AUTOMATED ENHANCED PHASE I ENVIRONMENTAL SITE ASSESSMENT PROTOCOL

By

MD MAHMUDUR RAHMAN

Bachelor of Science

Mechanical Engineering

Bangladesh University of Engineering & Technology

Dhaka, Bangladesh

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1997

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SITE ASSESSMENT PROTOCOL

Thesis Approved:

Will Fisher
Thesis Advisor

Gregory G. Wilber

Thomas C. Collins
Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Dr. Will Focht, my thesis advisor, for his support and encouragement during this research project. His guidance and friendship has been vital to my professional development in the environmental risk assessment field over the last two years. His insight and experience have provided huge learning opportunities for me that one can not be found in any classroom.

This thesis is a part of on-going joint research project conducted by Dr. Will Focht, and Nomadics Inc., Stillwater. There are many to whom I am indebted in support of this research. I wish to express my gratitude to Colin Cumming, President, Nomadics Inc. and Joel Roark, Nomadics, principal investigator of this research, for providing the hand-held environmental site characterization device and PC cards which were essential for this research. I am grateful to Andy Olson, computer software specialist at Nomadics for his support in this research project. I also thank Mark Gregory, an expert in geographical information systems and global positioning system technologies for helping us in selecting the GIS system and in generating numerous maps for the field demonstration.

I owe a special debt of gratitude to Wibb Truby, an expert in ESA for looking at the forms I developed. His professional advice and valuable suggestions helped me to fill the voids within the forms.

I wish to thank Dr. Wayne Turner, Professor of School of Industrial Engineering and Management and Gregory Wilber, Assistant Professor of School of Civil and Environmental Engineering for their valuable suggestions and advice during this research project.

I am grateful to Professor Zuhair Al-Shaieb, head of the School of Geology for allowing me use of the various facilities of the department. Thanks to Rachel Jackson, Master student, in

the School of Geology and Roya, Master student, in Environmental Engineering for their assistance in this research project.

Most of all, I wish to express my gratitude to my family, for their support and love they have provided as I have pursued my aspirations at OSU. They have always encouraged me to never to settle for less than my best.

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NOMENCLATURE

ASCE	American Society of Civil Engineers
ASGWR	Association of Ground Water Scientists and Engineers
AST	Above-ground Storage Tank
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BRAC	Base Realignment and Closure Program
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act (also known as Superfund)
CERCLIS	CERCLA Information System
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulation
CWA	Clean Water Act
DLL	Dynamically Linked Library
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DGPS	Digital Global Positioning System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERNS	Emergency Response Notification System List
ESA	Environmental Site Assessment
ESA	Endangered Species Act

FR	Federal Register
GIS	Geographic Information System
GPS	Global Positioning System
HA	Hazard Assessment
HH&E	Human health & the environment
HHWE	Human health, welfare and the environment
HM	Hazardous Material
HMTA	Hazardous Material Transportation Act
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
HW	Hazardous Waste
ISO	International Organization for Standardization
IRIS	Integrated Risk Information System
MSDS	Material Safety Data Sheet
NAS	National Academy of Science
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Regulatory Commission
O/O	Owner /Operator
OSHA	Occupational Safety and Health Act
OTA	Office of Technology Assessment
PA	Preliminary Assessment
PCB	Polychlorinated biphenyl's
POC	Point of Compliance
POD	Point of Departure
POE	Point of Exposure

POTW	Publicly-owned Treatment Works
PR	Preliminary Review
PRP	Potentially Responsible Party
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfC	Reference Concentration(Inhalation)
RfD	Reference Dose (Oral)
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEC	Security and Exchange Commission
SI	Surface Impoundment
SI	Site Inspection
SOP	Standard Operating Practice
STTR	Small Business Technology Transfer Research
SWDA	Solid Waste Disposal Act
TSCA	Toxic Substance Control Act
TSD	Treatment, Storage or Disposal
UIC	Underground Injection Control Program
USC	United States Code
USCA	United States Code Annotated
UST	Underground Storage Tank
USGS	United State Geological Survey
VOC	Volatile Organic Compound
WP	Waste Pile

CHAPTER ONE

LIABILITY ASSOCIATED WITH PROPERTY TRANSACTION

1.1 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9607 (a)), enacted on December 11, 1980, requires the federal government, through the Environmental Protection Agency (EPA), to clean up sites contaminated with hazardous substances. CERCLA created a Hazard Response Trust Fund, commonly referred to as the Superfund, to pay for remediation of hazardous substance contamination at abandoned sites, or in emergency situations. A threat to human health, welfare or the environment must exist to justify CERCLA action. EPA has authority to conduct investigations and response actions with Superfund trust money. Cost recovery under CERCLA is authorized by Section 107. Section 106 allows treble costs under an enforcement order, if a PRP will not pay, and EPA proceeds with remediation that is justified by showing a imminent and substantial endangerment (Focht 1992).

A recent Superfund cost estimate by researchers at the University of Tennessee shows that the ultimate cleanup cost for the most threatening sites, based on current cleanup policy requirements, will range from $102 to $306 billion, depending on whether 2100 or 6300 sites need to be remediated, excluded administrative and transaction costs (Russell and et al 1991). As government funds are limited, most of the costs will be deferred to potentially responsible parties.

Under CERCLA, there are five classes of parties who may be responsible for cleanup costs. A "Potentially Responsible Party" (PRP) may be any of the followings (Hess 1993):

1) current owners and operators

2) previous owners or operators who were present at the time the hazardous substance contamination occurred

3) intervening owners who had knowledge of the presence of hazardous waste and failed to disclose this information to the prospective buyer;

4) hazardous waste generators who arranged for the disposal of hazardous substances to the property; and

5) persons who accepted hazardous substances for transport to facilities which resulted in a subsequent release.

Current public policy dictates that cleanup costs should be borne by all those presently and previously connected with a property and those engaged in activities resulting in contamination of property.

Under CERCLA, liability for a site cleanup is strict, joint and several, and retroactive. Under "strict" liability, property owners may be liable for cleanup costs, even if they had only minor involvement with contaminating the property. For example, ignorance of a preexisting or ongoing occurrence is not a defense.

Under "joint and several" liability, the liability may be shared by one or several parties, including owners, operators, transporters, and waste management companies. Any or all persons involved, both directly or indirectly, may find themselves sharing the liability, irrespective of their relative degree of contribution to the overall threat posed by the site.

"Retroactive liability" means that any party who owned or conducted business on the property at the time the contaminants were disposed of may be held liable for cleanup costs regardless of when the release occurred. The same holds true for intervening landowners. If a landowner has knowledge of contamination and does not disclose it upon selling the property, he may be held liable for cleanup costs along with all others found to be responsible.

