

Guidelines for the Assessment and Remediation of Oilfield Releases

North Dakota Department of Environmental Quality

Division of Water Quality

Spill Investigation Program

Bismarck, North Dakota

Original Version: February 2026



Environmental
Quality

4201 Normandy Street
Bismarck, North Dakota 58503
Phone: 701-328-5150
Fax: 701-328-5200

TITLE: Guidelines for the Assessment and Remediation of Oilfield Releases
 TYPE: Department Guideline Document
 PROGRAM / DIVISION: Division of Water Quality, Spill Investigation Program
 VERSION: 1.0
 VERSION DATE: 2/19/2026
 AUTHOR(S): Paige Wallery, pwallery@nd.gov, 701-328-5243

AUTHORIZATION

	Name	Signature	Date
Approved by	L. David Glatt		2-19-2026

REVISION HISTORY

Revision	Change Description	Date	Authorization

THIS PAGE LEFT INTENTIONALLY BLANK

Table of Contents

Guidelines for the Assessment and Remediation of Oilfield Releases.....	1
DEFINITIONS AND ACRONYMS	7
SECTION 1. INTRODUCTION	11
SECTION 2. INITIAL RESPONSE, CONTAINMENT, AND REPORTING	13
2.1. Reporting Requirements	13
2.2. What is considered waters of the state?	14
2.3. What is containment?.....	14
2.4. What is confined to property of origin?.....	15
SECTION 3. SITE ASSESMENT AND DELINEATION	17
3.1. Delineation in Water	17
3.2. Delineation in Soil	20
3.3. Delineation Example Scenarios.....	21
3.3.1. Soil Delineation Example.....	21
3.3.2. Water Delineation Example	24
3.3.3. Soil and Water Delineation Example	26
3.4. Location Assessment and Area Mapping	29
3.5. Choosing a Remediation Method	29
SECTION 4. EXCAVATION	30
4.1. North Dakota One Call and Excavation Fencing	30
4.2. Confirmation Sampling.....	30
4.3. Capillary Breaks and Impermeable Barriers	30
4.4. Soil Disposal	31
4.5. Excavation Backfill	31
SECTION 5. WATER REMOVAL	32
5.1. Water Removal Methods.....	32
5.2. Water Disposal.....	32
SECTION 6. OIL SPILLS AND ALTERNATIVE OIL REMEDIATION TECHNIQUES	33
6.1. Bioremediation.....	33
6.2. Burning	34
6.3. Landfarming.....	34

6.4. Natural Attenuation	34
6.5. Experimental Techniques.....	34
SECTION 7. SALTWATER SPILLS AND ALTERNATIVE SALTWATER REMEDIATION TECHNIQUES ..	35
7.1. Electrokinetics	36
7.2. Phytoremediation	36
7.3. Soil Flushing and Amendments.....	36
7.4. Experimental Techniques.....	37
SECTION 8. OTHER COMMON OILFIELD RELEASES	38
8.1. Bentonite (Drilling Mud)	38
8.2. Diesel and Gasoline.....	38
8.3. Fires.....	38
8.4. Freshwater	38
8.5. Hydraulic Oil	38
8.6. Liquefied Natural Gases (LPG, LNG, Propane, Butane, etc.).....	38
8.7. Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)	39
8.8. Used Motor Oil	39
8.9. Uncommon Materials	39
SECTION 9. LIMITED ACTION OPTION	40
SECTION 10. LABORATORY ANALYSIS AND REMEDIATION ACTION LEVELS	41
10.1. Laboratory Analysis and Remediation Action Levels for Oilfield Spills	41
Table 1. Requirements for Analytical Testing of Releases Impacting Water	41
Table 2. Analytical Testing for Impacted Soils.....	42
10.2. Field Testing Methods	42
10.3. North Dakota Risk Based Corrective Action (NDRBCA)	43
SECTION 11. SEEDING, MONITORING, AND INCIDENT CLOSURE	44
11.1. Seeding.....	44
11.2. Monitoring.....	44
11.3. Incident Closure	45
SECTION 12: SPILL RESPONSE AND DOCUMENTATION CHECKLISTS.....	46
12.1. Spill Response Checklist	46
12.2. Site Assessment and Work Plan Checklist	47
12.3. Final Report Checklist.....	48

SECTION 13. RESOURCES AND CONTACT INFORMATION.....49

13.1. Additional Resources.....49

13.2. NDDEQ Division Contact Information.....50

 Division of Air Quality.....50

 Division of Chemistry.....50

 Division of Municipal Facilities50

 Division of Waste Management50

 Division of Water Quality.....50

DEFINITIONS AND ACRONYMS

DEFINITIONS

Background sample – A sample collected from outside the impacted area nearby, that is representative of the previously unimpacted soil or water conditions.

Brine – Another term for saltwater and produced water.

Close/Closure – Closure is the North Dakota Department of Environmental Quality's (NDDEQ) determination that no further action is necessary for a remediation of a spill at this time. Closure does not release the responsible party from liability and the site can be reopened at any time if the NDDEQ determines additional remediation is necessary.

Compatible soils – Soils that are similar in composition. The United States Department of Agriculture (USDA) Soil Survey can provide locations for compatible soils. The USDA soil survey information is available on the USDA's Web Soil Survey.

Competent person – A person who has a thorough understanding of the conditions and regulatory requirements associated with a remediation project.

Constructed well pad – Also known as a well pad, this is an area used by an oil or gas company for the equipment or facilities necessary for the drilling, production, or plugging of an oil or gas related well. A constructed well pad will have an associated North Dakota oil and gas permit. The boundaries of a well pad are determined by a tertiary berm or vegetation growth.

Delineation – Delineation is the practice of defining the area impacted by a spill. Defining impacts requires determining both the horizontal and vertical boundaries of the contaminant. Delineation must also document the contaminant concentrations of the impacted media.

Downgradient – The direction down a gradient from a starting position. In most cases, this means downhill, downstream, or the direction that groundwater flows towards.

Ecosystem – A community of living organisms in conjunction with the nonliving components of their environment. This includes all terrestrial and non-terrestrial life.

Emulsion – A mixture of gas, oil, and produced water existing before the separation process.

Facility – Refers to any location or structure that can be the source or recipient of a release. This includes all permanent and mobile sources.

Flow-back water – Water recovered during the hydraulic fracturing process.

Formation water – Naturally occurring subterranean water. Formation water can have elevated total dissolved solids (TDS) which lead to elevated salt concentrations and may be considered saltwater.

Freshwater – Naturally occurring water that is not salty and is suitable for consumption if clean or processed. Freshwater has a TDS of less than 3000 mg/L.

Grab sampling – Also known as spot sampling. A soil sampling technique in which soil is collected from a single location on a site for laboratory testing. This sampling technique provides data only for the exact location of the sample collected.

Groundwater – The water present beneath the Earth’s surface in soil pore spaces and in the fractures of rock formations. Groundwater is considered waters of the state.

Hydric soils – Soils that are permanently or seasonally saturated with water. Due to the limited oxygen levels, hydric soils have different biological and chemical properties than other soils.

Impermeable material – A material, often soil, with very fine particles that pack closely together and leave minimal space for fluid movement (e.g. clay or silt). Impermeable materials have a hydraulic conductivity less than 0.1 inches per hour.

In situ – Remediation in place.

Landform – A natural feature of the Earth’s surface.

Landscape position – The landforms in and around an impact area that are likely to have similar soil series, i.e. drainage bottoms, slopes, hilltops.

Leachate – Water that has percolated through a solid and leached out some of the constituents.

Must – Failure to complete this task may result in enforcement action.

NDDEQ certified laboratory – Analytical laboratories that have been certified by the NDDEQ Division of Chemistry to perform environmental chemical analyses. Information about the North Dakota Environmental Laboratory Certification Program (NDELCP) can be found by contacting the Division of Chemistry.

Produced water – A type of saltwater recovered as a byproduct of oil and gas extraction operations.

Promulgated – Put into effect by law.

Receptor – Any area where a contaminant may collect. Receptors may include, but are not limited to, groundwater, surface water, wells, utility corridors, and basements.

Remediation – Reversing or stopping environmental damage. This can be accomplished by altering a contaminant or moving it to a non-sensitive area.

Responsible party – The individual or party responsible for the remediation of a release.

Root zone – The zone of the soil profile penetrated by plant roots.

Salt – In this document, a general term for sodium chloride.

Saltwater – In this document, any water containing sodium chloride greater than NDDEQ action levels.

Should – Not required by law but will be considered during any enforcement action.

Sodium Adsorption Ratio – A ratio of sodium to calcium and magnesium.

Soil series – Soil series is classification system of soils that are similar in color, texture, structure, chemistry, and other characteristics. Often, but not always, similar landscape positions nearby will be of the same soil series. The USDA soil survey information is available on the USDA’s Web Soil Survey.

Source water – Source water is water from an aquifer used in the advanced recovery of crude oil from an oil producing formation. Source water is typically pumped from a formation that is too high in TDS to be considered freshwater, such as the Lodgepole or Dakota formations.

