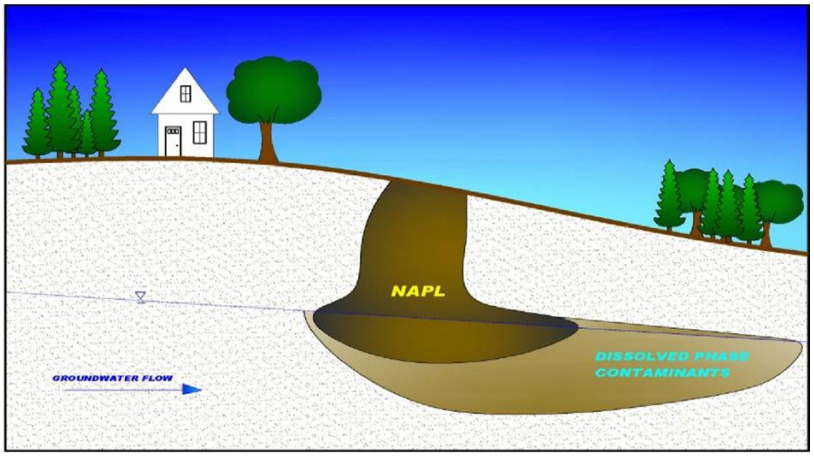
MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

NON-AQUEOUS PHASE LIQUID – PETROLEUM RELEASES

Characterization, Remediation, and Management Guidance

To promote a consistent and informed approach for Michigan Department of Environment, Great Lakes, and Energy (EGLE), this document was developed to provide information to EGLE staff and contractors for characterizing, remediating, and managing non-aqueous phase liquids (NAPL) related to petroleum releases.

This document is available as a technical reference to assist any party conducting investigations and evaluating NAPL associated with petroleum releases to support recovery and risk management decisions.



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Approved: _____

Mike Neller, Division Director
Remediation and Redevelopment Division
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ABBREVIATIONS AND ACRONYMS

ASTM..... ASTM International
BTEX ..... Benzene, Toluene, Ethylbenzene, Xylenes (total)
COC..... Chemicals of Concern
CSM..... Conceptual Site Model
DNAPL..... Dense Non-aqueous Phase Liquid
EGLE ..... Michigan Department of Environment, Great Lakes, and Energy
FAR ..... Final Assessment Report
FID..... Flame Ionization Detector
GSI ..... Groundwater Surface Water Interface
IAR..... Initial Assessment Report
IC ..... Institutional Control
ITRC ..... Interstate Technology & Regulatory Council
LIF ..... Laser-Induced Fluorescence
LNAPL ..... Light Non-aqueous Phase Liquid
MIP ..... Membrane Interface Probe
MLE ..... Multiple Lines of Evidence
NAPL ..... Non-aqueous Phase Liquid
NREPA ..... Natural Resources and Environmental Protection Act
NSZD..... Natural Source Zone Depletion
PHIC ..... Public Highway Institutional Control
PID..... Photoionization Detector
RBCA..... Risk-Based Corrective Action
RBSL ..... Risk-Based Screening Level
RRD..... Remediation and Redevelopment Division
SMART ..... Specific, Measurable, Attainable, Relevant, Time-bound
SSTL..... Site-Specific Target Level
TPH ..... Total Petroleum Hydrocarbons
TPH-DRO .... Total Petroleum Hydrocarbons, Diesel Range Organics
TPH-GRO .... Total Petroleum Hydrocarbons, Gasoline Range Organics
TPH-ORO .... Total Petroleum Hydrocarbons, Oil Range Organics
USEPA ..... United States Environmental Protection Agency
VIAP ..... Volatilization to Indoor Air Pathway
VOC..... Volatile Organic Compound

PURPOSE

Within the state of Michigan, there are thousands of properties that are contaminated by petroleum releases. These petroleum products, such as gasoline, diesel, heating oil, bunker fuel, and aviation gas consist of a large number of chemicals that have limited solubility in water and will often remain as non-aqueous phase liquids (NAPL) for many years in the sub-surface. However, over time the finite mass of many of the chemical constituents of NAPL will biodegrade, volatilize, and/or dissolve in water and will change the chemical composition.

The NAPL discussion and management approaches referenced throughout this document are limited only to petroleum. The use of the term NAPL in this document is inclusive of both petroleum light non-aqueous phase liquids (LNAPL) and petroleum dense non-aqueous phase liquids (DNAPL) - petroleum is more commonly a LNAPL. To promote consistency in the implementation of this document, references that use the term LNAPL have been modified to reflect the more inclusive term (i.e., NAPL). If this document uses the term LNAPL or DNAPL, it should be assumed that the information is applicable only to that specific type of NAPL. This document is intended for Department of Environment, Great Lakes, and Energy (EGLE) staff and other environmental professionals working on characterizing, evaluating the potential for risk, remediating, and/or managing petroleum NAPL resulting from releases of petroleum products to the environment under Part 201 and Part 213. The NAPL Guidance document is intended to identify an approach that, for most petroleum releases, will aid in effective site and risk management under Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).

EXECUTIVE SUMMARY

When a release of petroleum has occurred and is not physically removed (e.g., all contaminated material excavated), NAPL will likely be present. In the environment all NAPL will be, either in combination or individually, in one of the following states or occurrences: residual NAPL, mobile NAPL, and/or migrating NAPL. When the term NAPL is used in this document it includes both DNAPL and LNAPL and all states or occurrences (i.e., residual NAPL, mobile NAPL, and migrating NAPL).

The obligations identified in Part 201, Part 213, and the risk based corrective action (RBCA) process are consistent with the Interstate Technology and Regulatory Council's (ITRC's) LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, 2018). To meet the Part 201, Part 213, and RBCA obligations for NAPL and move sites ("sites" in this document is a general term) toward regulatory closure, the following must be completed:

1. The release must be stopped at the source and all immediate risks evaluated and abated.
2. The extent of the NAPL body must be determined. In addition, the state or occurrence of the NAPL (residual, mobile, and/or migrating) and locations must be known. The presence of migrating NAPL at a site requires actions to stop the NAPL body from expanding.
    a. A single line of evidence can be utilized to conservatively infer the presence of NAPL. To verify the absence of NAPL, a minimum of five (5) lines of evidence are needed for investigations conducted after the date of this publication. For releases that are greater than 5 years old and no continuing sources, a minimum of three (3) lines of evidence is needed to verify the absence of NAPL (see Table 3-1 for a list of acceptable lines of evidence). If an evaluation using multiple lines of evidence (MLE) indicates the absence of NAPL, EGLE will assume that detections of petroleum compounds exceeding applicable criteria, risk-based screening levels (RBSLs), or site-specific target levels (SSTLs) is contaminated soil and not residual NAPL. A table to aid in the MLE evaluation is provided as Appendix A.
    b. EGLE recognizes that it is possible to have single or multiple lines of evidence indicating that NAPL is present, but all chemicals of concern are at concentrations less than applicable criteria, RBSLs, or SSTLs. These sites can move toward closure utilizing appropriate land or resource use controls (if needed) and following all applicable statutory requirements.
3. The nature and extent of dissolved-phase (groundwater) and soil vapor plumes associated with the NAPL must be delineated. The plumes must be stable, and the potential risks posed must be evaluated using the appliable criteria, RBSLs, or SSTLs.
4. The recoverability of the NAPL must be evaluated. If the recovery of mobile NAPL is necessary to abate a risk, the mobile NAPL must be recovered.
5. Sites can move to closure once the following have been completed:
    i. The delineation of NAPL is complete, the locations of the NAPL states or occurrences are known, and the NAPL body is stable;
    ii. The nature and extent of all associated plumes (dissolved and vapor) and contaminated soil is known; and
    iii. All potential risks from the NAPL, soil contamination, and associated plumes are evaluated, and remedial or corrective actions are completed, if necessary. Sites can be closed with residual and mobile NAPL remaining in the subsurface if all current and reasonable future risks to human health and/or the environment from the NAPL, soil contamination, and associated plumes have been addressed or controlled either by active remediation, engineering controls, land or resource use controls, or a combination. For releases regulated under Part 213, all active remediation or mitigation must be completed prior to closure.

1.0 INTRODUCTION

Petroleum products and petroleum compounds are commonly used in many industries and applications across the state. Given their wide use, petroleum releases have occurred from a multitude of sources, including releases from oil and gas exploration and production, bulk storage, refining operations, retail sales (underground storage tanks), pipelines, home heating tanks, and industrial and manufacturing operations. The presence of NAPL in the subsurface does not equate to an unacceptable risk but can lead to risks to human health and the environment if not properly characterized, remediated, and/or managed. Risks can be abated using appropriate remedial and/or management practices to reduce NAPL toxicity, remove constituents of concern, recover the NAPL, and/or prevent exposures.

NAPL management decisions required under Part 201 and Part 213 are risk-based, but if NAPL is present at a site and can be recovered in an efficient and cost-effective manner, recovery of NAPL should be considered. A recoverability analysis**,** which is required under Part 213, aides in the decision-making process and has been demonstrated to be beneficial for determining the volume of NAPL that may be removed and what corrective action strategy may be most effective. It is important to document the location of the NAPL body, chemical composition, and current and future risks posed by the NAPL using a conceptual site model (CSM) to ensure the resulting risk-based decision making is protective, efficient, and cost effective. The following sections will outline EGLE's guidelines for completing the NAPL characterization, development of a CSM, risk evaluation, and recoverability analysis.

The NAPL characterization, remediation, and management strategy will utilize the RBCA process and is based on three basic concepts:

1. The presence of NAPL should be assumed when there is a known release of petroleum **and/or** sustained subsurface petroleum contamination is detected (e.g., persistent groundwater or soil vapor plumes over time) **and/or** NAPL has been visually observed (e.g., accumulating in a well or excavation). In general, if NAPL was released at a site and all states or occurrences not physically removed (e.g., excavation), it is likely present at a finite location on the site.
2. Following a release, there are two general stages in the development of the NAPL body:
    a. The first stage is the expansion stage, which is generally relatively short in duration after the release has stopped. During this stage, there is sufficient saturation for mobility and the NAPL body is actively migrating under a sufficient NAPL gradient (driving force); and
    b. The second stage is much longer in duration, when NAPL migration is minimal to nonexistent. This stage occurs when the hydraulic forces driving NAPL migration have declined relative to counteractive forces that limit migration (e.g., pore entry pressures, decreasing gradient, decreasing saturation).

3. The NAPL body may act as a long-term source for chemicals of concern (COCs) in the aqueous (dissolved) and soil vapor phases. The dissolution or volatilization of the COCs from the NAPL body are the primary mechanism by which most NAPL bodies create unacceptable risks. Over time, these mechanisms and biodegradation will deplete the finite mass of COCs. With sufficient time, the NAPL body, while still present, may not have enough mass of COCs to cause unacceptable risks.

Terms that are used throughout this document to describe various aspects of NAPL assessment and management, as well as definitions established in Part 201 and Part 213, are listed in Appendix C. Additional references, some of which provide a more thorough discussion of the concepts presented in this document, are presented in Appendix D.

