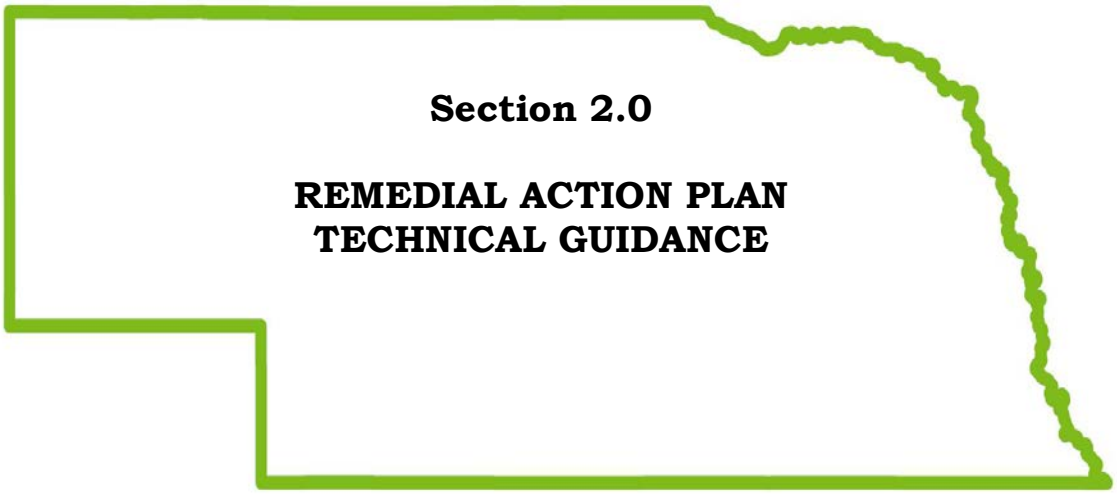

Section 2.0

REMEDIAL ACTION PLAN TECHNICAL GUIDANCE

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SECTION 2.0 REMEDIAL ACTION PLAN TECHNICAL GUIDANCE

INTRODUCTION

After NDEQ approves an application, the applicant must submit a Remedial Action Plan (RAP) within ninety (90) days, unless granted an extension by NDEQ. The RAP consists of two main elements:

- An Investigation Report (IR)
- A Remedial Action Work Plan (RAWP)

The IR contains fundamental information – what is known about the site, where the contamination is located, who is or could potentially be affected by the contamination – and presents a conceptual site model based on this information. The RAWP contains the cleanup plan for the site. It presents the remedial action objectives, describes how, when, and to what degree the site will be cleaned up, and explains why the proposed remedy has been chosen.

There are several ways in which this section of the technical guidance is designed to help environmental consultants prepare a complete and thorough RAP:

1) The **narrative** of the guidance describes how to collect information and present it in the RAP. The narrative also provides some discussion of the relationships among the collected data. Example figures and tables are provided in Appendix B to further illustrate how to present information in the RAP.

   The intent of the VCP guidance is to provide a process or "framework" for conducting a site investigation. Sites will vary considerably in respect to property size, historical uses, extent and degree of contamination, geology, etc. Therefore, the guidance cannot provide specific details or particulars on such investigative concerns as the number and location of analytical samples, specific sampling and analysis methods, determination of appropriate chemicals of concern (COCs), etc. Such determinations will need to be made by the applicant and their contractor based on their professional judgment.

2) The **checklist** within this guidance (Attachment 2-1) outlines the information that should be collected and where it can be found. Although it is impossible to provide an exhaustive list of every piece of information that may appear in a RAP, the checklist does provide a *detailed* list of the common pieces of information and potential sources of this information. For a more extensive list of information sources, a bibliography has been provided at the end of the guidance. To expedite NDEQ review of the RAP, the checklist should be completed and submitted along with the RAP.

3) The investigation process **flowchart** (Attachment 2-2) illustrates the relationship among the various pieces of information and depicts the overall investigative sequence.

In general, the outline of the RAP should parallel the organization of the technical guidance. However, the guidance is intended to provide sufficient flexibility to accommodate different types of VCP sites. Some elements of this guidance may apply to your site, and others may not. For example, this guidance describes how you should summarize previously reported investigations at your site in the IR. If no previous investigations (other than the VCP investigation) exist for your site, you will not have such a summary in your report. It is the responsibility of each applicant to determine which parts of the guidance are applicable and which parts are not.

2.1 EXECUTIVE SUMMARY

The first part of the RAP should be an executive summary that presents an overview of the entire plan. The executive summary should be clear and concise, yet contain enough information to give the reviewer a basic understanding of the site, the nature and extent of contamination, potential receptors, and the proposed remedial action. It should include all of the following elements:

- Summary and conclusions of the completed investigation
- A list of potential receptors
- A conceptual site model
- A description of any interim remedial actions completed before entering the VCP
- Future land use plans
- The remedial action objectives (RAOs), including the proposed remediation goals from the Remediation Goals Lookup Tables
- A description of the proposed remedial action and how it meets the RAOs developed for the site. For sites receiving an EPA Brownfields cleanup grant or revolving loan funds, a description of how the remedy meets the five remedy evaluation criteria must also be addressed.
- Any other site-specific issues that should be considered during completion of remedial actions

Generally, no more than 4-5 pages are recommended. However, the length of the Executive Summary depends on the number and complexity of issues at the site. See the checklist in Attachment 2-1 for additional details about creating an Executive Summary.

2.2 INVESTIGATION REPORT

The methods and findings of this investigation should be presented in the **Investigation Report (IR)**. The IR should present background information, describe how this information was used to devise a thorough field investigation, and describe the nature and extent of contamination at the site. It should present information regarding the fate and transport of the chemicals found at the site and potential receptors that may be impacted by the contamination. Finally, the IR should present a conceptual site model based on this information. The information presented in the IR will be the basis for your selection of remedial actions. Thus, having a technically sound and complete report will facilitate and expedite NDEQ's review of the feasibility and adequacy of the selected remedial action.

The IR should contain the information outlined in the checklist (see Attachment 2-1) and should be organized according to the sequence in this guidance (Sections 2.2.1 – 2.2.8). All maps, figures, tables, and graphs should be included in appendices to the RAP. While conducting the investigation, you should use the investigation process flowchart (Attachment 2-2) to visualize how the various pieces of information fit within the overall investigative sequence.

NDEQ would also like to emphasize that the level of effort for conducting a complete investigation is not based on future land use. That is, even if the site land use was, and will remain as commercial or industrial use, ***the extent of soil, groundwater, and/or soil gas contamination must still be defined to the most conservative remediation goals***, as specified below, using the Remediation Goals Lookup Tables found in Attachment 2-6. Specifically:

- The extent of soil contamination should be defined to the remediation goals for the residential direct contact exposure pathway or the migration to groundwater pathway, whichever is less

- The extent of groundwater contamination should be defined to the remediation goals for the groundwater direct contact exposure pathway or the residential groundwater vapor intrusion pathway, whichever is less

- The extent of soil gas contamination should be defined to the remediation goals for the residential soil gas vapor intrusion pathway

Because sites differ in regard to setting, conditions, and contamination, IRs will vary from site to site. The checklist of information should be used and adapted to appropriately address each site, but regardless of the specific site characteristics, all IRs will share some common elements:

- A discussion of background information, including physical setting and operational history, and identification of data gaps based on review of this information

- Details of the methods, objectives, and procedures of the field investigation

- Physical characteristics of the site based on the field investigation, including site-specific hydrology, geology, and hydrogeology

- Nature and extent of contamination in impacted media and locations of contaminant sources based on the results of the field investigation

- Discussion of contaminant fate and transport based on site conditions and chemical characteristics of contaminants

- Identification of potential human and ecological receptors, including a well survey and land use survey of the site and surrounding area

- Presentation of a conceptual site model based on the investigation results, potential receptors, and the intended land use of the site

- Summary and conclusions of the investigation

The IR should provide enough information to justify the proposed remedial action presented in the Remedial Action Work Plan (RAWP) (see Section 2.3). All conclusions of the investigation should be supported by scientifically valid, defensible data. All results, whether positive or negative, should be included. For example, if samples of groundwater were taken, the IR should show the results of these samples whether or not they indicated contamination. If information from previous investigations is used to support the conclusions of the investigation, this data should be cited in the body of the report, and

copies of the source documents should be provided in the appendices. Data tables should include both compiled historical data and data collected during the field investigation.

2.2.1 Compilation and Analysis of Background Information

The compilation and analysis of background information is an essential part of a successful investigation. By researching a site's physical setting, operational history, and previous environmental investigations, an investigator can identify data gaps – those pieces of information that are unknown, but necessary in order to fully characterize the site. These data gaps can then be addressed by conducting a field investigation. The information from the background study and field investigation can be integrated to define the full nature and extent of contamination.

The search for information about the site's physical setting, historical operations, and current use need not be exhaustive, but should be comprehensive. In other words, if multiple sources of information are available about an aspect of the site, but one or two of these sources are sufficient to adequately describe it, the remaining sources need not be included in the report. However, if information about a particular aspect of the site is unavailable, the IR should clearly indicate that all available sources were reviewed.

The RAP checklist (Attachment 2-1) provides a list of sources for documents such as aerial photographs and topographic maps that can be used to collect background information. The bibliography (Appendix C) contains additional resources.

2.2.1.1 Site Information

Since the RAP is intended to be a stand-alone document, basic information about the site and its owners/operators should be provided (even though this information is also requested on the application form). The site name should be provided and the site location should be described and illustrated on a U.S. Geological Survey 7.5-minute quadrangle. This section should also include contact information for the owner of the site and the environmental contractors or consultants hired to prepare the RAP.

Documentation should be included that indicates that the applicant holds or can acquire title to all lands, or has the necessary easements and rights-of-way required for the investigation and remedial process. See the checklist in Attachment 2-1 for additional details about what to include regarding site information.

2.2.1.2 Physical Setting

This section of the IR should present information about the physical setting of the site at local as well as regional scales. Detailed descriptions of the surface features, climate, vegetation, hydrology, soils, geology, and hydrogeology of the site and the surrounding area should be included. The following discussions briefly outline the types of information that should be submitted. For a more detailed listing of information, refer to the checklist in Attachment 2-1.

Surface Features

Both natural and manmade surface features should be described. A detailed site layout map showing these features should be provided. Ideally, this map will serve as a base map for other maps throughout the rest of the report. Site grids should be based on latitude/longitude, and coordinates should be referenced to the State Plane coordinate system NAD 83. See the RAP checklist in Attachment 2-1 for more information about preparing a site layout map.