Waters of the state – All waters within the jurisdiction of this state, including all streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, and other bodies or accumulations of water on or under the surface of the earth, natural or artificial, public or private, situated wholly or partly within or bordering upon the state, except those private waters that do not combine or effect a junction with natural surface or underground waters just defined. N.D.C.C. § 61-28-02(15).

ACRONYMS

BKG – Background

BTEX – Benzene, Toluene, Ethylbenzene, and Xylenes

C.F.R. – Code of Federal Regulations

DRO – Diesel Range Organics

EC – Electrical Conductivity

EM – Electromagnetic

EPA – Environmental Protection Agency

E&P – Exploration and Production

GPS – Global Positioning System

GRO – Gasoline Range Organics

LNG – Liquefied Natural Gas

LPG – Liquefied Petroleum Gas

MCL – Maximum Contaminant Level

MDL – Method Detection Limit

N.D.A.C. – North Dakota Administrative Code

N.D.C.C. – North Dakota Century Code

NDDEQ – North Dakota Department of Environmental Quality

NDDWR – North Dakota Department of Water Resources

NDELCP – North Dakota Environmental Laboratory Certification Program

NDRBCA – North Dakota Risk Based Corrective Action

NDWQS – North Dakota Water Quality Standards

NRCS – National Resource Conservation Service

ORO – Oil Range Organics

PID – Photoionization Detector

SAR – Sodium Adsorption Ratio

SDS – Safety Data Sheet

SHPO – State Historic Preservation Office

TDS – Total Dissolved Solids

TENORM – Technologically Enhanced Naturally Occurring Radioactive Material

TPH – Total Petroleum Hydrocarbons

USDA – United States Department of Agriculture

UST – Underground Storage Tank

VOC – Volatile Organic Compound

SECTION 1. INTRODUCTION

Guidelines for the Assessment and Remediation of Oilfield Releases establishes guidelines for use by the North Dakota Department of Environmental Quality (NDDEQ), responsible parties, and their consultants in the reporting, assessment, and clean-up of sites impacted by releases of common oilfield materials. Common oilfield spills may include, but are not limited to:

- Crude oil
- Compressed or liquefied natural gases
- Saltwater (also known as produced water, source water, formation water, brine, etc.)
- Diesel
- Solvents
- Emulsion
- Hydraulic oil
- Drilling fluids
- Freshwater

It is intended that these guidelines will help return sites impacted by spills to pre-release conditions or background levels to adequately protect waters of the state. Clean-up of such sites will consider the specifics of the site and release, but the site is to be restored to its pre-release conditions when possible.

The NDDEQ will apply these guidelines based on site-specific geological, hydrological, or environmental conditions, and will be consistent with the requirements of laws, the policies outlined in these guidelines, and best professional judgement. The guidelines set forth are explanatory in nature in accordance with the North Dakota Century Code (N.D.C.C.) under N.D.C.C. § 28-32-01(12)(k).

The NDDEQ evaluates releases based on the specific site conditions and will follow the action levels in these guidelines for all applicable sites. It is understood that there may be cases where some of the action levels may need to be modified to meet site-specific or contaminant-specific circumstances. If it is appropriate to deviate from these guidelines, the reasoning should be explained and documented. In addition, the NDDEQ may institute more stringent requirements to protect water quality or public health when appropriate.

The primary responsibility of all personnel involved in the assessment and clean-up of a spill site is to ensure the protection of the following:

- Health and human safety
- Livestock
- Aquatic life
- The ecosystem

Owners/operators of a permanent or mobile facility are responsible for ensuring their facilities do not pollute waters of the state, and for assuring compliance with N.D.C.C. ch. 61-28, N.D.C.C. ch. 23.1-08, and the rules promulgated under that authority. Examples of facilities include, but are not

limited to well pads, tank batteries, compressor stations, manufacturing plants, refineries, pipelines, rigs, and vehicles of all types. The facility owner or responsible party is also responsible for adequately reporting the spill, investigating the site, and recommending additional investigation or corrective action as appropriate. This is best performed by a competent person who is familiar with all local, state, and federal regulations, as well as NDDEQ guidance documents which address technical and reporting requirements. The competent person should also be well-versed in industry-accepted remediation technologies and be aware of appropriate emerging technologies. The North Dakota Administrative Code (N.D.A.C.) considers failure to remediate a spill to constitute abandonment of waste under N.D.A.C. § 33.1-20-01.1-04.

SECTION 2. INITIAL RESPONSE, CONTAINMENT, AND REPORTING

In the event of a spill, the primary concern is the protection of human health and safety. If the release has resulted in the injury of personnel or presents a safety risk, address this immediately. Once it is safe to do so, the source of the release should be eliminated as quickly as possible, and the spilled material contained using reasonable methods. Every effort must be made to prevent releases from entering waters of the state.

2.1. Reporting Requirements

In accordance with N.D.A.C. § 33.1-16-02.1-11(4), N.D.A.C. § 43-02-03-30, and N.D.A.C. § 43-02-03-30.1, any spill or discharge of waste which causes or is likely to cause pollution of waters of the state or is a risk to human health or safety must be reported by the responsible party immediately by calling 1-833-99SPILL (1-833-997-7455). Spills must also be reported online within 24 hours of discovery. Online reporting is accomplished using North Dakota's Unified Spill Reporting System, found at <https://www.spill.nd.gov/>. In the event of an emergency, call 9-1-1 immediately. Immediate spill reporting criteria include:

- Any spill/release that has an impact, or potential impact, to public health
- Waters of the state are impacted/threatened
- Injuries or deaths
- Evacuations, or potential need for
- Any spill/release that has immediate impact to wildlife

Information that will be requested when reporting includes:

- Contact information
- Volume and type of material spilled, including a Safety Data Sheet (SDS) if available
- The date and time of the spill
- The Global Positioning System (GPS) coordinates and associated well pad or facility information
- The source or cause of the spill
- If the spill was confined to the property of origin
- Details of the impact to water or potential impact to water
- Details of the containment or remediation efforts that have already been completed
- Photos are not required, but can be attached to reports

Spills reported by phone must also be reported online through the Unified Spill Reporting System. ***Spilled materials of all types and sizes are required to be reported to the NDDEQ, and there is no minimum reporting limit. When in doubt, report it!***

The responsible party should notify all landowners affected by a release and obtain permission to access the areas needed to address any impacts. If a landowner cannot be reached, notify the NDDEQ and document attempts at contact. The responsible party should also keep all landowners

informed as to the status of all assessment and remediation activities. If permission for access cannot be obtained, notify the NDDEQ as soon as possible.

A sample of the spilled material should be collected from the source of the release (e.g., pipeline, truck, tank) if possible, or from areas of pooling if pooling exists. It is important to collect enough sample material for an approved laboratory to complete analyses for the constituents listed in [Section 10: Laboratory Analysis and Remediation Action Levels](#).

2.2. What is considered waters of the state?

“Waters of the state” means all waters within the jurisdiction of this state, including all streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, and all other bodies or accumulations of water on or under the surface of the earth, natural or artificial, public or private, situated wholly or partly within or bordering upon the state, except those private waters that do not combine or effect a junction with natural surface or underground waters just defined. N.D.C.C. § 61-28-02(15).

This definition is different from the federal definition for “Waters of the United States” used by the Environmental Protection Agency (EPA) and Department of the Army. Additionally, note that drainages, ponds, creeks, or waterways may be dry at times, but spills into them still threaten to impact waters of the state.

Some signs a drainage, wetland, or waterway is nearby include:

- Culverts and erosion features
- Valleys or other lower elevation terrain
- Depressions where snow or water may collect seasonally
- Hydric soils (soils that are permanently or seasonally saturated by water)
- Trees, wetland plants, or other changes in vegetation
- A stock dam or pond

A resource to help clarify if an impacted location has potential to impact waters of the state is the North Dakota Department of Water Resources (NDDWR) map found at <https://mapservice.dwr.nd.gov/>.

2.3. What is containment?

Any release impacting waters of the state must be contained to prevent spread downstream or to additional bodies of water. Containment is also required to prevent migration into water due to weather or terrain and to keep the spill in the smallest area possible. Containment should be constructed as soon as possible.

Vertical containment barriers such as steel sheet piling, sandbags, or earthen berms and dikes, as well as diversion trenches, can help to control and limit the flow of fluids. Vertical containment barriers should be constructed tall enough to hold the spill plus an additional 3 inches of rainfall and long enough to prevent any fluids from leaving the site. Containments should be regularly monitored to ensure integrity and maintained by removing standing fluids.

An example of earthen berm construction is to first clear the area of any vegetation and debris and remove topsoil to smooth the land surface. Then, use compacted layers of clay or other sufficiently impermeable material to create a barrier with an approximate width to height ratio of 3:1. A curved design slows moving fluids and directs them towards the center of the berm, lowering the chance of loss of containment.

