of subsurface LNAPL in fractured bedrock may be possible with geophysical methods. Most common are: Ground Penetrating Radar (GPR) Electrical Resistivity Imaging (ERI) Electrical Resistivity Tomography (ERT) ElectroMagnetic (EM) Conductivity	Fractured Rock Guidance Table DNAPL Tool Table D-1a. Geophysics tools: surface geophysics
Downhole Testing	T1	T2	T3	T4	Downhole observation of LNAPL can be achieved using: Optical Televiewer - (LNAPL Staining) Video Log - (LNAPL Staining) Temperature Profiling	Fractured Rock Guidance Table DNAPL Tool Table D-1b. Geophysics tools: Downhole geophysics
Hydraulic Testing	T1	T2	T3	T4	Methods for evaluation of LNAPL transmissivity in fracture rock are generally consistent with unconsolidated formations. However, interpretation of data may be more complex. Specific methods which are most commonly used include: Partitioning Interwell Tracer Test (PITT) LNAPL Baildown Testing	Fractured Rock Guidance Table LNAPL transmissivity section
Vapor and Soil Gas Sampling	T1	T2	T3	T4	Methods may provide understanding of fracture geometry. Direct sampling of surficial Type 1 and 2 bedrock may not be representative if collected from the low permeability rock matrix.	Fractured Rock Guidance Table
Solid Media Sampling Methods	T1	T2	T3	T4	Sampling methods such as rock coring, air rotary and mud rotary can provide indications of LNAPL such as core staining and sheens on fractures. However, the use of air/water/mud during sample collection can flush LNAPL out of the sampled interval. Monitoring of changes in LNAPL/water elevation in previously installed monitoring wells and boreholes during advancement of new wells may provide understanding of transmissive fracture connectivity.	Fractured Rock Guidance Table Table D-4. Solid media sampling methods

Direct Push Methods	T1	T2	T3	T4	Direct-push methods are unable to penetrate competent bedrock and would require highly weathered bedrock. This includes direct sensing methods such Laser Induced Fluorescence.	Fractured Rock Guidance Table Table D-5. Direct-push logging
Discrete Groundwater Sampling & Profiling	T1	T2	T3	T4	Methods for evaluation of groundwater may also provide indications of LNAPL. Specific methods which are most commonly used include: -FACT Flute™ -Straddle packer sampling -Groundwater Field Measurements (temperature, resistivity, DO, ORP, turbidity, salinity)	Fractured Rock Guidance Table Table D-6. Discrete groundwater sampling
LNAPL Presence	T1	T2	T3	T4	LNAPL presence can be observed.	Fractured Rock Guidance Table Table D-7. NAPL presence
NAPL FLUTe	T1	T2	T3	T4	FLUTe™ dye-liners can provide understanding of the location of fractures and matrix with LNAPL. Liners are inserted into the borehole and pressed against the walls. LNAPL will dissolve the dye stripes and/or cause staining on the FLUTe™ liner. Once the liner is extracted from the borehole, indications of LNAPL intervals can be made based on the dye response/staining. One observation is that between installation of the borehole and placement of the liner, LNAPL can smear down the inside of the borehole causing an increased vertical staining/response than is actually present.	Fractured Rock Guidance Table Table D-7. NAPL presence
Dye Techniques	T1	T2	T3	T4	Dye Techniques can indicate the presence of LNAPL in soil or water. May be less applicable to fractured bedrock if NAPL is flushed from the core during drilling.	Fractured Rock Guidance Table Table D-7. NAPL presence
Ultraviolet Fluorescence	T1	T2	T3	T4	Ultraviolet light can be used to illuminate the presence of LNAPL. May be less applicable to fractured bedrock if NAPL is flushed from the core during drilling.	Fractured Rock Guidance Table Table D-7. NAPL presence

NAPL Interface Probe	T1	T2	T3	T4	Evidence of mobile LNAPL is observed in monitoring wells and boreholes. Collection of temporal gauging data can provide understanding of variability in gauged LNAPL thickness. Further evaluation of the data can be performed using diagnostic gauge plots. Diagnostic gauge plots can provide understanding of the location of transmissive fractures, but interpretation of the plots can be complicated where multiple transmissive fractures are present or where lateral redistribution of LNAPL occurs during water-level fluctuations. Diagnostic gauge plots can also be useful in determining if the LNAPL behaves more similarly to unconfined conditions that can indicate that Type 4 bedrock is present, or if more perched/confined characteristics are observed indicating Type 1, 2 or 3 bedrock.	Fractured Rock Guidance Table Table D-7. NAPL presence
Chemical Screening	T1	T2	T3	T4	Methods for unconsolidated formations are generally applicable to LNAPL present in fractured bedrock, except for direct-push based methods.	Fractured Rock Guidance Table Table D-8. Chemical screening
Environmental Molecular Diagnostics	T1	T2	T3	T4	Methods for unconsolidated formations are generally applicable to LNAPL present in fractured bedrock.	Fractured Rock Guidance Table Table D-9. Environmental molecular diagnostics
General Bedrock Investigation Tools	T1	T2	T3	T4	Detailed information on general tools to investigate fractured rock is provided in ITRC Fractured Rock Tables.	ITRC Fractured Rock Tables

Notes:

a. Applicability of tools in: T1 – Type 1 bedrock, T2 – Type 2 bedrock, T3 – Type 3 bedrock, T4 – Type 4 bedrock