Climate and Meteorology

Climatic descriptions should include information about the average annual rainfall, temperature, wind velocity, wind direction and daily variances in these parameters. If available, figures such as wind roses and precipitation or temperature graphs should be included.

Vegetation

Descriptions of vegetative cover should address the type and density of plant cover, with an emphasis on identifying sensitive environments (e.g., wetlands, vineyards, gardens), both locally and regionally.

Topography and Hydrology

This section should provide information about surface water flow, flood frequency, drainage direction, and topography. Wetlands, floodplains, and other hydrologic features should be described and indicated on a map.

Soils and Geology

This section should include general descriptions and maps of soil units found at the site. This information can be obtained from a U.S. Department of Agriculture Soil Survey or other source.

Descriptions of regional geology should include geologic formations, lithology, unconformities, and structural features such as faults and joints. Any available geologic cross-sections and maps should be referred to in this section. Local geology should address geologic heterogeneity and complex stratigraphy. Features that might act as preferential pathways, such as coarse-grained channels or horizons, solution cavities, and/or features that may impede the downward movement of contaminants, such as paleosols or clay-rich horizons, should be emphasized.

Hydrogeology

Descriptions of regional hydrogeology should include information about the estimated depth to groundwater, estimated depth to bedrock, and groundwater flow direction and rate. Local hydrogeologic considerations should include describing the locations of springs or seeps, perched aquifers, or large-volume extraction wells nearby. Report the thickness of the primary aquifer, the orientation and general depth of the water table, and refer to any available maps for the area that show these characteristics.

2.2.1.3 Historical Operations and Site Conditions

This section should describe the results of a comprehensive review of the site's industrial or commercial history. It is important to conduct a thorough review of this information because it will be used to help focus your investigative efforts. Special emphasis should be given to potential contaminant sources throughout the site's history, as this information will be used to define the list of sampling parameters for the field investigation. This section should include detailed information regarding the following:

- A list of the previous owners and ownership dates
- Any alternative or historical facility names
- A discussion of the historical use of the site, previous business operations, and periods of operation

- Possible contaminant sources
- Information regarding historical non-hazardous wastes generated, received, disposed of, or managed at the site
- Types, quantities, management practices, and rates of hazardous wastes historically generated, received, disposed of, or managed at the site
- Historical aerial photographs
- Processing or storage locations
- A chronology and description of known or suspected environmental incidents, spills, or releases of hazardous substances or pollutants

The checklist in Attachment 2-1 contains detailed information about each of the topics listed above, including suggested sources of the information.

2.2.1.4 Current Operations and Site Conditions

This section should present the business operations and conditions under the current owner or operator. The description should emphasize possible contaminant sources currently associated with the facility. In addition to the sources listed in the checklist, interviews with the site owner, administrator, or former employees can reveal useful information. This section should include the following information:

- Discussion and illustration of site use and current business operations, including all readily available aerial photographs, topographic maps, or city directories
- Potential sources of contamination
- Types, quantities, management practices, and rates of hazardous constituents currently generated, received, disposed of, or managed at the site
- Known or suspected releases of hazardous constituents
- Location, number, type, size, age, and condition of all above and below ground product or waste storage, transfer, and/or disposal vessels/tanks and systems
- Descriptions of existing institutional controls
- List of current environmental permits
- Descriptions of interim remedial actions
- Descriptions of any ongoing investigations, remediation, or monitoring activities
- A list of search results indicating whether the site or property adjacent to the site appears on federal or state environmental databases
- Results of interviews with site owner, administrator, and/or former employees

The checklist in Attachment 2-1 contains additional information about what to submit.

2.2.1.5 Previously Reported Investigations

Previously reported investigations should be summarized, evaluated for data quality, and attached to the RAP. Examples of previous investigations may include Superfund preliminary assessments/site investigations, RCRA facility investigations, Title 118 investigations, and Phase I or II environmental site assessments. Existing information in such reports can be used to streamline the investigation by focusing the investigative efforts or eliminating some data collection efforts altogether. To determine whether previously reported data should be used in your investigation, you are encouraged to summarize these reports and thoroughly evaluate the data quality and temporal variability of data in each.

Summary of Previous Reports

Information from previously reported investigations of the site should be summarized in the narrative of this section. Data from the reports should be tabulated, and the original reports should be included in an appendix. The narrative of this section should refer to the location of these tables and reports. This summary section should include the following:

- Narrative summary of previous reports in chronological order
- Copies of any relevant correspondence from NDEQ, Environmental Protection Agency (EPA), private entities (such as consulting firms), or other federal and state agencies regarding previous environmental reports
- Summary of findings, conclusions, and recommendations of previously reported investigations

Data Quality and Temporal Variability

The investigation report should include an evaluation of the quality and temporal variability of data from each of the previous reports. To minimize the labor and time spent on this task, use best professional judgment to determine the level of effort required for each type of data.

The evaluation of data quality should include a review of the Quality Assurance/Quality Control (QA/QC) standards and procedures, sample collection records, and laboratory method detection limits of the previous reports to ensure that they are adequate for the intended use of the data. The QA/QC sample results should be reviewed to determine whether any data quality problems exist. To define data quality expectations for technical defensibility, please refer to the quality assurance documents (such as EPA Requirements for Quality Assurance Project Plans [QAPP] [EPA QA/R-5]) listed in the bibliography. Field data sheets and chain-of-custody records should be reviewed to determine whether proper procedures were followed and whether the holding times for any of the sampling parameters were exceeded. It will be especially important to determine whether the laboratory method detection limits used in any of the previous reports were below the *current* maximum contaminant levels (MCLs) commonly used as groundwater cleanup standards. If the detection limits were higher than current MCLs, the previously collected data may not be appropriate to determine the lateral and vertical extent of contamination at or below the level of the MCLs. For example, if a previous report indicates that the method detection limit for trichloroethylene (TCE) was 20 micrograms per liter (µg/l) instead of 5 µg/l (the current MCL for TCE), it will not be appropriate to use this data to define the extent of a TCE plume to the level of the MCL.

You should also determine the temporal variability of the previously collected data. Temporal data is data that may change significantly over relatively short time periods, such as between separate field investigations. Examples of such data include chemical data used to define the extent of a groundwater plume and water level data from monitoring wells. An example of data that is not temporal is data from geotechnical boring logs used to define physical lithologic characteristics. If temporal data presented in previous reports is likely to be outdated, you may need to collect additional data.

Finally, this portion of the IR should include a map that depicts site features and all previous sampling locations, and a table of the sampling results from each location. Briefly discuss these maps and tables in the narrative and refer to their locations in the report.

2.2.1.6 Potential Chemicals of Concern

A list of potential chemicals of concern (COCs) should be identified based on a review of previous investigations, historical operations, and facility documents. This list will aid in identifying data gaps and selecting analytical parameters. It is important to note that the list of potential chemicals of concern should be based on all materials used on-site, not simply on a list of the wastes processed or disposed on-site.

The following narrative is an example description of potential chemicals of concern based on a hypothetical site that was previously operated as a metal salvage facility.

> *"The transformers received on-site may have contained PCBs, so PCBs were included as a potential chemical of concern. The facility had underground tanks for storage of gasoline and diesel fuel, so benzene, ethyl benzene, toluene, total xylenes, and MTBE were identified as potential chemicals of concern. The facility received demilitarized munitions, so black powder, TNT, and RDX were identified as potential chemicals of concern. The pile of lead acid batteries may have been a source of sulfuric acid, lead and other metals, so soil and groundwater were analyzed for pH, sulfate, and metals. Motor vehicle air conditioners may have been a source of CFCs, so soil and groundwater were analyzed for CFCs."*

2.2.1.7 Data Gaps

This section should summarize the significant data gaps and/or deficiencies found based on review of all existing historical data and previous investigations. Data gaps are key unknown conditions or unresolved issues that are needed to characterize the site or solve the problem being investigated. For example, if there was a coal gasification plant formerly on the property, but none of the previous field activities examined coal gasification related waste, this is a data gap. Another example of a data gap is an area or subsurface interval in which there is a lack of data points regarding contaminant concentrations. This is a data gap because without that information, you cannot fully define the horizontal and vertical extent of contamination. A third example of a data gap would be a lack of previous soil gas data for the evaluation of the vapor intrusion pathway if a volatile COC has been previously documented.

Data gaps should be summarized in bulleted lists under one or more of the following categories:

- Physical site characteristics
- Nature and extent of contamination

- Contaminant fate and transport
- Potential receptors

See the checklist in Attachment 2-1 for more information regarding data gaps.

2.2.2 Field Investigation

This section of the IR should describe how a scientific field investigation to fill data gaps and define the nature and extent of contamination at the site was planned and conducted. The following aspects of the investigation should be described in this section:

- Investigation objectives
- Data quality objectives
- Sampling and analysis procedures
- Health and safety
- Investigation-derived waste management

2.2.2.1 Investigation Objectives

This section should state the objectives of the field investigation. Investigation objectives are statements that clearly identify the major inputs needed to fill data gaps, answer key questions, and support further decisions about the investigation and cleanup of the site. Examples of investigation objectives include:

- Determine whether contamination exists at the site;
- Identify the source areas of contamination;
- Determine whether any potential human or ecological receptors are being exposed to contamination, and;
- Determine the magnitude and lateral and vertical extent of soil, groundwater, and/or soil gas contamination to the most conservative remediation goals. Specifically:
    - The extent of soil contamination should be defined to the remediation goals for the residential direct contact exposure pathway or the migration to groundwater pathway, whichever is less
    - The extent of groundwater contamination should be defined to the remediation goals for the groundwater direct contact exposure pathway or the residential groundwater vapor intrusion pathway, whichever is less
    - The extent of soil gas contamination should be defined to the remediation goals for the residential soil gas vapor intrusion pathway

For some sites, this information may already be known. For example, based on a previous Phase I environmental site assessment, it may already be known that both the soil and the groundwater are contaminated. Therefore, the investigation objectives might be more specific, such as:

- Define the extent and magnitude of soil, groundwater, and/or soil gas contamination, or;
- Determine whether nearby private drinking water supply wells are contaminated.

Briefly state the basis for each investigation objective in this section. The rationale should be based upon the compilation and analysis of background information. For example:

> *"Historical operations indicate that Building A was used to wash machine parts with industrial solvents, including PCE. Interviews with employees suggest that these solvents may have been spilled during these operations. PCE has been detected in groundwater in a down-gradient, on-site well. Based on this information, the investigation objective is to define the full nature and extent of PCE and its degradation products in the soil, soil gas, and groundwater both near and down-gradient from Building A."*

The specific details of the investigation, such as methods, design, and analysis, should be reserved for the Sampling and Analysis section (2.2.2.3) below.