CERCLA was re-authorized on October 17,1986 by the Superfund Amendments and Reauthorization Act (SARA). This law responded to concerns that property buyers and lenders could be held liable for Superfund cleanups even though they had no knowledge that the property was contaminated and had nothing to do with the operation of the property at the time of the contamination. These are addressed in the next section.

1.2 CERCLA Liabilities

SARA Title I addresses defenses against liability under Superfund. A buyer or lender can utilize any of these defenses against liability for environmental remediation.

Third Party Defense: An owner may be able to prove that a third party placed hazardous substances on the property. An owner cannot utilize this defense if the third party has a "contractual relationship, existing directly or indirectly, with the defendant" (42 USC 9607 (b)(3)). The term "contractual relationship" has been interpreted broadly, including deed transfer, therefore this defense is narrow.

If a person assessed a property for environmental contamination prior to purchase, the report could support the third party defense. The owner will not be held liable, if he can establish by a preponderance of the evidence that the contamination was caused solely by an act or omission of a third party (O'Brien 1989).

Innocent Landowner Defense: Under 42 USC 9601 (35) (A), SARA provides that a landowner will not be considered to be in a contractual relationship with the previous owner if : (O'Brien 1989, p. A12)

"(i) At the time the [landowner] acquired the facility the [landowner] did not know and had no reason to know that any hazardous substance which is the subject of the release or threatened release was disposed of on, in or at the facility.

(B) To establish that the [landowner] had no reason to know, as provided in clause (i) of subparagraphs (A) of this paragraph, the [landowner] must have undertaken, at the time of acquisition, all appropriate inquiry into the previous ownership and uses of the property consistent with good commercial or customary practices in an effort to minimize liability. For purposes of the preceding sentence the court shall take into account any specialized knowledge or experience on the part of the [landowner], the relationship of the purchase price to the value of the property if uncontaminated, commonly known or reasonably ascertainable information about the property, the obviousness of the presence of contamination to the property, and the ability to detect such contamination by appropriate inspection."

SARA Due Diligence Clause:. The opportunity to utilize an innocent landowner defense poses the challenge of proving that inquiry was performed prior to purchase. What methods and procedures are reasonable? This issue was examined by the courts in U.S. v. Louis Serafini. The defendants purchased a property in 1969, which had been used as a landfill and waste disposal site. In 1983 the EPA removed more than 1,100 drums of hazardous waste from the site and filed suit against the owners to recover the cleanup costs. The defendants claimed to be innocent landowners and that they had not caused or known of the contamination.

The government presented evidence that at the time of purchase the land was visibly contaminated, with hundreds of drums on the surface. The defendants stated that they had not inspected the site prior to purchase, having relied upon maps and records to evaluate the land. Furthermore, the defendant claimed that it was not "customary and good commercial practice" to field inspect a property in 1969. They claimed not to have been aware of the wastes until EPA began an investigation in 1980.

The government argued that a buyer can not close his eyes to contamination, fail to inspect and then claim to be an innocent landowner. Government witnesses testified that in 1969, no reasonable purchaser of commercial property would have neglected to make a site inspection prior to purchase. The issue was whether the defendant's failure to inspect the property prior to purchase was inappropriate and therefore rendered the innocent landowner defense useless. Attorney James P. O'Brien's analysis of this case notes that, "Importantly, the court did apply the innocent landowner provision as it was contemplated by the statute. Even though the court held that it was conclusively established that the drums were visible at the time of acquisition, the court focused on whether the defendant's inaction was appropriate inquiry under the statute." (O' Brien 1989)..

The legislative history behind the innocent landowner defense is outlined in the Congressional Conference report to SARA, noting that;

> The duty to inquire under this provision shall be judged as of the time of acquisition. Defendant shall be held to a higher standard as public awareness of the hazards associated

with hazardous substance releases has grown, as reflected by this Act, the 1980 Act and other federal and State Statutes.

> Moreover, good commercial or customary practices with respect to inquiry in an effort to minimize liability shall mean that a reasonable inquiry must have been made in all circumstances, in light of best business and land transfer principals (H. R. Conf. Rep. No. 962, 99th Cong. 2d Sess. 186-187 (1986)) (BNA 1989, p. A-15).

Environmental site assessments can provide "good commercial or customary practices" which will reduce the possibilities for liability claims and cleanup costs. Besides, environmental site assessment can help any purchaser to prove that an environmental hazard can be attributed solely to contamination which existed prior to the date of his/her acquisition, if he/she wants to be considered an *Innocent Landowner* under CERCLA.

1.3 Parties involved in Environmental Site Assessment

The purpose of environmental site assessments depend on the client's association with the property. The client may be a (1) seller, (2) buyer, (3) lender, (4) lessor/lessee, (5) broker representing a buyer or seller, or (6) corporate shareholder. They all seek to determine the probability that the property is or can become a liability due to hazardous substances on and/or associated with the property, and some may seek to be informed as to environmental factors which could restrict land use and development. Reasons for performing environmental real state audits vary with the perspective of the parties involved in any property transfer. The following describes the different vested interests of the parties involved in a property transaction.

Perspective of a Buyer: A buyer desires to avoid acquiring contaminated property, which could result in an expensive clean-up, along with indeterminate legal liability and loss of property use. If a buyer desires the property after knowledge of contamination, the buyer needs to establish extent and severity of contamination by the time of closing the purchase. The buyer may wish to use this information to negotiate a lower price, force disclaimers into the contract, or establish a shared responsibility for remedial action. The buyer may use an environmental site assessment to establish the property's condition at the time of changing ownership.

Perspective of a Seller: A seller also desires that needs for the environmental condition of the property be established at time of transfer so that the seller will not be held liable for contamination that occurs after the sale. This type of report is called a baseline environmental assessment. The seller also may desire an environmental real estate audit to document a property's clean conditions to improve its marketability and enhance its value.

Perspective of a Lender: Any party that serves as a lender in a property transaction should require an environmental real estate audit. A lender's risk is created by holding a secured interest in the property (BNA 1989). Should a borrower default, the lender may be forced to foreclose and thereby become an owner of the property. Without having performed a due diligence investigation, the lender becomes liable for environmental contamination just like any other owner.

Lessor and Lessees: Lessors have no exemption from liability merely because the property is leased to a lessee who is actively contaminating the land. The lessors are exposed to strict liability for environmental contamination as a result of activities of their lessees. If the lessee is financially unable to bear the costs for cleanup, the problem reverts to the lessor. Therefore, ESA should be performed for the site before leasing it to the lessees.