To obtain a better understanding of the principles and information presented in this document, all users are encouraged to attend Interstate Technology and Regulatory Council's (ITRC) three-part training course: Connecting the Science to Managing LNAPL sites, based on the ITRC guidance: LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, 2018). All users are also encouraged to read the ITRC Guidance on LNAPL.

2.0 REGULATORY FRAMEWORK

Part 201 and Part 213 identify the following obligations of the persons liable for the release of NAPL:

1. Take action to prevent further release of NAPL into the environment;
2. Abate any immediate (i.e., fire and explosion hazard) and acute human health risks resulting from the presence of the NAPL;
3. Determine distribution and extent of the NAPL body including the location and presence of any residual NAPL, mobile NAPL, or migrating NAPL;
4. Identify NAPL that is recoverable and recover NAPL if the recovery is necessary to abate a risk;
5. Evaluate any long-term human health and environmental risk due to NAPL that is not recoverable or does not create an unacceptable risk requiring recovery; and
6. Initiate and complete response activities under Part 201 or corrective actions under Part 213.

To address NAPL obligations identified under the applicable statute (response activity under Part 201 and corrective actions under Part 213), an early step in the risk-based process is to identify NAPL risk-driven concerns. Once identified and verified, the next step is to establish specific remedial goals.

The NAPL risk-driven concerns and conditions that must be considered and addressed (if applicable) are:

- **NAPL Saturation**
  - Determines if there is an ongoing release and if there is the potential for NAPL migration.
- **NAPL Composition**
  - Determines if there is the potential for fire, explosion, or acute vapors; and
  - Evaluates if there are potential exposure risks to human and/or environmental receptors arising from the presence of NAPL.
- **NAPL Aesthetics**
  - Determines if there is the potential for odors, stains, or visual evidence of NAPL (sheens) in the soil or groundwater.

When conducting an evaluation under Part 201 or Part 213, it is possible that not all NAPL concerns will need remediation. Therefore, not all NAPL concerns will generate remedial goals and objectives. Only the concerns that cannot be addressed or managed with land or resource use controls will require remediation and a remedial goal. A compilation of example concerns, potential threshold metrics, and remedial goals are presented in Table E-1 of Appendix E.

2.1 NAPL Conceptual Site Model

ASTM Guide E2531 is the Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface and should be read to gain a full understanding of the requirements and information necessary to construct a CSM. The CSM is the compilation of key qualitative and quantitative information related to the location and occurrence of the NAPL, site setting, and site geology and hydrogeology. The CSM supports the site assessment process and corrective action decision-making. Though ASTM Guide E2531 specifically identifies the development of a CSM for LNAPL, the principles outlined in this section may also be applied to petroleum DNAPL.

The CSM integrates specific NAPL body information and considerations to the risks of the contaminant source, exposure pathways, and receptors with the information needed to develop the CSM for the site. The CSM will evolve over time as knowledge and information is gained throughout the different phases of the corrective action (Part 213) or response activities (Part 201) process. The CSM should continue to be developed and updated as information is collected and as natural or engineered processes alter the NAPL body, groundwater, and vapor conditions (ASTM Guide E2531, Section 3.1.19.1). What remains consistent is the emphasis in the CSM on characterizing and understanding the source component - the NAPL (ITRC, 2018).

The CSM development should be a tiered approach as outlined in the ASTM Guides, where an increase in site data (higher tier) is necessary when there is an increase in the site complexity, risks, and the required site-specific information for the decision-making process. The CSM for a given site is deemed adequate (in terms of level of detail) when the understanding is sufficient for all parties to agree on a path forward (ITRC, 2018). A complete CSM will typically include or provide enough information to create a cross-section, as seen in Figure 1. A CSM should also include information related to defining the vertical extent of the NAPL body, understanding the fluctuations of groundwater and the effect it has on the NAPL body, and receptor distances from the NAPL and vapor and dissolved plumes. In addition, a complete CSM would include a plan view defining the horizontal extent of the NAPL body, vapor and dissolved plumes, and receptor distances.

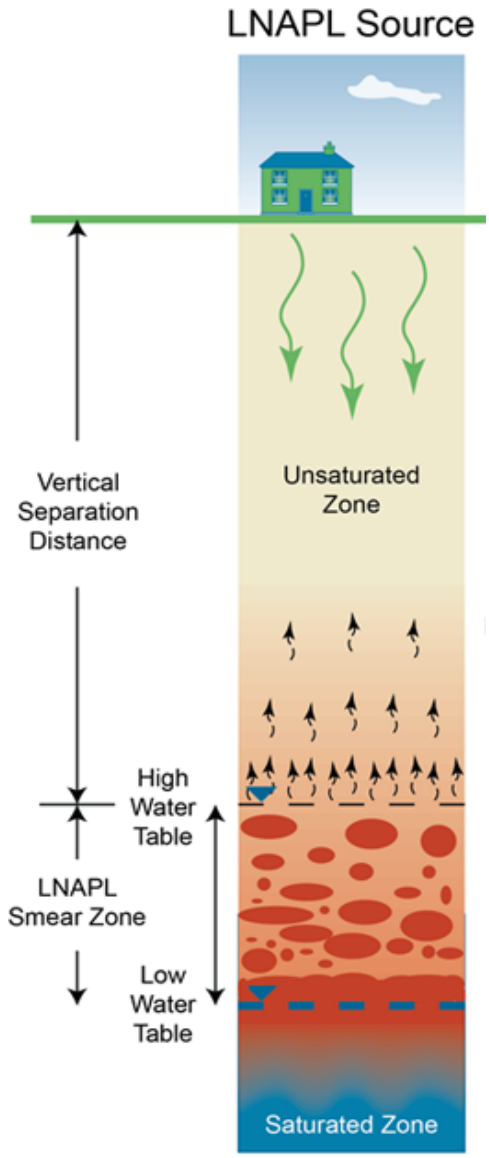


Figure 1. Schematic cross-section of information to be presented in a CSM for NAPL, from ITRC, 2014.

The CSM is based on site information that includes the following:

- **Site setting (historical and current)** – includes land use (as it informs potential sources), groundwater use, presence and proximity of receptors, etc. Consideration of the potential future land uses should be included.
- **Geological and hydrogeological information/setting** – includes lithology, depth to groundwater and fluctuation potential, groundwater flow direction, etc.
- **NAPL body spatial distribution (vertical and horizontal delineation)** – geometry of the NAPL body both horizontally and vertically. Accomplished with MLE that could include laboratory data [e.g., Volatile Organic Compounds (VOCs), Total Petroleum Hydrocarbons (TPH)], field screening data, and/or with high resolution characterization data [e.g., Laser Induced Fluorescence (LIF)].

- **NAPL mobility and body stability information** – location of where the NAPL is residual and mobile; is mobile NAPL footprint expanding (migrating NAPL).
- **NAPL recoverability information** – assess if mobile NAPL is recoverable and if recovery is necessary to abate an unacceptable risk. See Section 3.3.
- **Location of all soil contamination** – determination of where the soil is contaminated versus where residual NAPL is located.
- **Associated dissolved-phase and vapor-phase plume information** – location and distribution of COCs in groundwater and soil gas (nature and extent) and seasonal variability (stability) of all associated plumes. Determine if the plumes are potential risks to current or future human and/or environmental receptors.
- **Temporal variability of the NAPL body** – using graphs of NAPL thickness vs. groundwater elevation over time if mobile NAPL is present. NAPL thickness can vary as a function of monitoring well screen placement and with changes in water table elevation.

The following information could be used to supplement the CSM:

- NAPL physical properties (density, viscosity, interfacial tension, vapor pressure) and chemical properties (constituent solubilities and mole fractions) – if a known petroleum product was released, this can be assumed; if unknown, characterization will be needed.
- NAPL natural source-zone depletion processes, including rate measurements or estimates, if available – this could also include an estimation of the remaining mass of constituents of concern in historic releases.

The precision in the data collection that may be needed for the CSM depends on other available lines of evidence, the current and future land use(s), and location of the release relative to potential receptors. Generally, the risk potential at a site will dictate the precision in data collection. For example, at a site where there are little or no historical data or where the data sets are extremely sparse and sensitive receptors are nearby, there will be a greater need for detailed data collection to obtain site-specific laboratory data, possibly supplemented with high resolution data (e.g., LIF) to characterize the NAPL body and evaluate stability. Conversely, at a site with an abundance of historical data (that has been properly collected) or no potential receptors in close proximity (e.g., the contamination is a small footprint relative to distance to adjacent parcels), the need for detailed data collection to develop a precise CSM is lessened. For additional details refer to ASTM International Guide E2531 and ITRC, 2018 Section 4.

3.0 NAPL AND THE RBCA PROCESS

Implementation of the RBCA process for a site where NAPL is present requires an understanding and evaluation of the NAPL composition, the NAPL state or occurrence, the extent and stability of the NAPL body, the extent and stability of any soil contamination, the extent and stability of groundwater and vapor plumes, and any potential receptors. If risks are identified during the characterization of the NAPL body, they must be abated, addressed, or controlled. The successful characterization of the NAPL body will achieve the following goals:

- ✓ Determine the distribution and extent of residual and/or mobile NAPL and determine the stability of the NAPL body (ensure migrating NAPL is not present);
- ✓ Identify recoverable NAPL; and
- ✓ Evaluate risks from the NAPL that cannot be recovered or is anticipated to remain in the subsurface. This includes any vapor or dissolved-phase plumes and soil contamination associated with the NAPL body.

The goals outlined above are achieved by using various investigative approaches and remedial technologies. A MLE approach is always recommended, as each line of evidence has advantages and limitations. ITRC, 2018 Table 4-2 describes and provides detailed references for further information about tools and their capabilities that can be used for investigation. Appendix B also identifies other requirements in Part 201 and Part 213 as it relates to NAPL. A discussion about each of the goals and how to achieve EGLE approval of a submittal is provided below.

3.1 Determine Distribution and Extent of NAPL Body

Defining the extent of the NAPL body requires identifying the vertical and horizontal location where residual NAPL and mobile NAPL are present at a site, which includes the vadose zone and saturated zone (see Figure 2). If mobile NAPL is present, the stability must be sufficiently evaluated to ensure that migrating NAPL is not present. NAPL does not float on the water table in a uniform, high-saturation, “pancake”-like layer and will be distributed above, at, and below the water table at varying levels of saturations, as shown in Figure 2. The vertical saturation variability will depend on past conditions, such as NAPL driving head and water table fluctuations (ITRC 2018) and the lithology. The delineation or characterization of the NAPL should be to points where the absence of NAPL is demonstrated by the MLE. It is critical under Part 201 or Part 213 that the extent of the NAPL body is clearly established as this is typically an issue that prevents a site from progressing through the response activity (Part 201) or corrective action (Part 213) process.