Floating oil containment booms can be used to collect hydrocarbons such as floating oil or sheen in water. However, booms do not work on higher density substances that sink such as the salts present in saltwater. Absorbent socks, straw waddles, and tarps are *not* considered containment methods.

After the spill has been adequately contained, fence out any people or livestock that may have access to the contamination. In the case of spills near roads, contact state or county officials responsible for road safety to determine any fencing requirements.

2.4. What is confined to property of origin?

For the purposes of reporting, a spill confined to property of origin is entirely within the bounds of the surface of a non-vegetated constructed well pad, the surface of a saltwater disposal pad, or the surface of a chemical manufacturing facility. Spills on lease roads, a pipeline right-of-way, range or agricultural land, or into an excavation on a well pad are *not* considered confined to the property of origin.

The bounds of a constructed well pad as regulated by the NDDEQ are determined in two ways.

- 1) For well pads with tertiary berms, the edge of the well pad is the top of the berm. If all fluid would flow off the side of the berm back onto the well pad, the spill is considered confined to property of origin. See Figure 1.
- 2) For well pads without tertiary berms, the edge of the well pad is determined by where vegetation begins. If a spill touches vegetation, the spill impacts areas off the well pad. See Figure 2.

A constructed well pad is often smaller than the lease fence surrounding it.



Figure 1. Berm on the edge of a well pad example. The well pad is to the right of the berm. If fluid flows off the berm in the direction of the black arrow (right), the spill remains on the well pad. If water flows off the berm in the direction of the white arrow (left), the spill is not contained to property of origin.



Figure 2. Well pad without a berm example. The well pad is to the left of the white line. If the spill passes to the right of the white line, the spill is not contained to property of origin.

SECTION 3. SITE ASSESSMENT AND DELINEATION

The objective of a responsible party's investigation at an oilfield spill site is to determine the extent and environmental impact of the release. This investigation includes:

- Mapping and photo-documenting the site
- Delineating the horizontal and vertical extent of impacts in the soil, surface water, and groundwater
- Identifying and evaluating receptors, geology, and hydrogeology

Receptors are anywhere a contaminant may collect. This includes, but is not limited to, groundwater, surface water, wells, drinking water intakes, utility corridors, and basements. The following tasks should be done for all spills to create a full site assessment to be submitted to the NDDEQ:

- Estimate the volume of released material
- Estimate the volume of the material not contained within a well pad
- Estimate the area of impact, horizontal and vertical
- Document the method used to estimate volume and area
- Estimate depth to groundwater
- Determine if waters of the state have been impacted or are threatened
- Determine land use and vegetation impacted
- Estimate the actual or potential exposure to humans and livestock
- Estimate the actual or potential impact to aquatic life and terrestrial life

The assessment documentation should include:

- The horizontal and vertical delineation of contaminants
- The date, time, location, and results of any samples collected
- A site evaluation in respect to groundwater, surface water, sensitive groundwater areas, wells, wellhead protection areas, topography, or potential receptors
- Any additional information regarding site geology and hydrogeology
- The area of impact, sample locations, and all potential receptors on a site map

The investigation, in conjunction with a site assessment, should determine the ongoing or historical source or sources of the release and adequately identify background conditions. The investigation should provide adequate and reliable information that can be used to determine if further remedial action is required. A useful resource to help determine nearby surface water locations and approximate depth to groundwater is the NDDWR Map found at <https://mapservice.dwr.nd.gov/>.

3.1. Delineation in Water

The key objective of delineation in water is to define the extent of the spill impacts to a water source. Both contaminant concentration and area impacted are important information needed for ensuring the safety of humans and animals and confirming the full remediation of an impacted

water body. *All waters that may have been impacted by oil, saltwater, or other spills should be sampled and laboratory tested for all contaminants of concern.*

A delineation in water should always begin with the collection of background samples for analysis by an NDDEQ certified laboratory. Background information for surface and groundwater is important to collect for comparison to the contaminated area and to determine the natural state of the site. In some cases, background conditions may determine an alternative action level for a site due to naturally occurring elevated constituents. Background sampling should take place before sampling of any contaminated material to prevent the risk of cross-contamination.

Background samples are collected from outside of the spill area and should be representative of the landscape position the spill is in. For instance, a background sample would be collected upstream from where a spill entered the water for a creek, or in a different nearby wetland for a spill into a pond. Record the GPS coordinates of all background samples taken for future reference. A minimum of two (2) background samples should be collected per landscape position impacted. After background samples are collected, delineation of the main spill area can begin.

Impacts to water by petroleum materials can usually be visually observed by floating oil or a sheen. However, nonvisible impacts may exist in concentrations above water quality standards. While most oil floats, a percentage naturally disperses down through the water column and can impact areas below the water surface. Total petroleum hydrocarbons (TPH) can be tested by using a field TPH water test kit.



Figure 3. Sheen on a river from a distance.



Figure 4. Close-up of sheen on water.

Saltwater impacts are often not visually observable in water. A path of dead vegetation from the spill site towards a water body is a sign that the water body has been impacted but may not always be present. Saltwater sinks in bodies of freshwater, so higher impacts may be found at the bottom of the water column and delineation should include both the surface and bottom of an impacted water body. Chloride test strips can be used for quick, approximate field measurement of saltwater impacts to a water body.

In addition to surface water, any groundwater potentially impacted should be sampled. Groundwater can be collected for analysis using temporary or permanent monitoring wells. Monitoring wells, also known as observation wells, are a type of well used to measure groundwater levels, flow direction or rate, and to collect samples for analysis of groundwater quality.

- Temporary monitoring wells are used for a one-time collection of groundwater to determine if groundwater has been impacted.
- Permanent monitoring wells are for long-term repeated use and are often used on sites with known groundwater impacts.

To fully delineate the impact area of a spill into water, samples are used to determine the extent the spill has traveled in the water body and the concentrations of impact along the flow path. Samples should be collected from both the top and bottom of the water column to determine impact at both surface and depth. Sampling should begin beyond the furthest point the spill has traveled downstream (also known as the leading edge of the spill) to determine or confirm the end point of the spill. This also helps prevent cross-contamination from higher-concentration samples. Samples should then be taken at the leading edge of the spill and progress to the highest concentration area at the release point. Field testing methods can be used to quickly approximate the extent of the spill for immediate remediation response; however, laboratory tested water samples are required for confirmation.

The number of samples required depends on the size and location of the spill but should always adequately characterize the spill. Sampling of additional water bodies downstream is required in the case of a spill into a tributary to another water body to determine if the downstream water body has also been impacted. Confirmation laboratory samples proving successful remediation to below NDDEQ action levels will be required along the length of the flow path after remediation has occurred. The action levels are based on the NDDEQ water quality standards, which can be found at <https://ndlegis.gov/information/acdata/pdf/33.1-16-02.1.pdf>. Common oilfield-specific action levels can be found in [Section 10: Laboratory Analysis and Remediation Action Levels](#).

Record the location and depth of all samples collected for future reference. Background and delineation samples should be sent to an NDDEQ certified laboratory for the analysis of constituents listed in [Section 10: Laboratory Analysis and Remediation Action Levels](#).

3.2. Delineation in Soil

The key objective of delineation in soil is to define the area affected by the spill, both horizontally and vertically, and the concentrations to which the soil is impacted. Delineation can be accomplished in a variety of ways depending on the contaminant of concern.

The beginning of a soil delineation should always include the collection of background samples. Background soil information is important to collect for comparison to the impacted area and to determine the natural state of the site. In some cases, background conditions may determine a different clean-up standard for a site due to naturally occurring elevated constituents. Background sampling should take place before sampling of any contaminated material to prevent the risk of cross-contamination.

Background samples are collected from outside of the spill area, but should be representative of the landscape position the spill is in. A spill at the top of a hill would have background samples collected from somewhere else on the top of the hill. Similarly, a spill into a drainage would require soil samples collected from somewhere else in the drainage. *Do not collect background samples from downgradient of a release site.*

When possible, background samples should be collected from the same soil series as the area impacted by the spill. Soil series is a classification system of soils that are similar in color, texture, structure, chemistry, and other characteristics. Similar landscape positions nearby may be of the same soil series. Information on an area's soil series can be found using the United States Department of Agriculture (USDA) Web Soil Survey Map found at <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>. Determination of soil classification is not required by the NDDEQ.

A minimum of two (2) background samples should be collected per landscape position impacted. After background samples are collected, delineation of the main spill area can begin.

In the case of some very small spills, heavy oils, or other highly colored substances in soil, visual delineation with photographic documentation may be enough to determine the extent of contamination for immediate removal. A common field delineation tool for oil and petroleum products is a photoionization detector (PID), which will measure volatile organic compounds

(VOCs) in gases released from the soil. PID results are easily impacted by a variety of environmental conditions and should be verified with laboratory soil sampling and periodic calibration.