2.2.2.2 Data Quality Objectives

Data Quality Objectives (DQOs) are statements that define the quality of data required to make valid, defensible conclusions about the nature and extent of contamination at the site based on the investigation objectives. DQOs may include statements about the minimum detection limits required to carry out the investigation objectives. If, for example, the investigation objective is to distinguish areas where cleanup is needed from areas where cleanup is not needed, the DQOs should specify detection limits that are lower than the concentration values given in the VCP lookup tables for that contaminant. If the investigation objective is to determine whether gross contamination exists on-site, the DQOs might specify higher detection limits that are adequate for making screening-level decisions.

By using DQOs throughout the investigation process, you are more likely to collect scientifically valid, defensible data and conserve resources by answering the right questions. The annotated bibliography contains references to material that can be used to assist you in defining DQOs.

2.2.2.3 Sampling and Analysis Procedures

This section of the report should describe and explain the design, methods, and rationale of the investigation. It should include information about field sampling as well as laboratory analyses of these samples. In addition, the QA/QC measures that were employed throughout the investigation should be described.

Field Sampling Procedures

This section should include the following information:

- *Sample Locations and Intervals*—The rationale for the selection of sampling locations and intervals should be described in this section. The rationale should be based on the review of the operational history, materials received, processed and/or disposed on-site, and the vertical and horizontal extent of the data gaps identified previously. Refer to the

page numbers of maps showing the locations of sampling points and tables listing the sampling intervals in the report. For example:

"To determine whether PCBs were present in the on-site soils, soil samples were collected from various locations. Eighteen soil samples were collected from six locations near the area where the transformers were stockpiled, and nine soil samples were collected from three locations near the transformer shear area (see Figure 5 - Sampling Locations). Soils were collected from 6"and 18" below ground surface, and from just above the water table."

- *Sample Types*—Samples for site characterization are generally collected from various media: groundwater, surface water, soil, sediment, soil gas and/or air. The media that were sampled during the investigation should be identified.

- *Sample Collection*—This section of the IR should describe the sample collection procedures, including whether grab or composite soil samples were collected, well purging method and rate, the number of samples collected, the labeling and identification system used, and the order in which they were collected. Preferred or recommended sampling methods/considerations include:

    - At sites for which the metal chromium may be considered a potential COC (such as a former metal plating facility), valance-specific (i.e., chromium III and chromium VI) media sampling should be conducted
    - At sites that have groundwater contaminated with volatile organic compounds (VOCs), samples should be collected from the upgradient well(s) first, then in order from the anticipated least contaminated to most contaminated downgradient wells
    - At sites that have groundwater contaminated with various types of chemicals, the order of sampling should be:
        1. VOCs
        2. Semi-volatile organics (SVOCs)
        3. Metals
    - Groundwater and soil gas should be sampled using low-flow rate sampling methods when using an acceptable pumping method (i.e., one that does not put a vacuum on the sample); groundwater samples specifically should be collected using a pumping rate not exceeding 100 milliliters per minute
    - Groundwater sampling utilizing no-purge sampling procedures (e.g., use of passive diffusion bags [PDBs] or HydroSleeves™) may be considered under appropriate conditions (e.g., COCs compatible with the use of PDBs)
    - Soil gas and indoor air sampling results are subject to greater temporal variability than soil or groundwater sampling results such that multiple sampling events are recommended to better evaluate potential vapor intrusion impacts
    - Soil gas collection/monitoring points should be carefully sealed to assure that samples are representative of actual subsurface conditions and not introducing ambient or indoor air into the sample

- *Field Screening Methods*— Describe all field screening methods employed during the investigation.

- *Sampling Equipment*—The equipment used during the investigation should be identified and described.

- *Analytical Parameters*—This section of the IR should describe the rationale used to select analytical parameters. The rationale should be based on the list of potential chemicals of concern described above, and the chemical and physical properties of each. All analytical parameters should be listed in the IR.

- *Analytical Methods*—The laboratory analytical methods should be appropriate to achieve the data quality objectives. For any one contaminant, there are usually several different laboratory analytical methods capable of measuring contaminant concentrations. However, some laboratory analytical methods are capable of detecting lower contaminant concentrations than other methods. The sensitivity of an analytical method is referred to as the practical quantitation limit (PQL). If the goal is to characterize a groundwater plume to the MCL, the laboratory analytical method should have a PQL that is less than the MCL. Similarly, if the goal is to demonstrate that you have identified all soils where the metals concentrations exceed the cleanup levels, the laboratory analytical method should have a PQL that is less than or equal to the levels given in the VCP lookup tables. Prepare a table, organized by media and contaminant, showing the EPA analytical method used for each parameter. For groups of parameters that have a common laboratory analytical method, such as VOCs, it is not necessary to list each analytical parameter individually. The table may specify that VOCs in groundwater were analyzed using method 8260b. See the checklist in Attachment 2-1 for a complete list of information to include regarding analytical methods.

- *Well purging data*—When groundwater samples are collected, well purging data should be reported in tables at the end of the RAP. This information includes purging dates, techniques, rates, volumes removed, and stabilization parameters, such as pH, temperature, conductivity, redox potential, turbidity, or dissolved oxygen, as recorded over time. Information regarding the detection of immiscible layers should also be included.

Quality Assurance/Quality Control

In general, the information provided in this section should explain why the data collected and analyzed is of the appropriate type, quantity, and quality for making suitable decisions about what, where, and how to clean up the site.

Careful sampling design and methodology is essential for performing a good-quality investigation. Ideally, variability among samples will be indicative of variable levels of the contaminant(s) in the environment. Such variability can be used to understand the actual nature and extent of contaminant concentrations at the site. However, other natural factors and/or human procedural errors can produce variability among samples. Such variability yields false results about the contamination at the site.

Variability between media properties (i.e. groundwater and surface water) and/or temporal variability in weather can result in natural variations in sample results. By selecting sampling location, time, and medium carefully, errors due to these variations can be minimized.

Erroneous results are also caused by sampling errors such as incorrect sampling procedures, cross-contamination, and improper sample preservation. Sampling errors may result in false negative results (a substance is not detected, but is present at the site) or false positive results (substance is detected, but is not present at the site). Because contaminant concentrations in air, soil gas, soil, and water can potentially be diluted by environmental influences, proper sampling procedures are particularly important. Even minimal sample contamination or loss could significantly affect analytical results. By choosing the

correct type of sample for site-specific conditions and contamination, you increase the likelihood of receiving accurate results.

To minimize the chance for variability due to procedural errors and poor design, a Quality Assurance Project Plan (QAPP) should be prepared and used. The QAPP should state how data collection activities will be implemented and how the results will be assessed. A QAPP defines the specific QA/QC procedures that will be applied. Defining and following the QAPP in detail can reduce erroneous results. A copy of the QAPP should be included in the Appendices to the IR. Please refer to the quality assurance documents (such as EPA QA/R-5) listed in the bibliography to define data quality expectations for technical defensibility.

Please note – Although you will generally not provide a QAPP for NDEQ review prior to conducting fieldwork, if you are a recipient of Brownfields funding you must submit a QAPP for NDEQ's review and approval before fieldwork begins.

Current EPA requirements for QAPPs identify four major areas that must be addressed:

- *Project management*. This section of the QAPP describes the project history, objectives, and roles and responsibilities of the investigation team. It ensures that the project goals and approach are clearly understood and that project planning is documented.

- *Measurement and data acquisition.* This section of the QAPP describes the measurement system design and implementation and the document sampling, analysis, data handling, and QC methods that will be used.

- *Assessment and oversight*. This section identifies activities for assessing the effectiveness of project implementation and associated QA/QC efforts. Assessment and oversight activities ensure that the QAPP is implemented as described.

- *Data validation and usability*. This section describes the QA/QC activities that occur after data collection. Such activities ensure that the data collected conforms to stated acceptance criteria and achieves the DQOs.

One QAPP may be developed for the entire process – from the investigation through the completion and confirmation of remedial action. Alternatively, the QAPP for the investigation may be modified for the planned remedial action if the results of the investigation indicate that this is necessary. Please refer to the bibliography (Appendix C) for more information about developing a QAPP.

The following QA/QC samples and procedures should be described in the QAPP:

- *Trip blanks*. Trip blanks are used to assess the potential for sample contamination during handling, shipment, and storage. Trip blanks are sample bottles filled with an uncontaminated medium that are sealed and transported to the field. There should be one trip blank per sample container. They are kept with empty sample bottles, and then with the investigative samples throughout the field effort. When sampling is completed, they are returned to the laboratory for analysis with the investigative samples.

- *Field blanks.* Field blanks are samples of an uncontaminated medium that are exposed to the sampling environment at the same time that investigative samples are collected. They are used to assess contamination resulting from ambient conditions. One field blank should be collected for every 20 (or fewer) investigative samples.

- *Equipment rinsate blanks*. Some equipment, such as portable pumps, soil samplers, and groundwater samplers, can introduce cross-contamination if not operated properly. Equipment rinsate blanks are collected to assess the cleanliness of the sampling equipment and the effectiveness of equipment decontamination. Equipment rinsate blanks are collected by pouring analyte-free water over the decontaminated surfaces of sampling equipment that contact sample media. Equipment rinsate blanks should be collected for each type of decontaminated sampling equipment.

- *Field split samples*. Field split samples are usually a set of two or more samples collected from a larger homogenized sample. Field split samples can be sent to two or more laboratories and are used to provide comparison data between laboratories.

- *Field duplicate samples*. Field duplicate samples are independent samples collected as close as possible in space and time to the original investigative sample, using the same collection methods. Field duplicates are sent to the same laboratory and are used to provide data on precision of the field procedures and the laboratory. Field duplicates also can provide information on the heterogeneity of the sample matrix. One field duplicate sample should be collected sequentially for every 20 (or fewer) investigative samples.

2.2.2.4 Health and Safety

All investigative field activities should be carried out according to a site-specific Health and Safety Plan (HSP), consistent with the requirements of the Occupational Health and Safety Administration (OSHA). The HSP will not be reviewed by NDEQ and does not need to be attached to the RAP. However, a written statement indicating that a HSP was prepared and followed in accordance with 40 Code of Federal Regulations (CFR) 1910.120 should be provided.