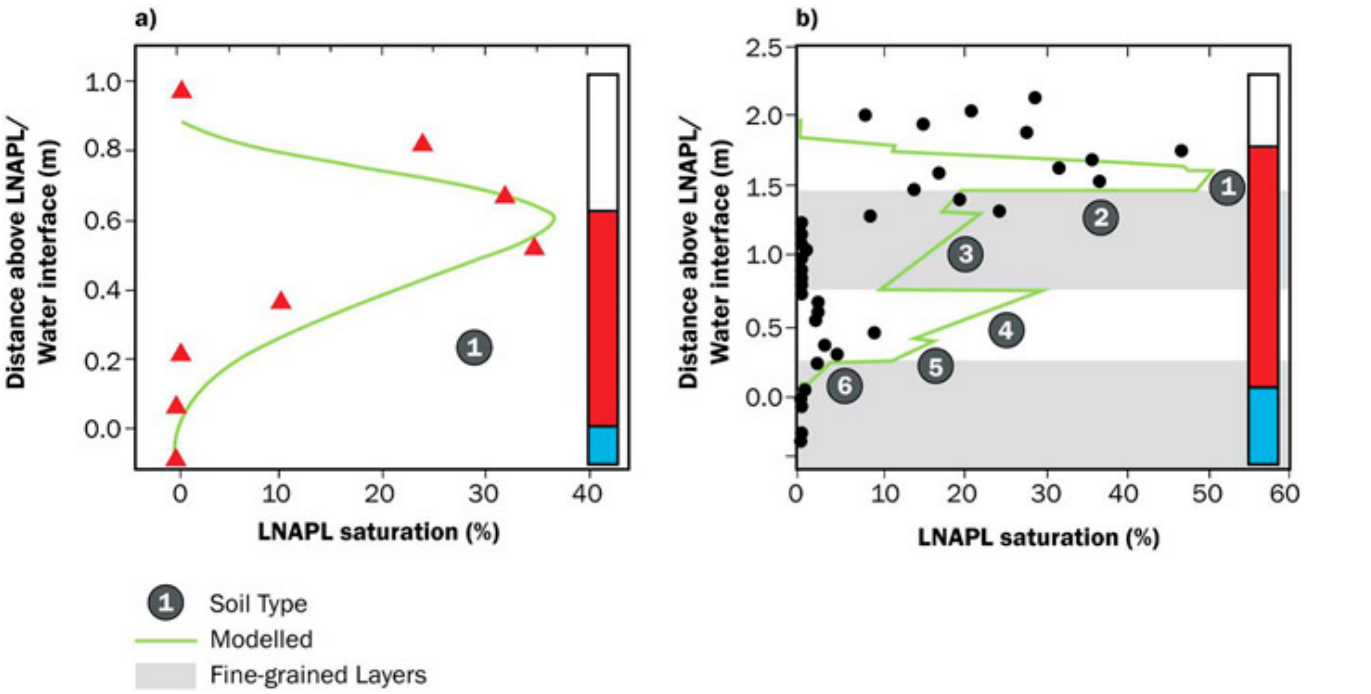


Figure 2. From ITRC, 2018, Depiction showing the degree of NAPL saturation above the water interface with uniform soil type (left) and heterogeneous soil types (right). The NAPL saturation profile is commonly referred to as "shark fin" distribution.

EGLE, as well as the United States Environmental Protection Agency (USEPA) and ITRC, recommends a MLE approach to make informed decisions about the distribution and extent of NAPL. The various lines of evidence do not have equal weight in determining the absence or presence of NAPL. For example, some lines of evidence such as visual observation can provide a more definitive proof of NAPL presence, whereas the absence of visual observation may lead to a false conclusion that NAPL is not present.

NAPL characterization will require, at a minimum, evaluation both above and below the water table. For site investigations conducted after the date of this document, EGLE recommends that additional lines of evidence data are collected in addition to the required COCs for NAPL delineation. The other lines of evidence recommended by EGLE include, but are not limited to, TPH analysis, ultraviolet fluorescence, petrophilic dye, and LIF can be used to enhance, supplement, and/or augment the understanding of the NAPL (see Table 3-1 for a more complete list and limitations). Regardless of the characterization methods used at a particular site, once characterization is complete, it should be known where the NAPL is located (including vadose zone, smear zone, and below the water table) and its state or occurrence (residual NAPL, mobile NAPL, and migrating NAPL). Table 3-1 identifies common petroleum NAPL lines of evidence that can be used to identify the presence or absence of NAPL and aid in defining the extent. Each petroleum NAPL line of evidence used should contain a brief discussion on the rationale, origin, and/or limitations for consideration when planning the NAPL characterization.

NOTE: Upon completion of the investigation, the location, nature, and extent of the NAPL body, soil contamination, and groundwater and vapor plumes must be determined. There should be established points where NAPL is not present that define the extent and monitoring wells installed to evaluate stability. When creating a visual depiction of the NAPL body for the CSM, the extent of NAPL may be estimated between the borings if supported by site data.

When implementing a MLE approach, a single line of evidence can be used to conservatively infer the presence of NAPL. Conversely, more lines of evidence are needed to confirm with reasonable certainty where NAPL, including residual NAPL, is not present. MLE used should be presented in a table to clearly show the rationale for the presence/absence of NAPL. An example table is included in Appendix A that can be downloaded and included with all submittals. EGLE has identified **that a minimum of 5 lines of evidence from Table 3-1 should be included in evaluations** to determine where NAPL is not present for investigations conducted after the date of this document. This is a total of 5 lines of evidence and can be any combination of general, soil, groundwater, or vapor. For releases that have previously been adequately characterized to make risk management decisions or releases greater than 5 years old with all sources of contaminants previously removed or repaired (e.g., underground storage tanks and dispensers), 3 lines of evidence can be used to make the evaluation. The MLE evaluation is generally not necessary at all boring locations at a site, just the borings necessary to delineate the extent of the NAPL body. This biased approach for the delineation of NAPL allows site resources to be more focused on identifying and confirming with a higher level of confidence the extent of the NAPL body. Furthermore, most of these NAPL indicators are not capable of establishing if the NAPL is residual NAPL or mobile NAPL.

NOTE: Locations where the MLE determine NAPL is not present and the presence of petroleum compounds are detected in the soil above generic cleanup criteria, RBSLs, or SSTLs are considered soil contamination and not residual NAPL.

TPH-GRO**,** TPH-DRO, and TPH-ORO as a line of evidence are not analytical methods that identify gasoline, diesel fuel, or oil specifically, but rather identify petroleum hydrocarbons that are in the “range” of those found in gasoline, diesel fuel, or oil. For TPH-GRO, EGLE is referring to an analysis for “extractable” petroleum hydrocarbons in the volatile range between C6 and C10 using USEPA Method 8260; for TPH-DRO, an analysis for “extractable” petroleum hydrocarbons in the semi-volatile range between C10 and C20 using USEPA Method 8015; for TPH-ORO, an analysis for “extractable” petroleum hydrocarbons between C20 and C34 using USEPA Method 8015.

NOTE: TPH cannot be reliably estimated using calculations based on the analysis of individual COCs. In addition, EGLE does not have soil or groundwater criteria for TPH, so their use for soil and groundwater characterization is limited to a line of evidence for the determination of the presence/absence of NAPL.

Table 3-1 Petroleum NAPL Indicators and Considerations and Limitations
(modified from Table 3-2 in ITRC 2018 and Table 3-1 in ITRC 2014)

General NAPL Line of Evidence	Considerations and Limitations
Adjacent to (e.g., within 20 feet) a known or suspected NAPL release area or petroleum equipment (ITRC 2014; ITRC 2018)	The probability of encountering NAPL increases as you move closer to the suspected or potential areas of release.
Current or historical presence of NAPL (ITRC 2014; ITRC 2018)	If NAPL was historically present and not physically all removed, it is likely still present as either mobile or residual NAPL. This includes staining, sheens, and mobile NAPL.
Soil NAPL Line of Evidence	**Considerations and Limitations**
Observed or visible NAPL (ITRC 2014; ITRC 2018)	If NAPL is not observed or visible, does not necessarily mean NAPL is absent.
Ultraviolet fluorescence (UV) or LIF response in NAPL range (ITRC 2014; ITRC 2018)	Positive response is a good indicator of NAPL presence, but cannot determine if the NAPL is residual, mobile, or migrating. The soil type can alter the response, especially in fine vs. coarse grained soil. The NAPL must have poly-cyclic aromatic hydrocarbons to fluoresce.
TPH-GRO, TPH-DRO, or TPH-ORO greater than 250,000 ug/kg (ITRC 2014; ITRC 2018; EPA 2015)	Economical and allows for estimation of the degree of NAPL saturation. Data should be evaluated with some caution as organics could interfere with the results. Methods are available to reduce or remove interferences. Not applicable with fractured rock or sediment.
Benzene greater than 10,000 ug/kg (ITRC 2014; ITRC 2018)	High concentrations of benzene in the soil is an indicator that NAPL is present in an area. However, as benzene is likely to undergo biodegradation, lower concentrations of benzene in the immediate area of a release may not be an indicator that NAPL is absent.
Photoionization Detector (PID) or Flame Ionization Detector (FID) readings for a recent release > 500 ppm (ITRC 2014; ITRC 2018)	High PID and FID readings are an indicator of NAPL. However, the ability for the equipment to detect and identify NAPL is dependent on many factors, including the composition of the NAPL, the soil type, the equipment utilized, and the equipment maintenance.
Field screening tests positive (e.g., dye test or shake test) (EPA 1995)	Economical screening tool for presence or absence only. Soil type will affect the results – clays and silts will not readily allow for dye to contact the NAPL and the NAPL is not readily released with shaking.

Groundwater NAPL Line of Evidence	Considerations and Limitations
Observed NAPL, including sheens (e.g., in wells or other discharges) (ITRC 2014; ITRC 2018)	If NAPL is not observed or visible, does not necessarily mean NAPL is absent.
Near effective solubility in dissolved phases (ITRC 2018)	Effective solubility is dependent on mole fraction of the compound in the mixture – this is widely variable among petroleum and will change over time for the same petroleum product, so there are no specific concentrations that define all NAPL.
Dissolved plume persistence and center-of mass stability (EPA 1995)	With a persistent groundwater plume with a relatively stable source origin, it is likely that there is NAPL providing the mass in dissolved phase.
TPH-GRO greater than 30,000 ug/L in groundwater (ITRC 2014; ITRC 2018)	The presence of higher TPH-GRO concentrations is an indicator that NAPL is present.
Benzene greater than 1,000 ug/L (ITRC 2014; ITRC 2018)	Higher concentrations of benzene can aid in identifying the location that NAPL is likely present and contributing to a dissolved groundwater phase.
Sum of Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX) greater than 20,000 ug/L (ITRC 2014; ITRC 2018)	Higher concentrations of BTEX can aid in identifying the location that NAPL is likely present and contributing to a dissolved groundwater phase. Caution should be utilized due to the potential of biodegradation and that petroleum consists of a larger range of hazardous substances.