For saltwater spills, an initial delineation in soil can sometimes be completed using an electrical conductivity (EC) probe. The concentration of salts in soil directly correlates with EC; however, chloride is only one of many salts in soil and cannot be exclusively tested for using an EC probe. EC probe values lower than 2 mS/cm sometimes have laboratory sample results within NDDEQ chloride action levels. For areas with naturally high EC, a value less than 1 mS/cm higher than measurements of the surrounding area may have results within chloride action levels. For example, in an area with a natural EC value of 3 mS/cm, an EC value of 3.5 mS/cm is likely within NDDEQ action levels. EC probes are an approximate field measurement that can be impacted by naturally occurring soil conditions and should be verified with laboratory soil analysis.

An electromagnetic (EM) survey can more accurately determine the extent of saltwater spills. EM surveys can be used to compare the presence of minerals and salts in different areas and depths of soil without excavation or other invasive work. An EM survey will provide a heatmap of the electrical properties of the soil, which will visually show areas with elevated salt concentrations. With soil sample confirmation of the heatmap, a full delineation of a spill can be created using significantly less soil sampling.

To determine vertical impacts, auger, direct push, or test pit sampling can be used to collect subsurface soil samples for laboratory analysis of a variety of constituents.

Not all soil contamination is visible. Contamination can migrate below the winter frost line and many other natural barriers. The only way to determine the full extent of an impacted area is by laboratory sample analysis. The number of delineation samples varies by site but should always adequately characterize the extent of the spill.

Record the location and depth of all samples collected for future reference. Background and delineation samples should be sent to an NDDEQ certified laboratory for the analysis of constituents listed in [Section 10: Laboratory Analysis and Remediation Action Levels](#).

3.3. Delineation Example Scenarios

Note: All scenarios described in this section are fictional examples. Maps are not to scale.

3.3.1. Soil Delineation Example

A pipeline breaks at a depth of 8 feet (ft), and the rancher leasing the rangeland finds a produced water spill due to visible standing water and salt crusting. The landscape is flat, but the horizontal and vertical extent of the spill are currently unknown. The spill has been reported and the remediation area has been fenced to protect the rancher's cattle. Standing fluids have been removed using a vacuum truck. Because the responsible party intends to use excavation as the remediation method, the spill will be delineated during the remediation and laboratory confirmation samples will be collected when the spill is believed to be fully remediated. Additional details on confirmation sampling requirements can be found in [Section 4.2. Confirmation Sampling](#).

The following delineation steps are taken next:

- 1) Two (2) background surface soil samples are collected from other flat, unimpacted areas of the same field. Field EC meter readings are also taken where the background samples were collected. The background EC readings are approximately 1 mS/cm.
- 2) An EC meter is used to determine the approximate horizontal extent of the spill. Where the EC meter readings approach background level, the locations are flagged as potential final sidewall locations.
- 3) The spill is horizontally excavated to the flagged areas.
- 4) The spill is vertically excavated until the area surrounding the pipeline break has EC readings similar to background levels.
- 5) Several field EC meter readings are collected from the surface, floor, and all sidewalls of the excavation to determine if any areas are likely to still have elevated salt levels.
- 6) The final excavation is approximately 10 ft long, 10 ft wide, and 10 ft deep. Because one (1) confirmation sample should be collected for each 100 square feet of each sidewall, four (4) sidewall samples should be collected. One (1) sample is collected from each of the sidewalls.
- 7) Because the excavation floor is 10 ft by 10 ft, one (1) floor sample is collected. The floor sample is collected near the pipeline break where the highest contamination levels would be expected.
- 8) The collected soil samples are sent to the laboratory and tested for the produced water analytes of percent sodium, sodium adsorption ratio (SAR), chloride, bromide, sulfate, EC, and pH. The samples are also tested for TPH. Every saltwater spill is assumed to have a hydrocarbon component until proven otherwise.

A map of the spill scenario and potential sample point options can be found in Figure 5.



Figure 5. Soil delineation example map.

3.3.2. *Water Delineation Example*

A truck crashes into a slow flowing creek. The driver is safe; however, diesel is leaking from two large fuel tanks directly into the water, creating a sheen. The spill was immediately reported and containment efforts are in progress. The extent of the spill has not yet been fully delineated. In this example, the creek flows to the south.

The following delineation steps are taken next:

- 1) Two (2) background water samples are collected from a distance upstream of the truck crash.
- 2) A likely spill endpoint is determined using the visual indicator of sheen.
- 3) Water samples are then collected in order of expected least to most contaminated. In this case, the spill samples would be collected in the order Downstream Water, Endpoint Water, Water 1, and Spill Entry.
 - a. A sample is collected downstream of containment where the spill endpoint is determined to be.
 - b. A sample is collected at the endpoint of the spill.
 - c. A sample is collected midway between the spill entry point and the end of the sheen.
 - d. A sample is collected near where the truck entered the creek.
- 4) The collected water samples are sent to the laboratory and tested for the diesel analytes of TPH and benzene, toluene, ethylbenzene, and xylenes (BTEX).

A map of the spill scenario with potential water sample points can be found in Figure 6.



Figure 6. Delineation in water sample map. Bkg is an abbreviation for background.

3.3.3. Soil and Water Delineation Example

Erosion has caused an exposed flowline over a narrow drainage, approximately 1 ft wide. After significant weathering, the flowline breaks, causing an emulsion spill. Emulsion runs down the drainage, eventually entering a small but slowly flowing creek. Standing oil is present in the drainage. A sheen is visible flowing down the creek and dead fish are seen floating nearby.

The responsible party immediately reported and contained the spill, removed livestock from the area, and began vacuum truck removal of impacted creek water. Visible contamination has been removed from the narrow drainage by vacuum truck. However, the extent of the impacted area has not yet been fully delineated. In this scenario, the creek flows to the South.

The following delineation steps are taken next:

For the soil delineation:

- 1) Two (2) background surface soil samples are collected from unimpacted areas further up the same drainage. Field EC meter readings are also taken where the background samples were collected. The background EC readings are elevated due to the location in a drainage, approximately 4 mS/cm.
- 2) The drainage is excavated by shoveling to EC readings similar to the background level of approximately 4 mS/cm, with a final excavation depth of approximately 2 ft.
- 3) Soil samples are then collected from the base of the drainage at 20 ft intervals to confirm the field delineation. Because the excavation is less than 3 ft deep, only floor samples are collected. Samples are collected in order of expected least to most contaminated. In this example, the collection order would be Soil Entry, Soil 1, Soil 2, and Soil Release Point.
- 4) The collected soil samples are sent to the laboratory and tested for the produced water and oil analytes of percent sodium, SAR, chloride, bromide, sulfate, EC, TPH, and pH.

For the water delineation:

- 1) Two (2) background water samples are collected from a distance upstream of the release point. One (1) of the samples is collected from the surface, and one (1) sample is collected from the bottom of the water column.
- 2) A likely spill endpoint is determined using the visual indicator of sheen for oil and a chloride strip field method for produced water.
- 3) Water samples are then collected in order of expected least to most contaminated. Due to the spill having both a saltwater and an oil component, each sample point will require a set of two (2) samples: one (1) sample from the top of the water column and one (1) sample from the bottom of the water column. In this case, the spill samples would be collected in the order Downstream Water, Endpoint Water, Water 1, Water 2, Water 3, and Entry Water.
 - a. A set of samples is collected downstream of where the spill endpoint is determined to be.
 - b. A set of samples is collected at the spill endpoint.
 - c. A set of samples is collected moving upstream to the spill entry point.
 - d. A set of samples is collected at the spill entry point to the creek.

- 4) All collected water samples are sent to a certified laboratory and tested for the produced water and oil analytes of percent sodium, chloride, sulfate, alkalinity, total dissolved solids (TDS), bromide, ammonium, EC, TPH, BTEX, and pH.

A map of the spill scenario and possible sample points can be found in Figure 7.



Figure 7. Soil and water delineation example map.

3.4. Location Assessment and Area Mapping

A visual assessment of the area is the first step to a location assessment. Look for any nearby ponds, streams, or drainages and determine their distance from the site. Additionally, determine if any buildings or farmsteads with wells are nearby and could be affected. Evaluate if the spill has immediate impacts to any water bodies found and prepare the site for any upcoming weather events to prevent additional impact. Determine the land use and secure the location from any unauthorized personnel or livestock. Ensure the spill area is well-marked. Depending on the location, an assessment of nearby archeological sites may be necessary as well. Archeological information can be obtained from the State Historic Preservation Office (SHPO). The SHPO information can be found at <https://www.history.nd.gov/hp/index.html>.

The NDDWR provides maps that can be of use in determining potential threat to waterways. A map of water data for the state can be found at <https://mapservice.dwr.nd.gov/>. Drillers' logs from an area can also be found on the water resource map and used to determine an approximate depth to groundwater. *Not all groundwater wells are reported to the state. Communicate with nearby landowners to ensure all nearby wells are accounted for.*

Another useful tool for location assessment may be the USDA Natural Resources Conservation Service (NRCS) Web Soil Survey Map. The Web Soil Survey provides information on the soils and waterways of an area, as well as a variety of federal land maps. The USDA Web Soil Survey map can be found at <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>.

