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PHASE II ENVIRONMENTAL SITE INVESTIGATION PROCEDURES AND TECHNOLOGIES FOR PROPERTY TRANSFER AND PS&E DEVELOPMENT

by

John H. Overman
Associate Research Scientist
Texas Transportation Institute

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TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
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16. Abstract

The purpose of this project is to provide TxDOT with an improved procedure for conducting environmental site investigations at various stages during transportation infrastructure development. The project seeks to identify modern assessment technologies, procedures, and regulatory requirements that can be incorporated into a new TxDOT site assessment procedure. The major tasks for this project include a review of current literature for the procedural and regulatory aspects of conducting site investigations; a review of the technological and geophysical investigative tools used in site investigations; the development of a procedure for conducting site investigations; and a provision for training TxDOT engineers and planners in the use and application of the procedure. The project will enable TxDOT to incorporate the use of investigation techniques and procedures into right-of-way and design manuals and to promote a better understanding of the site investigation process to TxDOT divisions and districts.

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IMPLEMENTATION RECOMMENDATIONS

Based on the results of this research project, the author proposes the following recommendations for TxDOT:

1. **Technology Transfer.** Additional technology transfer is needed in the use of risk-based site assessment and corrective action. The draft Texas Risk Reduction Program (TRRP) rules were released in March 1999 and are due to become final in the summer of 1999. Workshops and/or training courses should be developed and delivered on the TRRP rules and the use of risk-based assessment. These workshops could be conducted in conjunction with project 0-1807: Development of a Risk-Based Manual for the Use of Contaminated Material in Highway Construction. The two projects both have very similar regulatory requirements.

2. **Direct Technical Assistance.** An information resource could be established to provide direct technical assistance to districts planning or conducting Phase II environmental site investigations. The technical assistance could include:
   - reviewing/developing scopes of work for site investigations,
   - reviewing the results of site investigations using new technologies, or
   - preparing plan notes and/or specifications for construction activities in contaminated sites.

3. **Streamlining and Improving Communication.** Develop methods for streamlining environmental review and enhancing communication during project development between operational units of TxDOT, contractors, and consultants. Implementation of improved site investigation procedures and technology is contingent on improving the communication and the flow of information among the various participants involved in the process. This includes the flow of information from and between TxDOT staff and environmental consultants and construction contractors. TxDOT should encourage and facilitate the sharing of experiences and lessons learned from performing environmental assessments and site investigations between district and division environmental staff, as well as other participants.

4. **Design and Construction**. Develop improved design and construction methods for projects occurring in contaminated environments in order to minimize project impacts, prevent contaminant migration, and limit exposure to contaminants. These may include development and dissemination of successful project case studies where contaminants were encountered and managed effectively.

CHAPTER ONE - PROJECT SUMMARY

The purpose of this project is to provide TxDOT with an improved procedure for conducting environmental site investigations at various stages during transportation infrastructure development. The project seeks to identify modern assessment technology, procedures, and regulatory requirements that can be incorporated into TxDOT site investigation procedures. The major tasks for this project include: a review of current literature for the procedural and regulatory aspects of conducting site investigations; a review of the technological and geophysical investigative tools used in site investigations; the development of a procedure for conducting site investigations; and a provision for training TxDOT engineers and planners in the use and application of the procedure. The study will enable TxDOT to incorporate the use of site investigation techniques and procedures into right-of-way and design manuals and to promote a better understanding of the site investigation process to TxDOT divisions and districts.

PROJECT BACKGROUND

All transportation projects have the potential for encountering hazardous material contamination during right-of-way acquisition or construction. The purpose of environmental assessment is to identify potential environmental hazards early in project development in order to avoid or minimize impacts as the project advances. The advanced planning and environmental documentation stages of project development incorporate the interests of the Texas Department of Transportation (TxDOT), the Federal Highway Administration (FHWA), and the National Environmental Policy Act (NEPA)(1).

The situations and environmental conditions encountered in TxDOT right-of-way (ROW) are diverse. This project focuses on site investigation processes that can be used in a variety of situations and site conditions at various stages of project development. The scope of the site investigation procedures presented herein are generally referred to as Phase II environmental site assessments (ESAs) or environmental site investigations and does not include the initial site assessments (sometimes referred to as Phase I environmental site assessments). It should also be noted that the investigation procedures presented herein relate primarily to identification and delineation of potential and actual contaminated media. The primary distinction between the initial site assessment and subsequent Phase II environmental site investigations is that site investigations are generally intrusive and quantitative in nature.

Encountering contamination in existing or proposed right-of-way has become increasingly burdensome and costly in the development of transportation infrastructure. One strategy to reduce the cost associated with environmental site investigations is to develop improved procedures that use modern geophysical investigative techniques and present the results in a form that clearly communicates the occurrence of contaminants in the environment as well as risks to human health and the environment.

One of the problems faced during the assessment phase of a project is that potential sources of contamination, or potential risks, may go unidentified and require repetitive assessments. The problem faced during the design phase of a project is similar; the extent and magnitude of contamination discovered in the ROW may be inadequately defined and require increased assessment, clean-up, and waste disposal. Additionally, ill-defined risks to worker health and safety may also hamper the project. In each phase of development, project delays, project costs, and increased TxDOT liability could be reduced with improved site investigation approaches.

Ideally, a site investigation process should ensure that every reasonable action has been taken prior to ROW acquisition, design, or construction, to identify potential risks and future costs. Although site investigations can account for many foreseeable scenarios, it is impossible to foresee all occurrences of contamination and identify all environmental risks that may occur. It is also not economically prudent to expend extraordinary resources conducting exhaustive assessment activities that yield only marginal benefits. The research efforts have focused on site investigation processes and technology that are economically viable and balanced to meet regulatory and liability requirements. There is no magic bullet or process that can substitute for experience and expertise when conducting site investigations, but adherence to proven techniques can improve decision-making and reduce risks associated with contaminants in ROW.

Contamination from petroleum sources is the most prevalent chemical of concern (COC) found in TxDOT ROW. Fortunately, the science of investigating and assessing petroleum contaminants is maturing. Risk-based corrective action (RBCA) and risk assessment models for petroleum contaminates in soil and groundwater are more abundant and accepted by regulators than ever before. The processes and technology presented in this study are in keeping with the risk-based approach to site investigation.