Brokers: Brokers do not have liability under CERCLA or state Superfund laws if acting solely in the capacity of a broker. However, brokers have a professional duty to inspect and disclose. Under this premise, they may be held liable where environmental matters have not been handled properly during a real estate transaction.

Real estate brokers must obtain extensive disclosures from the seller regarding the seller's knowledge of the condition of the property as to both environmental and other matters. The broker also has a duty to inform the parties to a transaction of the existence of environmental laws and concerns. He is obligated to inform the buyer of any potential problems found during a property inspection.

Corporate Officers, Directors, Shareholders and Successors: Corporate structure has traditionally been used as a means for limiting the liability of shareholders. The shareholders

risk loss of their stock investments, but have no personal liability if the assets of the corporation are insufficient to satisfy obligations.

The corporate structure, however, does not provide protection against direct liability for one's own breach of civil or criminal law. Unlawful conduct by an individual shareholder is not shielded by the corporate veil. Operators of contaminated real estate can obviate the corporate shield. Strict liability for cleanup of hazardous substance releases is imposed on operators of contaminated property and on others who operated the property at the time of disposal. "Operators" may include corporate officers, employees, and shareholders who manage or operate the property.

1.4 Uses of Environmental Site Assessment

Environmental site assessments have been increasingly incorporated into various environmental programs everywhere. Because of public sentiment concerning environmental hazards and growing Congressional interest in risk-based decision making, the practice of environmental site assessment has grown explosively during the last ten years. The uses of environmental site assessments (ESAs) in different federal and public sector programs are discussed in the following paragraphs.

Site assessments are now conducted under a number of federal programs (Roark and Focht 1996). For example, as part of the Superfund ((CERCLA) sections 104 and 106) remedial response action program, specifically the preliminary assessment/site investigation (PA/SI) and remedial investigation (RI) phases (EPA 1989a, 1989b, 1992) environmental site assessments are performed. The Agency for Toxic Substances and Disease Registry (ATSDR) in the Public Health Service, U.S. Department of Housing and Human Services, is mandated by CERCLA to conduct health assessment at all National Priorities List sites (NPL) sites and to develop toxicological profiles of CERCLA hazardous substances for use in site assessments under Superfund. Similarly, the Resource Conservation and Recovery Act (RCRA) corrective action program under sections 3004(u), 3004(v), 3008(h), 3013, and 7003, particularly in the RCRA facility assessment (RFA) and RCRA facility investigation (RFI) stages, included site assessments (see proposed regulations at 40 CFR 264 Subpart S). RCRA section 3019 requires

environmental site assessments under its exposure information and health assessments provision. Under the National Environmental Policy Act (NEPA) section 102(2)(C), environmental impact studies are required which involve environmental site assessments (Henson 1993). Federal agencies involved in land management, such as the Department of Defense (DOD), the Department of Energy, and the Department of the Interior, also conduct environmental site assessments. DOD performs site assessments as part of its Base Realignment and Closure (BRAC) program.

The popularity of ESA exceeds beyond the boundaries of the United States. The international community is also rapidly moving toward the routine use of ESAs in business transactions. The International Organization for Standardization (ISO), based in Geneva, Switzerland developed a series of standards such as ISO's 14000 for performing environmental auditing and ESAs.

The expense of environmental cleanup has exerted extreme pressures on the private sector as well. ESAs are now conducted in order to identify environmental impairment liability as prerequisites for property, investment, and loan transactions.

1.5 Outline of this Research

The main objective of this research is to develop a handheld site characterization device in the conduct of environmental site assessments. Three different groups worked together in this research project. Nomadics Inc. was responsible for selecting hardware and software that are required for this project and developing various PC cards such as pH, video etc. Mark gregory, an expert in geographical information systems (GIS) and global positioning system (GPS) technologies was responsible to do research on GIS and GPS technologies; recommend the purchase of an efficient, effective and compatible paired system; develop expertise necessary for system operation and integration; oversees data entry to populate GIS database; and ensure successful demonstration of system performance. Dr. Will Focht was charged with the responsibility of developing a software package for performing Phase I environmental site assessments which will utilize the capabilities of all pen, mouse, keyboard, video, GPS and environmental sensors.

1.6 Contribution of OSU's Research Team

Environmental site assessments have become an integral part of routine government operations and private sector transaction (Roark and Focht 1996). Several guidance documents have been published to date on the performance of the environmental site assessments (e.g. Mikeska and Baldwin 1989; Marburg and Parkin 1991; AGWSE 1992; ATSDR 1994; Cahill and Kane 1994; and Sara 1994). Several organizations have also been founded which claim to certify environmental site assessors and auditors. Some efforts have been made for standardizing environmental site assessments. Foremost among these are the standards issued by the American Society for Testing and Materials (ASTM 1993a, 1993b, 1994, 1995).

Environmental Site Assessments have been guided by checklists developed by individual practitioners (e.g., Hess (1993) and Cooper (1996)), in response to agency guidance documents. More recently, attempts have been made to automate Phase I ESAs (Truby 1995 and MacNeill 1995)). It is very difficult to perform environmental site assessment using ASTM standards. Because ASTM standards are neither comprehensive nor complete. Furthermore, they are not sufficiently organized to guide the assessors for conducting ESAs efficiently. These problems in ASTM standards need to be solved and some more information needs to be added in ASTM standards in order to properly identify the conditions of the property. Because of all of these, environmental site assessment practiced to date, has been of variable consistency and dubious quality. The lack of consistency is due, in part, to the lack of a well-defined ESA protocol. The low quality is due, in part, to the failure of assessors to incorporate sufficient site-specific data into their environmental assessment. The objectives of this research are to develop a standard environmental site assessment protocol which will address the deficiencies in the ASTM standards and which contain enough information so that the assessor can accurately, effectively and efficiently assess environmental condition of the property.

There were three phases undertaken in this research project. During the first phase, OSU research team reviewed existing guidelines and standards to evaluate their adequacy and sufficiency at meeting the ESA performance standards. The team has selected several main

criteria for judging adequacy and sufficiency of any standard. Those criteria are discussed in the following section.

Comprehensiveness: An environmental site assessment standard should be comprehensive enough to be applicable to all sites and assessments.

Scope: An environmental site assessment standard should be broadly focused. Instead of focusing on particularized information, it should focused on each of the features or events so that the assessor can portray the actual condition of the site.

Completeness: An environmental site assessment standard should be designed in such a way it will aid the assessor to make a decision whether there is a recognized environmental condition at the site. According to National Academy of Sciences risk analysis paradigm (NAS 1983) and Focht (1995), five categories of information are required in order to define recognized environmental condition at the site. The categories include: source of releases, releases, pathways of migration, receptors and responses due to exposure form the releases. An environmental site assessment standard will be incomplete if it fails to include any of these five categories of information.