Compile all information found into a map or report documenting the site and containment activities preventing damage to sensitive receptors.

3.5. Choosing a Remediation Method

The goal of remediation is always to return sites impacted by spills to pre-release conditions, but several factors can influence which method best accomplishes this goal. Considerations to be accounted for when choosing a remediation tactic include:

- Would greater environmental damage be caused by additional work?
- Does depth to contamination make excavation impracticable?
- Are there culturally or environmentally sensitive areas to avoid disturbing?
- Is public safety or infrastructure at risk?
- What are the wishes of the landowner?
- What are the limits of current technology?

Remediation method options are also dependent on the material spilled. Not all spilled materials related to oilfield activities are considered exploration and production (E&P) exempt waste and will need to be disposed of in accordance with federal, state, and local regulations. The Code of Federal Regulations (C.F.R.) defines E&P waste at 40 CFR § 261.4(b)(5).

SECTION 4. EXCAVATION

A common remediation tactic, especially for small release sites, is to remove all impacted vegetation and soils. Excavation tactics can be used with most spilled materials. In some cases, the NDDEQ may allow excavations to be limited in depth with the implementation of a capillary break or impermeable barrier.

4.1. North Dakota One Call and Excavation Fencing

Before any disturbance below 18 inches, North Dakota One Call must be contacted in accordance with N.D.C.C. ch. 49-23. The North Dakota One Call number is 800-795-0555 or 811.

Seek landowner approval to fence around excavations for safety. All fencing should be of sufficient quality to keep livestock out. In the case of excavations near roads, contact the county or state officials responsible for the road's stability and safety.

4.2. Confirmation Sampling

Once the impacted soil has been removed, clean-up confirmation samples must be collected. Confirmation samples are to be collected from the excavated area before backfilling the excavation. Samples should be analyzed for the constituents listed by spill type in [Section 10: Laboratory Analysis and Remediation Action Levels](#). Confirmation samples should be collected at a minimum of one (1) sample from the base of the excavation and one (1) sample from each sidewall greater than 3 ft deep. For excavations less than 3 ft in depth, floor samples are sufficient if the horizontal extent of the spill has been otherwise delineated.

All confirmation samples collected should be grab samples. Grab (spot) sampling is a soil sampling technique in which soil is collected from a single location on a site for laboratory testing. Grab sampling provides data only for the current conditions of the exact location and time of the sample collected. The GPS coordinates and depth of each grab sample should be recorded. Grab samples should be collected at a minimum rate of one (1) sample location per 100 square feet of excavation base or sidewall.

In some situations, additional samples may need to be collected to adequately characterize the site. Final confirmation sample results will only be accepted from an NDDEQ certified laboratory. The final laboratory report should be submitted to the NDDEQ spills program with a map detailing how and where samples were collected.

4.3. Capillary Breaks and Impermeable Barriers

Typically, excavation removal is required to continue until all remaining soils on site are within NDDEQ action levels for the contaminants of concern. There are times when the excavation has extended to a depth that it becomes impractical to continue digging. In these situations, the NDDEQ may allow the site to be backfilled if a capillary break layer, impermeable barrier, or other migration prevention measures are installed and an adequate monitoring plan is established. In some cases, the NDDEQ may require monitoring wells to be installed. Backfilling without complete contamination removal is situation-dependent and requires prior NDDEQ approval.

4.4. Soil Disposal

Excavated contaminated materials must be disposed of at an NDDEQ-approved special waste landfill permitted to accept oilfield waste. A list of active special waste landfills can be found at <https://deq.nd.gov/FOIA/SolidWaste/ActiveLandfillsOilfieldSpecial.aspx>. Depending on the release, the removed material may or may not be considered E&P exempt waste. The responsible party should check with the landfill to determine landfill requirements for disposal. If a delay for waste characterization is required, the excavated material should be stored in covered, leak-proof containers or on a bermed and poly-lined revetment and covered to prevent stormwater contact and runoff. Conduct any waste characterization necessary to satisfy the requirements of the landfill as quickly as possible. A copy of the waste manifest should be retained by the responsible party and be made available to the NDDEQ upon request.

For petroleum contaminated soils, land treatment may be permitted as an alternative to landfill disposal. Information on land treatment requirements can be found at <https://deq.nd.gov/Publications/WM/SW/LandTreatment/Guideline7LandTreatmentPetroleumContaminatedSoilSingleApplicationSites.pdf>.

Additional information about soil disposal options can be obtained by contacting the NDDEQ Division of Waste Management at 701-328-5166.

4.5. Excavation Backfill

If the excavation takes place on agricultural land, an agreement should be made with the landowner about backfilling with compatible soil, addition of topsoil, and reseeding the excavation. Reseeding may not be necessary if the land is to be put back into crop production; however, steps should be taken to prevent erosion prior to replanting crops. Cover crops are a good option to prevent erosion on agricultural land.

On non-agricultural or range lands, backfill should be completed with an uncontaminated soil series similar to the surrounding area. Contour the site to match the grading prior to impact and reseed with a seed mix compatible with existing vegetation. In some situations, the use of a cover crop prior to reseeding may be beneficial. Erosion control should be used to prevent soil erosion prior to revegetation and should be addressed as necessary.

Regardless of location, the site should be monitored for at least one (1) full growing season to ensure that the seeding is successful, and no significant erosion has occurred. Longer monitoring may be necessary depending on the rate of vegetation return.

Excavations are best backfilled with soil obtained from as close as possible to the spill site. Avoid excessive compaction, which may delay healthy vegetation return.

SECTION 5. WATER REMOVAL

For spills impacting waters of the state, contaminated water removal is often one of the quickest response actions to reduce contamination and prevent it from spreading further in the waterway. Water removal requirements may include both pooled contamination behind a berm and impacted water in a creek or wetland. Water samples must be collected from any impacted water body to evaluate if sufficient removal has been accomplished. While removing surface water may be adequate for some oil spills, saltwater tends to sink in a water body and will need to be removed from the bottom of the water column. In some cases, sediment removal may also be necessary.

5.1. Water Removal Methods

Water removal from a remediation site can be accomplished in several ways. For immediate response, a vacuum truck is one method of water removal. When using a vacuum truck, ensure the truck tank has been adequately cleaned and will not introduce its own source of contamination to the waterway.

For longer term projects or soil flushing operations, a sump can be used to collect contaminated water for removal. Pumps can be used to remove the contaminated water and pipe it to a frac tank or other storage container stationed nearby. If a water removal project uses extensive piping or tubing, make sure to carefully inspect tanks and tubing for leaks that may create additional spill impacts. Do not drive machinery over tubing used for water removal operations unless adequate protection has been installed. Tubing should be protected from any potential sources of damage.

5.2. Water Disposal

Water removed from an oilfield spill site can typically be disposed of at a nearby permitted saltwater disposal well. A copy of the waste manifest should be retained by the responsible party and be made available to the NDDEQ upon request.

SECTION 6. OIL SPILLS AND ALTERNATIVE OIL REMEDIATION TECHNIQUES

Crude oil is a mixture of organic compounds primarily comprised of carbon and hydrogen. These compounds are known collectively as hydrocarbons. After being extracted and refined, the hydrocarbons of crude oil can be used in a large variety of products. Due to the similar nature of crude oil and other hydrocarbon product spills, they can often be remediated using the same methods.

The main component of concern in the remediation of an oil spill is the TPH. TPH can be categorized by three (3) different components, all of which can be found in North Dakota crude oil:

- Gasoline range organics (GRO) are the light ends, containing between six (6) and 12 carbon atoms. GROs evaporate easily and are very flammable. They are typically found in solvents or gasoline fuel. GROs can also contain BTEX.
- Diesel range organics (DRO) are the mid-range, usually referring to hydrocarbons in the 10 to 28 carbon atom range. DROs are also flammable and produce a lot of energy when burned. They are used in many different products including a variety of household oils and fuels. Bakken crude oil is most closely associated with this range, and a DRO analysis may be used if TPH analysis is not available at a laboratory.
- Oil range organics (ORO) are heavier hydrocarbons, typically referring to hydrocarbons with a range of 20 to 35 carbon atoms. OROs are more challenging to ignite and are typically used in lubricants, greases, and motor oils.

Oil and other hydrocarbon spills also contain VOCs. VOCs have high vapor pressures, making them easily emitted from solids or liquids in gas form. The most common VOCs to be tested are benzene, toluene, ethylbenzene, and xylenes, collectively known as BTEX. BTEX compounds are very volatile and have increased short and long-term health risks for humans and animals. BTEX must be tested for during remediation of all oil spills impacting water.

During the upstream separation process, most produced water and related contaminants are removed from crude oil, but a small portion remains. All oil and hydrocarbon spills except liquefied gases or those from final refined products are assumed to have a saltwater component until soil or water sampling results have proven otherwise. All sites are to be clean-up confirmation sampled before remediation will be considered complete.