The traditional methods for assessing contamination in ROW typically involve the sample collection and chemical analysis of the suspected or affected media. The traditional remedy is to remove the contaminated media to a prescribed level or "safe" concentration in all instances. The regulated community and the regulators, realizing that these traditional approaches to assessment and remediation are often expensive and do not yield significant benefits, began using a risk-based approach to assessment. A risk-based approach to remediation and control of contaminated media is a "new end" in comparison to the "old end" of physical contaminant removal. It was discovered that a uniformly prescribed cleanup to background concentrations is not always appropriate for all settings; rather it is more effective to estimate an acceptable level of risk posed by the COC for an individual site based on site characteristics and use.

The Texas Risk Reduction Program (TRRP) proposed by the Texas Natural Resource Conservation Commission (TNRCC) is an attempt to unify several existing risk-based regulatory programs. The TRRP will have an effect on ROW investigations and transportation infrastructure development. Site remedies under this proposed plan will vary with respect to

their setting and use because Texas highways encounter a diversity of geological and environmental settings. Traditional assessment tools as well as innovative assessment tools can still yield meaningful information; however, all of these assessment tools must be used with the "new end" in mind. The range of available assessment tools was selected based on the ability of each tool to provide the information which contributes to the construction of a conceptual model, or picture, of the risks posed by the COC and not just to strictly identify the occurrence of the COC.

Since many forms of transportation development begin with obtaining ROW and generally end with construction and ultimately operation and maintenance, then each step of the environmental investigation during development should begin with the new end in mind. The site investigation should identify the contaminants that pose the greatest risks to the project. The progression of investigation from the initial site assessment to site investigation should build a conceptual model of the problem based on the findings. Site investigations should not necessarily produce more data indicating the occurrence of the COC but a more complete conceptual picture of the risk which is present.

Environmental site investigation techniques and processes can also be useful in the management and disposal of contaminated soils and groundwater during construction. In some instances, disposal of contaminated soils and groundwater can be minimized or even avoided using the risk-based approach and the TRRP. However, the planning, data collection, and regulatory requirements in order to achieve the reductions in soil and groundwater disposal are more sophisticated and will likely require greater care and scrutiny.

SUMMARY OF RESEARCH TASKS

The literature search was the major focus of the research effort. A computerized information search of the Transportation Research Board (TRB) bibliographic database was conducted to ensure consideration of previous work on the subject. The literature search found limited information in transportation databases using risk-based assessment in this process. The bulk of the literature on site investigation procedures used in this report is not from transportation databases. Most of the innovative information came from U.S. Environmental Protection Agency (EPA), Department of Defense (DOD), and Department of Energy (DOE) resources. Publications and guidance from the TNRCC regarding site investigation procedures were also utilized. The TRRP proposed rules (Title 30 TAC, Chapter 350), the Petroleum Storage Tank Risk Based Corrective Action Rules (Title 30 TAC, Chapter 334), and the Risk Reduction Rules for Industrial and Hazardous Waste Management (30 TAC Chapter 335, Sub-chapter S) were reviewed to ascertain regulatory requirements.

Information from the American Society for Testing and Materials (ASTM) and DOE provided a foundation for site investigation procedure recommendations and investigative processes. Site investigation technology was readily available in traditional geophysical, geological, and environmental sciences literature. Resources from the Environmental and

Engineering Geophysical Society and the Symposium on the Applications of Geophysics to Environmental and Engineering Problems (SAGEEP) provided valuable insight into geophysical survey methods used in site investigations.

The literature review and information search consisted of 1) the regulatory, administrative, and procedural aspects of assessment; and 2) the technological aspect of site assessment. Both of these components have been investigated to provide a foundation for the research effort. Although the TRRP was expected to play a greater role in the development of the project, its role was ultimately limited. This occurred because TNRCC withdrew the proposed rules from consideration very late in the project and did not reissue them until after the draft research report was submitted.

In addition to the review of literature and Internet resources, researchers conducted limited telephone interviews with engineering and environmental consulting firms that specialize in site investigations and that have worked for TxDOT. The interviews confirmed the nature of contamination encountered in ROW and the investigation methods currently used. Limited telephone interviews were also conducted with the Dallas Area Rapid Transit Authority and with a consultant for the regional commuter rail (Trinity Express) about their experiences. Software and technology vendors were visited during the TNRCC Trade Fair and Conference to identify products with potential applications. The interviews generally indicated that there is a willingness among consultants to use new site investigation technologies, but the opportunities to do so are limited.

The task to develop site investigation procedures was primarily based on the *accelerated site characterization* process and the *expedited site characterization* process. These processes are derived from a combination of resources and recommended guidance from TNRCC, ASTM, and DOE.

SUMMARY OF RESEARCH RESULTS

This project addresses three fundamental aspects of the Phase II environmental site investigation process as it relates to TxDOT:

1. the regulatory background and requirements for conducting Phase II site investigation (why do we do it?),
2. the process and procedural aspects of conducting a Phase II site investigation (how do we do it?), and
3. the technology and investigative techniques used in conducting site investigations (what tools do we use?).

Each of these aspects—the regulatory requirements, the process, and the technology—evolve over time. Sometimes this change occurs very rapidly and coincides with developments in technology or new regulations; other times the technology and recommended site

investigation processes stay relatively unchanged. Therefore, it is important to recognize that certain laws, regulations, rules, and regulatory guidance are subject to changes that may affect the investigation process. Also, advances in the technology or the economic viability of certain technologies may change quickly, so it is incumbent upon those who conduct Phase II environmental site investigations to refresh their knowledge of the regulations and technology. Finally, site investigation procedures are frequently modified to compensate for regulatory changes and advances in technology.

The results of the research are presented in greater detail in the research report. Chapter one of the research report reviews the basic concept of risk assessment, which is used as the basis for most environmental site investigation processes and new regulations. In addition, Chapter One presents information on the characteristics of contaminated sites in Texas and the current regulatory framework.

Chapter Two of the research report presents the approach to conducting Phase II environmental site investigations and the standards and guidelines that form the foundation for the process. First, a screening process to determine if a site investigation is necessary is presented, followed by the planning steps prior to conducting a site investigation. The investigation procedures that follow are based primarily on the accelerated site characterization process and selected TNRCC guidance documents for the investigation of leaking petroleum storage tanks (LPST). In addition to the accelerated site characterization process, a review of the data quality objectives and dynamic workplans process is presented to enhance the site investigation process.