Vapor NAPL Line of Evidence	Considerations and Limitations
Near volatility limits in vapor phase (EPA 1995)	Partial pressure is dependent on mole fraction of the compound in the mixture – this is widely variable among petroleum and with change over time with the same petroleum product, so there are no specific concentrations that defines all NAPL.
Oxygen (O2) less than 4% by volume (Lahvis et al., 2013)	This is based on work from petroleum vapor intrusion screening research. Verification of the vadose zone lithology will be needed as oxygen may be utilized in the vadose zone by naturally occurring organics (e.g., Peat layers).
Hexane concentrations greater than 100,000 ug/m3 (Lahvis et al., 2013)	If present in the release and detected in vapor samples, aliphatic compounds tend to have a lower solubility and higher vapor pressure and are often found in the soil gas near NAPL.

When using MLE and there are conflicting lines of evidence, the full weight of evidence and limitations listed in Table 3-1 will need to be evaluated to assess the presence or absence of NAPL. Also, if the presence or absence of NAPL at the location does not alter the site risk decisions based on current and future land uses or land or resource use controls, then less precision with the lines of evidence may be acceptable. Many sites may not have developed a MLE approach for soil to evaluate residual NAPL. To initially evaluate NAPL at these sites, use the collected lines of evidence from the site data and present them in the table provided in Appendix A or similar presentation to determine if a NAPL CSM can be adequately developed to allow for risk management decisions. If this evaluation results in a CSM that can be utilized to evaluate all current and future risks from NAPL with the data previously collected, then no further data collection is necessary for NAPL. If there is missing information and/or if the NAPL CSM is not sufficiently developed and results in the inability to make site decisions, supplemental information will need to be collected.

> **NOTE:** Csat concentrations, which represent a soil concentration in equilibrium with water at a specific chemical's saturation limit, do not provide significant value with mixtures such as petroleum. The MLE approach and mobility evaluation is a more appropriate evaluation for NAPL that is required under the criteria rules (R.299.6(2), R299.18(2), and footnote "C" in Rule R299.49).

The following sections provide additional information on residual NAPL**,** migrating NAPL, and mobile NAPL and information that aids in characterizing and identifying the extent of each.

3.1.1 Migrating NAPL

NAPL is considered to be migrating when the overall NAPL body footprint is expanding; in other words, NAPL is observed to spread or expand laterally (most common) or vertically. For the NAPL to expand its footprint, two conditions must be present:

1) The NAPL is of sufficient saturation that it is mobile, and
2) There is a driving force "pushing" the NAPL body. Generally, once the release has stopped, the migration of NAPL continues for a short duration and is a self-limiting process.

Further discussion on mechanisms and resistive forces that drive the NAPL migration can be found in ITRC, 2018.

> **NOTE:** If migrating NAPL is observed at a site, interim response actions must be conducted to stop the NAPL from migrating.

To determine if the NAPL body is migrating, the extent of the NAPL must first be determined and established as discussed in Section 3.1. After the extent is known and established, appropriately placed and screened monitoring wells (if not previously installed) can be placed within and around the extent of the NAPL to monitor for NAPL migration. NAPL is considered migrating when it is observed to expand into previously unimpacted locations (e.g., NAPL

appears in a monitoring well that had an initially clean borehole) (ITRC, 2018). Permanent monitoring wells should be located hydraulically downgradient of the NAPL based on a reasonable expectation that if NAPL were to migrate from the known extent, it would be detected during the timeframe monitoring occurs prior to closure being obtained. Care must be taken when using NAPL thickness data from monitoring wells to assess NAPL migration as vertical re-distribution of NAPL with a rising or falling water table can result in the appearance of an increased (i.e., growing) or decreased (i.e., shrinking) footprint, or apparent lateral migration of NAPL that is not representative of actual conditions (ITRC, 2018).

> **NOTE:** The presence or absence of NAPL in a well based on fluctuating groundwater elevations does not indicate migrating NAPL. Initial investigation knowledge and tools such as hydrographs depicting NAPL thickness vs. groundwater elevations are helpful tools for the evaluation. In addition, where the release was previously stopped, the site will likely have a stable NAPL body.

Some general lines of evidence that can be used to aid in the determination that a NAPL body is not migrating include:

- Stable NAPL footprint over time.
- Stable or decreasing dissolved-phased plume in the groundwater.
- Residual NAPL located beyond where mobile NAPL is located in a NAPL body.

3.1.2 Mobile NAPL

Mobile NAPL is when petroleum NAPL is present and is at a high enough saturation to be hydraulically interconnected in the soil or aquifer pore spaces that it has the ability to flow. NAPL that accumulates in a properly constructed well is considered mobile NAPL. The presence of NAPL in a well, however, does not necessarily mean that the NAPL body is migrating, but may mean that the NAPL is hydraulically recoverable (see Section 3.3).

Mobile NAPL is most often present adjacent to areas where capillary barriers (e.g., finer grained lithology or water saturated pores) prevent or reduce further vertical migration during a release. Around the capillary barriers, the degree of NAPL saturation increases and has been repeatedly found during investigations. See ITRC, 2018 for the “shark fin” discussion for NAPL distribution and Figure 2 in Section 3.1 for a depiction.

In order to properly characterize mobile NAPL at or beneath the groundwater, groundwater monitoring wells should be appropriately placed and screened in locations where NAPL is known or suspected from the MLE. The monitoring well will act as a large pore space and will accumulate NAPL if mobile NAPL is present and adjacent to the well. In instances of fluctuating groundwater elevations, the NAPL body at the location can change states or occurrences between mobile and residual. Petrophysical testing, such as Dean-Stark extractions, a centrifuge, or water-drive, can be used to determine if mobile NAPL is present, but the testing

can be expensive, and the sample volume is small relative to the volume represented by a monitoring well.

NOTE: When evaluating mobile NAPL, it has been found that mobile NAPL can be unconfined (most frequent), confined, and perched. Perched and confined NAPL can exaggerate the in-well measured thickness which may lead to erroneous conclusions on the extent of NAPL. The determination of perched, confined, or unconfined mobile NAPL can be accomplished by MLE and the mobile NAPL measured thickness as it changes in wells in response to groundwater elevation changes (plotted in hydrographs). If confined or perched NAPL is present at a site, the risk evaluation may be different than it would be if the NAPL was unconfined. Please see ITRC, 2018 for further guidance.

3.1.3 Residual NAPL

Residual NAPL occurs when the saturation is sufficiently low so that NAPL occupies a fraction of pore spaces and is often discontinuous, resulting in the inability for the NAPL to flow under the conditions during time of observation. Residual NAPL can be a source of COCs dissolved in groundwater, for direct contact, or in the vapor-phase in soil gas. Residual NAPL spans a range of NAPL saturation levels for a given soil and NAPL type, both vertically and horizontally, in the NAPL body. Often the minimum and maximum saturation levels span a factor of 10 across a given NAPL body (ITRC, 2018). Similar to mobile NAPL, the greatest amount of residual NAPL saturation will be adjacent to a capillary barrier, see Figure 2 in Section 3.1. In addition, residual saturation is often higher in the center of the NAPL body than on the fringes. Water table fluctuations can help to reduce variability in residual saturation at some locations; however, variability still exists (ITRC, 2018).

NOTE: EGLE does not have criteria for water saturated soil (aquifer matrix) and data should not be compared to soil criteria for pathway evaluations. However, characterization of the water saturated soil and smear zone from water table fluctuations using a MLE approach (using NAPL indicators from Table 3-1) will be necessary to delineate the NAPL body and understand the mass of contamination to ensure adequate characterization of dissolved and vapor phase plumes. This data should be clearly presented in the CSM to avoid confusion.

In the unsaturated/vadose zone, generally once a release has stopped, any NAPL saturated soil will be drained by gravity to equilibrium and only residual NAPL will remain. Therefore, as long as there are not ongoing releases, NAPL in the vadose zone should be considered residual (ITRC, 2018).

NOTE: Soil with residual NAPL may often look like clean soil, however, it can pose the same risks as mobile NAPL as a source of dissolved and vapor contamination. The MLE should be evaluated to determine if and where residual NAPL exists at a site.

3.2 Abate NAPL Risks

Once the distribution and extent of NAPL is determined, the next step is to determine if the NAPL or COCs from the NAPL poses an unacceptable risk to human health, safety, welfare, or environmental receptors as a necessary part of the process outlined in Part 201 and Part 213.

Conditions, receptors, and/or exposure pathways that will need to be evaluated to ensure NAPL or their associated chemicals are not creating an unacceptable risk include:

- Fire and/or Explosion (Immediate risk – abate immediately upon discovery)
- Acute vapor hazards – Petroleum vapors in indoor air in concentrations above acceptable screening levels (Immediate risk – abate immediately upon discovery)
- Drinking Water Ingestion
- Direct Contact
- Inhalation (Volatilization to Indoor Air)
- Soil Inhalation (Ambient Air)
- Groundwater-Surface Water Interface (GSI)
- Sensitive Environmental Receptors

When an immediate risk has been identified, an interim response action appropriate to abate the risks in accordance with Part 201 and Part 213 must be implemented. Examples of immediate risks with NAPL could include, but are not limited to, NAPL entering a storm or sanitary sewer or petroleum vapors in a structure.

3.3 Recoverable NAPL

If it is determined that mobile NAPL is present (Section 3.1), the amount of NAPL that is recoverable must be evaluated. In addition, if NAPL recovery is necessary to abate a risk, the recoverable NAPL must be recovered. NAPL recoverability refers to the ability to hydraulically remove (e.g., pump liquids) mobile NAPL from the subsurface at a given location. Understanding NAPL recoverability is important, particularly for sites where one or more remediation endpoints are based on removal of mobile NAPL. Reaching a recoverability limit does not mean all NAPL is removed or that NAPL saturations are reduced to residual saturations (mobile NAPL will likely still exist), but it does typically represent an endpoint where the majority of remaining NAPL is of limited mobility (ITRC, 2018).

A NAPL transmissivity evaluation can be a useful tool in assessment of NAPL recoverability at some sites; the greater the NAPL transmissivity, the higher the NAPL recoverability. If there is greater than 0.2 feet of mobile NAPL in a well, NAPL transmissivity is a reliable indicator of the ability of the formation to transmit NAPL to a well (ITRC, 2018) and is a more accurate metric for evaluating recoverability of mobile NAPL than gauged NAPL thickness (ASTM E2856, 2011). Refer to Appendix E and ASTM Guide E2856, titled the “Standard Guide for Estimation of NAPL Transmissivity” for additional details on the field data collection and calculation methodologies for the estimation of NAPL transmissivity in unconsolidated porous sediments.

