

Guidelines for the Assessment And Cleanup of Saltwater Releases



North Dakota Department of Health
Environmental Health Section
Division of Water Quality
Bismarck, North Dakota

September 2016

Table of Contents

Definitions	1
SECTION 1. INTRODUCTION	2
1.1 Total Petroleum Hydrocarbons	3
1.2 Chlorides	3
1.3 Sodium	4
SECTION 2. INITIAL RESPONSE	5
SECTION 3. SITE ASSESSMENT	6
SECTION 4. EVALUATION OF POTENTIAL ACTIONS	7
4.1 Excavation	6
4.2 Site Investigation	7
SECTION 5. MONITORING	11
SECTION 6. REPORTING	12

Tables

Table 1. Groundwater Cleanup Standards	13
Table 2. Soil Cleanup Standards	13

DEFINITIONS

Background Sample – A sample collected from outside the impacted area that is representative of the impacted soils.

Compatible Soils – Soils that are similar in composition. The USDA Soil Survey can provide locations for compatible soils. USDA soil survey information is also available on 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.

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

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

Groundwater - The water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. Groundwater is considered a "water of the state."

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.

NDDoH Approved Laboratory – Analytical laboratories that have been certified by the North Dakota Department of Health, Division of Laboratory Services. Other analytical laboratories may be allowed at the discretion of the Department.

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.

SAR – Sodium Adsorption Ratio(SAR) is a ratio of sodium to calcium and magnesium.

$$\text{S.A.R.} = \frac{\text{Na}^+}{\sqrt{\frac{1}{2}(\text{Ca}^{2+} + \text{Mg}^{2+})}}$$

Waters of the State- 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)

SECTION 1. INTRODUCTION

The *Guidelines for the Assessment and Cleanup of Saltwater Releases* establish guidelines for use by the North Dakota Department of Health (NDDoH), responsible parties and their consultants in the assessment and cleanup of sites impacted by saltwater releases. It is intended that these guidelines will help return sites impacted by saltwater releases to pre-release conditions or background levels in order to adequately protect the waters of the state. Cleanup of such sites must take into account the specifics of the site and the release, but the site shall be restored to its pre-release conditions if reasonable.

Some factors to be considered include:

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

The NDDoH may vary application of these guidelines based on site-specific geological, hydrological or environmental conditions, but only in ways that are consistent with the requirements of law, the policies set forth in these guidelines and best professional judgment. The guidelines set forth are explanatory in nature, *and do not have the force and effect of law*, North Dakota Century Code (NDCC) § 28-32-01(11)(k). The NDDoH evaluates releases based on the specific site conditions and will follow the standards in these guidelines for all applicable sites. It is understood, however, that there may be cases where some of the standards may need to be modified to meet site-specific or contaminant-specific circumstances. The responsible party may request alternative standards for specific sites. If it is appropriate to deviate from these standards, the reasoning shall be explained and documented. In addition, the NDDoH may institute more stringent requirements to protect water quality or public health if appropriate.

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

- Public health
- Safety of personnel
- Livestock
- Aquatic life
- The ecosystem

Owners/operators of the facility are responsible for ensuring their facilities do not pollute waters of the state, and for assuring compliance with NDCC 61-28, NDCC 23-29 and the rules promulgated under that authority.

The objective of an investigation at a saltwater release site is to determine the extent and environmental impact of the release. The investigation includes:

- Mapping and photo-documenting the site.
- Identifying and evaluating receptors.
- Delineating the horizontal and vertical extent of impacts in the soil and groundwater.
- Adequately defining the site geology and hydrogeology.

The investigation, in conjunction with a site characterization, should determine the ongoing or historical source or sources of the release and must adequately identify background conditions. The investigation must provide adequate and reliable information that can be used to determine if further remedial action is required.

The facility owner or responsible party is responsible for adequately 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 NDDoH 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 responsible party must notify all landowners affected by a release and obtain permission to access the areas needed to address any impacts. The responsible party shall keep all landowners informed as to the status of all assessment and remediation activities.