Chapter Three of the research report presents relevant geophysical and geotechnical site investigation technology. A summary of the geophysical survey methods is presented in a matrix to allow easy comparison of the strengths and weaknesses of the various methods. In addition, the steps in planning a geophysical survey are presented to help ensure successful execution. Direct push technology is reviewed, along with the use of cone penetrometer testing as a new method of subsurface characterization that can speed up the site investigation.

This summary report condenses the material presented in those three chapters. The procedures and technology reviewed and presented in both this summary report and the research report generally represent the current state of the practice in Phase II environmental site investigation in Texas. For detailed guidance on the environmental site investigation processes and technology, refer to the research report.

CHAPTER TWO - ENVIRONMENTAL SITE INVESTIGATION

Environmental site assessments or site investigations are typically divided into three distinct phases of investigation:

- **Phase I initial site assessment is a qualitative investigation** that consists primarily of a visual survey and a records search to determine if any suspected hazards may exist on the site. Phase I initial site assessments are generally conducted on existing and proposed ROW or on easements that may be used in the project.

- **Phase II environmental site investigation is a quantitative investigation** if environmental hazards are discovered or suspected at the site. The purpose of the Phase II environmental site investigation is to confirm the existence and nature of the hazard or contamination through the collection of site specific data and, if possible, to determine the extent of the hazards. Phase II site investigations include invasive and non-invasive subsurface investigation, chemical analysis of various media, and some form of risk assessment. A environmental site investigation is complete when sufficient data have been collected to allow the user to build an accurate conceptual understanding of the site which can then be used for making sound decisions regarding human and ecological risk, as well as regulatory and liability issues.

- **Phase III** generally involves collecting additional data about the site in order to develop a plan to manage or remediate the site.

The divisions between the phases of assessment may sometimes overlap. The point where a Phase I stops and Phase II begins is not always clearly defined. In fact, many Phase I assessments include sampling on a limited basis, and Phase II investigation may include revisiting qualitative factors as well as development of management plans for dealing with hazards that are discovered. The content and scope of site investigations should be dependent on the objectives of the investigation and the site, but strict adherence to the divisions between phases of assessment is not as important as getting the most from assessment budgets. The purpose of examining the Phase II environmental site investigation process is to provide a framework for sound decision making when dealing with and investigating environmental hazards.

REFERENCE DOCUMENTS

Because there can be wide variation within the scope and content of Phase II environmental site investigations, standardized processes and guidance documents have been developed by various organizations to improve the efficiency and effectiveness in site assessments and site characterizations. ASTM is most notable and prolific of these organizations. Additionally, since the purpose of conducting many Phase II environmental site investigations is to meet regulatory requirements, TNRCC and EPA often prescribe procedures in the form of a rule or guidance in order to achieve their regulatory objectives. The standards,

rules, and guidance documents listed below are the primary references used in describing the Phase II environmental site investigation process. These documents may be ordered from the organization and, in many cases, are available for either viewing or downloading from the organization's Internet web site.

Table 1.
Phase II Environmental Site Investigation and Assessment Reference Documents.

Organization	Title of Document	Type of Document	Internet Availability
ASTM	Environmental Site Assessments: Phase II Environmental Site Assessment Process. E 1903-97	Standard	http://www.astm.org/index.html
ASTM	Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases. PS 3-95	Standard	http://www.astm.org/index.html
ASTM	Risk-Based Corrective Action Applied at Petroleum Release Sites. E 1739-95	Standard	http://www.astm.org/index.html
ASTM	Developing Conceptual Site Models for Contaminated Sites	Standard	http://www.astm.org/index.html
ASCE	Environmental Site Investigation Guidance Manual (Practice No. 83)	Guidance Manual	http://www.asce.org
TNRCC	Texas Risk Reduction Program (TRRP), Title 30 TAC, Chapter 350	Draft Rule	http://www.tnrcc.state.tx.us/
TNRCC	TNRCC Title 30 TAC Chapter 335, Subchapter S (Risk Reduction Rules)	Rule	http://www.tnrcc.state.tx.us/
TNRCC	Guidance for Risk-Based Assessments at LPST Sites in Texas. RG-175	Guidance	http://www.tnrcc.state.tx.us/ waste/pst/rpr/download.htm
TNRCC	Risk-Based Corrective Action for Leaking Storage Tank Sites. RG-36	Guidance	http://www.tnrcc.state.tx.us/ waste/pst/rpr/download.htm
EPA	Expedited Site Assessment Tools for UST Sites: A Guide for Regulators. EPA 510-B-97-001	Guidance	http://www.epa.gov/swerust1/ cat/samconts.htm
EPA	Technology Innovation Office, Various Assessment Guidance Documents and Links on this Site	Guidance	http://www.clu-in.com/

RISK ASSESSMENT AND TRRP

Understanding the concept of ***risk assessment*** is critical to conducting Phase II site investigations. This term has evolved from the implementation of regulatory guidelines that, in some cases, have been promulgated into rules relating to the assessment, characterization, and remediation of contaminated sites. In most instances, the purpose of a Phase II environmental site investigation is to collect data and build a conceptual model of the site for use in a risk assessment.

Risk assessment entails the evaluation of scientific information on hazardous properties of environmental agents and the extent of human exposure to those agents **(2)**. The product of the evaluation is a statement regarding the probability that a population so exposed will be harmed and to what degree. The probability may be expressed quantitatively or in a relatively qualitative way.

The risk assessment process involves the following four components **(2)**:

1. hazard identification,
2. dose-response assessment/toxicity assessment,
3. exposure assessment, and
4. risk characterization.

The objective of **hazard identification** is to determine whether the available chemical-specific data describe a causal relationship between exposure to the chemical and adverse human health effects. In other words, is exposure to the COC found in the investigation harmful to human health or the environment?

The **dose-response assessment** quantifies the relationship between the dose (amount of COC) that the organism is exposed to and the response (adverse health effects). Or, how much of the chemical does it take to cause harm?

The objective of the **exposure assessment** is to analyze site-specific information to estimate the most likely dose to potential human receptors. The exposure assessment involves determining how, or if, the COC enters the body, whether through ingestion, inhalation, dermal absorption, injection, or any combination.

The **risk characterization** uses information from the previous three steps to estimate adverse human health effects. In other words, all the information is analyzed to determine if, and approximately what chance, there is that harm may come to human health and the environment as a result of the occurrence and exposure to a chemical.