2.2.2.5 Investigation-Derived Waste

Investigation-derived waste (IDW) includes soil cuttings, drilling mud, well development water, purged groundwater, decontamination fluids, disposable sampling equipment, and disposable personal protective equipment. Minimizing IDW helps to leave the site in the same condition or no worse than prior to the investigation and reduces wastes that pose an immediate threat to human health or the environment. This section of the IR should describe how IDW was managed during the investigation. In addition, this section should explain the procedures that were used to ensure compliance with all relevant federal and state regulations. NDEQ has a guidance document that should be used to help you manage IDW (see Attachment 2-3).

2.2.3 Physical Site Characterization

This section of your IR will describe the occurrence and character of each of the significant physical features of the site: Surface Water, Soils, Geology, and Hydrogeology. This section should consist of a written summary of the physical site characteristics as determined by the field investigation. The summary should focus on significant findings that characterize the site **beyond what was known from the physical setting information and previously reported investigations,** as detailed in Sections 2.2.1.2 and 2.2.1.5, respectively, of this guidance. The details of the physical site characterization should be presented in tables and figures in the last part of the RAP (see example Tables and Figures in Appendix B). The narrative should discuss these results and refer to their location in the document. Categories of physical features are discussed below. Please refer to the checklist (Attachment 2-1) for a more detailed list of information that should be provided for each feature.

2.2.3.1 Surface Water

Surface water data may be collected from aerial surveys, ground mapping, surficial sampling, and measurements of water levels. The narrative of this section should contain information related to the physical aspects of surface water bodies (e.g., lakes, rivers, impoundments) and related features (e.g., gullies, sedimentation). Flow rates, channel dimensions and elevations, river stage, historical flooding characteristics, and surface water/groundwater relationships should be summarized. The specific details of these features should be provided in maps, diagrams, and tables at the end of the RAP. Refer to these details in the narrative of this section, and indicate the nature of the information shown, important findings, and the location of the relevant figure or table. Provide topographic map information that shows the relationship of the property to surface water bodies, elevation above flood stage, etc.

2.2.3.2 Soils and Geology

Soil and geologic data can be obtained from surficial soil sampling, soil borings, monitoring well borings, direct-push sampling, or geotechnical laboratory analysis. This section should summarize the findings of these sampling efforts. This summary should refer to information from the tables, figures, and appendices, and their locations in the report. The following figures should be included in the report:

- *Sampling location maps* should be prepared to show the locations of soil borings or direct-push sampling locations. If multiple media are investigated, it may be appropriate to prepare more than one sampling location map.

- *Geologic cross-sections* should be prepared to illustrate the vertical and horizontal geometry and lithology of geologic strata underlying the site. At least two cross sections oriented at right angles to each other should be prepared. If possible, one should be oriented parallel and the other perpendicular to the direction of groundwater flow. If oriented features such as paleochannels, fractures, stratigraphic terminations, or man-made structures exist in the subsurface, include additional cross sections oriented parallel and perpendicular to these features.

2.2.3.3 Hydrogeology

Hydrogeologic data may be derived from samples collected from monitoring wells or direct-push sampling points. This section should summarize these findings and refer to specific data in the tables, figures, and appendices. The following figures and tables should be included in the report:

- Sampling location maps should be prepared to show the locations of monitoring wells, piezometers, direct-push probe locations, or other investigation points used to characterize hydrogeology.

- Potentiometric surface and water table maps should be provided to illustrate the observed water levels at the site. If significant changes in the potentiometric surface or water table are observed over time, several maps should be provided to illustrate these variations. Control points, such as piezometers or monitoring wells, and water-level elevations at these points, should be shown and clearly labeled on the map(s). All elevations should be given in relation to mean sea level.

- Aquifer characteristics, such as hydraulic conductivity and transmissivity, should be summarized in the narrative and listed in tables at the end of the RAP.

- Well completion information should be reported in the tables and appendices. This information includes dates of completion, the Nebraska Department of Natural Resources well registration numbers and any other well identification system(s) used, well elevation data, screen lengths and intervals, and construction material specifications.

2.2.4 Nature and Extent of Contamination

This section of the IR should describe the full nature and extent of contamination in each of the environmental media (air, surface water and sediments, soils and vadose zone, soil gas, and groundwater) at the site. It is important to describe the horizontal *and* vertical extent of contaminants in all media, both at the site and migrating from the site. The lateral and vertical extent of contamination should be defined to the most conservative remediation goals, as specified below, using the Remediation Goals Lookup Tables found in Attachment 2-6. Specifically:

- The extent of soil contamination should be defined to the remediation goals for the residential direct contact exposure pathway or the migration to groundwater pathway, whichever is less

- The extent of groundwater contamination should be defined to the remediation goals for the groundwater direct contact exposure pathway or the residential groundwater vapor intrusion exposure pathway, whichever is less

- The extent of soil gas contamination should be defined to the remediation goals for the residential soil gas vapor intrusion exposure pathway

In assessing the nature and extent of soil gas contamination, exterior soil gas samples should be collected around a potentially impacted building. It is also advisable to consider multiple soil gas sampling events to evaluate temporal soil gas concentration variances due to potential season effects of building heating/cooling systems on soil gas migration. In some cases (e.g., addressing an industrial building of large areal extent or other site-specific complications), sub-slab sampling for soil gas contamination may be warranted.

You should also describe how the contamination relates to specific source areas identified during the investigation.

In order to make sound conclusions about the nature and extent of contamination, you should evaluate all valid data from the study as well as previous investigations, interpret the results, and describe the contamination based on scientific reasoning. You should explain your reasons for refuting or accepting certain hypotheses. For example, if a low-permeability layer separating upper and lower aquifers is observed beneath the site, you might hypothesize that the layer impedes the downward flow of contaminants. To support this hypothesis, you should provide data to show that the lower aquifer is not contaminated. If you don't have any data from the lower aquifer, you can't make valid conclusions about the ability of the low-permeability layer to impede contaminant migration.

You should summarize and interpret screening and analytical data for each of the media listed below. Field screening and laboratory analytical results should be tabulated and included at the end of the RAP. Refer to these tables in the discussion and indicate the page numbers where the tables can be found. For these tables, high values (i.e. values that exceed a remediation goal) should be formatted with a bold font

or otherwise emphasized. In addition, refer to tables containing the QA/QC sample results for each media.

A general discussion of the information that should be provided for each media is provided below. Please refer to the checklist in Attachment 2-1 for a more detailed list of information that should be considered.

2.2.4.1 Sources

The discussion of sources should identify known and suspected on-site sources, potential sources of any contamination that is migrating from off-site, and any contamination "hot spots" identified on-site. Refer to maps showing the locations of tanks, lagoons, pits, contaminated soil, "hot spots," or other sources.

Suspected source areas should be identified based on historical, background, and regulatory research, then investigated during the field activities. If contamination is confirmed, suspected source areas become known source areas. In some cases, areas of contamination are discovered during field sampling even though there is no reason to suspect contamination based on the background information. Discovery of such areas may warrant additional review of background information and/or field sampling to investigate whether the area is isolated or related to other suspected or known source areas.

There may also be contamination that is migrating from a suspected off-site source. If such sources are suspected, a reasonable attempt should be made to identify the locations of these sources based on visual observation or a review of documents such as aerial photographs and Sanborn fire insurance maps. Provide *Source Location Maps* that show the locations of known and suspected on-site source areas and potential off-site sources. These maps should indicate areas of relatively high contaminant concentrations, or "hot spots." The presence of a hot spot may indicate a former operation area, waste disposal location, or other activity that contributed to contamination. Refer to these maps in the narrative of the report.

The following example is based on a hypothetical site where three groundwater plumes were discovered. Each plume is attributable to a different source area: an on-site source discovered during historical records review and confirmed during sampling, an area of contamination discovered during field sampling that is not attributable to any known current or historical site activity, and a suspected off-site source.

> *"During the course of the investigation at the site, three groundwater contaminant plumes were identified. The first groundwater plume consists of chlorinated volatile organic compounds, TCE, 1,1,1-TCA and 1,1-DCE. This plume is located on-site under the former drum storage area (figure 5-7) and is attributable to spills of the chemicals stored in the drums."*
>
> *"The second groundwater plume is located near the north side of the site (figure 5-8) and consists of relatively low concentrations (less than 5 ppb) of several pesticides, atrazine, cyanizine, and metolachlor. A search of the available records for this site did not provide any indication of the source of these chemicals. City directories dating back to 1935, Sanborn maps dating back to 1910 and aerial photographs dating back to 1954, do not provide any indication the site was ever used as a pesticide formulation plant or distributor."*
>
> *"The third plume is located at the up-gradient (west) edge of the site (figure 5-9) and consists of benzene, ethyl benzene, toluene, and xylenes. This plume appears to be attributable to an off-site source: the gasoline station located immediately west, across*

the street from the site."

2.2.4.2 Ambient Air

Most sites in the VCP will not have an ongoing source of ambient air contaminants. In some cases, however, contaminated surface soils can release vapors and particulates into ambient air. To address such situations, ambient air inhalation of contaminant vapors and particulates are factored into the VCP lookup tables. However, if it is determined that an on-going source of ambient air contamination (such as an off-gassing lagoon) does exist, you should notify NDEQ to discuss potential air sampling requirements, including sample location, number, and method. Such sites will be dealt with on a case-by-case basis. If air sampling is performed, report the sample results.

2.2.4.3 Surface Water and Sediments

Surface water and sediment sample results should be reported. This includes field screening results, target compounds, and concentrations of compounds detected. Discuss these results in the narrative and refer to specific data in tables or figures included in the report.

2.2.4.4 Soils and Vadose Zone

Discuss the nature and extent of contamination in soils and the vadose zone. Refer to cross sections and maps that illustrate the spatial distribution of these contaminants, and include tables that contain field screening results, target compounds, and concentrations of compounds detected in soils and soil gas. In some cases, it may be useful to include data tables as "call out" boxes included on sampling location or similar maps.

2.2.4.5 Soil Gas (Vapor Intrusion)

Discuss the nature and extent of contamination in the form of soil gas. Refer to cross sections and maps that illustrate the spatial distribution of contaminants in soil gas and potential impact to any on- or off-site structures. This section of the IR would also be an appropriate place to discuss the results of any indoor air sampling, if performed.