3.3.1 NAPL Recovery and Removal under Part 213

As outlined in Part 213, if the recovery of mobile NAPL is necessary to abate an unacceptable risk, then mobile NAPL recovery is required to the maximum extent practicable. **If there are no unacceptable risks associated with mobile NAPL, there are no statutory requirements for mobile NAPL recovery**; however, EGLE encourages the development of a saturation-based goal for NAPL recovery be developed to recover all cost-effectively and efficiently removed NAPL. A NAPL transmissivity of 0.8 ft^2/day can be used as the metric for mobile NAPL that can be recovered in a cost effective and efficient manner (ITRC, 2018). Other factors, such as "net environmental gain" (i.e., the amount of energy required and carbon dioxide emissions for removal versus the amount of NAPL being recovered), NAPL composition, dissolved and/or vapor plume stability, distances to property boundaries and/or receptors, financial considerations, and legacy reduction, may also be considered in the evaluation of mobile NAPL recoverability and saturation-based goals. A recoverability analysis is a useful tool for determining the quantity of NAPL that may be recovered. For the recoverability analysis to be the most useful, at a minimum, it should take into account the feasibility of NAPL recovery, current and potential future risks posed by the NAPL, and current and future land uses. Environmental factors, such as the potential seasonal changes in recoverability, may make data from multiple events or during different seasons necessary to identify any seasonal effects to complete the analysis.

Recovery of mobile NAPL will likely decrease the complexity of the site and may reduce the monitoring required to determine the potential for risks from the remaining NAPL. However, scientific studies, experience, and risk assessments have shown that there are cases where all NAPL cannot be recovered and there are instances where no recovery is necessary if all current and future risks are addressed or controlled. If there are risks from the dissolved and/or vapor phase plumes or soil contamination, composition-based removal or remedial goals will also be necessary. ITRC, 2018 describes, in detail, performance metrics and remediation endpoints for NAPL to consider. A table of metrics is included in Appendix E to help with the development of composition-based goals.

The most cost-effective and efficient way to address new releases is to immediately recover (e.g., begin recovery within the first 24 – 48 hours) as much NAPL as technically feasible and practicable when the release is discovered. Generally, experience has demonstrated that this will provide the greatest amount of recovery, reduce risk, and save time and money for all involved.

> **NOTE:** With the RBCA process, if the NAPL, soil contamination, or associated dissolved or vapor phase plume are posing a risk, corrective actions or remedial activities are necessary to abate the risks, regardless of the NAPL state (mobile or residual) or if the NAPL is recoverable.

3.4 Applicable Criteria for any NAPL Body that Cannot be Removed or Will Remain

Evaluating the risks to human health, the environment, and adverse aesthetic characteristics (i.e., stains, sheens, and odors) requires that the NAPL, soil contamination, and any associated dissolved or vapor plumes be delineated. While petroleum NAPL is comprised of hundreds of compounds, EGLE has identified a list of recommended parameters that must be analyzed in the soil, groundwater, and/or soil gas as part of the evaluation process (see the Recommended Parameter List). RBSLs and generic cleanup criteria have been developed to evaluate potential risks from individual chemicals associated with various exposure pathways. To evaluate these risks, concentrations of individual chemicals in specific media are compared to generic cleanup criteria, site-specific criteria, RBSLs, or SSTLs for the exposure pathway. If the source of the release is unknown, the composition of the NAPL may need to be determined so appropriate investigative techniques and analytical methods can be implemented.

The RBSLs and generic cleanup criteria are calculated with the assumption that NAPL is not present. Using the results of a MLE evaluation that was conducted in accordance with Section 3.1 will support the determination of where NAPL is present or absent and at what state or occurrence (residual, mobile, or migrating). The NAPL body delineation and Table 3-2 can be used to determine the applicability of the generic cleanup criteria and RBSLs for risk evaluation using soil data for each pathway. If the generic soil criteria or RBSL are not applicable, the EGLE preferred evaluation or action is provided in Table 3-2.

> **NOTE:** TPH is a recognized line of evidence, but EGLE does not have RBSLs or generic cleanup criteria for TPH concentrations. Therefore, risk assessments will be based on concentrations of the individual COCs. EGLE recognizes that it is possible to have MLE, including TPH concentrations that are indicative of NAPL, but all individual chemicals are below RBSLs or generic cleanup criteria. These sites can move towards Part 213 closure or Part 201 No Further Action (NFA) when the appropriate land and resource use controls are in place (if necessary) and following all statutory requirements.

As outlined in Section 3.1.3, NAPL in the vadose zone can be considered residual. Therefore, all generic criteria or RBSLs for soil will be applicable in the vadose zone except the generic soil volatilization to indoor air inhalation criteria (SVIIC). For the SVIIC to be applicable, all other assumptions associated with the development of the criteria must be met. Even when the SVIIC is applicable, site-specific soil, groundwater, and soil vapor criteria or screening levels to evaluate the risk for the volatilization to indoor air pathway (VIAP) can be developed. See Table 3-2 for soil criteria or RBSL applicability with the NAPL determination and EGLE's preferred action or evaluation.

When MLE demonstrate that NAPL is present and the evaluation outlined in Section 3.1.2 concludes that mobile NAPL is present, the generic cleanup criteria or RBSLs for soil can be assumed to be exceeded or site-specific criteria (Part 201) or SSTLs (Part 213) must be developed to evaluate the potential risk for each relevant pathway at that location. If the soil

criteria or RBSLs are assumed to be exceeded, a site-specific pathway evaluation using data from other media, response activities, or corrective action will be necessary. Each pathway has a unique approach to conducting a pathway evaluation with data from other media, therefore when the soil criteria or RBSLs are not applicable, the specific pathway guidance material should be consulted for further guidance.

NOTE: While the applicability of criteria applies to soil data, it is the preference of EGLE to collect direct measurements of the media for the pathway of concern – groundwater for the drinking water and groundwater-surface water interface pathway and soil gas for volatilization to indoor air pathway. NAPL presence should not significantly impact the ability to evaluate these exposure pathways from soil gas or groundwater media.

Table 3-2 Soil Generic Cleanup Criteria or RBSLs Applicability with NAPL Determination from MLE

Soil Criteria for Pathway	NAPL Absent	Residual NAPL	Mobile NAPL	Migrating NAPL
Direct Contact	X	X	Use land or resource use controls if mobile NAPL is greater than 2 feet below ground (See note below)	Stop NAPL Migration
Soil Volatilization to Indoor Air Inhalation	X	Use Horizontal and Vertical Separation Distances or Soil Gas Data	Use Horizontal and Vertical Separation Distances or Soil Gas Data	Stop NAPL Migration
Drinking Water Protection	X	X	Use Groundwater Data	Stop NAPL Migration
GSI Protection	X	X	Use Groundwater Data	Stop NAPL Migration
Volatile Soil Inhalation	X	X	X	Stop NAPL Migration
Particulate Soil Inhalation	X	X	X	Stop NAPL Migration

X = Generic Soil Criteria or RBSLs Applicable. When not applicable, the EGLE preferred method is provided.

NOTE: If mobile NAPL is less than 2 feet below ground, to address the direct contact pathway, engineered controls or other actions, such as capping or removal, may be necessary in addition to the land or resource use control.

For the soil volatilization to indoor air criteria, all other assumptions associated with the pathway and the development of the criteria must be met as well.

3.5 Part 213 Corrective Action or Part 201 Response Activity Plan for NAPL

The response activity under Part 201 or a corrective action under Part 213 must include an evaluation and determination of whether the NAPL is mobile or migrating (see Section 3.1) and an analysis of the recoverability of the NAPL (see Section 3.3). The response activity or a corrective action must also describe the NAPL remediation objective and how the remedial goal will be accomplished. The remediation objective and remedial goal should be linked to the technology(ies) used, combined with performance metrics and a remediation endpoint. Once this occurs, the NAPL remediation objective becomes a "SMART" objective in that it must identify and make clear Specific, Measurable, Attainable, Relevant, and Time-bound objectives. See Section 5 in ITRC, 2018 for more information. NAPL remedial goals identified in Table E-1 in Appendix E are grouped by NAPL Saturation, NAPL Composition, and NAPL Aesthetics to aid in this analysis. Refer to Section 6 and the LNAPL Technology Appendix in ITRC, 2018 for a discussion of technologies and uses for NAPL corrective action or response activity to aid in the selection of the most appropriate technology for the NAPL remedial goals.

If NAPL is present and NAPL removal is not proposed, the Part 213 corrective action plan or Part 201 submittal for EGLE approval must provide an analysis and demonstration of how the remaining NAPL will not pose any current or potential future risks by evaluating:

- all current and potential future health risks or adverse aesthetic characteristics posed by the NAPL Composition and NAPL Saturation,
- any NAPL Aesthetics issues that are to remain,
- effectiveness of any land use restrictions and how they will be monitored in the future,
- any potential seasonal changes in mobile NAPL recoverability and seasonal changes in risk,
- an analysis of NAPL and associated dissolved and vapor phase plume stability and/or natural source zone depletion (NSZD), and
- other pertinent site factors that the submitter considered in leaving NAPL in place.

NOTE: If mobile NAPL remains in the sub-surface at depths greater than 25 feet below ground, restrictive covenants may not be necessary for mobile NAPL, and a Notice of Aesthetic Impact or other notice may be acceptable as long as the drinking water pathway is controlled with other mechanisms. The depth can be less with adequate characterization of potential risks, but the actual depth will be site specific.

4.0 NO FURTHER ACTION UNDER PART 201 OR CLOSURE UNDER PART 213

For most facilities under Part 201 and sites under Part 213, implementing successful NAPL management as outlined in Section 3 and moving the site toward no further action or closure will include:

- Determining the extent of the NAPL body, developing a CSM, ensuring the NAPL body is stable (no migrating NAPL), and demonstrating all risks are addressed, controlled, or managed.
- Determining if and where the NAPL is residual and/or mobile.
- Determining the extent of all associated plumes (dissolved and vapor) and soil contamination, ensuring plume stability, and ensuring all risks are addressed, controlled, or managed.
- Conducting an analysis of the recoverability of NAPL and recovering mobile NAPL if the mobile NAPL is creating an unacceptable risk (Part 213).
- Demonstrating that current and future risks from the NAPL and all associated plumes are managed.

In many cases, there will be residual NAPL or mobile NAPL that remains and must be managed with restrictions to prevent future exposures because of exceedances of risk-based target levels in one or more media. Statutory obligations and requirements for NAPL and obtaining a No Further Action or a Closure are briefly described in Appendix B. The references and statute should be reviewed for additional details and information.

> **NOTE:** It is possible for sites with residual NAPL only and no applicable criteria or RBSL exceedances to be Closed under Part 213 or obtain No Further Action under Part 201 without a restriction. These scenarios must be evaluated on an individual site basis. In general, if there are no health risks or aesthetic issues that will require institutional controls for long term management, then there may not be a need for the land or resource use controls.

APPENDIX A – EXAMPLE MULTIPLE LINES OF EVIDENCE (MLE) EVALUATION TABLE

EGLE has developed an Excel Spreadsheet to use for evaluating multiple lines of evidence.

APPENDIX B – STATUTORY REFERENCES

Statute and Rules

Part 201. Environmental Remediation of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended. legislature.mi.gov/doc.aspx?mcl-451-1994-ii-7-201

Part 213. Leaking Underground Storage Tanks of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended. legislature.mi.gov/doc.aspx?mcl-451-1994-ii-8-213

Part 201 Administrative Rules. Administrative Rules of Part 201 of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended, R 299.1 to R 299.50.