Risk assessment is followed by the ***risk management*** step which answers the question, "What should be done with the risk that has been quantified?" Risk management is a term used to describe the process by which risk assessment results are integrated with other information to

make decisions about the need for, method of, and extent of risk reduction. Policy considerations derived largely from statutory requirements dictate the extent to which risk information is used in decision making **(2). Risk-based corrective action** (RBCA) is one example of risk management.

Understanding the risk assessment process is now an integral part of conducting environmental site investigations. New regulatory approaches to dealing with contamination use the Phase II site investigation to analyze the risk posed by contaminants and derive site specific cleanup objectives, taking into account land use and exposure pathways. Before, the Phase II environmental site investigation would gather as much information as possible incrementally, with the knowledge that further assessment would likely be needed to define the extent of contamination precisely before it was removed. Now, the objective of most environmental site investigations is to gather enough of the right information early to develop a conceptual model of the site that often prevents future mobilization. The conceptual model is then used to evaluate the potential risk posed by the contamination and, in most cases, manage contamination instead of removing it.

The risk-based approach focuses more on the quality of data than on the quantity of data. The objective of the environmental site investigation is not to see what we find but to confirm what is thought to exist based on the review of existing information.

The most recent regulatory development is the proposed rules for the Texas Risk Reduction Program, originally released by TNRCC for comment in April 1998. The rules were subsequently withdrawn and revised. The proposed TRRP rules were released again in March 1999 and will establish a uniform set of risk-based, performance-oriented technical standards to guide response actions at affected properties regulated via the TNRCC's Office of Waste Management program areas and other applicable program areas. The rule was promulgated as a new chapter (i.e., 30 Texas Administrative Code (TAC) Chapter 350). (The following discussion is based on the proposed rule and preamble which are subject to change pending the publication of the final rule **(3)**.)

Currently, several different rules govern corrective actions, closures, and post-closure care within the agency's waste management programs. The State Superfund Program, the Industrial and Hazardous Waste Program, and the Voluntary Cleanup Program (VCP) use the existing Risk Reduction Rules in 30 TAC Chapter 335, Subchapters A and S, for risk-based corrective action. Any person who stores, processes, or disposes of hazardous waste is also subject to the closure and post-closure care requirements in 30 TAC Chapter 335, Subchapters E and F. The Petroleum Storage Tank (PST) program uses 30 TAC Chapter 334, Subchapters D and G, for risk-based corrective action. The adoption of the existing Risk Reduction Rules in 1993 and the PST risk-based rules in 1995 established the commission's philosophy that risk-based cleanups are an acceptable remedial response to affected environmental media because risk-based corrective action ensures protection of human health and the environment while making response actions more economically feasible than complete, or background, cleanups.

Prior to 1993, TNRCC required all affected media to be restored to background levels or to be closed as a landfill with post-closure care. The agency recognized for the first time in the Risk Reduction Rules that a limited quantity of COCs could remain within an environmental medium and not present an unacceptable risk to human health or the environment.

The goals of the proposed TRRP are:

- to create a unified, performance-based approach to corrective action which will be the same regardless of which of the agency's program areas review the adequacy of a proposed response action;
- to complete the movement away from background as a cleanup standard; and
- to implement a consistent, streamlined approach that will expedite the remediation of affected properties.

The proposed Chapter 350 is subdivided into Subchapters A through F:

Subchapter A General Information, §§350.1-350.5.
Subchapter B Remedy Standards, §§350.31-350.36.
Subchapter C Affected Property Assessment (PCLs),§350.51-350.55.
Subchapter D Development of Protective Concentration Levels (PCLs), §350.71-350.78.
Subchapter E Reports, §350.91-350.96.
Subchapter F - Institutional Controls, §350.111.

A tiered process is provided to establish both human health and ecological protective concentration levels (PCLs): Tier 1, 2, and 3. This tiered process for human health PCLs is patterned after the tiered process of the *ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* ES-1739-95. The first tier is based on conservative, generic models that do not account for site-specific factors. These Tier 1 protective concentration levels are published and updated by TNRCC. Tier 2 allows persons to apply site-specific data and use the TNRCC lateral transport equation which may increase risk-based protective concentration levels. Tier 3 allows for the use of site-derived natural attenuation factors and alternative models in development of PCLs. In all cases, the person must identify "critical" PCLs, which is the cleanup level for a COC within a media considering all of the exposure pathways and other media.

EVALUATING SITES

The desired approach for the environmental investigation process is to discover all contamination problems as early in the project development process as possible. If the discovery is identified early in project development, the contamination may be avoided or mitigated more easily with less project impact.

How much evaluation of a potential or known contamination problem is dependent on what stage of development the project is in, who owns the land, and how much time and money are available. The FHWA Technical Advisory T 6640.8A provides the following (4):

> "Hazardous wastes sites are regulated by the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). During early planning, the location of permitted and nonregulated hazardous waste sites should be identified. Early coordination with the appropriate Regional Office of the EPA and the appropriate state agency will aid in identifying known or potential hazardous waste sites. If known or potential waste sites are identified, the location should be clearly marked on a map showing their relationship to the alternatives under consideration. If a known or potential hazardous site is affected by an alternative, information about the site, the potential involvement, impacts and public health concerns of the affected alternatives and the proposed mitigation measures to eliminate or minimize impacts or public health concerns should be discussed in the Draft EIS.
>
> If the preferred alternative impacts a known or potential hazardous waste site, the final EIS should address and resolve the issues raised by the public."

The initial site assessment should hopefully provide enough information to identify known or suspected areas/sites with contamination. The next step is to determine if further action is required. At that point, one should screen the known and suspected sites to determine if the suspected area impacts the project. Each area suspected of posing a threat to human health and the environment and that would affect the proposed project should be evaluated for possible Phase II environmental site investigation.

Screening Evaluation for Phase II

Each property within or adjacent to the proposed ROW limits for each alignment or activity should undergo a determination for potential contamination. A generalized rating system can aid in that property evaluation. Phase II environmental site investigations should generally be conducted only on those projects identified for property acquisition or construction. If the suspected site would not be affected by construction activities or acquisition, there is usually no need to conduct a Phase II investigation. However, it is important to remember that consideration must be given to contaminated soils and groundwater that may be encountered during construction from sources outside the project boundaries.

The following is a generalized rating system that can be used to determine the need for Phase II environmental site investigations.