Organization: An environmental site assessment standard should be organized in such a way that it will be consistent with the assessment procedure and at the same time lead the assessor efficiently for conducting the assessment.

There are couple other criteria which include requirement of skilled and experienced assessors and cost to conduct the assessment were also considered during evaluating the standards.

During the second phase of this project, a standardized enhanced Phase I ESA site assessment protocol was developed. The ASTM standards were adapted as a foundation for the design of the protocol but was extended via incorporation of information from other guidance documents and the lessons learned in the field by site assessors. During development, the protocol attempts to improve upon guidance documents and standards which were retrieved during the first phase of the research project.

The third phase of this research was to automate the enhanced Phase I ESA protocol, developed in the second phase. An automated enhanced Phase I ESA was developed for loading into a user-friendly, field compatible, hand-held environmental site characterization device that guides the assessor in the conduct of a legally sufficient, technically competent, highly efficient site assessment process.

CHAPTER TWO

THE PRACTICE OF ENVIRONMENTAL SITE ASSESSMENT

2.1 Definition

Environmental site assessments (ESAs) are performed for commercial real estate transactions in order to evaluate a property's condition. ASTM (American Society For Testing and Materials) defines (ESA) as the process by which a person or entity seeks to determine if a particular parcel of real property (including improvements) has "recognized environmental conditions". According to the ASTM standards (E 1527 & E 1528), recognized environmental condition is the presence or likely presence of any hazardous substances on the site under conditions that indicate an existing release, a past release or a potential of releases of any hazardous substance into the structures or into the ground, groundwater or surface water of the property. This practice is intended to permit a user to satisfy one of the requirements to qualify for the innocent landowner defense to CERCLA liability. But to qualify the defense to CERCLA liability, a party has to prove that the release at the site does not threaten human health, welfare or the environment.. Therefore, recognized environmental condition should be defined as the presence or likely presence of any hazardous substances or petroleum products at a site which may threaten human health, welfare or the environment. So, ESAs can provide a measure of control and protection for owners, buyers, lenders, and other persons involved with properties. This control can facilitate in liability management, risk avoidance, positive business and public relations, and regulatory compliance.

2.2 Objective of Environmental Site Assessment :

Environmental site assessment is a good management tool. The purpose of ESA practices is intended to allow a responsible party to :

1. satisfy one of the requirements to qualify for the *innocent landowner defense* to CERCLA liability;

2. identify the hazard associated with the presence or likely presence of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property;

3. better understand liabilities of acquiring property with environmental problems;

4. avoid significant remediation costs;

5. minimize tort liabilities;

6. avoid acquiring environmental problems; and

7. establish baseline for protection.

2.3 Three Phases of ESA

Environmental site assessment is an investigatory procedure developed to guide documentation of the environmental condition of a property, as it exists at the time of the investigation. An environmental site assessment is typically conducted in three phases. Phase I generally involves a nonintrusive record search and site visit to determine the potential for significant onsite contamination and the regulatory, business, and exposure liability which may result from such a finding. The environmental professional will initially investigate a property through a review of archival data, then proceed to site investigation. An assessment should include a detailed examination of records developed by the property's prior owners and operators. The initial focus of an assessment is to determine if the potential for contamination exists. Documented information concerning the business(es) formerly occupying the site will aid in judging what types of potential contamination should be investigated.

Typically, the second phase of an environmental site assessment involves defining the extent and character of confirmed contamination. Sample collection followed by certified laboratory analyses of soil, water, sediment and groundwater, products, wastes, and unidentified materials are usually required. Geophysical investigation also may be employed, electrical resistivity and conductivity surveys can be used to locate buried metal, such as waste drums, and to delineate high chloride concentrations in groundwater.

The third phase of an environmental investigation entails remediation of contamination that was delineated. This may be a relatively minor activity, such as excavation and landspreading of contaminated soil. Conversely, site contamination may be extensive and complex, such as in Superfund cleanups, involving both soil and groundwater remediation. Costs for environmental cleanups vary widely, but can easily reach millions of dollars. Phase III ends with case closure. Several periods of sampling in which contaminant levels are shown to be acceptable are usually necessary prior to case closure. Currently, post-closure care is primarily an aspect of hazardous waste facility closure under RCRA. Expenses for post-closure care can be considerable due to the length of time required for competent closure control.

2.4 History of Environmental Site Assessment

The history of environmental site assessment began during 1977 as companies faced increasing environmental liabilities. It was originally performed as a part of environmental auditing. Environmental auditing was initiated by Security and Exchange Commission (SEC) enforcement actions against three large companies - the first against Allied Chemical Corporation in 1977, the second against United States Steel in 1979, and the third against Occidental Petroleum in 1980. Under SEC actions, each of these companies were required to determine their financial liability more accurately from environmental issues through a corporate-wide environmental auditing program. That audit program is often cited as a model for audits by other companies.

During that period, environmental auditing usually means environmental compliance auditing. More specifically, audits were done to ascertain whether a facility or operation was in compliance with applicable environmental laws.

Around 1979, EPA started promoting environmental auditing. Consultants began to sell the benefits of environmental auditing to numerous industries who were bewildered by the explosion of complex environmental regulations and an apparent need for third-party verification of compliance status. A large number of parties entered the environmental auditing business with different objectives. The rapid increase in the conduct of environmental audits, without any standardized protocol, produced audits with widely varying quality, comprehensiveness and utility.

So in 1981, managers of several environmental audit programs began meeting to compare their approaches and openly discuss their experiences in achieving the goals of a successful environmental auditing program. They later formed the Environmental Auditing Roundtable dedicated to further development and professional practice of environmental auditing.

Though risk-based auditing was encouraged by CERCLA's strict liability provision, requirements for financial assurance under RCRA, and corrective action assurance provisions of the Hazardous and Solid Waste Amendments (HSWA) to RCRA, it was SARA's innocent landowner defense that provided the real boost. Driven mainly by concerns about financial liability from hazardous waste disposal practices under CERCLA of 1980, SARA of 1986, and emerging state-level laws, property owners, sellers, buyers, and lenders learned that there was value in having an assessment of these liabilities. The consulting community responded enthusiastically to the need for these assessments. Environmental site assessment (ESA) became the predominant environmental audit activity. Compliance audits were still completed, but their numbers were small in comparison.

2.5 Non-ASTM standards for Performing ESA

At the beginning, there was no standardized protocol for the performance of ESAs. Different agencies and organizations developed various ESA guidelines according to their needs and perspectives to reduce the possibility of liability claims and at the same time protecting the value of property investments. Additionally, several organizations have been established which claim to certify environmental site assessors and auditors. All different guidelines and standards developed so far, except ASTM standards for performing ESA are discussed in the following section.