"RBCA Process" or "RBCA" as defined in Part 213 which is incorporated by reference [Sec. 21303(g)] and includes:

- Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites. E 1739-95 (reapproved 2010) E1. ASTM International. www.astm.org/Standards/E1739.htm.
- Standard Guide for Risk Based Corrective Action. E 2081-00 (reapproved 2010) E1. ASTM International. www.astm.org/Standards/E2081.htm.
- Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface. E 2531-06 E1. ASTM International. www.astm.org/Standards/E2531.htm.

NOTE: Part 213 incorporates these specific ASTM standards. However, EGLE has determined that updated versions of ASTM E1739-95(2015), E2081-00(2015), and ASTM E2531-06(2020) comply with the standards that were incorporated during the promulgations of Part 213 but may contain other obligations or requirements that are not specifically required by statute.

Part 213

Obligations associated with NAPL are identified throughout multiple sections of Part 213. Below is a list of the obligations related to NAPL. There are other obligations and requirements associated with NAPL that must be addressed; therefore, it is important to understand all of Part 213 and the obligations identified in it.

- Sec. 21307 identifies multiple obligations associated with NAPL as part of the **initial response actions**, including:
    - the need to immediately begin and expeditiously identify and mitigate immediate fire, explosion hazards, and acute vapor hazards;
    - to take steps as identified in **RBCA** regarding NAPL that are necessary and feasible to address unacceptable immediate risks;

  - to excavate and contain, treat, or dispose of soils above the water table that are visibly contaminated with a regulated substance if the contamination is likely to cause a fire hazard; and
  - to take any other action necessary to abate an immediate threat to public health, safety, or welfare, or the environment.

- Sec. 21308a identifies multiple obligations to be completed within 180 days after a release has been discovered as part of the **initial assessment report (IAR)**, which includes:
  - the mobile or migrating NAPL investigation and evaluation conducted and an analysis of the **recoverability** of the NAPL and whether the NAPL is mobile or migrating;
  - if the evaluation of NAPL concludes that NAPL is **recoverable** and removal is necessary to abate an unacceptable risk;
  - a description of the actions taken to remove any NAPL;
  - the name of the person or persons responsible for implementing the NAPL removal measures;
  - the estimated quantity, type, and thickness of NAPL observed or measured in wells, boreholes, and excavations;
  - the type of NAPL recovery system used;
  - the quantity and disposition of the recovered NAPL; and
  - if **migrating** or **mobile NAPL** is discovered at a site after the submittal of an IAR, perform the actions identified Sec. 21307(2)(c) and submit to the department an amendment to the initial assessment report within 30 days of discovery of the migrating or mobile NAPL that describes response actions taken as a result of the **migrating** or **mobile NAPL** discovery.
- Sec. 21311a is the **final assessment report (FAR)** that includes the **corrective action plan (CAP)** described in Sec. 21309a that identifies obligations and requirements that are completed within 365 days after a release has been discovered. The FAR and CAP obligations and requirements include:
  - identify the extent of contamination relative to the applicable **RBSLs** or applicable **SSTLs**;
  - an analysis of the **recoverability** and whether the NAPL is **mobile** or **migrating**;
  - alternatives that permanently and significantly reduce the volume, toxicity, and mobility of the regulated substances if above the applicable RBSL or applicable SSTL; and

- an explanation of how that action will meet the requirements of the tier I, II, or III evaluation in the **RBCA process**.

- **RBCA** includes ASTM Guide E2531; the obligations are further described in Section 2.1 above.
- Aesthetic criteria are addressed in Sec. 20120a(5) and **Sec. 20121(3)(g)**, which requires notice of hazardous substances that exceed aesthetic-based cleanup criteria.

Part 213 Corrective Action Plans

If the initial actions performed under Sections 3.2 and 3.3 have not resulted in completion of **corrective action**, an owner or operator that is liable under Section 21323a is required to prepare a **corrective action plan** to address contamination at the site. Section 21309a should be reviewed as it details the information that must be included.

Part 213 Closure Reports

A "**closure report**" details the completion of **corrective action** under Part 213 and the **RBCA** process. At any time that sufficient **corrective action** has been undertaken to address contamination, the owner or operator that is liable under must complete and submit a site closure report and omit the remaining interim steps identified in Part 213 and the RBCA process.

Any contamination that remains above applicable RBSLs or applicable SSTLs must be reliably restricted with institutional controls, restrictive covenants, alternative mechanisms, or notices described in Section 21310a. The most common institutional controls include a Public Highway Institutional Control (PHIC) to address NAPL beneath a road right of way or a Notice of Corrective Action or a Notice of Aesthetic Impact that are be recorded with the register of deeds for the county in which the site is located prior to submittal of a closure report under Section 21312a. How these institutional controls relate to NAPL is further described below.

PHIC – When environmental contamination or NAPL is proposed to remain in place within a public highway owned or controlled by a county road commission or local unit of government, including a road right of way, the “Public Highway Institutional Control” may be used to satisfy all the requirements under Section 21310a(3)(c) of Part 213.

Notice of Corrective Action – Used when the corrective action relies on nonresidential land use and identifies basic information and the location of the NAPL and shall state that if there is a proposed change in the land use at any time in the future, that change may necessitate further evaluation of potential risks to the public health, safety, and welfare and to the environment and that the department shall be contacted regarding any proposed change in the land use. More information on the Notice of Corrective Action and form is provided in EQP3853. EQP3853 provides an explanation on the necessary information in a model document.

Notice of Aesthetic Impact – An institutional control mechanism that has been approved by EGLE in accordance with Sec. 21310a(2) that could be used when the NAPL that is present does not contain any health risks associated with the **NAPL Composition** and the only issue that remains is associated with **NAPL Aesthetics**. The use of the Notice of Aesthetic Impact provides future owners notification of the presence of NAPL and that it has been investigated for any known and unacceptable risks to human health. More information on the Notice of Aesthetic Impact and form is provided in EQP3887. EQP3887 provides an explanation on the necessary information in a model document.

When NAPL is present, an institutional control may not be necessary if the corrective action plan relies on alternative mechanisms. More information about alternate mechanisms is provided in Sec. 21310a(3). In addition, if only residual NAPL remains and there are no health or aesthetic concerns, institutional controls may not be necessary.

Part 201

Sec. 20114(1) of Part 201 has specifical obligations that are directed toward NAPL and requires that an owner or operator of property who has knowledge that the property is a facility shall initiate necessary and feasible remedial action to:

- Sec. 20114(1)(e) – Immediately identify and eliminate any threat of fire or explosion or any direct contact hazards.
- Sec. 20114(1)(f) – Initiate necessary and feasible remedial action to address unacceptable risks associated with **residual NAPL**, **migrating NAPL**, and **mobile NAPL**. Though timeframes are not specifically established to meet this objective, Part 213 identifies timeframes that would be reasonable for most sites to accomplish the investigative process.

Aesthetic criteria are addressed in Sec. 20120a(5) and **Sec. 20121(3)(g)**, which requires notice of hazardous substances that exceed aesthetic-based cleanup criteria**.** The administrative rules also identify other requirements for NAPL to address aesthetic-based cleanup criteria in R 299.1, R 299.2, R 299.6, R 299.9, R 299.10, and R 299.28.

Part 201 Response Activity Plans

If the initial actions have not resulted in completion of the remedial action where a no further action or a closure could be obtained, Sec. 20114 requires a party that is liable under Sec. 20126 to continue to implement measures to address, remove, or contain hazardous substances if those measures are technically practicable and to diligently pursue response activities necessary to achieve the cleanup criteria identified in Section 3.4. R 299.6(2) also requires that the person proposing or implementing response activity must evaluate whether additional response activity is required to control free-phase liquids (Part 201 rule definition for NAPL) or to protect against risks associated with free-phase liquids that are not accounted for in development of the generic criteria. R 299.49(1)(C) similarly requires a person document

whether additional response activity is required to control free-phase liquids or NAPL using methods appropriate for the free-phase liquids present. Alternative methods to assess whether additional actions are necessary may be identified in the rules specific for the relevant exposure pathways.

Under Part 201, this can be implemented by either self-implementing and conducting response activities under Sec. 20114a or under Sec. 20114b if the owner or operator wishes to, or is required to, obtain departmental approval by submitting a **response activity plan** containing a plan for undertaking interim response activities and undertaking interim response activities consistent with that plan. Sec. 20114b should be reviewed as it identifies the necessary information and form to complete.

Part 201 No Further Action

A "**no further action report**" details the completion of **remedial actions** and includes a **postclosure plan** and a **postclosure agreement**, if appropriate. It may be submitted by a person under Sec. 20114d(1) that is, or is not, liable. If NAPL is to be considered as part for a **no further action report,** then it must also consider whether:

- Additional **response activity(ies)** is required to control free-phase liquids or NAPL to protect against risks associated with free-phase liquids or NAPL that are not accounted for in development of the generic criteria [R 299.6 (2); R 299.49(1)(C)];
- If a site-specific risk evaluation for each relevant exposure pathway where free-phase liquids or NAPL are present must be conducted and completed [R 299.18(2), R 299.49(1)(C)];
- If a **land or resource use restriction** as a restrictive covenant [MCL 324.20121(2)-(6)], institutional control [MCL 324.20121(8)], or an alternative mechanism [MCL 324.20121(9)] is required;
- If a **notice of aesthetic impact** [R 299.2(d)] or a **notice of hazardous substances** that exceed aesthetic-based cleanup criteria is required [Sec. 20121(3)(g)] in a **land or resource use restriction.**

This document is not intended to detail all the obligations, responsibilities, and requirements of a **no further action report**, **postclosure plan**, and a **postclosure agreement**. It is intended to identify considerations for NAPL in their development. Part 201 and the Part 201 Administrative Rules should be consulted for additional information on the specific requirements.

APPENDIX C – KEY NAPL DEFINITIONS, ADDITIONAL TERMS, AND ABBREVIATIONS

A list of key definitions and terminology used. When appropriate, a brief discussion of how these terms relate follows the definition.

KEY NAPL DEFINITIONS

"Conceptual Site Model" or "CSM"

An integration of site information and interpretations generally including facets pertaining to the physical, chemical, transport, and receptor characteristics present

DISCUSSION: This term is defined in RBCA as a conceptual model.

"Dense Nonaqueous-Phase Liquid" or "DNAPL"

Sec. 21302(i): "means a dense nonaqueous-phase liquid with a specific gravity greater than 1 and composed of 1 or more organic compounds that are immiscible or sparingly soluble in water. DNAPL encompasses all potential occurrences of DNAPL."

DISCUSSION: This term includes all states (or occurrences) of DNAPL; therefore, when used, it specifically includes residual DNAPL, mobile DNAPL, and migrating DNAPL.

"LNAPL Conceptual Site Model" or "LCSM"

Describes the physical properties, chemical composition, occurrence, and geologic setting of the LNAPL body from which estimates of flux, risk, and potential remedial action can be generated. It is a dynamic CSM that changes through time as new knowledge is gained or as a result of natural or engineered processes altering the LNAPL body, groundwater, and vapor plume conditions.