Very Low Potential for Project Impact

No further assessment needed. After a review of all available information, there is no indication that contamination would affect the project or health and safety of workers. An example of this would be a gas station that has undergone assessment and has been closed, or no further action is required by TNRCC, and there is documentation that no contamination exists. Another example would be a closed facility that stored hazardous material in sealed containers with no record of violation or indications of releases. It should be noted that a closed facility does not necessarily indicate that no contamination exists.

Low Potential for Project Impact

No further assessment is needed. Contamination may exist, but there is no reason to believe there would be any involvement in the project. After review of all available information, there is no indication that there would be any involvement with contamination or the contamination, is very limited and proven not to extend beyond the site. This would be a site that may contain hazardous material within its boundaries but is managed appropriately.

An example would be an operating gas station which is in full compliance with regulations, or an operating facility that stores hazardous material and is in full compliance with no record of releases that affect off-site properties. This would also be a site where known contamination is reviewed and is below TRRP Tier 1 PCLs. It should be noted that special considerations during ROW acquisition of these properties may be required.

Medium Potential for Project Impact

Possible site investigation needed. After a review of all available information, documentation indicates that known contamination exists, but the problem does not require remediation or is undergoing remedial action, and continued monitoring is required. The details of remediation and the extent of contamination should be reviewed to evaluate if the property should be avoided or if it will impact the project.

An example of this would be an LPST site with known contamination that has undergone assessment and corrective action, and is being monitored or remediated. COCs detected at the site may exceed Tier 1 critical PCLs, but action is being taken by the individual responsible.

High Potential for Project Impact

Site investigation needed. After a review of all available information, there is a high potential for contamination problems to affect the project. Further investigation will be required to determine the actual presence or need for future action to address the contamination. Also, known contamination exists where there is no responsible party or action by individuals to assess or address the contamination.

An example would be a closed landfill or a gas station with known contamination that was closed and was not evaluated or assessed, or a gas station with known contamination that extends beyond the site and would affect the project. The contamination exceeds Tier 1 PCLs, and regulatory action is required.

After a review of all the available information, if it is determined that a Phase II investigation is needed, then the next step is to define the purpose and objective of the Phase II investigation.

PLANNING A PHASE II ENVIRONMENTAL SITE INVESTIGATION

Taking the time to plan before undertaking a Phase II environmental site investigation will ultimately save time, money, and improve the effectiveness of the investigation activities. Effective planning steps prior to undertaking a Phase II environmental site investigation should generally include:

- determining the purpose and objective of the investigation;
- reviewing existing information, site conditions, and limitations;
- developing a conceptual model of the site/area;
- developing a work plan, or scope of work; and
- establishing project management and budget guidelines **(5)**.

The following checklist summarizes the recommended Phase II environmental site investigation process. A more detailed discussion and review of the various steps are presented in the research report.

PHASE II ENVIRONMENTAL SITE INVESTIGATION PROCESS CHECKLIST

STEP 1 EVALUATE SITE TO DETERMINE IF PHASE II IS NECESSARY

☐ Screening Evaluation for Phase II
__Very Low Potential for Project Impact - No further assessment needed.
__Low Potential for Project Impact - No further assessment is needed.
__Medium Potential for Project Impact - Possible site investigation needed.
__High Potential for Project Impact - Site investigation needed.

Project Comparison Matrix

Potential for Project Impact	Alternative A Site _____	Alternative B Site_____	Alternative C Site_____
High			
Medium			
Low			
No			

STEP 2 PLANNING A PHASE II ENVIRONMENTAL SITE INVESTIGATION

☐ State the Purpose and Objective:_____
☐ Review Existing Information, Site Conditions, and Site Limitations
__ Previous Phase I Reports
__ Regional/Site Setting and Previous Phase II Reports
__ Other Reports
__ Regulatory Review
__ Existing Site Conditions & Receptor Survey
__ Identify Site Limitations, Contaminant Concentrations and Distribution

STEP 3 DEVELOP A CONCEPTUAL MODEL FOR THE STUDY AREA

☐ Background concentrations and PCLs
☐ Source(s) of contamination
☐ Migration pathways (groundwater, surface water, soil, biotic pathways)
☐ Factors affecting contaminant transport (including direction and rate)
☐ Potential receptors (human and ecological)

STEP 4 DEVELOP A SCOPE OF WORK

- ☐ Provide a general description of the proposed project.
- ☐ Provide the type of investigation to be undertaken (subsurface, surface, multi-media).
- ☐ Describe the methods of investigation to be used
  - __equipment to be used (Direct push - Geoprobe, GPR, rotary auger, etc.)
  - __expected size and depth for the installation of soil borings
  - __size, construction, and completion of wells

- ☐ Present a sampling plan or strategy (also see data quality objectives process)
  - __analytical methods and parameters
  - __frequency and depth of samples
  - __chemical analysis - analytical parameters for samples
  - __allowances and contingencies for additional sampling

- ☐ Prepare an action plan for unexpected conditions including:
  - __who makes the field decisions - name and contact of field supervisor
  - __who should be notified of unexpected conditions / emergencies
  - __ maximum dollar amount of additional work resulting from unexpected conditions

- ☐ Schedule for completion of work
  - __working hours
  - __access schedule

- ☐ Baseline assumptions of expected conditions and responsibilities
  - __responsibility for regulatory notifications
  - __responsibility for locating utilities
  - __responsibility for disposal of wastes
  - __site access
  - __safety plan

- ☐ State the desired report format
  - __establish the information to be reported
  - __establish the regulatory body or intent the report should be used for
  - __state the purpose of the report, why it is being prepared
  - __establish the number of copies of the report needed
  - __determine who will receive the report
  - __determine how may additional copies of the report are needed
  - __determine the need for review or draft reports

- ☐ On-site kick-off meeting prior to mobilization (if appropriate)

STEP 5 CHARACTERIZE THE SITE - COLLECT SAMPLES & DATA

☐ **Soil Assessment**
- ☐ Method of obtaining sample
- ☐ Soil description and characteristics
- ☐ Chemical constituents analyzed for the COC (e.g., benzene, toluene, etc.)
- ☐ Geotechnical analysis (e.g., bulk density, fraction organic carbon, etc.)
- ☐ Soil samples from the following depths:
  - 0-2 feet if affected soil is not covered
  - 2-15 feet
  - greater than 15 feet (if depth to water is less than 15 feet)
- ☐ Percent of affected soil zone covered with impervious cover
- ☐ Public access to the affected surface soil (0-2 feet) that is not covered
- ☐ Affected soil zone thickness
- ☐ Affected soil zone surface area dimensions
- ☐ Maximum depth of contamination exceeding appropriate screening levels (PCLs)
- ☐ Estimated volume of soil exceeding screening levels (PCLs)
- ☐ Distance from affected soil zone to property boundary
- ☐ Distance contaminated soil extends beyond property boundary