ATSDR Standard: Under SARA, ATSDR was mandated to conduct health assessments within strict time frames for each site on or proposed for inclusion on the U.S. Environmental Protection Agency's National Priorities List (NPL) which lists the nation's most contaminated Superfund sites. Prior to 1986, ATSDR only conducted health assessments in response to requests from the EPA. Under the amended CERCLA section 104(I), the

responsibility to conduct health assessments at all NPL sites becomes mandatory. ATSDR defines a health assessment as:

> "... the evaluation of data and information on release of hazardous substances into the environment in order to: assess any current or future impact on public health, develop heath advisories or other recommendations, and identify studies or actions needed to evaluate and mitigate or prevent human health effects." (Health Assessments and Health Effects Studies of Hazardous Substances Releases and Facilities, 53 Fed. Reg. 32259 (1988) (to be codified as 42 CFR 90)).

In 1994, ATSDR developed the manual, *Environmental Data Needed For Public Health Assessments: A Guidance Manual*, to guide the performance of public health assessments. According to this guidance document, the information that is required for performing an assessment includes items such as site identifiers; site history; site geographic and demographic data; regional land use; relationship to nearby communities, hazardous substances present at the site; exposure pathways such as soil, surface water, sediment, groundwater, air and food-chains; identification of physical hazards; and analytical information concerning environmental contamination. The manual requires the integration of environmental sampling data, health outcome data and community concerns in the evaluation of the health implications of hazardous substances released into the environment.

SOP Guidance: National Registry of Environmental Professionals, Florida Environmental Assessors Association and National Association of Environmental Assessors proposed a Standard Operating Practice (SOP) Guidance document on June 8, 1992. The purpose of this guidance is to define the minimum scope of inquiry and methodology for the performance of a Phase I ESA. Another purpose of the guidance document is to identify other potential sources and evidence indicating the presence of contamination that is not covered under CERCLA/SARA including various types of petroleum products and other substances.

Tasks to be performed according to this guidance document include review of existing records (e.g., maps, aerial photographs, and regulatory agency documents such as NPL, CERCLIS, FINDS, ERNS, TSD, local fire department, local health department, etc.), followed by a

site reconnaissance in which an inspection of the site is conducted to determine possible sources of contamination. Before, during and after the site reconnaissance, interviews may be conducted with the property owners, facility operators, adjacent property owners and operators, local government officials, and state and federal regulatory officials to augment site assessment findings. Finally, a report which evaluates the condition of the property and characterizes pollutant releases is prepared.

AGWSE Standard: During September 1992, the Association of Ground Water Scientists and Engineers (AGWSE) developed a guidance document for performing environmental site assessments. The document was intended to guide parties involved in a property transaction with a wide range of information that may be sought about a property. Besides regulatory and public records information, this guidance document inquires about geological and hydrological information; receptor data; site history; potential environmental problems at and adjacent sites; visual disturbance at and adjacent property; underground storage tank; sources of lead, asbestos, drinking water; urea formaldehyde foam insulation contamination; chemical uses; and waste storage, treatment and disposal areas, etc. There are four standards applicable to four different land use scenarios. Land use scenarios include vacant land, agricultural land, commercial land with improvements and industrial land with improvements. AGWSE did not make any recommendation about the scope of the site assessment, but attempted instead to provide the user with the tools to design his or her own scope of work. The parties could select a few or all of the items recommended depending on the goals of each party.

ASCE Guidance Manual: In 1996, the American Society of Civil Engineers (ASCE) published a guidance manual on the conduct of environmental site investigations. The purposes of this manual are to determine the presence or absence and distribution of potential contaminants that pose, or could pose, a threat to human health and the environment or that might precludes certain uses of the property. This manual prescribed ESA actions beyond the traditional assessment phase and include risk management activities. Besides all other regulatory information, this manual inquires information on physical features and surface conditions; surface water conditions; utilities, buildings and structures; environmental

characterization (evidence of hazardous substances, discolored surface water, stained soil); waste management practice; waste disposal methods; underground storage tank and above-ground storage tank.

International Standards: Environmental site assessments are becoming more popular beyond U.S. borders as well. Their increasing popularity has motivated the Swiss-based International Organization for Standardization (ISO), Technical Committee 207, to develop a standardized environmental site assessment process (ISO1401x) for use worldwide (Stec and Rabac 1995).

2.6 Private Sector Manuals and Texts:

In addition to a number of government and professional organization standards and guidance manuals, guidelines have been published that have been developed by individuals. Some of these include Marburg Associates and Parkin (1991), Hess (1993), Sara (1994), Cahill and Kane (1994), Cahill (1996), and Cooper (1996). In addition, various texts have been written on the subject of ESAs. A few of these are Haimes and Stakhiv (1986, 1990), Chechile and Carlisle (1991), Lind, Nathwani, and Siddall (1991), Geweke (1992), Shineldecker (1992), Hallenbeck (1993), Cothern (1993), Asante-Duah (1993), Focht (1995), Mast (1995), Graham and Wiener (1995), and Kumamoto (1996). Most of these manual adopted ASTM standards as a standard protocol for doing Phase I ESAs.

2.7 Problems Associated with Non-ASTM Standards

Comprehensiveness: All of the guidance documents described above were designed for specific purposes: ATSDR standards were designed for health assessments; AGWSE standards were designed for doing site assessments for different land use scenarios; and SOP standards were developed to investigate releases of contaminants into the environment.

All of the above standards ignore information important to assess hazards. For example, these standards fail to include meteorological information important for characterizing the physical setting of the site. They also ignore potential sources of release such as landfill, land treatment

unit, thermal treatment unit, physical, chemical and biological treatment unit, etc. So, these standards were not comprehensive enough to be used as a standard in all different scenarios.

Scope: None of the standards require a broad scope ESA. Instead they focus on particularized information for which they were designed. The ATSDR standard focuses on health hazards. AGWSE standards devotes emphasis to geological and hydrological information. SOP standard and other guidance documents concentrate on the presence of contaminants at the site. Each of the above standards is therefore limited in scope.

Completeness: According to National Academy of Sciences risk analysis paradigm (NAS 1983), five essential elements - a source, release, pathways of migration, receptor and responses have to be present at the property or site in order for a risk to exist i.e. a recognized environmental condition will exist. If any one of the above five is absent, no risk is present. Both ATSDR and AGWSE standards wants information about each of the five elements. But SOP and other guidance documents did not inquire about receptors and their responses. So it is difficult to determine the magnitude of recognized environmental condition at the site using SOP and other guidance documents.