This document is designed to provide guidance for performing a site investigation and cleanup of a saltwater release in North Dakota.

The primary sources of saltwater releases in North Dakota are produced water and flow-back water from oil field production and development. There are three primary constituents of concern regarding a produced or flow-back water release:

- Sodium (Na^+)
- Chloride (Cl^-)
- Total petroleum hydrocarbons (TPH)

The term “saltwater” will be used in this document to refer to water produced in association with oil production, hydraulic fracturing (flow-back) and any other brine releases. It should be noted that saltwater does contain other constituents that can cause detrimental impacts to the environment. Safety Data Sheets (SDS) shall be made available for all additives that may be present in any saltwater release. Although this document focuses on salt, these other constituents (Tables 1 and 2) also must be addressed in accordance with the *Guidelines for Investigation of Contaminant Release Sites*. This document can be found on the NDDoH website.

The term “remediation” is loosely used in this document to define the mobilization and redistribution of salt impacts. There are no known biological or chemical additives that can remove or consume salt. Salts can only be redistributed by means of excavation or mobilizing them so they can be moved.

1.1. Total Petroleum Hydrocarbons

Separators remove most of the petroleum hydrocarbons from saltwater; however, total petroleum hydrocarbons (TPH) may still be present. Although this document will not specifically address the remediation of petroleum hydrocarbons, TPH sampling will be initially required for all saltwater releases. If no TPH is present in initial sampling, then further sampling for TPH will not be required, unless new information is provided to the contrary. If TPH impacts are present, sampling for benzene, ethyl benzene, toluene and xylenes (BETX) may be required by the NDDoH.

1.2. Chlorides

Due to the negative charge of the chloride ion, it is generally mobile and easily migrates below the root zone of most plant species. Although sampling for chlorides will be required on all saltwater releases, remediation generally occurs with the treatment or removal of the sodium ions.

Chlorides are far more likely to impact groundwater, however. For this reason, chlorides will be used as the indicator for potential risk to groundwater and surface water.

1.3. Sodium

Due to the positive charge of the sodium ion, it will bond with clay particles and organic matter in soil. Sodium is a soil dispersant (particles repel each other) whereas calcium is a soil flocculant (particles are held strongly together). When sodium concentrations in the soil are high, and dispersion occurs, water movement will be slow or non-existent compared to when a soil has a high concentration of calcium. A common measure of the amount of sodium in a soil is the SAR, and is recorded as a ratio of sodium to calcium plus magnesium in the soil from a saturated-paste extract. SAR does not determine the concentration of sodium from the soils' exchange sites and only measures Na, Ca, and Mg that have dissolved from soluble salts in water. The more calcium present, the less likely it is for the sodium to bond with the clay particles and cause dispersion. Therefore, one method of remediation is to increase the level of calcium (e.g. add gypsum) in the soil solution which then promotes the flocculation of clay particles.

SECTION 2. INITIAL RESPONSE

In the event of a saltwater release, 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 issue, this must be addressed first. Once safe to do so, the source of the release should be eliminated as quickly as possible and the release contained using reasonable methods. Temporary earthen berms and dikes, as well as diversion trenches, can help to control and limit the flow of water. Oil booms can collect hydrocarbons in the water, but the booms do not absorb saltwater. Every effort shall be made to prevent saltwater releases from entering waters of the state.

A sample of the released water must be collected if possible. The sample shall be collected from the source of the release (e.g., pipeline, tanker, produced water tank). If no water is available at the source, a sample may be collected from areas of pooling. It is important to collect a sufficient volume of water for an NDDoH-approved laboratory to complete the analyses for the constituents listed in Table 1.

For any disturbance below 18", North Dakota One Call must be contacted. Except in an emergency, an excavator shall contact the notification center and provide an excavation or location notice at least forty-eight hours before beginning any excavation excluding Saturdays, Sundays, and holidays. The North Dakota One Call number is 800-795-0555 or 811.