☐ **Groundwater Assessment**
- ☐ Method of sampling
- ☐ Description of water bearing zone
- ☐ Number of wells sampled, screened interval, well construction
- ☐ Chemical constituents analyzed for the COC (e.g., benzene, toluene, etc.)
- ☐ Depth, base, and thickness of water bearing zone
- ☐ Distance from edge of plume to property boundary
- ☐ Areal extent of water bearing zone
- ☐ Groundwater quality/total dissolved solids
- ☐ Groundwater Classification (Category 1, 2, or 3)
- ☐ Inorganic parameters (e.g., dissolved oxygen)
- ☐ Aquifer type (perched, confined, unconfined)
- ☐ Water level fluctuations
- ☐ Gradient (ft/ft)/direction
- ☐ Saturated hydraulic conductivity (ft/day)
- ☐ Approximate well yield (gpd)
- ☐ Geologic Formation/major/minor aquifer name

STEP 5 CHARACTERIZE THE SITE (CONTINUED)

☐ **Surface Water Assessment**
- ☐ Surface water samples should be collected when contaminant migration is known or suspected to affect a surface water body, especially if the project may use or impact surface waters.

☐ **Receptor Survey**
- ☐ Identify potential receptors and exposure pathways
- ☐ Field survey and a water well records inventory
- ☐ Migration pathways

☐ **Ecological Risk Assessment**
- ☐ Provide a description of the area and the nature of the release
- ☐ Identify environmental media known or suspected to contain COCs
- ☐ Provide the information for the nearest surface water body
- ☐ Identify where COCs have migrated via runoff or groundwater discharge
- ☐ Identify the affected property
- ☐ Identify COCs are in the soil below the first 5 ft beneath ground surface or barriers that prevent migration

STEP 6 EVALUATE DATA AND REFINE CONCEPTUAL MODEL

- ☐ Data objectives are met; screening samples are verified
- ☐ Regulatory objectives and requirements are met
- ☐ Conceptual model is complete
- ☐ Additional sampling data is **not** needed
- ☐ Additional data/sampling is needed; return to **Step Four**

STEP 7 ISSUE REPORTS

- ☐ Issue Field Report
- ☐ Issue Final Report

As a general rule, more numerous sample points at a lower level of data quality can provide a better understanding of site conditions than fewer data points at a higher data quality level. As such, field screening can offer a bigger bang for the buck, especially when assessing large areas. The more quantitative the analysis, the lower the detection limit, the more accurate the results, and the more costly the analysis is to perform.

Consider using the Data Quality Objectives (DQO) process as a tool to select the appropriate mix of qualitative (screening) and quantitative (laboratory analysis) methods. Also, consider using or incorporating aspects of the Dynamic Workplan process. DQO and the Dynamic Workplan process are reviewed in the research report.

CHAPTER THREE - SITE INVESTIGATION TECHNOLOGY

GEOPHYSICAL SURVEYS

Geoscientists have developed many tools to characterize surface and subsurface features that have become an integral part of environmental site investigations. Geophysical methods that were initially developed for mineral exploration have been adapted for use in engineering and environmental applications. Many geophysical methods are found to be increasingly useful in environmental site characterization, hydrogeolgic investigation, and remediation of contaminants. The primary use for surface geophysics includes the location or identification of relatively shallow features such as shallow groundwater, buried objects (i.e., tanks and drums), buried infrastructure and utilities, and contaminant plumes. The research report discussion summarizes the most commonly used geophysical survey technologies used in environmental assessment and site investigation.

Of the geophysical survey methods presented, the most commonly used are electromagnetic conductivity (EM) surveys, resistivity surveys, and ground penetrating radar (GPR). This is primarily because of the relatively lower cost in comparison to other geophysical methods such as seismic survey methods. Additionally, EM, resistivity, and GPR are relatively mature technologies that are not intrusive and have broad applicability. These methods also typically do not generate waste or require extensive decontamination or equipment mobilization.

Most, if not all, geophysical methods should be used as a screening method that will ultimately need to be verified with an intrusive method of site characterization, such as conventional drilling and sampling. However, geophysical methods have the advantage over conventional search and find techniques because they can gather large amounts of data over broad areas and, in many cases, do so more rapidly than conventional methods. The geophysical methods listed here can provide a larger picture of a site's condition in advance of more detailed investigation.

Table 2 presents a comparison of geophysical methods commonly used in site investigations. A more detailed discussion is available in the research report.

Table 2.
Comparison Matrix of Geophysical Survey Methods for Environmental Site Investigation.(6)

	Terrain Conductivity (EM)	Metal Detection	Resistivity Methods	Ground Penetrating Radar (GPR)
Uses	Map contaminant plumes, locate buried conductive items, locate landfills, trenches	Locate buried ferrous metal objects	Measure bed thickness, Map contaminant plumes, location of aquifers	Locate buried objects, utilities, map lithology, fractures, locate landfills
Advantages	Fast, easy, portable, fair penetration, commonly used, relatively inexpensive	Fast, easy, portable Works in clay rich soils Relatively low cost	Good lateral/vertical resolution, Good penetration	Fast, relatively easy, portable, relatively inexpensive
Disadvantages/ Constraints	Affected by power lines, fences, utilities, other metal objects	Affected by concrete re-bar, fences, utilities, other metal objects	Labor intensive, buried pipes, metal fences, rugged topography	Not suitable in clays and wet clays, need smooth surface
Suitable for Metallic waste	Yes	Yes	Sometimes	Usually
Suitable for Inorganic Waste	Yes	na	Yes	Sometimes
Suitable for Organic Waste	Sometimes	na	Sometimes	Sometimes
Suitable for Inorganic Plumes	Yes	na	Yes	Sometimes
Suitable for Organic Plumes	Sometimes	na	Sometimes	Sometimes
Suitable for Site Geology	Yes	na	Yes	Yes
Suitable in Clayey Soils	Usually	Yes	Yes (depends on objective)	Seldom
Penetration	Depends on coil spacing (.5 to 60 m typical)	Typically 6-20 m	Depends on spacing (typically 2-30 m)	Typically 1-10 m
Resolution	Excellent lateral resolution. Vertical good, except thin layers	Good ability to locate targets	Good vertical resolution	Excellent resolution
Cost Relative to 1 Day of Drilling*	Slightly more	Usually same or less	Usually more	Slightly more

*Geophysical survey costs are generally equivalent to drilling when considering that geophysical surveys can collect more data over a greater area, but one should weigh the relative costs and benefits of any investigative method. Source: 1998 SAGEEP - Introduction to Environmental and Engineering Geophysics, notes by J. Greenhouse, P. Gudjurgis, and D. Slane.