2.8 ASTM Standards

Different organizations developed site assessment protocols according to their particular method of how best to protect themselves or their members from environmental liability. The assessments that were performed using those protocols were of varying quality. In early 1990, various segments of the real estate community joined under the auspices of the American Society for Testing Materials (ASTM) to form a committee on environmental assessments in commercial real estate transactions to clarify good commercial practices for performing Phase I environmental site assessments that satisfy the due diligence defense. ASTM has published two guidance documents, *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process (E 1527 -93)* and *Standard Practice for Environmental Site Assessments: Transaction Screen Process (E 1528 - 93)* to define good commercial and customary practice in the United States for conducting a high quality standardized environmental site assessment of a

parcel of commercial real estate. Both of the practices were intended to permit a user to qualify for the innocent landowner defense to CERCLA liability.

ASTM E 1527-93: Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process.: Phase I site assessments, equivalent to the hazard identification step of the NAS risk analysis paradigm, are used to identify the presence of hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or threat of release to structures, ground, groundwater, or surface water on the property. Phase I site assessments have four components. The first component is a review of existing records (e.g., maps, photographs, and regulatory agency documents such as permits, enforcement actions, citizen complaints and inspection reports) in order to gain familiarity with the property and to identify possible releases. This is typically followed by a site reconnaissance in which an inspection of the site is conducted to more fully record conditions at the site and to characterize releases. Before, during and after the site reconnaissance, interviews may be conducted with the property owners, facility operators, adjacent property owners and operators, local government officials, and state and federal regulatory officials to augment the site assessment findings. Finally, a report which evaluates the condition of the property and characterizes pollutant releases is prepared.

ASTM E 1528-93: Standard Practice for Environmental Site Assessments: Transaction Screen Process : The purpose of the transaction screen practice is to allow the user to attempt to qualify for the innocent land owner defense against CERCLA liability. To be eligible, the purchasing interest must demonstrate that it has made a good-faith effort to discover past releases for which it would otherwise be held liable. The transaction screen process consists of questioning knowledgeable persons such as current property owners and occupants about site conditions and history, verifying interview information during subsequent site visits, and further verifying the results of the previous two efforts by subsequently researching existing government and historical archival sources. If this initial inquiry provides suspicion that there may be releases at the site which may pose unacceptable risk to human health or the environment, a full Phase I environmental site assessment may be required.

2.9 Problems in ASTM Standards

Comprehensiveness: ASTM standards are not comprehensive enough to describe the entire ESA process. One of the objectives of a Phase I ESA is to identify the potential responsible party (PRP) for releases at the property. ASTM standards simply wanted to prepare an environmental Chain of Title summary but they did not mention what the beginning year of the Chain of Title summary should be.

ASTM standards require information about present and past land uses of the property. But they fail to require information about the regional environmental setting such as hydrogeology, hydrology, meteorology, geology and transportation structure around the property which are important to defining the physical setting of the site.

ASTM standards identify only building structures, underground storage tanks and above-ground storage tanks as a source or potential source of release. But there are many other units such as landfills, land treatment units, surface impoundments, waste piles, material storage piles, thermal treatment units, biological, physical and chemical treatment units, etc., which may be present at the property that may be a source or potential source of release.

ASTM standards require information about air, soil and surface water while describing pathways of migration of release. Interestingly, they do not require any information about ground water, even though groundwater is a major environmental pathway when releases are from land disposal unit, underground storage tank, injection wells and other sources.

ASTM standards also do not inquire about receptors. There may be human or ecological receptors present at or adjacent to the property.

Scope: ASTM standards do not require information about the types of ownership and operatorship of the property, mailing addresses of owners and operators, names and titles of site contact and responsible officials. Though the standards inquires about storage tank registration, chemical(s) stored in there and evidence of leaking, it does not inquire about the current status, physical condition, corrosion protection method, leak detection method, issued enforcement actions and corrective actions that the tank has undergone. ASTM standards do not require information on analytical results available or if sampling is required. Without previous analytical

results and sampling, it may be difficult to prove whether an environmental media is affected by the release.

Completeness: As mentioned earlier, five essential elements - release, source of release, pathways of migration for the release, receptor and response have to be present in order to produce a risk, i.e. a "recognized environmental condition". Though ASTM standard requires information about the sources, releases and pathways of migration of contaminant, it fails to address the receptor. If there is no receptor exposed to a release, there will not be any risk from that release. Without addressing the receptor, it is difficult to reach any conclusion that a recognized environmental condition exists at the site.

Skilled Assessor: Highly skilled and experienced assessors are needed to perform the Phase I ESA using ASTM standards. The standards provide only vague guidance which begs for additional interpretation. However, more specific answers are necessary to render the ESA technically competent and legally sufficient. For this reason, assessors with vast experience about the ESA process are required to perform high quality Phase I ESA. As mentioned earlier, it is difficult to determine recognized environmental conditions and the requirements for a Phase II ESA using this standard. What is needed, therefore, is a protocol which provides more detailed information.

Organization: Information that is required to comply with ASTM standards is not sufficiently organized to guide the conduct of an Phase I ESA. Information on Phase I ESA involves reviewing various federal, state, local and on-site records, investigating the site and interviewing with owners, operators, employees, neighbors and regulatory personnel. So the Phase I ESA process should be organized to ensure consistency with the Phase I ESA procedures and at the same time, lead the assessor to answer questions that are relevant to that site or property. When the questions required are not asked in an organized way, it makes the work of the assessor even harder. If the questionnaires are organized in an inflexible fashion, it may become difficult for the assessor to portray the actual condition of the property. The whole process becomes too time-consuming and the cost of performing Phase I ESA increases.

CHAPTER THREE

EXISTING PROTOCOLS FOR PERFORMING PHASE I ESAs

Environmental site assessments have been performed manually for the last 15 years or so. Often, these have been guided by a checklist developed by individual practitioners (e.g., Hess (1993) and Cooper (1996)), in accord with numerous guidance documents, promulgated regulations, or standards issued by independent organizations such as AGWSE (1992), ASTM (1993, 1994) and ASCE (1996). More recently, attempts have been made to automate Phase I ESAs (Truby 1995 and MacNeill 1995). Both manual and automated ESA protocols have deficiencies. this Each of the protocols along with a review of their problems are described below.

3.1 Traditional Manual Method

Traditionally, the assessor makes a checklist of the information he/she needs, for performing Phase I ESAs. In designing the checklist, the assessor makes sure that the checklist is consistent with the requirements described in ASTM standards. He/she then gathers information by reviewing different public records, inspecting the site and interviewing various knowledgeable persons familiar with the site. He/she records the information usually in writing directly on the checklist. Once the assessor gathers all necessary information, he/she prepares a report. The report contains the findings of the investigation.