DISCUSSION: This term is defined in ASTM Guide E2531. It has been modified in this document so that all petroleum releases can use the document as a reference as the information is the same.

"Light nonaqueous-phase liquid" or "LNAPL"

Sec. 21302(n): "means a light nonaqueous-phase liquid having a specific gravity less than 1 and composed of 1 or more organic compounds that are immiscible or sparingly soluble in water, and the term encompasses all potential occurrences of NAPL."

DISCUSSION: This term includes all states (or occurrences) of NAPL; therefore, when used, it specifically includes residual LNAPL, mobile LNAPL, and migrating LNAPL.

"Migrating NAPL"

Sec. 21302(q): “means NAPL that is observed to spread or expand laterally or vertically or otherwise result in an increased volume of the NAPL extent, usually indicated by time series data or observation. Migrating NAPL does not include NAPL that appears in a well within the historical extent of the NAPL due to a fluctuating water table.”

Sec. 20101(1)(dd): “means that terms as it is defined in Section 21302.”

DISCUSSION: Migrating petroleum NAPL occurs when the vertical and/or horizontal extent of the NAPL is expanding and can occur in the vadose or saturated zone, typically while the release is on-going or shortly after the release has stopped. Site-specific conditions or changes in site conditions after the release has stopped may allow petroleum NAPL to continue to migrate for an extended, but finite, period of time. All migrating petroleum NAPL is also mobile NAPL. It is also defined in ASTM Guide E2531 as “mobile NAPL” [ASTM Guide E2531 3.1.23], but that term should not be used when referring to NAPL that is migrating to be consistent with Part 213.

"Mobile NAPL"

Sec. 21302(r): “means NAPL that exceeds residual saturation, and includes migrating NAPL, but not all mobile NAPL is migrating NAPL.”

Sec. 20101(1)(ee): “means that term as it is defined in Section 21302.”

DISCUSSION: The term mobile NAPL is used when petroleum NAPL is present and is at a high enough saturation to be hydraulically connected in the pore spaces so that it can flow. If a well is placed in a location with mobile petroleum NAPL present, this NAPL will accumulate in the well. Mobile NAPL has the potential to move or expand its footprint, but it is not currently spreading vertically or laterally. Mobile petroleum NAPL is typically hydraulically recoverable, but recovery depends on several factors. It is also defined in ASTM Guide E2531 as “free NAPL” [ASTM Guide E2531 3.1.12], but to promote clarity, the term free NAPL should not be used when NAPL is mobile but not migrating.

"NAPL"

Sec. 21303(a): “means a nonaqueous-phase liquid or a nonaqueous-phase liquid solution composed of 1 or more organic compounds that are immiscible or sparingly soluble in water. NAPL includes both DNAPL and LNAPL.”

Sec. 20101(1)(ff): “means that term as it is defined in Section 21303.”

DISCUSSION: NAPL includes both DNAPL and LNAPL, but this document only addresses petroleum.

“NAPL Aesthetics”

Concentrations of the contaminants in the NAPL do not exceed applicable health-based criteria but are present in quantities that may adversely affect the taste, odor, color, appearance, or any aesthetic quality.

“NAPL body”

Three-dimensional form and distribution of NAPL in the subsurface existing in all phases (i.e., mobile NAPL, migrating NAPL, and residual NAPL).

DISCUSSION: This term is defined in ASTM Guide E2531 3.1.16 as “LNAPL body”. It has been modified in this document so that all petroleum releases can use the document as a reference as the information is the same.

“NAPL body footprint”

Two-dimensional form and distribution of NAPL in the subsurface existing in all phases (i.e., mobile NAPL, migrating NAPL, and residual NAPL).

DISCUSSION: This term is defined in ASTM Guide E2531 3.1.17 as “LNAPL body footprint”. It has been modified in this document so that all petroleum releases can use the document as a reference as the information is the same.

“NAPL Composition”

Regulated or hazardous substances in soil, groundwater, and/or vapor depend primarily on NAPL chemical composition. The chemical composition of the NAPL will need to be determined so appropriate investigative techniques and laboratory analytical methods can be implemented.

“NAPL recoverability” also “Recoverability” also “Recover Ability”

Defined in ASTM Guide E2531 3.1.33 as “general term for the degree to which NAPL can be removed from the subsurface, often defined as the fraction of the total in situ NAPL mass or of the free or residual volumes.”

Sec. 21309a(2)(a) uses recoverability as one word.

DISCUSSION: This term is defined in RBCA as “recover ability” but is generally used as *“NAPL recoverability*” also “*Recoverability*”.

“NAPL Saturation”

NAPL filled fraction of the total porosity, or the total pore space available for NAPL to occupy. The degree of NAPL saturation is dependent upon the soil and fluid properties, site history of releases, and volume of NAPL released.

“NAPL transmissivity”

Defined in ASTM Guide E2856 as the volume of LNAPL at the existing kinematic viscosity that will move in a unit time under a unit hydraulic gradient through a unit width of the aquifer [Length squared over time(L2 /t)]. It is an accurate metric for understanding LNAPL recovery and is directly proportional to LNAPL recoverability and tracking remediation progress towards residual LNAPL saturation.

Can be used to estimate the rate of recovery for a given drawdown from various technologies.

“RBCA”

Sec. 21303(g): "means the American Society for Testing and Materials (ASTM) document entitled standard guide for risk-based corrective action applied at petroleum release sites, designation E 1739-95 (reapproved 2010) E1; standard guide for risk-based corrective action designation E 2081-00 (reapproved 2010) E1; and standard guide for development of conceptual site models and remediation strategies for light nonaqueous-phase liquids released to the subsurface designation E 2531-06 E1, all of which are hereby incorporated by reference.”

“RBCA process”

Means the process described in RBCA – ASTM E 1739-95 (reapproved in 2010) and E 2081-00 (reapproved in 2010).

“Recoverable NAPL”

See “NAPL recoverability.”

"Residual NAPL saturation"

- Sec. 21303(j): “means the range of NAPL saturations greater than zero NAPL saturation up to the NAPL saturation at which NAPL capillary pressure equals pore entry pressure and includes the maximum NAPL saturation, below which NAPL is discontinuous and immobile under the applied gradient.”
- Sec. 20101(1)(uu): “means that term as it is defined in part 213.”

DISCUSSION: See “Residual NAPL” [ASTM Guide E2531 3.1.38].

"Residual NAPL"

ASTM Guide E2531 3.1.38: NAPL that is hydraulically discontinuous and immobile under prevailing conditions. It is based on residual NAPL saturation.

DISCUSSION: Residual NAPL that cannot move through hydraulic mechanisms (unless prevailing conditions change) but is a source for chemicals of concern dissolved in groundwater or in the vapor-phase in soil gas. The residual NAPL saturation is a function of the initial (or maximum) NAPL saturation and the porous medium.

“Relevant pathway”

R 299.2(g): An exposure pathway that is reasonable and relevant because there is a reasonable potential for exposure to a hazardous substance to occur to a human or nonhuman receptor. The components of an exposure pathway are a source or release of a hazardous substance, an exposure point, and if the exposure point is not the source or point of release, a transport medium. The existence of a municipal water supply, exposure barrier, or other similar feature does not automatically make an exposure pathway irrelevant.

ADDITIONAL TERMS

"Corrective action"

Sec. 21302(h): the investigation, assessment, cleanup, removal, containment, isolation, treatment, or monitoring of regulated substances released into the environment from an underground storage tank system that is necessary under this part to prevent, minimize, or mitigate injury to the public health, safety, or welfare, the environment, or natural resources.

“Corrective Action Plan (CAP)”

Sec. 21309a: a report that provides a description of the corrective action to be implemented, and if necessary, an operation and maintenance plan and a monitoring plan. Additional detail is provided in Sec. 21309a.

“Final Assessment Report (FAR)

Sec. 21311a: a report that is provided within 365 days after a release has been discovered that includes a corrective action plan developed under section 21309a. The information that is required is provided in Sec. 21311a.

"Hazardous substance"

Sec. 20101(1)(x): 1 or more of the following, but does not include fruit, vegetable, or field crop residuals or processing by-products, or aquatic plants, that are applied to the land for an agricultural use or for use as an animal feed, if the use is consistent with generally accepted agricultural management practices at the time of the application or stamp sands:

(i) Any substance that the department demonstrates, on a case-by-case basis, poses an unacceptable risk to the public health, safety, or welfare, or the environment, considering the fate of the material, dose-response, toxicity, or adverse impact on natural resources.

(ii) Hazardous substance as defined in the comprehensive environmental response, compensation, and liability act, 42 USC 9601 to 9675.

(iii) Hazardous waste as defined in part 111.

(iv) Petroleum as described as a regulated substance in section 21303.

"Interim Response Activity"

Sec. 20101(1)(y): the cleanup or removal of a released hazardous substance or the taking of other actions, prior to the implementation of a remedial action, as may be necessary to prevent, minimize, or mitigate injury to the public health, safety, or welfare, or to the environment. Interim response activity also includes, but is not limited to, measures to limit access, replacement of water supplies, and temporary relocation of people as determined to be necessary by the department. In addition, interim response activity means the taking of other actions as may be necessary to prevent, minimize, or mitigate a threatened release.

“Institutional control”

20121(8), 21310a, and R 299.1(q): a measure which is approved by the department, which takes a form other than a restrictive covenant, and which limits or prohibits certain activities that may interfere with the integrity or effectiveness of a remedial action or result in exposure to hazardous substances at a facility, or which provides notice about the presence of a hazardous substance at a facility in concentrations that exceed only an aesthetic-based cleanup criterion.

NOTE: For Part 201, see **“Land or resource use restrictions.”**

“Land or resource use restrictions (LRUR)”

20121(8) and R 299.2(a): the provisions of any of the following measures that are used to limit or prohibit activities that may interfere with the integrity or effectiveness of a response activity, or to limit or prohibit activities that may result in exposure to hazardous substances at a facility, or to provide notice about the presence of a hazardous substance at a facility in concentrations that exceed only an aesthetic-based cleanup criterion:

(i) A restrictive covenant.

(ii) A notice of approved environmental remediation.

(iii) An institutional control, which may be a local ordinance or any form of preapproved institutional control, such as a notice of aesthetic impact.

Part 213 (Sec. 21310a) does not use LRUR.

NOTE: See **"Institutional Control."**

"Multiple Lines of Evidence (MLE)"

Field data, modeling, and other pertinent site information from multiple sources used to assess a specific relationship or conclusion. Typically, this approach is used to support a conclusion because the analysis may not be fully supported on its own.

"No further action report"

Sec. 20101(1)(hh): a report under section 20114d detailing the completion of remedial actions including a postclosure plan and a postclosure agreement, if appropriate.

"Notice of aesthetic impact"

R 299.2(d): a document that describes conditions at a facility that result from the presence of hazardous substances at concentrations which exceed only cleanup criteria that are based on aesthetic impacts.

"Postclosure agreement"

Sec. 20101(1)(nn): an agreement between the department and a person who has submitted a no further action report that prescribes, as appropriate, activities required to be undertaken upon completion of remedial actions as provided for in Sec. 20114d.