SOIL & GROUNDWATER INVESTIGATION TECHNOLOGY

Most conventional soil investigation techniques involve the use of an auger to advance the drill string and sampling tools. In the past several years, a soil investigation method commonly referred to as "Direct Push" has become more common in environmental site investigations. This method hydraulically "pushes" small diameter hollow steel rods and measuring devices into the ground without the use of drilling augers to remove soil or to make a path for the tool. It can be used in most materials that can be augered or sampled with a split spoon. Direct push equipment relies on a relatively small amount of static weight combined with percussion/vibration as the energy for advancement of a tool string in contrast to use of conventional rotary augers. This technique is sometimes referred to as a Geoprobe, or Enviro-Core, after the manufacturers of the most commonly used direct push devices.

Direct push can drive tools to obtain continuous soil cores, discrete soil and groundwater samples, soil vapor samples, or advance a variety of sensory probes. The maximum penetration depth is 30 m (100 ft), but in most cases, the probes used penetrate to depths of 9-18 m (30-60 ft). Penetration can be limited by hard or dense formations, boulders, gravels, or massive bedrock in the subsurface. Direct push works best in unconsolidated materials such as soils, clays, sands, and alluvial deposits.

The advantages of direct push include:

- It is accepted as a good preliminary screening tool and can collect representative soil and groundwater samples.
- Its commercial availability is widespread at a relatively low cost.
- No drill cuttings are produced during probe advancement and, therefore, waste disposal from soil investigations is minimized.
- Probing and sampling is performed as fast or faster than conventional auger drilling.
- Smaller holes are created by the probes, so grouting is faster and easier.
- A variety of sampling and sensory tools are available to help analyze the subsurface conditions.

The limitations of direct push include:

- It provides one-time samples only.
- It cannot be used in very gravelly or dense consolidated formations.
- Samples must be taken 1 m (3-5 ft) below the water surface, meaning LNAPLs might be missed if floating near the surface.
- Small diameter well screens may be hard to develop and/or not representative in response to regulatory requirements.

There are four commonly used products in direct push technology:

- Direct push soil sampling,
- Direct push water sampling,
- Cone Penetrometer Testing (CPT), and
- Laser Induced Fluorescence (LIF).

Soil samples are collected by driving small diameter casing with an inner sample barrel. Continuous soil samples can be collected using either plastic or steel sample liners. Water sampling can be accomplished through temporary or permanent well installation with direct push technology. The well is assembled and installed through the probe rods and constructed with prepacked screens and well riser. Conventional flush-mount or aboveground well protection can be installed, or temporary wells can be removed and the holes grouted. Temporary type wells can provide accurate water level measurements and can be used as observation wells during aquifer pump tests, in most situations. When installed properly, these small diameter wells generally meet regulatory requirements for a permanent monitoring well.

Other CPT applications include the use of EM induction, resistivity, and SP- self potential in downhole tools. These tools use the same basic principles as the surface geophysical surveys except they may enhance penetration, resolution, and ease of operation.

Cone Penetrometer Testing (CPT)

The cone penetrometer is a truck-mounted sampling device used to penetrate the ground to collect samples. Although used in geotechnical investigations for many years, CPT is relatively new in environmental applications. CPT typically consists of an enclosed 20-40 ton truck with vertical hydraulic rams used to force a sensor probe into the ground, although some CPT equipment can be mounted on lighter weight trucks. The trucks are equipped with a computer and data, and signal processing equipment. CPT works best in soft soils, whereas hard consolidated materials and gravels are problematic. Sampling cones allow for in-situ sampling of liquids and gases. The operational cost is moderately expensive ($3,000 per day) depending on the array of sensors used during the investigation. Although the cost is somewhat more than conventional drilling, samples are available very quickly; real time data is achievable, and the amount of waste generated is small compared to drilling (**7**). Similar to direct push, there are several benefits to using CPT:

- CPT is less intrusive than conventional drilling because the CPT hole is relatively small, and there are no drill cuttings to dispose of.
- Decontamination of the push rods is easier than conventional drilling.
- A grout-pumping system allows grouting of the CPT hole through a port in the cone tip as the penetrometer probe and push rods are withdrawn.

Soil Gas Measurement

There are several procedures that can be used to analyze soil gas in order to detect volatile organic compounds (VOCs) in the substrate. Soil gas surveys are an effective way to screen and map the extent of VOCs, particularly low molecular weight halogenated compounds (solvents). All of the soil gas measurement techniques should be used as a screening tool. They can be used to measure relative quantification of volatile COCs but are generally not suitable for a definitive quantification, in most cases. However, in some cases, soil gas measurement is the only practical means to acquire data, such as when the size and shape or density of the soil and rock in the subsurface prevent the use of coring devices **(8)**.

On-site analysis of soil gas can be made using a field gas chromatograph (GC), photo-ionization detector (PID), flame ionization detector (FID), organic vapor analyzer (OVA), or even less sensitive combustible gas detectors. Soil gas samples can be collected in "tedlar" bags or containers for transport to a laboratory for analysis on conventional GC or mass spectrometer (MS). As with most analytical techniques, the greater the accuracy and sensitivity, the higher the cost and data quality. Field measurements do not typically yield absolute values but are useful for obtaining relative values used in the screening process, whereas, laboratory analysis yields a higher level of data quality that is defensible **(9)**.

Soil gases generally follow the path of least resistance and diffuse directly upward, and to some extent laterally from the source. VOCs exist in soils in either a gaseous phase, liquid (dissolved) phase, or solid (adsorbed) phase. The phase distribution is controlled by the VOC's physiochemical properties such as solubility (Henry's Law constant), soil properties, and environmental variables (temperature, water content, organic carbon content) **(9)**.