Problems using this method include:

Need for skilled assessors: Skilled and experienced assessors are required to perform traditional Phase I ESA. An experienced assessor knows which information is important and how to get that information easily. It is nearly impossible for a novice assessor to know, collect and evaluate all information needed for a competent assessment.

Time-consuming: Traditional Phase I ESAs are time consuming. The assessor must record all site information and later prepare a report. Significant time is wasted for doing the same process twice.

Expensive: Lengthy assessments by experienced assessors are expensive.

Lower Quality: If any assessment is done strictly on the basis of a checklist, the assessor might ignore some other features that are unique for that site which will lower the quality of the assessment.

In order to avoid the problems discussed above, there is a growing need to automate the site assessment process. Because one can easily generate report by using automated Phase I ESA process. So, an automated Phase I process will be faster. There are two software packages -"Softshel" and "Site Assessment" currently available in the market which automate the ESA process. The packages are evaluated in the next section.

3.2 Evaluation of Softshel's Automated ESA

Softshel was developed by W.J.Truby and is approved by the National Registry of Environmental Professionals. The software is written in Microsoft Visual Basic Version 4.0. Windows 3.1 or higher version is required as an operating system to run this software. The 1996 listed price of this software is $695.00.

ASTM standards underlie the design of this software. The information that is required for performing Phase I ESA is divided into four main sections: information on regulatory records; land use; site reconnaissance and interviews and report. Under each main section, there are several sub-sections. The sub-sections of regulatory records require information on the identification of the owner and operator of the property and local, state and federal records. Land use sub-sections describe information about the current and past land uses of the property. The site reconnaissance, description and interview section has sub-sections which include information about hazardous substances such as PCBs, asbestos, radon, lead, stored chemicals, pipelines, spills and leaks, air emission, wastes, agricultural chemicals, MSDS (material safety data sheet), interviews, physical layout and additional observations. Each sub-section includes at least one question. The answers to questionnaires are provided in free form text fields. In total, there are

forty questions in this software. After the assessor answers all the questions that are relevant to the site, the software will generate a pre-formatted report in which the answers, as inputs, are reproduced in the output.

As described earlier, ASTM standards are not comprehensive, detailed, complete and well-organized. Since the ESA process used in developing Softshel software is based on ASTM standards, the software inherited all those problems. Although Softshel is user-friendly, easy to operate and easily generates report, it does not support to answer the question of whether there is a recognized environmental condition at the site.

An experienced assessor is required to perform the assessment using Softshel software. Since, there are no suggested answers given for the questions, the assessor must develop the answer to each of the questions. Answers must be technically competent and legally sufficient to address the real condition of the property. Experience is important to an assessor to determine which information needs to be included in each answer and how to find it.

Repetitions are apparent in this software. For example, the software asks about the presence of hazardous substances in three different questions.

While performing Phase I ESA using "Softshel" software, the assessor takes notes on paper while reviewing records, investigating the site and interviewing personnel. He/she then inputs the answers from the notes into the software. The software generates a text-based report on the basis of the answers given for different questions. This report is sent to the client and/or regulatory agency by mail, depending for whom the assessor is performing the assessment. This process requires multiple data entry and thus is inefficient.

3.3 Evaluation of MacNeill's Automated Site Assessment

Another software package named "Site Assessment" is available in the market to produce Phase I and transaction screening reports faster and easier than the traditional method. This software is developed by environmental professionals at McNeill Software. The computer requirements to run this software are IBM^{tm} DOS^{tm} compatible PC or MacIntosh^{tm} using DOS emulation, 3 MB of hard disk space, 640K of RAM.

Site Assessment software requests information about the legal description, location of the site; site and vicinity characteristics; descriptions of structures, roads, improvements; storage tanks; present and past land uses on and adjoining site; federal and regulatory records; site reconnaissance and interviews; future land use scenarios; and hazardous substances. A number of checklists in this software are used as a guide for site observation and record gathering. Each of the checklists includes a number of questions. There are a number of possible answers given for each question. The assessor can choose the right answer appropriate to the site.

The software combines a word processor with a database containing huge libraries of expert, customizable site assessment report text. The software has the capability to allow the assessor to edit the text within the system or use a user's favorite word processor to include the inevitable extra notes to cover extra or unusual items. There is a Windows icon and instructions for setting up the program.

The design of this software incorporates ASTM standards and other guidance documents such as AGWSE, SOP standards as well as the expertise of the experienced assessor. Because of this, it is much more comprehensive than Softshel. But it is not comprehensive enough to identify the potentially responsible party for the release. It also does not require any information about the regional environmental setting such as, hydrogeology, hydrology, meteorology, geology and transportation structures around the property. As mentioned earlier, the environmental setting information is important for determining pathways of migration for any release at the site. The software also fails to require sufficient detail to allow a defensible determination of a recognized environmental conditions.

Since Environmental Site Assessment software is run in DOS, it is not as user-friendly as Softshel. It does not lead the assessor to the appropriate forms which are applicable for the site. Basically, it is left to the assessor to decide which information is important. The software also does not provide optional full-text input if the answers given for a question are not appropriate for the site.

Finally, like ASTM standards, both "Softshel" and "Site Assessment" software packages ask questions about releases, sources of releases and pathways of migration, but fail to ask about

receptors and anticipated response to exposure. Since neither software package inquires about receptors and responses, it is not possible to reach an informed conclusion that a recognized environmental condition exists at the site.

CHAPTER FOUR

A PROPOSED AUTOMATED ENHANCED PHASE I ESA PROTOCOL

4.1 An Enhanced Phase I ESA Protocol

The purposes of Phase I ESA are to determine whether there exists a recognized environmental condition at the site and to identify the potentially responsible parties associated with contaminant releases. There are five important requisites that must be present at the property for which an recognized environmental condition to exist. These factors are (1) source(s) of release(s) , (2) past or present release, (3) pathway(s) of migration from sources through the environmental, (4) receptors who may be exposed to the release(s) and (5) possible adverse response(s) due to exposure. If any of the above is absent, there can not be a recognized environmental condition at the property. ASTM standards fail to recognize the importance of the presence of human and ecological receptors. The Enhanced Phase I ESA protocol proposed below includes consideration of receptors and responses. There are a couple of reasons for which the protocol is called "Enhanced". None of the Phase I ESA standard documents mentions (a) the receptors who may be exposed due to the releases, or (b) sampling requirements. The enhanced Phase I ESA protocol includes both. The research adopts ASTM standards E1527 & E1528 as a basis for the design and demonstration of Enhanced Phase I Environmental Site Assessment Protocol but goes beyond them by incorporating information other site assessment standards, guidance documents, publications and lessons learned in the field by site assessors. Appendix A includes the enhanced Phase I environmental site assessment protocol as a series of input forms.