SECTION 3. SITE ASSESSMENT

The following tasks shall be performed for all saltwater releases, as appropriate:

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

The assessment should include (1) the lateral and vertical delineation of contaminants; (2) the date, time and location of any samples collected; (3) a site evaluation in respect to groundwater, surface water, sensitive groundwater areas, wells, wellhead protection areas, topography, etc.; and (4) an evaluation of potential receptors. The area of impact and all potential receptors shall be documented on a site map.

Background soil and groundwater samples shall be collected, as appropriate, for all saltwater release sites. Background samples shall be collected outside of the area of impact; however, the soils sampled should be representative of the impacted media (i.e. same landscape position). Background soil samples should be collected in sets and represent the soil profile at 12-inch intervals from the surface to the base of the root zone or 24 inches, whichever is deeper. The number of background samples must be sufficient to fully represent the impacted area, with a minimum of two (2) background samples per landscape position impacted. Background samples shall be sent to an NDDoH-approved laboratory and analyzed for the constituents listed in Table 2.

Laboratory Method Detection Limits (MDL) shall be of sufficient sensitivity to adequately characterize any impacts. Re-sampling may be required if the MDL is deemed to be too high for a constituent.

SECTION 4. EVALUATION OF POTENTIAL RESPONSE ACTIONS

In addressing a saltwater release, the responsible party has two options. The first option is to begin immediate excavation of impacted soils. This is typically used for smaller, confined releases where no groundwater or surface water has been impacted. The second option, for larger releases, is to conduct a site investigation.

4.1. Excavation

Remove all impacted vegetation and soils. In some cases, the NDDoH may allow excavations to be limited to the base of the root zone of the impacted vegetation. Excavated vegetation and soils shall be disposed of at an NDDoH-approved special waste landfill permitted to accept oil field waste. (<http://www.ndhealth.gov/wm/Publications/SpecialWasteLandfills.pdf>) Depending on the release, this material may or may not be considered exploration and production (E&P) exempt waste. The responsible party should check with the landfill to determine if laboratory analysis is needed to characterize the waste prior to disposal. If 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 storm water contact and runoff. Waste characterization shall be conducted as quickly as possible to satisfy the requirements of the landfill.

Once impacted soils have been removed, confirmation samples shall be collected. Confirmation samples shall be collected from the base of the excavation at a rate of one composite sample for every 10,000 square feet. For linear impacts, the distance between composite samples shall not be greater than 250 feet. Each composite sample should consist of a minimum of five sub-samples. If excavations are in excess of 3 feet in depth, then one set of sidewall confirmation samples shall be collected for every 50 feet of sidewall. In some situations, additional samples may need to be collected to adequately characterize the site. Confirmation samples shall be sent to an NDDoH-approved laboratory and analyzed for the constituents listed in Table 2.

There are times when the excavation has extended below the root zone and it becomes impractical to continue digging. In these situations the Department may allow the site to be backfilled if an adequate monitoring plan is established. In some cases, the Department may require monitoring wells to be installed as part of the monitoring plan.

In order to prevent loss of productivity on agricultural lands and subsequent private property damage, lower constituent levels may be needed. These levels will be negotiated between the landowner and responsible party and do not require the involvement of the NDDoH.

If excavation takes place on agricultural lands, the responsible party shall reach an agreement with the landowner with regard to backfilling with compatible soil 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.

On nonagricultural lands, the excavation shall be backfilled with a soil series compatible with the surrounding area. The area shall be contoured to match the grading prior to impact. The responsible party shall ensure that the backfill soils are not contaminated. The area shall then be reseeded with a seed mix compatible with existing vegetation. In some situations, the use of a

cover crop prior to reseeded may be beneficial. Erosion protection shall be used to prevent soil erosion prior to re-vegetation. The area shall be monitored by the responsible party for a minimum of one full growing season to ensure that reseeded is successful and no erosion has occurred. Erosion control shall be addressed by the responsible party.

A Notice of Completion report shall then be submitted to the NDDoH detailing the nature and cause of the release and the remedial actions taken. The report shall include all laboratory data summarized in tabular form, along with the original laboratory report as well as site maps and photographs. The report also must include any recommendations for continued work and/or monitoring and the proposed work plan.