2.2.4.6 Groundwater

In this section, you should discuss the nature and extent of groundwater contamination at the site. You should draw general conclusions from the results of the investigation and refer to figures and tables containing data to support these conclusions. For example:

> *"The VOC plume extends off-site for a distance of 3,000 feet (Figure 4-1). TCE concentrations vary from 5,000 µg/l near the source area on-site, to 5 µg/l at the distal end of the plume off-site (Figure 4-1, Table 4-1). The VOC plume occurs at a depth interval from 15 feet to 25 feet below ground surface on-site, to a depth of 35 feet to 50 feet below ground surface at the distal end of the plume off-site (Figure 4-2)."*

The report should include tables containing field-screening results, target compounds, and concentrations of compounds detected. It should also include cross sections and maps to illustrate the spatial distribution of contaminants in the groundwater. The following figures should be included:

- *Isoconcentration maps* should be provided to illustrate the general horizontal extent of groundwater contamination. Concentration contours and control points should be clearly

labeled and superimposed on the site layout map. It may be necessary to prepare several isoconcentration maps showing different areas of contamination or different suites of contaminants

- *Isoconcentration cross-sections* should be provided to show the vertical extent of groundwater contamination in relation to the site geology. Concentration contours, sample points, and screened intervals should be superimposed on geologic cross-sections. If source areas can be determined, they should be shown on the cross sections as well

In some cases, in may be useful or advantageous to include sampling results tables as "call out" boxes included on sampling location or similar maps.

- *Free product isopach maps and cross sections* should be included to show the extent and thickness, if any, of free product

2.2.5 Contaminant Fate and Transport

The two main aspects that determine contaminant fate and transport are contaminant characteristics and site characteristics. In the report, these two aspects should be discussed together under one or more headings titled according to the contaminant(s) of concern. The IR should provide a detailed analysis of the contaminant characteristics, occurrence, migration and exposure pathways that have been determined to be significant for the site. The analysis will include a discussion of the chemical and physical characteristics for each type of contaminant, the site-specific characteristics that will affect migration, such as organic carbon content of the soil, and the hazard posed by the migration or accumulation of the contaminant. For example:

> *"After the excavation of the underground storage tank, benzene was detected in the soil at a concentration of 10,000 ppm and in the soil gas at 5000 ppm. Although benzene has a strong tendency to adsorb to carbon, there is relatively little carbon in the soil at this site. Therefore, attenuation through adsorption is not expected to be a significant factor. Benzene is a toxic and combustible volatile organic compound, and is likely to migrate as soil gas to any nearby below grade structures and pose a threat of vapor intrusion into such structures. The potential for lateral migration of soil gas will be enhanced at this site by the presence of the parking lot, which will act as a cap to prevent upward migration of the soil gas to the open atmosphere. Therefore, there is a significant chance that benzene will migrate toward, and possibly accumulate in, the box culvert and elevator shaft on-site."*

Chemicals with similar properties may be grouped to facilitate a concise description. For example, the description provided above could have stated:

> *"Benzene, ethyl benzene, toluene, and xylenes were detected in the soil and soil gas on-site. These chemicals are all combustible, volatile organic compounds and are likely to migrate via the vapor intrusion pathway."*

You will use this analysis, along with information about potential receptors (Section 2.2.6), to develop a conceptual site model (Section 2.2.7) and select an appropriate remedial action (Section 2.3).

2.2.5.1 Contaminant Characteristics

This section of the IR should provide a description of the contaminant characteristics that affect fate and transport. The following information should be provided.

Chemical and Physical Properties of Contaminants

This section should provide a table containing names of detected contaminants and the most relevant chemical and physical properties of each. Focus on the properties of each contaminant that are most likely to affect fate and transport, such as density, solubility, octanol/water partition coefficient, vapor pressure, volatility, and other relevant properties.

Contaminant Persistence

Describe the persistence of each contaminant that occurs in each of the major media: air, surface water and sediments, soils and vadose zone sediments, and groundwater. For example, some VOCs are easily degraded by ultraviolet light in the atmosphere. Some of the constituents of gasoline degrade relatively quickly in the groundwater under oxidizing conditions, while the primary constituents of chlorinated solvents degrade much more slowly.

Transport and Partitioning

Provide a narrative that discusses the chemical and physical properties that affect how each contaminant is transported as well as the properties that facilitate or retard transport. Examples of properties that affect transport include solubility, density, and volatility. Properties that effect partitioning include the octanol/water partition coefficient, the octanol/carbon partition coefficient and Henry's Law constant.

Transformation and Degradation

Describe the likelihood that the contaminants will be transformed or degraded into other compounds. This discussion should place special emphasis on transformation or degradation compounds that are more toxic than the parent compound (e.g., vinyl chloride derived from the degradation of trichloroethylene). Describe the significance of each of the contaminant properties, and refer to tables containing data and contaminant characteristics to support this description.

The following is an example of language that might be used to describe the contaminant characteristics of a specific COC:

> *"Benzene is a volatile compound that will partition into the gas phase when encountered as a free-phase liquid or residual product trapped in soil. Benzene is fairly soluble in water compared to other hydrocarbons, binds easily with carbon, including any organic carbon in the soil, and degrades readily under aerobic conditions. See Table 7.4 for a summary of these properties*."

It is important that this description is thorough and complete because it will be used later in the report to support evaluation of the contaminant migration, and ultimately, to support selection of the appropriate remedy(s).

For sample language and a source for some of the information requested in this portion of the guidance refer to the following web site: www.atsdr.cdc.gov/toxprofiles/index.asp. This web site provides toxicological profiles for many of the contaminants commonly found in the environment. Each

toxicological profile includes a table of chemical and physical properties as well as other information about the fate and transport of these contaminants. Although the information on this website is relatively comprehensive, other sources of information are also available and should be consulted as appropriate.

2.2.5.2 Site Characteristics

This section of the IR should provide a description of the site characteristics that affect contaminant fate and transport. Specifically, the IR should describe: the properties of the environmental media, migration pathways, presence of preferential flow paths, and exposure pathways.

Environmental Media

For the purposes of this guidance document, there are five environmental media: ambient air, surface water (and associated sediments), soil and vadose zone sediments, soil gas, and groundwater. For each of these environmental media there are different characteristics and migration pathways that can affect the fate and transport of contaminants.

The first part of this section should describe the media characteristics that might influence the fate and transport of contaminants at the surface, through the soil and soil gas, and in the groundwater. Such factors may include total organic carbon content, porosity, permeability, volumetric water content, pH, alkalinity, cation exchange capacity, hardness, alkalinity, and any observed heterogeneity associated with these properties. You should present an evaluation of the likely affect that the existing aqueous geochemical conditions will have on contaminant persistence, transport/partitioning, and transformation/degradation. For example, you might describe whether the aqueous geochemical conditions are conducive to reductive dechlorination of chlorinated solvents. If so, you would also describe the likelihood that vinyl chloride will be produced as an end product and include this as an analytical parameter for future monitoring.

Migration Pathways

This section of the IR should describe the migration pathways that exist at the site. Each environmental media can have one or more migration pathways. For example, air can migrate through the open atmosphere or through the soil as soil gas. Water can migrate via the surface water pathway or groundwater pathway. Contaminated soil can migrate as windblown dust or in surface water as sediment. Because of the interrelated nature of environmental media, contamination can be passed from one media to another media via these migration pathways. Therefore, it is important to identify and describe migration pathways that are specific to the site as well as the media involved in each.

Each migration pathway (and associated exposure pathways) will have somewhat different characteristics that may affect exposure assessment. These differences should be noted in the IR. For example, at a site with significant soil contamination, contaminant concentrations in the open air tend to be much lower than contaminant concentrations in the soil gas. In addition, soil gas contaminants tend to migrate much more slowly than contaminants in the open air. The slower migration and higher concentrations result in a greater likelihood that soil gas will pose a threat to human health. Similarly, water flows more quickly in a stream than in the groundwater. The higher flow rate and exposure to the open atmosphere in the stream results in greater dilution and loss of contaminant mass due to volatilization. Therefore, the water in the stream is not as likely to pose a significant threat to human health.

Preferential Flow Paths

One significant aspect of contaminant migration is the existence of preferential flow paths. This section of the IR should include a description of typical anthropogenic and natural preferential flow paths. Examples of anthropogenic pathways include: sewers, utility trenches, wells, basements, tunnels, and elevator shafts. It is important to note that most utilities are constructed in a trench that is backfilled with pea gravel to support the pipe or conduit. The pea gravel backfill can act as a preferential flow path for both water and soil gas. Contamination can migrate long distances along these flow paths even if monitoring of the sewer pipe or conduit indicates there isn't any contamination in the pipe. Examples of natural preferential pathways include sand lenses, paleo-channels, and fractures in bedrock.

This section of your IR should also provide a brief description of the rationale for omitting any pathways from further evaluation consideration. For example:

> *"Migration of soil vapor through utility trenches was not evaluated because all utilities have been routed around the area of soil contamination."*

Exposure Pathways

Each migration pathway can affect human health via one or more exposure pathways. For example, people can be exposed to the contaminants in groundwater by ingestion of the water or by inhalation of the contaminant vapors released during bathing or showering. People can be exposed to contaminated soil via ingestion or dermal contact with contaminated soil or inhalation of wind-blown dust, such as may occur during construction activities. People can be exposed to contaminated air in the form of vapors in the open atmosphere or through exposure to contaminated soil gas migrating into buildings through the basements.

This section should identify and describe potential exposure pathways that exist at the site. Exposure pathways can be grouped into the following categories:

- Ingestion of soil
- Inhalation of volatiles and particulates from soils
- Dermal contact with soils
- Ingestion of water
- Inhalation of volatiles from water during showering/bathing
- Inhalation of volatiles from vapor intrusion into indoor air

2.2.6 Potential Receptors

This section of the IR should identify both human and ecological receptors. Identify and quantify any human populations, sensitive environments, and natural resources (such as groundwater supplies or agricultural land) that may be affected by potential or actual contamination at the site.

2.2.6.1 Human Receptors

In this section of the IR, you should identify the human receptors that may be exposed via one of the exposure pathways identified and evaluated, as discussed in section 2.2.5.2. You should document the following information:

- Nearby population centers, including general demographic descriptions
- Nearby sensitive populations, such as child care centers, schools, hospitals, or nursing homes
- A land use survey of the area within 500 feet of the site
- A well survey of nearby wells that includes locations of drinking water (private, community, or municipal), irrigation, livestock supply, and industrial supply wells within 1 mile of the site. (This well survey should be all-inclusive and the applicant should not rely solely on a search of the Nebraska Department of Natural Resources [DNR] registered well database, as not all water wells will be registered. It may be necessary to talk with local utility officials, review aerial photographs or conduct door-to-door surveys.)
- If groundwater contamination is present on-site and drinking water supply wells exist within one mile of the site, several of the nearest down-gradient wells should be sampled to determine whether the wells are contaminated. The results of this sampling should then be presented in the IR.