6.1. Bioremediation

Bioremediation uses microorganisms to break down hydrocarbon contaminants in soil or water. Bioremediation is a long-term remediation project that requires adequate oxygen, water, and nutrients. The site may require aeration, watering, amendments, monitoring wells, or other site enhancements. Bioremediation does not address saltwater contamination associated with emulsion or produced water spills. A work plan detailing the methodology and monitoring of the site should be submitted to and approved by the NDDEQ in advance.

6.2. Burning

Burning may be an option for surface soil or water hydrocarbon impacts. Burning does not address saltwater contamination and may make any required saltwater remediation more challenging. Additionally, heavier oils may not be combustible in cold or wet weather conditions. The area that is intended to be burned must be able to ignite without the use of accelerants or other additives. This option requires an open burn permit from the Division of Air Quality and approval from the local fire chief. Some counties also require approval from the District Health Unit. Additional information on open burning requirements can be found at <https://deq.nd.gov/AQ/permitting/openburning.aspx>.

6.3. Landfarming

Landfarming is a waste treatment process that uses microbes to degrade contaminants in soils. To reduce soil waste, off-site landfarming can also be used to remove hydrocarbon contaminants from soil. Landfarming requires a permit from the Division of Waste Management. Additional information on landfarming requirements can be found at <https://deq.nd.gov/Publications/WM/SW/LandTreatment/LandTreatmentGeneralPermit.pdf>.

6.4. Natural Attenuation

Allowing the environment to break down contamination without additional remediation action, also known as natural attenuation, may be used for some oil misting events or other very low concentration hydrocarbon spills. *Natural attenuation is not an option for saltwater spills.* This option is also not acceptable for large or thick oil spills, or if waterways or other sensitive receptors are nearby.

Remove and dispose of any impacted snow or vegetation before allowing natural attenuation to take place. For impacts to an agricultural field, oil misted vegetation cannot be allowed to enter the human or livestock food chain. Work with landowners to ensure impacted rangeland grasses or crops are not used for human or animal consumption.

Natural attenuation may also be used for some fertilizer or herbicide spills. Natural attenuation requires approval from the NDDEQ before implementation.

6.5. Experimental Techniques

Oil spills are an environmental concern in the state of North Dakota. The NDDEQ is always interested in new and improved methods for spill remediation. Other long-term or experimental oil clean-up projects will be considered but require a written work plan and prior NDDEQ approval. A breakdown of all chemicals, amendments, and equipment should be included in the work plan.

SECTION 7. SALTWATER SPILLS AND ALTERNATIVE SALTWATER REMEDIATION TECHNIQUES

The primary sources of saltwater releases in North Dakota are produced water and flow-back water from oilfield production and development. Water used for injection wells, often called source water or formation water, may sometimes be pulled from a different geological formation than oil but has potential for elevated salt levels and is still considered saltwater until sample testing has demonstrated otherwise. The toxicity of saltwater is due to the environmental damage caused by excessive salts, heavy metals, and oil components such as TPH or BTEX.

There are three primary constituents focused on during the remediation of saltwater releases:

- Sodium (Na^+)
- Chloride (Cl^-)
- TPH

Saltwater spill remediation must always address these three constituents. Heavy metals, BTEX, TDS, or other contaminants may be analyzed on a case-by-case basis.

Due to the positive charge of the sodium ion (Na^+), it will bond with clay particles and organic matter in soil. Sodium is a soil dispersant (particles repel each other) and calcium is a soil flocculant (particles are held strongly together). When sodium concentrations in the soil are high, and dispersion occurs, air and water movement will be slow or non-existent compared to soil with lower sodium concentrations. With lower air and water movement in soil, plants struggle to grow and erosion becomes a significant problem. The damage sodium causes to soil is persistent and difficult-to-reverse.

A common measure of the amount of sodium in soil is the SAR. SAR is a ratio of sodium (Na^+) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the soil from a saturated-paste extract. SAR only measures the Na^+ , Ca^{2+} , and Mg^{2+} that have dissolved from soluble salts in water and does not determine the concentration of sodium bound to the soils' exchange sites. However, sodium is less likely to bond with clay particles and cause dispersion with higher calcium concentrations present. An SAR value below 12 ensures plants have the best chance of returning. Therefore, one method of sodium remediation is to increase the level of calcium in the soil, which then promotes the flocculation of clay particles if dispersion has not already occurred.

While sodium is a long-term problem in soils, chloride (Cl^-) can have immediate toxicity to plants and will often have visible effects on plant life soon after a spill. Additionally, chloride ions are very mobile and migrate easily, resulting in a high potential risk to surface water and groundwater. Elevated chloride levels stress or kill plants and negatively impact invertebrates and aquatic organisms by acute toxicity or interfering with the osmotic balance and their body fluid levels. In groundwater, chloride additionally affects water taste in household wells and may promote the corrosion and release of heavy metals from soil or water infrastructure. A remediation action level of 250 mg/L is in place to protect the health of plants and animals in North Dakota. Lower action

levels may be implemented for certain waterways and in cases of impact to domestic drinking water sources.

All saltwater spills are assumed to have an oil component until soil or water sampling results have proven otherwise. Separators remove most of the petroleum hydrocarbons from saltwater, but TPH may still be present and therefore an analysis is required in initial sampling of all saltwater spills. If TPH is not present in the initial sampling, further TPH sampling may be discontinued unless new information is provided to the contrary. TPH impacts may additionally require sampling for BTEX. All sites must be confirmation sampled before remediation will be considered complete.

7.1. Electrokinetics

Electrokinetics applies direct current electrical fields between two electrodes to separate salts from soil and groundwater. Sodium and other cations migrate towards the cathode, while chloride or other anions move towards the anode for more targeted salt removal. The placement of electrodes is determined by the size and shape of the contaminant plume as well as soil parameters.

Electrokinetics is advantageous because it can be conducted on-site and without significant soil removal. However, this method does require substantial amounts of water and may take more time than other remediation methods. Additionally, electrokinetic systems may remove beneficial salts from the soil. Collected water may have special disposal requirements depending on the pH and components removed from the soil. The site should be adequately assessed for feasibility and a detailed work plan should be submitted to the NDDEQ before this remediation option is chosen.

7.2. Phytoremediation

Phytoremediation uses specific plant species with the ability to uptake salts or other chemicals into their plant matter. The plants are then removed from the site and disposed of in accordance with federal, state, and local regulations. An example of phytoremediation is the use of cattail harvesting to reduce chloride salts in a wetland.

This method is beneficial because it can be done in situ, preserves the topsoil of the area, and reduces erosion, typically causing less disruption to the native environment. However, this method requires repeated soil testing to determine the impact of the vegetation removal on the soil and may take multiple growing seasons. Phytoremediation does not work in areas too heavily contaminated to grow healthy plant life. Due to the long timeframe, a detailed work plan should be submitted to the NDDEQ before this remediation option is used.

7.3. Soil Flushing and Amendments

Soil flushing uses water to flush contaminants from the site. Soil flushing typically uses a drain tile and sump system to collect the water and contaminants. Collected material is then properly disposed of in accordance with local, state, and federal regulations. Without an adequate collection system, contamination is only moved or spread to a different location. Soil flushing requires significant amounts of water and varying amounts of time depending on the soil properties

of the site. Natural precipitation may not be adequate in many locations, and additional water may need to be introduced to the site.

In the case of saltwater spills, calcium amendments are often used to mobilize sodium for removal and to prevent sodic soil conditions. All amendments must be approved by the Division of Water Quality before use. Amendments with proprietary information must be disclosed to the NDDEQ or they cannot be used. Information regarding proprietary information and open records rules can be found in N.D.C.C. § 44-04-18.4. Some calcium amendments that have been approved in the past include calcium acetate, calcium magnesium acetate, and calcium carbonate. Calcium nitrate is rarely approved due to the risk of nitrates contaminating ground or surface water. A work plan detailing any collection system or amendment to be used should be submitted to the NDDEQ before this remediation option is chosen.

7.4. Experimental Techniques

Saltwater spills are a large environmental concern in the state of North Dakota. The NDDEQ is always interested in new and improved methods for saltwater spill remediation. Other long-term or experimental saltwater clean-up projects will be considered but may require a written work plan and prior NDDEQ approval. A breakdown of all chemicals, amendments, and equipment must be disclosed in the work plan.

SECTION 8. OTHER COMMON OILFIELD RELEASES

8.1. Bentonite (Drilling Mud)

The primary concern for drilling mud spills is preventing elevated sediment loads in streams and other water sources. Silt fences and straw wattles can be used to stop further spread of bentonite and prevent introduction or additional impact to a waterway. Spilled bentonite can then be removed using a vacuum truck. Include details and an SDS of any drilling mud additives used when reporting.

8.2. Diesel and Gasoline

Diesel and gasoline are hydrocarbon based and can be treated like crude oil for the purposes of remediation.

8.3. Fires

In the event of a fire emergency, call 9-1-1 and follow established fire safety procedures. Report any oilfield facility fire through the Unified Spill Reporting System at <https://www.spill.nd.gov/> as required by N.D.A.C. § 43-02-03-30.