4.2. Site Investigation

The purpose of the site investigation is to determine whether in-situ remediation or natural attenuation/remediation processes are viable options. The goal of in-situ remediation is to permanently move the salts away from the root zone of the local vegetation and restore soil structure, allowing for healthy plant growth and environmental protection.

To determine the depth to groundwater and flow direction, topography should be observed, and geologic maps and publications or borings should be utilized. If groundwater is in close proximity to the bottom of the root zone of the local vegetation, then moving the salts below that zone may impact groundwater. In this instance, the potential impacts to groundwater should be calculated using the following process.

- Mass chloride (lbs) = [volume released (bbls) X chloride concentration (mg/L)]/2,900
- Chloride loading (g/day) = [mass chloride (lbs) X annual rainfall (in/yr)²]/1,000
- Adjusted chloride loading (g/day) = chloride loading (g/day)/soil type factor
- Increase in chloride concentration (mg/L) = [adjusted chloride loading (g/day)/effective width (ft)] X 13

Soil Type Factor

Sandy soil = 1

Silty soil = 2

Clayey soil = 10

Effective width = the width of impact area perpendicular to groundwater flow

In-situ remediation may be used if (1) the background chloride concentration of the groundwater aquifer is known and (2) the increase in chloride concentration plus the natural chloride concentration in the groundwater is less than 250 milligrams per liter (mg/L).

In-situ remediation also may be used if (1) the background chloride concentration of the groundwater is not known and (2) the increase in chloride concentration is less than or equal to 170 mg/L. If the increase in chloride concentration is greater than 170 mg/L, then excavation methods shall be used unless the NDDoH determines otherwise.

If groundwater is at risk, in-situ remediation may still be used if a collection system, such as drain tile, is used to capture the brine leachate. The collection system must be placed to adequately

protect the groundwater. In some cases, the Department may require that monitoring wells be installed as part of the site investigation.

Soil samples shall be collected from the impacted area at a rate of one composite sample for every 10,000 square feet. Each composite sample should consist of a minimum of five sub-samples. Soil samples shall be sent to an NDDoH-approved laboratory and analyzed for the constituents listed in Table 2. Additional testing parameters may be required depending on the quality of the released saltwater and the presence of any additives.

If laboratory analysis reveals no exceedances in any of the constituents in Table 2, then no additional work is required, and a Notice of Completion report must be submitted to the NDDoH. If background sampling indicates a natural exceedance of any of these constituents, then the cleanup levels may be adjusted to require cleanup to the natural concentration at the discretion of the NDDoH. If soil concentrations exceed any of these values, then remediation is required.

4.2.1. Limited Action Option

Natural processes can be utilized in areas that are not accessible, such as steep and narrow drainages 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 monitoring plan shall be submitted to the NDDoH for review and approval. The plan should include methods and frequency for the following:

- Monitoring vegetation for signs of stress
- Soil sampling

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

4.2.2. In-Situ Remediation

Any in-situ remediation plan must be preapproved by the NDDoH and will only be allowed if it is the least damaging alternative. The in-situ remediation plan should be designed to allow salt impacts to migrate from the root zone of local vegetation and provide a sufficient nutrient base to allow for the reestablishment of vegetation. In some situations, the installation of drain tile can be utilized to collect and remove leachate from the soil. This can be used to prevent chloride impacts to groundwater. The NDDoH may require steps to be taken to monitor the fluids moving out of the root zone.

Remedial materials (e.g., gypsum, organic material) shall be placed on the impact area and tilled into the soil in such a manner as to disrupt surrounding vegetation as little as possible. Steps shall be taken to prevent erosion until vegetation in the impact area has been reestablished.

The quantity of remedial material used will be dependent on the type of material being used, sodium concentrations in the soil, type of soil and depth of the root zone. The deeper into the soil the remedial material can be tilled, the more effective will be the remediation. Depending on site conditions, additional applications of remedial materials may be necessary.