Refer to the checklist in Attachment 2-1 for additional information.

2.2.6.2 Ecological Receptors

You should document the following information regarding ecological receptors:

- Nearby sensitive environments, such as wetlands or state or federally designated threatened or endangered wildlife habitats
- Area natural resources, such as groundwater supplies or agricultural land
- A surface water survey that shows the location of the closest water body, the most susceptible water body, nearby drinking water intakes, and water bodies downgradient from the site
- Answers to the questions listed in Section 2.3 of the *Protocol for VCP Remediation Goals Lookup Tables* (Appendix A).

NDEQ will review this information to determine whether or not ecological receptors are likely to be exposed to contamination at the site. If so, a site-specific ecological risk assessment may need to be conducted. See the checklist in Attachment 2-1 of this guidance document and Section 2.3 of the *Protocol for VCP Remediation Goals Lookup Tables* for more information regarding this topic.

2.2.7 Conceptual Site Model

The IR should include a Conceptual Site Model. The conceptual site model will integrate all investigation results collected into a coherent representation of current site conditions. The model may be presented as a figure with explanatory text. It should provide a summary of how and where contaminants are expected to migrate and the affect that migration is expected to have on human health and the environment. Example Conceptual Site Models are included as Attachment 2-4.

In addition to describing current site conditions, the conceptual site model should illustrate intended land use at the site. This includes information about buildings and below-grade structures (i.e. basements, utility trenches, tunnels, elevator shafts, and tanks), landscaping features and decorative ponds, and any potentially sensitive environments.

It is important that all potential contaminant exposure pathways are evaluated and represented in the conceptual site model. These pathways are listed under *Exposure Pathways* in Section 2.2.5.2.

Finally, the conceptual site model should demonstrate why contamination is a problem and remedial action is necessary in light of proposed land use.

The following is a hypothetical example of part of the explanatory text that might go along with a conceptual site model:

> *"The plume of VOC contaminated groundwater that is migrating from the drum storage area has contaminated five private drinking water wells down gradient from the site at concentrations that exceed the MCLs for TCE and 1,1-DCE. The well owners were contacted in July 2003 and all have been connected to the municipal water supply. There are several homes located over the plume. During the investigation, the ACME XYZ Company evaluated the possibility for vapor migration from the site, and the possibility that VOCs would partition from the groundwater into the soil gas, and subsequently migrate into the homes. The soil gas investigation didn't reveal any evidence to suggest that VOCs are migrating via the soil gas beyond the property boundary. The concentration of TCE and 1,1-DCE in the shallow groundwater (5-25 feet below ground surface) is below the method detection limit of 1 ppb. Therefore, it does not appear that VOCs are migrating upward through the shallow groundwater into the soil gas."*

2.2.8 Summary and Conclusions

This part of the IR should summarize your findings and conclusions based on the results of the investigation. All of the conclusions should be supported by data, consistent with the conceptual site model, and valid in all other aspects so that they can be used to plan and implement remedial actions. Since this is the last section before the Remedial Action Work Plan, the narrative should be written such that the reader is left with a good understanding of the site, the nature and extent of contamination, and the potential impacts to human health and the environment. This section should be no longer than 2-3 pages, depending on the number and complexity of issues at the site.

2.3 REMEDIAL ACTION WORK PLAN

The next element of the RAP is the Remedial Action Work Plan (RAWP). The following categories of information should be described in the RAWP:

- Interim remedial actions

- Remedial action objectives
- Proposed remedial action
- Performance monitoring
- Remediation waste management plan
- Permitting and regulatory involvement
- Proposed schedule of remedial actions

The RAWP should address each of these categories as described in Sections 2.3.1 through 2.3.7, in the order given in this guidance. The level of detail will depend on site-specific conditions. It is important that you include sufficient and appropriate information to support the proposed remedial action.

2.3.1 Interim Remedial Actions

Interim remedial actions are used to control, minimize, or eliminate contamination that poses an actual or potential threat to human health or the environment. Typically, interim actions are taken in advance of the final remedial action. In some circumstances, an interim remedial action may become the final remedial action. In other cases, an interim remedial action may not be consistent with the approach chosen to meet the final remedial action.

The RAWP should provide a complete description of any interim remedial actions for the site. This description should include information about the location, duration, and method of any interim remedial actions, as well as a justification for their uses. You should evaluate the interim remedial action to determine if it is compatible with the final remedial action or whether the interim action can be the final remedial action. The results of this evaluation should be included in this section. In the event that the interim measure is not consistent with the final remedial action, the RAWP should describe the process by which the interim measure will be decommissioned or incorporated into the final remedy.

2.3.2 Remedial Action Objectives

A primary focus of the Nebraska VCP is to provide an applicant with options in determining remedial action objectives and remediation goals that are appropriate for their site. Towards that end, the NDEQ has developed a protocol that utilizes a three-tiered approach to establish or select specific remediation goals for a site. This tiered approach is presented in the *Protocol for VCP Remediation Goals Lookup Tables*, Section 3.0 (Appendix A). The NDEQ recommends that applicants familiarize themselves with this protocol prior to determining the RAOs.

In this section of the RAWP you should define RAOs. RAOs are statements that define qualitative goals and quantitative levels of cleanup that you intend to achieve for each of the contaminants identified at the site. Your selection of RAOs will be based on the intended land use for the site and groundwater use in the area of the site. The RAOs should be specific for the following:

- Chemicals of concern
- Exposure pathways

- Potential receptors that will be addressed.
- Cleanup levels as determined by the remediation goals lookup tables (Attachment 2-6)
- Location(s) or point of compliance at which the cleanup levels will be achieved
- Timeframe for which remedial actions will be completed

This section should also summarize the rationale for deciding which contaminants will be remediated and the level to which they will be reduced.

Provided below are examples of RAOs based on a site with PAH contamination:

> *"Remove and dispose of PAH contaminated soils from the affected residences that are above the residential remediation goals (RGs) provided below."*
>
> *"Prevent ingestion, dermal, and/or inhalation exposures by current or potential future domestic water supply well users to PAH contaminants in groundwater at concentrations greater than the maximum contaminant levels (MCLs) or RGs."*
>
> *"Restore the aquifer to the MCLs or RGs within a reasonable time frame and prevent further degradation and contaminant migration in groundwater."*

2.3.2.1 Land Use

Land use is to be based on future use considerations, especially if the property is to be redeveloped. If the intended land use is residential, the RAOs will be more stringent than if the intended land use is industrial. NDEQ recognizes that future land use may be consistent with present or historical land use.

2.3.2.2 Groundwater Use

Where protection of groundwater is determined to be a RAO, attention should be paid to the requirements of Title 118 – *Ground Water Quality Standards and Use Classification*, Appendix A - Ground Water Remedial Action Protocol. Under Title 118, protection and cleanup of groundwater directly relates to the site-specific Remedial Action Class (RAC) established by NDEQ for a pollution event. A RAC is essentially a pollution ranking designation defined for categories of groundwater (and overlying soils) in Nebraska, with the specific RAC determined for a specific site dependent on the current or potential use of groundwater as drinking water. The extent of remedial action required for groundwater will differ depending, in part, on the RAC of the contaminated or threatened groundwater. It should be noted that the RAC designation is determined from the condition of the groundwater prior to the occurrence of pollution. There are three RAC categories, each discussed in more detail below.

RAC-1

This category includes sites where groundwater is currently being used or has been proposed to be used for a public drinking water source, a portion of groundwater currently used as a private drinking water source, and groundwater within a designated Wellhead Protection Area (WHPA). RAC-1 will also be assigned anytime a public or private drinking water supply well has been polluted. RAC-1 sites receive the most extensive remedial action measures, including cleanup of readily removable contaminants (i.e., free product) and cleanup of dissolved phase contaminants to MCLs. If additional cleanup is not

required, the remaining contaminated groundwater will be managed and monitored to prevent further damage.

RAC-2

This category includes sites where groundwater has the potential to be used as a public or private drinking water source. Potential use exists if the groundwater is located in a highly populated area, is part of a regional, high-yielding aquifer, or is otherwise justified (e.g., the regional aquifer is low-yield but serves as the sole source of water). A RAC-2 designation would encompass the largest portion of groundwater in Nebraska. Remedial actions measures would include cleanup of readily removable contaminants (i.e., free product) and potential cleanup of dissolved phase contaminants to MCLs. If cleanup is not required, the remaining contaminated groundwater will be managed and monitored to prevent further damage.

RAC-3

This category includes sites where groundwater has little or no potential to be used as a public or private drinking water supply. Justification for assigning occurrences to RAC-3 is based on a combination of factors, including:

- Water is of such poor natural quality that it is unfit for human consumption
- Insufficient yield may limit or exclude groundwater being used for drinking water
- Historical contamination that occurred prior to the pollution event(s) currently being investigated that may have rendered groundwater unsuitable for drinking and uneconomical to treat
- Past and present intensive land use where groundwater is likely to be contaminated or will not be used as drinking water (e.g., areas of concentrated industrial development or densely populated areas)

Remedial action measures would generally be the least extensive for RAC-3 sites and would include cleanup of readily removable contaminants (i.e., free product). Monitoring may also be required.

A more extensive discussion and explanation of the RAC system may be found in Title 118, Appendix A, Step 8, pages A-4 – A-6. The applicant should be aware that drinking water criteria is not the only reason to perform additional cleanup of groundwater contamination and that other beneficial uses could necessitate such cleanup.

As stated previously, under Title 118 the RAC designation for a site is established by NDEQ. Knowledge of the probable RAC will be necessary for an applicant to determine appropriate remediation goals and evaluate potential cleanup technologies where groundwater contamination is a concern. However, such a determination by NDEQ under the VCP could likely hinder the intent of the VCP, namely to move sites along in as timely and efficient a manner as possible and allow the applicant to prepare an adequate Remedial Action Work Plan.

To allow a site to move as timely and efficiently through the VCP as possible, the NDEQ has developed a Preliminary RAC Determination Worksheet for use by a VCP applicant (see Attachment 2-5). The purpose of the worksheet is to allow an applicant to make a preliminary determination of the likely RAC designation that a contaminated site would receive from NDEQ, based on groundwater use within the area surrounding the facility. ***The conclusions reached by an applicant using this worksheet will be***

considered preliminary only and subject to a final, official RAC determination by NDEQ as part of its review of the VCP RAP. The applicant should include a completed worksheet as part of the RAWP.