Soil vapor surveys can be affected by soil and atmospheric conditions at the site, so caution must be exercised when interpreting the results. The composition of vapor measured in any particular location may not be representative of the typical soil mass at nearby locations because of varying diffusion rates, sorption rates, soil composition, oxygen and carbon dioxide content, and other physical parameter in the soil. Atmospheric conditions, moisture content, and soil composition may not only affect soil physical properties that influence soil gas measurement, but they may also affect some of the instruments used to detect the soil gases. The use of field FID and PID instruments are rapid and economical means for measurement but only yield a reading in relative units and are highly dependent on their calibration and, in many instances, weather conditions.

Soil gas survey data and headspace measurements from soil borings can be used to predict the occurrence of volatile soil gasses that may be encountered during construction and excavation. This can be a useful screening method to identify areas of concern where construction worker exposure will likely occur and estimate concentrations. However, it may not be possible to precisely predict if Occupational Safety & Health Administration (OSHA) permissible exposure limits (PELs) will be exceeded based on soil gas data from soil borings prior to construction.

Soil gas surveys, just as other investigative techniques, may require more planning and a detailed scope of work to ensure the desired outcome. When considering the use of a soil gas survey and developing a scope of work for soil gas surveys, it may be helpful to refer to ASTM D5314-92 *Standard Guide for Soil Gas Monitoring in the Vadose Zone*, ASTM D4700-91 *Standard Guide for Soil Sampling from the Vadose Zone*, or ASTM D5730-96 *Standard Guide for Site Characteristics for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone and Groundwater.*

Table 3.
Common Soil Gas Measurement Techniques.

Application	Uses	Methods	Benefits	Limitations
Soil Vapor Surveying	Identify sources and extent of gross contamination, distinguish between soil and groundwater contamination, detect VOCs beneath paved surfaces	Sampling from soil probes into canisters, bags, or direct measurement in soil using PID, OVA, FID, GC, etc.	Rapid inexpensive screening	False positives and negatives, missed detection of small spills, disequilibrium between adsorbed and vapor phase VOC concentrations
Soil Headspace Measurement	Able to screen large numbers of samples	Measure headspace above containerized soil sample, such as plastic bag, VOA vials, using PID, OVA, GC, etc.	More representative of adsorbed solid phase concentration	Losses of vapor phase component during sampling and sample transfer
Soil Core Screening	Soil cores are screened to locate depth where highest VOC levels are located	Collect core samples and scan for vapors near core surface using portable monitor	Convenient way to collect soil from "hot spots" in cores	False negatives and positives, environmental /weather condition can influence readings

Source: Boulding, R., Ed. 1996. EPA Environmental Assessment Sourcebook, Ann Arbor Press, 1996. (p. 260).

CHAPTER FOUR - RECOMMENDATIONS AND IMPLEMENTATION

RESEARCH RECOMMENDATIONS

Recommendations for additional research and technology transfer related to environmental site investigation include:

1. **Technology Transfer.** Additional technology transfer is needed in the use of risk-based site assessment and corrective action. This may take the form of a handbook, guidance, or seminar on the TRRP rules once they are implemented. The draft TRRP rules were released again in March 1999 and are due to become final in the summer of 1999.

2. **Streamlining and Integration.** Develop methods for streamlining environmental review and enhancing communication during project development between operational units of TxDOT and environmental consultants. Seek ways to minimize investigations and delays resulting from contamination throughout the entire life of a project by integrating a conceptual model of the site into plans and specifications.

3. **Design and Construction.** Develop improved design and construction methods for projects occurring in contaminated environments in order to minimize project impacts, prevent contaminant migration, and limit exposure to contaminants. This is being explored in project 7-3998 relating to storm sewer construction in contaminated environments.

4. **Encourage Innovative Methods**. Encourage the use of innovative site screening devices and methods by contractors and consultants conducting site investigations. When appropriate, geophysical methods, mobile laboratories, and use of CPT may save time and money on site investigations.

5. **Continue Communication.** Continuous communication among the various participants involved in the site investigation process allows each party to improve the final product. Meet with consultants and contractors to facilitate the sharing of experiences and lessons learned from performing environmental assessments and site investigations. As TRRP is implemented, confer with consultants and contractors conducting site investigations to improve the scopes of work and work products.

IMPLEMENTATION RECOMMENDATIONS

Recommendations for implementation of research from this report include:

1. **Workshops and Training Courses.** In cooperation with TxDOT and other state agencies/universities, conduct informational half-day workshops and training on the use of risk-based assessment and site investigation processes at selected district offices. These workshops could be conducted in conjunction with project 0-1807: Development of a Risk-Based Manual for the Use of Contaminated Material in Highway Construction. Projects 0-1806 and 0-1807 have very similar regulatory and site characterization requirements for conducting assessments under TRRP.

   The products from both projects 0-1806 and 0-1807 could be produced on CDROM and distributed in a cost effective manner.

2. **Technical Assistance.** TxDOT, in cooperation with other state universities/agencies, could provide technical assistance to districts planning or conducting Phase II environmental site investigations. The technical assistance could include:
   - reviewing/developing scopes of work for site investigations,
   - reviewing proposals for site investigations,
   - reviewing proposals for, or the results of, site investigations using new technologies, or
   - preparing plan notes and/or specifications for construction activities in contaminated sites.

3. **Proposals and Scopes of Work**. Use proposals and/or scopes of work for phase II investigations as information resources and opportunities to develop the conceptual model of the site. Place a greater emphasis on planning and detail when preparing either scopes of work for Phase II site investigations, or for consultant-prepared proposals. The proposal preparation and/or scope of work preparation provide an excellent venue and opportunity to conceptualize the site, communicate site information, and identify future site needs. Allow more flexibility in proposals and scopes of work for Phase II investigation by incorporating contingency plans, "if-then" scenarios and alternatives so that some decisions can be made in the field to reduce mobilizations and visits to the site. Allow for greater decision-making ability in the field.

4. **Enhanced Plans and Specifications.** Incorporate a summary of site specific environmental concerns into plans and specifications to include the identification and location of contamination as well as sensitive receptors. This can be accomplished through the use of special plan notes or a dedicated plan sheet(s) with a representation (conceptual model) of affected areas. Additionally,

contingency plans could be incorporated into the specifications that can be implemented upon the discovery of contamination.

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