The remediation plan must also include a monitoring and soil sampling plan. Monitoring shall be conducted on surrounding vegetation for signs of stress. Soil sampling shall be conducted semi-annually until the Department determines monitoring is no longer needed. In some cases, the Department may require that monitoring wells be installed as part of the remediation plan. The responsible party should reach an agreement with the landowner in regard to reseeded the impacted area. Reseeding may not be necessary if the land is to be put back into crop production immediately; however, steps should be taken to prevent erosion prior to replanting crops.

On non-agricultural lands, the impacted area shall be reseeded with a seed mix compatible with existing vegetation. Erosion protection shall be used to prevent soil erosion prior to re-vegetation. The area shall be monitored for a minimum of one growing season to ensure that reseeded is successful and no erosion has occurred.

SECTION 5. MONITORING

Site monitoring shall be part of any saltwater spill remediation. Monitoring of areas that require re-vegetation can take up to four years or longer, depending on environmental factors. Quarterly and annual monitoring reports shall be presented to the NDDoH and landowner. The following summarizes the monitoring goals for each year:

Year 1 - Weed control is required. Mow weeds or use appropriate herbicide and rate prior to their reproductive stage

Year 2 - Conduct electrical conductivity (EC) and vegetative health surveys at the original sample points. A 40 to 50 percent remediation improvement should be observed. Make any adjustments if required. Weed control is required, possibly two to three times per year. In some cases, cover crop should be seeded as dormant seeding.

Year 3 - Conduct EC and vegetative health surveys at the original sample points. A 70 to 100 percent remediation improvement should be observed. Record all of the plant types and growth rates within the impact area. Make any adjustments required.

Year 4 - Remediation should be complete and all goals of the remediation process achieved. If remediation is not completed, the site requires reevaluation, and causes other than salt contamination should be considered. Additional treatments may be required.

At anytime remediation criteria have been met, monitoring may be suspended at the discretion of the Department.

- Incident factors affecting remediation
 - Concentration of salt
 - Concentration of hydrocarbons
 - Remediation not a linear relationship to contamination concentration

- Environmental factors affecting remediation
 - Precipitation (minimum requirement of 12 to 14 inches rain per year)
 - Soil series
 - Soil texture
 - Historical land usage
 - Grade/slope
 - Drainage
 - Temperature
 - pH
 - EC
 - Organic Matter
 - Compaction

6. REPORTING

A Notice of Completion report shall then be submitted to the NDDoH detailing the nature and cause of the release and the remedial actions taken. The report should include all laboratory data summarized in tabular form as well as site maps and photographs. The report should also include any recommendations for continued work and/or monitoring.

7. Analysis

Table 1
Cleanup Standards for Protection of Ground and Surface Waters

Constituent	Analytical Method	Concentration	Basis
Chloride	EPA Method 300.0	250 mg/L	ND WQS
% Sodium	Calculated		ND WQS
Sulfate	EPA Method 300.0		
Alkalinity	Standard Method 2320 B	600 mg/L	NDDoH UST
TDS	Calculated or Volumetric	500 mg/L	EPA Secondary MCL
Benzene	EPA Method 524.2	0.005 mg/L	
Ammonium	EPA Method 350.1	5 mg/L ¹	ND WQS
Bromide	EPA Method 300.0		
pH	Field Measured	5-9	ND WQS

¹ A Guideline only, the Ammonium standard may vary based on temperature and pH.

Table 2
Soil Analytes

Constituent	Analytical Method
Chloride	<p>The Department will allow any analytical method, provided the Laboratory Method Detection Limits (MDL) is of sufficient sensitivity to adequately characterize any impacts and verify remediation.</p> <p>The Responsible Party shall inform the Department of all analytical methods used.</p>
SAR	
EC	
Bromide	
% Sodium	
pH	

Where pre-release conditions differ from these guidelines, cleanup to background conditions is acceptable. The values of Table 1 are for the protection of waters of the state, including surface and groundwater. In order to prevent loss of productivity on agricultural lands and subsequent private property damage, cleanup to lower levels may be needed. This level should be negotiated between the landowner and responsible party.

The responsible party shall keep all landowners informed as to the status of all assessment and remediation activities. Copies of all documents should be shared with the landowner.