"Postclosure plan"

Sec. 20101(1)(oo): a plan for land use or resource use restrictions or permanent markers at a facility upon completion of remedial actions as provided for in Sec. 20114c.

"Response activity"

Sec. 20101(1)(vv): evaluation, interim response activity, remedial action, demolition, providing an alternative water supply, or the taking of other actions necessary to protect the public health, safety, or welfare, or the environment or the natural resources. Response activity also includes health assessments or health effect studies carried out under the supervision, or with the approval of, the department of community health and enforcement actions related to any response activity.

“Remedial action”

Sec. 20101(1)(qq): includes, but is not limited to, cleanup, removal, containment, isolation, destruction, or treatment of a hazardous substance released or threatened to be released into the environment, monitoring, maintenance, or the taking of other actions that may be necessary to prevent, minimize, or mitigate injury to the public health, safety, or welfare, or to the environment.

"Risk-based screening level" or "RBSL"

Sec. 21303(k): “means the unrestricted residential and nonresidential generic cleanup criteria developed by the department pursuant to part 201.”

NOTE: See also “Risk-based screening level/screening levels (RBSLs)” [ASTM Guide E1739 3.1.34].

"Site-specific target level" or "SSTL"

Sec. 21303(o): “means an RBCA risk-based remedial action target level for contamination developed for a site under RBCA tier II and tier III evaluations.”

NOTE: See “Site-specific target level (SSTL)” [ASTM Guide E1739 3.1.38].

“Total Petroleum Hydrocarbons” or “TPH”

- Defined as the measurable amount of petroleum-based hydrocarbon in an environmental media. It is dependent on analysis of the medium in which it is found. Since it is a measured, gross quantity without identification of its constituents, the TPH “value” still represents a mixture and itself is not a direct indicator of risk to humans or to the environment.

- The measurement of non-specific petroleum hydrocarbons in contaminated soil or groundwater are gross quantities without identification of specific contaminants and do not substitute for contaminant-specific analyses and comparison to cleanup criteria or risked-based screening levels. The amounts of petroleum hydrocarbons measured may be useful in evaluating the magnitude of petroleum contamination, determining the absence or presence of NAPL, determining the nature of the product (i.e., carbon range), estimating the degree of NAPL saturation in the pore space of the soil, aiding in the delineation of the NAPL body, determining whether the comparison to generic criteria is appropriate, and evaluating aesthetic concerns at a facility.

Appendix D – References

ITRC, 2018, LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies, March 2018, Guidance Document (LNAPL-3). Interstate Technology & Regulatory Council (ITRC). LNAPL-3.itrcweb.org/.

Standard Guide for Estimation of NAPL Transmissivity. (June 2021). ASTM E2856-13(2021). ASTM International. www.astm.org/e2856-13r21.html.

ITRC, 2014, Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management, October 2014, Interstate Technology & Regulatory Council (ITRC). projects.itrcweb.org/PetroleumVI-Guidance/.

EPA, 2015, Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, June 2015, U.S. Environmental Protection Agency, Office of Underground Storage Tanks.

EPA 1995, Groundwater Issue: Light Nonaqueous Phase Liquids, U.S. Environmental Protection Agency, EPA/540/S-95/500.

Lahvis et al., 2013, Vapor Intrusion Screening at Petroleum UST Sites, Matthew A. Lahvis, Ian Hers, Robin V. Davis, Jackie Wright, and George E. Duval, Groundwater Monitoring & Remediation, Spring 2013.

Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites. E 1739-95 (reapproved 2010) E1. ASTM International. www.astm.org/Standards/E1739.htm.

Standard Guide for Risk Based Corrective Action. E 2081-00 (reapproved 2010) E1. ASTM International. www.astm.org/Standards/E2081.htm.

Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface. E 2531-06 E1. ASTM International. www.astm.org/Standards/E2531.htm.

Appendix E – Example of NAPL Concerns, Remedial Objectives, and Remedial Goals

Table E-1
Connecting NAPL concerns and objectives with remedial goals, from ITRC, 2018

NAPL saturation-based goals

NAPL Concern	Potential Threshold Metrics	NAPL Remediation Goal	NAPL Remediation Objective
NAPL occurrence in wells	**NAPL transmissivity** to assess **recoverability**	Reduce mobile **NAPL saturation**	Recover NAPL to a practicable limit
NAPL occurrence in soil	**TPH** in soil and, when necessary, the development of site-specific criteria or site-specific target levels (SSTLs)	Abate unacceptable soil concentrations even when NAPL is within **residual saturation** range	Reduce NAPL and associated soil concentrations (e.g., **TPH**) to below soil TPH limits
Potential NAPL migration	**NAPL body** footprint stability	Terminate **NAPL body** migration and reduce potential for NAPL migration	Abate **NAPL body** migration by sufficient physical removal of mobile NAPL mass. Stop NAPL migration by physical barrier.

NAPL composition-based goals

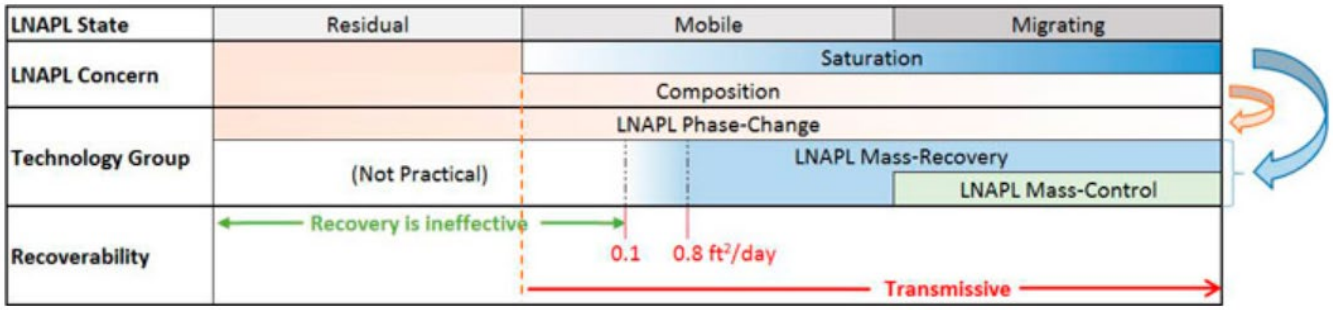
NAPL Concern	Potential Threshold Metrics	NAPL Remediation Goal	NAPL Remediation Objective
Groundwater impacts from a NAPL source	For dissolved-phase groundwater concentrations, use applicable criteria or RBSLs, which may require the use of **site-specific criteria** or **SSTLs**	Abate unacceptable constituent concentrations from a NAPL source	Control or treat soluble plume to abate dissolved-phase concentrations. Contain **NAPL body** and groundwater to prevent groundwater impacts at compliance point(s).
Groundwater impacts from a NAPL source (continued)	Dissolved-phase plume stability	Abate unacceptable concentrations in dissolved-phase from NAPL source	Control or treat soluble plume to abate dissolved-phase concentrations
Petroleum vapor intrusion for dissolved groundwater concentrations adjacent the NAPL source	When able to be applied, vapor intrusion screening distances; when not, **site-specific criteria** or **SSTLs**	Abate unacceptable concentrations source	Reduction of groundwater and vapor concentrations above **site-specific criteria** or **SSTLs**
Petroleum vapor intrusion overlying NAPL source	When able to be applied, vapor intrusion screening distances; when not, **site-specific criteria** or **SSTLs**	Reduce constituent concentrations in soil vapor and/or NAPL source	Abate unacceptable vapor concentrations by sufficient depletion of volatile constituents in NAPL
NAPL occurrence in soil	Additional soil regulatory standards	Abate unacceptable soil concentrations even when NAPL is within **residual NAPL saturation** range (e.g., **TPH** concentration)	Reduction of risk from specific components

NAPL aesthetic-based goals

NAPL Concern	Potential Threshold Metrics	NAPL Remediation Goal	NAPL Remediation Objective
Geotechnical instability of NAPL-affected soil	Geotechnical structural tests	Restore soil stability (saturation-based goal)	Abate geotechnical soil instability
Stains and odors	Field inspection	Remove aesthetic concerns (composition-based goal)	Abate offensive odors

Figure E-1 provides a graphical representation of **residual NAPL**, **mobile NAPL**, and **migrating NAPL** from ITRC, 2018 that illustrates where compositional, hydraulic recovery, and saturation reduction technologies are applicable within the spectrum. Since the practicable limits of NAPL hydraulic recovery is represented by a **NAPL transmissivity** of 0.1 to 0.8 ft^2/day, NAPL recovery cannot meet a remedial goal of removing all NAPL. If the NAPL has a transmissivity greater than 0.8 ft^2/day, it is likely that the NAPL can be recovered in a cost-effective and efficient manner and should be considered for removal whenever possible unless a demonstration is made to show otherwise. Additional information on NAPL recovery can be found in ITRC, 2018.

Figure E-1.
Relationship between NAPL concern, NAPL state, technology group, and recoverability. (from ITRC, 2018)



NAPL Transmissivity

In addition to summarizing the existing methods to calculate **NAPL transmissivity**, ASTM Guide E2856 provides guidance on refined field procedures for data collection and minimum requirements for data sets. As identified and discussed in ASTM Guide E2856, the accurate calculation of **NAPL transmissivity** requires certain aspects of the **CSM** to be understood and defined to calculate NAPL drawdown correctly. Therefore, it is important to ensure as part of

any transmissivity testing that the CSM, as presented in Section 2.1 of this document, has been updated and is representative.

ASTM Guide E2856 should be consulted for a better understanding of transmissivity testing. It contains four test methods to evaluate **NAPL transmissivity** based on data objectives, site setting, and hydrogeologic conditions. They are:

- Bail down/Slug Test
- Manual Skimming
- Recovery System Data
- Tracer Testing

Prior to completing any transmissivity testing, and to derive the most accurate **NAPL transmissivity** values, appropriate well development should be conducted to ensure connectivity between NAPL in the formation and the well. Industry experience has observed that NAPL can require up to several months following well installation to saturate the filter pack and establish connectivity within the well. Well development can help to reduce this time frame (see ASTM Guide E2856, Section 4.2.1.4). Because of the amount of time required to saturate the filter pack and establish connectivity, any well selected for testing should be confirmed to be screened over the entire interval of **mobile NAPL**. For locations where multiple discrete mobile intervals exist, it may be preferable to screen individual wells across each mobile interval. This will simplify the calculation of drawdown and derivation of **NAPL transmissivity** and may require the installation of specific wells.

Appropriately screened wells can be substantiated based on vertical delineation of the entire NAPL impacted interval (see ASTM Guide E2856, Section 4.2.1.2). Additional information on both these items can be found in ASTM Guide E2856.

An overview of the methodologies is provided in Table A2.1 and Table A2.2 of ASTM Guide E2856, and a review of the required parameters to be measured is provided in Tables A2.3-A2.9 of ASTM Guide E2856.