2.3.2.3 Remediation Goals

The cleanup levels or Remediation Goals (RGs) for the site should be determined from the attached Remediation Goals Lookup Tables (Attachment 2-6). Chemical-specific RGs are provided for specific exposure pathways and land use categories. These RGs were developed based on accepted risk assessment principles. The policy decisions and risk assessment framework used to develop the RGs, as well as documentation for the calculation of the RGs, can be found in the *Protocol for VCP Remediation Goals Lookup Tables* (Appendix A).

The RGs selected as cleanup levels should be included as a specific table (see also Section 2.4) in the RAWP. This table should include the selected RG for each COC, indicate whether the RG represents a residential or commercial exposure, and the rationale for that selection.

2.3.3 Proposed Remedial Action

As mentioned in Section 1.0, the VCP is a streamlined, results-based cleanup program. This approach minimizes the number of steps in the regulatory review process and involves setting goals. It provides VCP applicants with the responsibility and latitude to determine how to achieve these goals. You will use the conclusions from the investigation to develop adequate RAOs, including cleanup levels taken from the lookup tables. Nebraska's VCP program does not require a formal and extensive evaluation of numerous potential remediation technologies, as do more traditional programs such as CERCLA or RCRA. However, VCP applicants who are also Brownfields Cleanup and Revolving Loan Fund grantees are required by EPA to perform a remedial alternatives evaluation of at least two remedial alternatives other than the no action alternative for the following criteria:

- Protect human health and the environment
- Comply with Applicable or Relevant and Appropriate Requirements (ARAR)
- Provide short-term and long-term effectiveness
- Implementability
- Cost
- Achieve community acceptance

With the results-based approach, NDEQ does not ordinarily second-guess the chosen remedial action. However, you should evaluate the proposed remedial action in terms of its effectiveness in achieving the RAOs and, if necessary, the remedy evaluation criteria. Effectiveness in achieving the RAOs will be based on monitoring and sampling results. In this guidance, such monitoring and sampling is termed *performance monitoring* (see Section 2.3.4). If performance monitoring results show that the RAOs are not met in the proposed timeframe, additional remedial actions will likely be necessary.

Performance Monitoring

In this guidance document, the term *performance* in performance monitoring refers to the effectiveness of the remedial action in achieving the RAOs. It does **not** refer to operational performance, or the ability of an engineered system to meet certain performance criteria. Since the VCP is a result-based program, NDEQ does not evaluate the design and operation of the remediation system, but rather, focuses on evaluating whether the remedial action will achieve the RAOs and, if necessary, the remedy evaluation criteria.

The following sections provide information on different types of remediation technologies that you may choose to select as your proposed remedial action. Each of these sections identifies the type of information that should be included in the RAWP for the remediation technology that you select.

2.3.3.1 Presumptive Remedies

One way to simplify and streamline the remedy selection process is to use presumptive remedies. Presumptive remedies are techniques that have been used at a wide variety of sites across the country. The widespread use of these technologies means that environmental professionals, regulators and consultants alike are familiar with the effectiveness and limitations of these technologies; therefore, it generally is not necessary to perform a lengthy evaluation of the technology. Instead, efforts can be focused on collecting the site-specific information necessary to determine whether to implement the remediation technology at the site. EPA's guidance document *Presumptive Remedies: Policy and Procedures* (EPA 540-F-93-047) provides a discussion of several presumptive remedies. For more information about presumptive remedies, see the resources listed in the bibliography (Appendix C).

2.3.3.2 Innovative Technologies

NDEQ encourages the use of innovative technologies. In some cases, innovative technologies can achieve cleanups that are as effective, faster, and cost less than traditional remediation technologies. Some examples of innovative technologies and the type of information that should be provided in the RAWP include:

- *In-Situ Bioremediation of Groundwater* – Describe the type of biodegradation mechanism to be used. Include maps showing the locations of wells, diagrams illustrating well construction information, and cross sections, descriptions, and construction information for any reactive barriers or other systems used to introduce reactants into the subsurface.

- *Phytoremediation* – Descriptions of phytoremediation should include type of application and details of the process employed. Types of plants, root depths, locations, and other applicable construction information should be included.

- *Monitored Natural Attenuation* – Any proposal to use monitored natural attenuation should provide sufficient and appropriate information to support the proposal. Include the results of sampling and monitoring to verify that natural attenuation is occurring at a rate that makes it suitable as a remedy. It is important to note that the occurrence of

degradation products alone is not sufficient to make this demonstration. EPA's guidance, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (EPA/600/R-98/128) provides a description of the information to demonstrate that monitored natural attenuation will be an appropriate remedy. The methods to be used to monitor degradation should be described in detail in Section 2.3.4.

- *Other Technologies* – If another innovative technology is proposed, specify the type of technology and include maps, cross sections, and/or diagrams to illustrate the basic construction of the system.

2.3.3.3 Traditional Technologies

There are many different kinds of traditional remediation technologies available to clean up contaminated sites. Some of the more commonly used technologies are listed below. Included with each is a brief summary of the information that should be provided in the RAWP.

- *Soil Excavation and Removal* – Descriptions of soil excavation should include the extent and depth of soil to be excavated and plans for refilling and regrading excavated areas. Include maps and diagrams to illustrate the locations, sizes, and shapes of these areas.

- *In Situ Treatment of Soil* – Describe the type of in situ treatment to be used and the overall systems for injection or extraction. Include maps or cross-sections showing system components, treatment points, and radius of influence of the treatment system.

- *Groundwater Pump-and-Treat* – Describe and illustrate the basic treatment process and construction of the groundwater pump-and-treat system, including the number and locations of wells, well construction information, and capture zones. Include maps, cross sections, and diagrams as appropriate.

- *Air Sparging/Soil Vapor Extraction* – Descriptions of air sparging/soil vapor extraction systems should include maps of wells locations, well construction information, radius of influence of the system, and cross sections illustrating the relationship among wells, contaminated zones, water table, and stratigraphic features.

2.3.3.4 Engineering Controls

Engineering controls are physical barriers or other engineered measures that limit exposure to contamination or access to the site. Some common engineering controls include low-permeability barriers and containment structures (e.g., clay caps, parking lots, landfill caps) and physical access barriers (e.g., fences).

If an engineering control is the proposed remedial action, describe and illustrate the area to be addressed and the type of engineering control to be used.

- *Low-permeability barriers and containment structures* – describe and illustrate the type, thickness, and engineering properties of the cover material. Include grading plans for the site. Include maps, cross sections, and diagrams as appropriate. If a landfill cap is the proposed remedial action, contact NDEQ regarding other applicable guidance and checklists of information to submit.

- *Physical access barriers* – describe and illustrate the type of barrier, location, size, and other construction information. Include maps and diagrams as appropriate.

Although some engineering controls may effectively prevent direct contact with contamination, they may not always be appropriate for the site. For example, a clean soil cap may limit exposure to contaminated soil, but the cap will not always be sufficient to prevent ongoing contamination of the groundwater. Residual contamination from contaminated soil or waste may continue to leach into the groundwater. This is especially true if it is located at or below the water table. In other cases, construction of a low-permeability barrier may exacerbate an existing contamination problem. For example, if a low-permeability cap is constructed over soils that are contaminated with volatile organic compounds, the cap may enhance lateral migration of vapors, potentially toward buildings. In this case, it may be necessary to supplement the cap with a remedial technology such as a soil vapor extraction system.

The narrative of this section should include a discussion of why the engineering control is appropriate for the site. In general, an engineering control is appropriate if the following criteria are met:

- the remedy will be protective of human health and the environment
- the wastes and contaminated media can be reliably contained to limit exposure and prevent ongoing contamination of other media
- the remedy will not cause or enhance other related contamination problems
- the wastes and contaminated media pose relatively low long-term threats
- treatment is impracticable

2.3.3.5 Institutional Controls

One way to minimize the potential for human exposure to contamination and/or protect the integrity of a remedy is through the use of institutional controls. Institutional controls are legal or administrative measures that limit land or resource use. They are typically used when the chosen remedial action involves leaving the contaminants in place or when implementing long-term cleanup actions. Often, institutional controls are used in combination with engineering controls or long-term groundwater cleanup actions.

There are four categories of institutional controls:

- *Governmental controls* – these controls use the authority of an existing governmental unit to impose land or resource restrictions. Examples include zoning, building codes, drilling permit requirements, and State or local groundwater use regulations.
- *Proprietary controls* – these controls, such as covenants and easements, are based on real property law and use a variety of tools to prohibit activities that may compromise the effectiveness of the remedy or restrict activities or future uses of resources that may result in unacceptable risk to human health or the environment. An example of this type of control is an easement that grants property access rights to a site owner/operator or regulatory agency for routine inspection and monitoring.
- *Enforcement and permit tools with institutional control components* – these tools may be used to require and ensure long-term compliance with site use restrictions. Examples

include remedy agreements, administrative orders, consent decrees, and permit conditions.

- *Informational devices* – these tools provide information or notification about whether a remedy is operating as designed and/or that residual or contained contamination may remain on-site. Examples include state registries, deed notices, and advisories.

The RAWP should list the category and type of each proposed institutional control. The narrative should describe how the institutional control will minimize the potential for human exposure to contamination and protect the integrity of the remedy.

Applicants may choose to use an environmental covenant pursuant to the Nebraska Uniform Environmental Covenants Act (Attachment 2-7). NDEQ has developed a model covenant (Attachment 2-7) pursuant to the Act to assist in the preparation of an environmental covenant. Environmental covenants established pursuant to the Act must include written documentation providing, among other things, the nature of the activity and use limitations, and information on where the administrative record documenting the remedial action may be found. A copy of the control must be recorded with the county where the property is located, as well as a copy provided to NDEQ.

2.3.4 Performance Monitoring

Performance monitoring is a key component of the VCP streamlined, results-based approach. Performance monitoring consists of periodic measurement of physical and/or chemical parameters to evaluate the progress of the remedial action in achieving the RAOs defined for the site. Performance monitoring can also be used to verify or adjust estimates of remediation timeframes or determine whether advances in remediation technologies or approaches could improve the ability to achieve the RAOs. Your approach to conducting performance monitoring will depend on which remedial action is chosen. For example, with remedial actions selected to control groundwater migration, both chemical analysis of groundwater samples and hydrogeologic measurements of groundwater elevations should be performed. At sites where engineering controls and institutional controls are used, performance monitoring may be necessary to demonstrate that ongoing contamination of the groundwater is prevented, groundwater contamination is not spreading to uncontaminated areas, and potential receptors are being protected.