All oilfield-related fires are assumed to have an associated spill. In the event of a fire that extends beyond a well pad or other oilfield facility, observe the burned area for evidence of spilled contaminants and document possible spill-impacted locations. The extent of the burned area is to be documented with photographs, mapped GPS coordinates, or aerial imagery as necessary. The impacted area should be monitored until normal vegetation has returned.

8.4. Freshwater

Freshwater spills originating from the oilfield or other industrial sources must be confirmed to be freshwater through laboratory testing. Waters with additives, salts, or other components above the NDDEQ water quality standards are not considered freshwater. NDDEQ water quality standards can be found in N.D.A.C. ch. 33.1-16-02.1. A laboratory sample of the water spilled should be collected from the source if available and tested for chloride and any other contaminants of concern. If a water sample cannot be collected, a soil sample from the spill area should be collected.

8.5. Hydraulic Oil

Hydraulic oil is hydrocarbon based and can be treated like crude oil for the purpose of remediation.

8.6. Liquefied Natural Gases (LPG, LNG, Propane, Butane, etc.)

Due to the highly evaporative nature of most constituents in liquefied gases, natural attenuation is an option for most spill sites. In the case of small or moderate amounts of saturated soils or soil at depth, soils may be excavated, placed on an impermeable barrier nearby, and occasionally turned

or raked until soil sample results from the pile are within NDDEQ action levels. Liquefied natural gas spills should be sampled for GRO or BTEX.

8.7. Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)

Materials containing Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM), must be properly transported and disposed of at a special waste disposal facility that accepts them. Common TENORM containing materials include:

- Scale from oil production and processing equipment (e.g., well pad tank battery bottoms, saltwater pipes)
- Tank sludge
- Used filter socks or cartridges
- Contaminated soils or equipment

TENORM transportation and disposal information can be found at <https://deq.nd.gov/WM/Radiation/TENORM.aspx>. For additional information on radioactive material handling, contact the Division of Waste Management at 701-328-5166. Additional NDDEQ contact information can be found in [Section 13: Resources and Contact Information](#).

8.8. Used Motor Oil

Used motor oils may be considered hazardous waste. For more information on hazardous waste disposal, contact the Division of Waste Management at 701-328-5166. Additional NDDEQ contact information can be found in [Section 13: Resources and Contact Information](#).

8.9. Uncommon Materials

Spills of less common materials must also be reported and remediated. For spills such as fertilizers, pesticides, herbicides, acids, or other chemicals, include an SDS of the spilled material when reporting. Action levels for uncommon materials will be based on the Standards of Quality for Waters of the State found at <https://ndlegis.gov/information/acdata/pdf/33.1-16-02.1.pdf>.

SECTION 9. LIMITED ACTION OPTION

Full remediation may not be possible in areas that are not safely accessible or in areas where remedial activity is likely to disrupt the following:

- Critical habitat
- Sensitive vegetation
- Cultural resources

If limited action is proposed, a site assessment and monitoring plan must first be submitted to the NDDEQ for review and approval. The site assessment should include a full horizontal and vertical laboratory sample delineation of the contamination and other components discussed in [Section 3. Site Assessment and Delineation](#). The plan should also include methods and frequency for the following:

- Monitoring vegetation for signs of stress
- Soil sampling
- Water sampling of nearby surface water and groundwater sources as applicable

Monitoring should be conducted for a minimum of three (3) years following remediation, with no adverse conditions to the local restored vegetation, or until the NDDEQ determines monitoring is no longer needed. In some situations, the length of monitoring may be adjusted based on site conditions and sampling results.

SECTION 10. LABORATORY ANALYSIS AND REMEDIATION ACTION LEVELS

The NDDEQ must be provided with laboratory soil or water results documenting successful clean-up. All confirmation samples collected from a site must be sent to an NDDEQ certified laboratory. Laboratory Method Detection Limits (MDL) should be sensitive enough to adequately characterize any impact. Resampling may be required if the MDL is too high for a constituent. Contact the laboratory to confirm it has an active North Dakota Environmental Laboratory Certification Program (NDELCP) certification and for additional information regarding sample collection and transportation requirements for the selected test methods.

10.1. Laboratory Analysis and Remediation Action Levels for Oilfield Spills

All saltwater spills are assumed to have an oil component, and all oil spills are assumed to have a saltwater component until demonstrated otherwise. Constituents may be dropped from analytical requirements of further testing after the initial sampling at NDDEQ discretion. Any dropped constituents and the reasons for dropping them should be documented in the sampling plan.

Where pre-release conditions differ from these guidelines, clean-up to background conditions is acceptable. Clean-up action levels may be determined on a site-by-site basis.

Table 1. Requirements for Analytical Testing of Releases Impacting Water

Constituent	Analytical Method	Action Level	Basis
Chloride	EPA Method 300.0	250 mg/L	NDWQS
% Sodium	Calculated		NDWQS
Sulfate	EPA Method 300.0		
Alkalinity	Standard Method 2320B	600 mg/L	NDDEQ UST
TDS	Calculated or Gravimetric	500 mg/L	EPA Secondary MCL
Benzene	EPA Method 524.4	0.058 mg/L	NDWQS
Toluene	EPA Method 524.4	0.520 mg/L	NDWQS
Ethylbenzene	EPA Method 524.4	0.130 mg/L	NDWQS
Xylenes	EPA Method 524.4	10 mg/L	NDWQS
Ammonium	EPA Method 350.1	5 mg/L	
Bromide	EPA Method 300.0		
pH	Field Measured	6-9	NDWQS
TPH	Any EPA approved method	0.5 mg/L	NDDEQ UST

Table 2. Analytical Testing for Impacted Soils.

Constituent	Action Level
Chloride	250 mg/L or mg/kg
SAR ¹	12
Sulfate ²	
EC ³	2 mS/cm
Bromide ⁴	<2 mg/L or mg/kg
% Sodium	
pH	6-9
TPH ⁵	100 ppm

The NDDEQ will allow any soil analytical method, provided the MDL is of sufficient sensitivity to adequately characterize any impacts and verify remediation. The responsible party must inform the NDDEQ of all analytical methods used. BTEX analysis may also be required depending on the size and location of the spill.

¹SAR is highly variable and may be naturally above 12 in many areas of the state. This will be taken into consideration for remediation requirements.

²Sulfate can be naturally very high. This analyte is used to determine the natural salt conditions of the area.

³EC is highly variable and may be naturally above 2 mS/cm in many areas of the state. This will be taken into consideration for remediation requirements.

⁴Bromide is not naturally occurring above ~2 ppm in North Dakota surface water and is an indicator of a deep well water spill.

⁵While TPH analysis is preferred, DRO analysis can substitute for TPH if TPH is not available at the laboratory. Gasoline and other light hydrocarbon spills should also be tested for GRO/VOCs or BTEX.

10.2. Field Testing Methods

Several field testing methods are often used to obtain a rough estimate of remaining contamination on a site during remediation. These methods include but are not limited to the use of:

- An EC meter
- A PID
- Chloride test strips
- TPH test kits

Field methods can be useful but are not the equivalent of laboratory analysis and will not be accepted as proof of successful remediation.

10.3. North Dakota Risk Based Corrective Action (NDRBCA)

An alternative to established remediation action levels is the site-specific North Dakota Risk Based Corrective Action (NDRBCA) process. NDRBCA uses scientific assessment of the risks posed by contaminants at specific locations now and in the future to ensure the protection of human health and the environment.

Information on the NDRBCA program can be found at <https://deq.nd.gov/NDRBCA/>.

NDRBCA is applicable to many types of oilfield spill locations and materials. ***NDRBCA is not applicable to saltwater releases.***

SECTION 11. SEEDING, MONITORING, AND INCIDENT CLOSURE

Seeding, erosion control, and site monitoring for revegetation are a part of any spill remediation. The end goal is for the area to appear as close as possible to the previous or surrounding terrain.

11.1. Seeding

For rangeland, this revegetation includes the return of native surrounding grasses and forbs. Trees killed by the spill or during remediation should also be replaced with a ratio of two (2) trees for each one (1) tree killed. Rangeland areas should be seeded with a compatible seed mix for the location. Seeding is best completed in the fall or very early spring. State and federal landowners may have their own seeding requirements.

For agricultural fields, revegetation will require plant growth of visually similar strength and thickness to the rest of the crop. Discuss seeding desires and plans with the landowner. Agricultural fields may not need seeding depending on the landowner's planting schedule.

Incidents may be closed with at least 75% native or beneficial vegetation return at the discretion of the NDDEQ. Naturally challenging soil types and weather conditions may be taken into consideration for the closure of incidents with struggling vegetation return.

11.2. Monitoring

Monitoring of areas that require revegetation can take multiple years, depending on environmental factors. During this time, erosion should be controlled to allow the regrowth of plant life. Common erosion control methods include silt fencing, erosion control matting, and straw wattles. The use of a cover crop during the first summer of revegetation may also be useful in promoting plant return. Temporarily fencing out livestock can be of significant benefit as well.

Incidents may not be closed if they are primarily growing salt-tolerant and noxious or invasive plant species. Mowing noxious weeds before they go to seed may improve the plant species mix in the following summer. Avoid impacting native or beneficial vegetation when possible if applying herbicides. Common noxious or invasive plant species in North Dakota include, but are not limited to:

- Kochia
- Common Burdock
- Field Bindweed
- Bull, Canada, Musk, Plumeless, and Scotch Thistles
- Leafy Spurge
- Downy Brome
- Absinthe Wormwood
- Spotted or Russian Knapweed
- Black Henbane

11.3. Incident Closure

Once remediation has been completed, a final report is required to be submitted to the NDDEQ detailing the nature and cause of the release and the remedial actions taken. The report should include all original laboratory reports, a site delineation, a data summary table, site maps, and photographs. The report should also include any plans for future work or monitoring. Spill incidents remain open with the NDDEQ until the following conditions are met:

- Laboratory sample results within NDDEQ action levels or other sufficient documentation of successful remediation is received
- Previously vegetated areas of the site have reached 75% or greater revegetation with desirable species
- All trash and debris from the remediation including straw waddles, tubing, plastic bottles, sandbags, containment structures, or other nonbiodegradable materials have been removed

To prevent loss of productivity on agricultural lands and subsequent private property damage, constituent levels lower than NDDEQ action levels may be required. Constituent levels lower than NDDEQ action levels will be negotiated between the landowner and the responsible party and do not require the involvement of the NDDEQ. The responsible party should keep all landowners informed of the status of all assessment and remediation activities. Share copies of all documents with the landowner.

SECTION 12: SPILL RESPONSE AND DOCUMENTATION CHECKLISTS

This section includes checklists of the major elements required in a spill response and the information to be included in remediation reports.

12.1. Spill Response Checklist

Below is a checklist of the primary spill response and remediation steps. If the answer is “yes” to all questions, the incident may be recommended for closure with the NDDEQ.

Spill Response Checklist

- Are all personnel safe?
- Has the spill been stopped?
- Has the spill been contained?
- Has the spill been reported?
 - If the spill impacts or has potential to impact waters of the state, call 1-833-997-7455 as soon as possible, then report within 24 hours through <http://www.spill.nd.gov/>.
 - If the spill has not impacted and does not have potential to impact waters of the state, report within 24 hours through <http://www.spill.nd.gov/>.
- Have livestock been fenced out of the site?
- Has the spill been fully delineated?
 - Horizontally?
 - Vertically?
 - Were background samples collected?
 - Are contaminant concentrations known?
 - Has the spill volume been updated from the original report, if necessary?
- Have a site assessment and work plan been submitted and approved?
 - See [Section 12.2. Site Assessment and Work Plan Checklist](#).
- Has the work plan been completed?
- Have confirmation samples been collected and sent to an NDDEQ certified laboratory?
 - Were the date and time of samples recorded?
 - Were the locations of all samples recorded and mapped?
- Are final sample results within NDDEQ action levels?
- Has the site been seeded?
- Has erosion been controlled?
- Have noxious and invasive weeds been controlled?
- Has 75% or greater beneficial vegetation returned?
- Have all trash and debris been removed from the site?
- Has a final report been submitted to the NDDEQ spills program?
 - See [Section 12.3. Final Report Checklist](#).

12.2. Site Assessment and Work Plan Checklist

Below is a list of information to be included in a complete site assessment and work plan.

Site Assessment and Work Plan Checklist

- The incident name, incident number, and location information
- The estimated volume released
 - For spills originating on a constructed well pad, include the volume not confined within the bounds of the well pad
 - Include both the original volume estimate and any volume updates
 - Include the method used to determine all volumes recorded
- Any containment and remediation measures already taken
 - Document any containment measures taken
 - Include photographs and dates of containment
 - If the spill has not been fully contained, include information on why and what amount of the spill remains uncontained
 - Include quantity estimates of any soil or water removed
- Details on spill exposure or potential exposure to humans and livestock
 - Include documentation of any fencing or other protective measures taken
- A delineation of the site
 - Include a horizontal delineation
 - Include a vertical delineation
 - Include the method used to delineate the site
- An evaluation of nearby receptors including, but not limited to:
 - Groundwater
 - Surface water
 - Wells
 - Wellhead protection areas
 - Topography
 - Drinking water intakes
 - Utility corridors
 - Basements
- An evaluation of the potential to impact water
 - Include the estimated depth to groundwater
 - Include the estimated distance to surface water
 - Include the methods used to determine potential for water impacts
- A map of the area of impact, sample locations, and all potential receptors
- Any additional site geology and hydrogeology information
- A description and details of the planned remediation method
 - Required details are dependent on the remediation method used
- Waste disposal plans
- A confirmation sampling plan
- Plans for seeding, revegetation, or any other long-term monitoring and next steps

12.3. Final Report Checklist

Below is a checklist of information to be included in the final report. The final report should be submitted once final confirmation sample results are available and may be submitted while monitoring and vegetation return are still in progress.

Final Report Checklist

- The incident name, incident number, and location information
- The spill delineation information
- Final laboratory confirmation results
 - Include both the full laboratory report and tabulated results
 - Include chain-of-custody document copies
 - Include a map of all confirmation sample locations
- Information and documentation of all remediation steps taken
- Photos of the site
- The current site status. The site status should be able to answer questions such as:
 - Have any excavations been backfilled?
 - Have containment structures been removed?
 - Has the area been seeded?
 - Has any vegetation returned?
- Any waste disposal documentation
- Any long-term monitoring or vegetation return next steps

SECTION 13. RESOURCES AND CONTACT INFORMATION

13.1. Additional Resources

Division of Air Quality Open Burn Permit

- Open burning of a spill can only be done under certain conditions and requires prior approval.
- Information on the open burn requirements can be found on the NDDEQ website at <https://deq.nd.gov/AQ/permitting/openburning.aspx>

Division of Waste Management Landfarming Requirements

- Landfarming is an alternative option for the treatment of petroleum contaminated soils.
- Information on landfarming requirements can be found on the NDDEQ website at <https://deq.nd.gov/Publications/WM/SW/LandTreatment/Guideline7LandTreatmentPetroleumContaminatedSoilSingleApplicationSites.pdf>
- The land treatment general permit requirements can be found at <https://deq.nd.gov/Publications/WM/SW/LandTreatment/LandTreatmentGeneralPermit.pdf>

North Dakota Department of Water Resources (NDDWR) Map

- The NDDWR Map is useful for determining the distance to surface water or approximate distance to groundwater.
- Any areas marked with blue indicate surface water areas. Some of these areas are dry at times but are still considered waters of the state.
- Drillers logs can be used to determine approximate depth to groundwater and are accessed using the Drillers Logs tab under the Water Resources folder on the right-hand side of the map.
- The NDDWR Map can be found at <https://mapservice.dwr.nd.gov/>

North Dakota Risk Based Corrective Action (NDRBCA)

- NDRBCA may be used in site-specific cases as an alternative to established remediation action levels. NDRBCA cannot be used on saltwater releases.
- Information on the NDRBCA process can be found at <https://deq.nd.gov/NDRBCA>

State Historic Preservation Office (SHPO)

- The SHPO can help with determining any archeological significance in an area.
- The SHPO information can be found at <https://www.history.nd.gov/hp/index.html>

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)

- TENORM can be created by a variety of oil and gas production processes and has special handling procedures due to its radioactivity.
- Information on TENORM transportation and disposal can be found at <https://deq.nd.gov/WM/Radiation/TENORM.aspx>

Unified Spill Reporting System (Hazconnect)

- All spills and any fires originating at oilfield locations must be reported through the Unified Spill Reporting System.
- The Unified Spill Reporting System can be found at <https://www.spill.nd.gov/>

United States Department of Agriculture (USDA) Web Soil Survey Map

- The USDA Web Soil Survey Map can be used to find information about the native soils of an area, including soil series data.
- The USDA Web Soil Survey Map can be found at <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>

13.2. NDDEQ Division Contact Information

Division of Air Quality

- 4201 Normandy Street
Bismarck, ND 58503-1324
- 701-328-5188
- <https://deq.nd.gov/AQ/>

Division of Chemistry

- 2635 East Main Avenue
Bismarck, ND 58501
- 701-328-6140
- <https://deq.nd.gov/chemistry/>

Division of Municipal Facilities

- 4201 Normandy Street
Bismarck, ND 58503-1324
- 701-328-5211
- <https://deq.nd.gov/MF/>

Division of Waste Management

- 4201 Normandy Street
Bismarck, ND 58503-1324
- 701-328-5166
- <https://deq.nd.gov/WM/>

Division of Water Quality

- 4201 Normandy Street
Bismarck, ND 58503-1324
- 701-328-5210
- <https://deq.nd.gov/WQ/>