In this section you should prepare a performance monitoring plan that includes a description of the RAOs, locations, frequency, type and quality of samples, techniques, and measurements that will be used to assess the performance of the remedial action. The plan should include sampling and analysis and quality assurance procedures consistent with the procedures discussed earlier in Section 2.2.2.3. In addition, a schedule for submittal of periodic monitoring reports should be included in the plan. The plan should also include an operation and maintenance plan for the monitoring system. Finally, the plan should discuss the proposed remediation timeframe during which performance monitoring activities will be conducted.

Performance monitoring reports should be submitted to NDEQ on a periodic basis after approval of the RAP. These reports should include the following:

- Analytical results
- QA/QC results
- Chain of custody records

- Groundwater sampling and field data sheets
- Data tables containing groundwater elevations and well data
- Groundwater contour maps
- Contaminant plume concentration maps

The timeline for submittal of performance monitoring reports, in relation to approval of the RAP, submittal of the RAR, and issuance of the NFA, will vary from site to site. For sites with long-term remedies, the general sequence will be as follows: (1) approve RAP, (2) submit periodic monitoring reports, (3) submit RAR, and (4) issue NFA. The NFA will only be issued if the regulatory standard has been met in the specified long-term timeframe.

For sites where engineered controls/institutional controls are the remedy, the general sequence will be different: (1) approve RAP, (2) submit RAR, (3) issue NFA, and (4) submit periodic monitoring reports.

Startup Reports and Long-Term Remedies

If a long-term remedy is chosen as the cleanup approach, you may need to submit a startup report after the RAP is approved.

Startup reports are submitted once remedial actions have begun. They should include as-built diagrams illustrating the construction information of the remedial system. You should confer with NDEQ to determine whether a startup report will be necessary.

This section should include an operation and maintenance plan (O&M plan) for the performance monitoring system. This plan should be used to ensure that that the monitoring system will continue to function properly and provide data of the appropriate quality and quantity to allow NDEQ to evaluate the performance of the remedial action. The O&M plan should include:

- A description of the inspection procedures and tasks to be completed as part of the routine operation and maintenance of the system.
- A general description of the contingencies that will be used in the event the performance monitoring system requires repair or modification beyond the scope of routine operation and maintenance.

Finally, this section should include an outline of the expected remediation timeframe. An acceptable timeframe for remediation will be the period of potential exposure to the contamination in the absence of any remediation or 20 years, whichever is less. A longer period of time may be allowed on a case-by-case basis, if adequately justified by the applicant.

2.3.5 Remediation Waste Management Plan

For all remediation approaches, you should describe procedures for managing and disposing of any Remediation Waste (RW) generated during remedial action. Due to the generation of RW, remedial actions can trigger RCRA requirements at a facility that is otherwise not regulated under RCRA. Carefully selecting and implementing appropriate remedies can avoid or minimize the regulations that apply. For example, designating an area of contamination (AOC), managing waste within the AOC, and selecting in-situ treatment methods whenever possible are ways to avoid triggering the RCRA land disposal restrictions. Please refer to the NDEQ guidance document in Attachment 2-3 for more information on developing a RW plan.

2.3.6 Permitting and Regulatory Involvement

Permits and regulatory requirements are commonly associated with remedial actions. For example, a RCRA permit, order, RCRA Remedial Action Plan (RAP), or other enforceable mechanism may be required when conducting ex-situ treatment or management of waste outside of an AOC, or when using corrective action management units (CAMUs), temporary units (TUs), and staging piles. A Nebraska Title 129 permit may be required when construction activities or remediation systems, such as air stripping towers, cause or create contaminated airborne dust and vapors. Therefore, it is important to work with federal, state, and local agencies to identify and address all applicable permitting and regulatory issues.

There are two important issues that should be considered when obtaining a permit. First, obtaining a permit and complying with its terms means that the project is no longer strictly voluntary. Second, you will need to allow sufficient time to complete the permit process. If the VCP project is operating according to a relatively tight schedule, the time required to obtain a permit can significantly affect the timeframe for startup and/or completion of certain parts of the project.

This section should identify all applicable local, state, and federal permitting or regulatory requirements. Some permitting or regulatory requirements typically needed for remedial action are those for:

- Air discharge
- Solid waste disposal
- Groundwater well permits
- Surface water appropriations
- Injection or re-injection activities
- Discharge to surface water or sanitary sewers
- Local building, plumbing, or electrical permits
- Easements for sampling on public property
- Access agreements

You do not need to include copies of permits in the RAWP, but you should demonstrate that the regulatory framework has been considered in the remediation design.

Finally, you should include a statement in the RAWP that a site-specific Health and Safety Plan will be used for field activities associated with the remedial action.

2.3.7 Proposed Schedule of Remedial Actions

This section should contain the proposed schedule of remedial activities. The schedule should be in tabular format and contain a brief description of the activity, date of initiation, date of completion, and other relevant information.

If the intent is to move forward with remedial action implementation at a fairly fast pace, there are several things that should be considered. First, NDEQ should be notified before the remedial action is implemented. Second, the schedule should allow time for NDEQ to issue a 30-day public notice. Third, fast-moving schedules may be difficult to implement because the VCP process includes some NDEQ oversight and guidance. You can expedite this process by submitting a thorough, high-quality RAP. Finally, the regulatory issues identified in Section 2.3.6 can have a significant impact on the timing and overall construction schedule. To expedite the project, you should identify concurrent tasks and get NDEQ involved very early in the planning stage of these tasks.

2.4 TABLES

This section should include all tables referred to in the narrative of the RAP. Several example tables have been included in Appendix B to demonstrate how to effectively communicate tabulated information. Tables should be formatted in the following manner:

- Tables should be listed in the RAP Table of Contents (with RAP page number)
- Tables themselves should be numbered and should appear in the order that they are mentioned in the RAP.
- They should have a title that describes the contents of the table and be clearly labeled and prepared with an appropriate font size so that they are easily legible and understandable
- Table rows and columns should have titles or numbers, and data presented in the respective rows and columns should be consistent with the titles
- Units within each row or column should be consistent (i.e, do not mix units within any one row or column)

2.5 FIGURES

This section should include appropriate maps, aerial photographs, cross sections, and other figures. Several example figures have been included in Appendix B. All figures in the RAP should be formatted in the following manner:

- Figures should be listed in the RAP Table of Contents (with RAP page number)
- Figures themselves should be numbered and should appear in the order that they are mentioned in the RAP
- They should have a title that describes the contents of the table and be clearly labeled and prepared with an appropriate font size so that they are easily legible and understandable
- Labels on printed figures should be part of the printed image rather than an adhesive label that is affixed to the figure or as hand-drawn labels or symbols
- Figures in every submitted copy of the RAP should be printed and in color (i.e., not a photocopy of the original figure)

- Whenever possible, historical documents such as Sanborn maps, deeds and certified survey maps included as figures should be scanned rather than photocopied, at a resolution of 1200 dpi and as grey scale (8 bit)
- Cross sections should include vertical and horizontal scale bars and legends.

2.5.1 Maps

There will be several maps included in the RAP, not only of the subject site, but also of the surrounding area/region. All maps should be properly formatted, as follows:

- Maps should contain a legend with the following information:
    - Project name, facility address, and NDEQ file information (e.g., NDEQ Integrated Information System Facility Number)
    - North arrow (not hand drawn)
    - Scale in standard units (e.g., 1 mile, ½ mile, 1000 feet, etc.)
- Maps should contain legible symbols and all symbols and labels should be of sufficient size and contrasting color to be readily visible. (In general, symbols smaller than 0.10 inches in diameter and/or in shades of blue or green do not contrast well with grey scale photographs. Shades of red and yellow tend to work best against a grey background.)
- Maps should use different symbols for different types of features (e.g., different types of water wells should indicated by different symbols).
- All maps that include the subject property should show the property boundaries of the subject property. On area maps, the property boundaries of the subject site should be digitally drawn on the maps.
- The latitude and longitude of the center of the subject property should be provided on at least one of the site maps, presented in decimal degrees and referenced to the State Plane Coordinate system NAD 83.
- Full size copies of any Sanborn Maps should be provided in the RAP, with the maps folded and placed in a plastic sleeve. (A full size Sanborn map will be approximately 20”x24”. If possible, the maps should be purchased/obtained in digital [i.e., *.pdf] format.)

2.5.2 Aerial Photographs

Prints of aerial photographs should be obtained whenever possible and scanned images provided in the RAP. (Some potential sources of aerial photos, such as the Nebraska State Historical Society, may not release the actual aerial photographs and will usually will not be able to make additional prints, but may be willing to allow the photographs to be scanned.) All information necessary to obtain any aerial photographs should be provided in the RAP, including:

- Source of photos, whether government agency (e.g., NDOR, EPA, USGS, NRCS) or private company (e.g., Terraserver, EDR)
- Date of photograph

- Flight and frame number, Compressed Ortho Quarter Quad (COQQ) number, or other information that would be sufficient to document or obtain the aerial photographs

Additionally, aerial photographs should be formatted as follows:

- The highest quality digital image possible of an aerial photograph should be obtained
- Aerial photographs should be scanned at 1200 or 2400 dpi (the resolution of most historical photos is unlikely to be much higher than 2400 dpi)
- Grey scale aerial photographs should be scanned as 8-bit grey scale; color aerial photographs should be scanned as 24-bit or greater color scale
- Aerial photographs used as base maps should include key features (such as property boundaries) provided in color

2.6 APPENDICES

The RAP should include appendices containing information collected during the investigation. Only one document or "type" of information should be provided per appendix. For example, monitoring well construction logs should be placed in a different appendix than the soil boring logs. Another example would be copies of previous investigation information or reports related to the facility (e.g., a LUST investigation report, Phase I or II environmental assessment report) placed into separate appendices. NDEQ recommends that numbered tab dividers be used between appendices for ease of review. The following material should be included, if applicable:

- Soil boring logs
- Monitoring well construction logs
- Complete results of field screening
- Analytical reports for all soil gas, groundwater, and soil data referred to in the report, including QA/QC results
- Data validation and usability summary
- Vadose zone or aquifer testing data and estimation calculations
- Flow modeling data, calculations, and results
- Photographic documentation of investigative activities
- Copies of log books, field sheets, chain-of-custody forms, or other supporting documentation for field sampling and analysis
- Copies of waste manifests, aerial photographs, and any other document used to identify suspected source areas or probable release areas at the site

- Copies of deeds and other property documentation
- Other applicable documentation of investigation findings
- QAPP used during the investigation