4.2 Components of the Enhanced Phase I ESA Protocol

Enhanced Phase I ESA protocol is composed of four main sections: legal, environmental settings, source and hazard identification sections. Each of the main sections consists of several subsections. Each sub-section includes a number of questions. A number of possible answers are also provided for each question. The assessor can either check the box(es) corresponding to the correct answer(s) or input free -field text. The assessor can also provide audio or video inputs. To record the position of a feature or an event, the protocol is designed to accept GPS (Global Positioning System) input data and store them in a GIS (Geographic Information System) database structure. Four main sections of this protocol are described below.

The legal section requires information about the legal description of the property, its location and size and its owners and operators. It also contains information about the assessor and the types of assessment to be performed.

The environmental setting section inquires information about the current, past and future land uses of the property and the transportation structures on the property. This section also needs information about the meteorology, hydrology, hydrogeology and geology of the region where the property is located. Finally, it prompts requests for information about archeological, historical, recreational resources and about endangered species that may be located in close-proximity to the property.

The source section describes various types of waste or material management units that may be present at or adjacent to the property which may be a source of contaminant releases to the environment. For each source, information concerning its operational history (date of installation, types of waste/material handled, etc.), design (operating conditions, pollution prevention measures, etc.) and legal history (regulatory agency, violations, corrective actions, etc.) can be inputted.

The hazard identification section contains information about releases, pathways of migration and potential or actual receptors. Information about each release includes its location, probable date(s) of release, chemical(s) released and probable environmental media that may be affected by the release. Four environmental media-ground water, surface water, soil and air are

included as potential migration pathways. Media - specific information includes evidence of contamination, whether sampling is required and available sampling results. Information about the types of receptors, exposure duration and concentration of the chemical(s) at the receptor are input in the receptors subsections.

Finally, the protocol determines whether a recognized environmental condition exists at the site. It also suggests whether a Phase II ESA is appropriate.

4.3 Organization of the Enhanced Phase I ESA Protocol

The organization of the enhanced ESA software protocol is based on logical and efficient data acquisition, analysis, and reporting procedures. First, graphical user interface (GUI) forms will prompt the user to gather and input data concerning the facility and its legal, location, and assessment characteristics. Next, GUI forms will inquire into the hydrogeological, hydrological, geological, meteorological and land use characteristics of the site and surrounding area. Now that the site setting is defined, an inquiry into the potential sources of release of environmental contaminants is prompted. Only those forms needed for a particular site are displayed automatically, though the assessor can call up a new form with a click of a button or point of a pen. Once sources are defined and located, forms designed to gather data concerning the existence and nature of environmental releases are presented to the assessor. For each identified release, the assessor is further prompted for a complete description of the environmental media through which the release may be migrating away from the source and the characteristics of any receptors who or which may be exposed to the migrating contaminant plume.

The protocol will trigger only those inputs which are mandatory for all sites or which are called by appropriate responses to earlier questions. In this way, efficiency is maximized and the user will not be forced to consider (or even see) questions or prompts that are not applicable to the site.

Completeness is ensured through the a priori designation of inputs as supermandatory (the failure to provide an input will return the assessor to the main menu), mandatory (the assessor will be prompted immediately and on subsequent log-ins that a response is required),

optional (the assessor may elect not to provide an input, through the question or prompt will remain visible), or conditional (the question or prompt will appear only if an appropriate answer is given to earlier question).

4.4 Automated Enhanced Phase I ESA Protocol

An Enhanced Environmental Site Assessment Protocol can be made effective, accurate, and efficient through the use of a powerful handheld pen-entry-based computer augmented with a number of PC Card slots. The slots allow cards to capture video images, GPS (Global Positioning System) time and position, and environmental sensor data in real time and to store them in an object-oriented data base for processing and display by a GIS and report generator. The availability of GPS, video and environmental sensors allow the site assessment to be documented in a multi-media mode.

The project team selected GIS software from MapInfo and combined it with a suite of field data collection modules from All Points Software called GeoFirma. The GeoFirma product selected was the Mobile Professional DGPS Development Kit. The Kit included MapInfo Desktop, Fieldpack Designer DGPS, and Fieldpack Mobile Professional DGPS for an integrated data collection and analysis package. MapInfo Desktop is one of the first and still a leading mapping software package for the personal computer environment. Fieldpack Designer DGPS is a tool for building customized forms which can be designed to allow efficient data collection. Fieldpack Mobile Professional DGPS provides sophisticated GPS data-logging functions and supports differential post-processing of GPS data. These products, when combined with a pen-based computer and a Trimble Mobile GPS Gold Card provide an opportunity to integrate text, GPS data, digital photographs, signatures and sample data into a customized database format.

The automated Phase I ESA protocol proposed herein consists of sixty different pen, mouse, keyboard, audio, video, GPS and sensor date entry forms. These multi-media forms will work in tandem with a Geographic Information System (GIS) to provide the user with a portable, powerful, user-friendly environmental assessment decision tool that will not only allow site-specific flexibility while maintaining comprehensibility but also will enhance the legal sufficiency of the site assessment report. The assessor is not required to input data in all the forms. The software will

lead prompt data input for only those forms appropriate for the particular site that the assessor is investigating. At the end of data entry, the software can either generate a plain text report or a text report with embedded sound and video images with links to geographic information systems (GIS) maps and databases.

4.5 Advantages of the Automated Enhanced Phase I ESA Protocol

The Enhanced Phase I ESA protocol incorporates information from ASTM standards, other guidance documents and publications and the lessons learned in the field by site assessors as well. As a result, the protocol is not only more comprehensive, but also more complete than all other existing protocols. It also provides more guidance for providing inputs. It is designed to be an environmental site assessment tool applicable to all sites and assessment scenarios.

The Enhanced Phase I ESA software is user-friendly. It adopts graphical user interface (GUI) as the basis for the design and development of inputs and output forms. There are sixty forms in this protocol. The assessor does not have to input the data in all forms. The software will lead the assessor to input only those data in those forms that are appropriate for the site. Thus, the software does not require a skilled assessor.

One of the unique features of this software is its ability to accept real-time data-entry features such as keyboard, mouse, pen, microphone, cameras, sensors and GPS. After completion of data entry, the software will generate a text report with embedded sound and video images and links to GIS maps and data tables. The automated ESA process is faster than other existing processes that are used for performing ESA.

The initial cost of this entire system will be higher than the other existing systems, but it takes a shorter time to complete and does not require highly skilled assessors to operate it. As a result, the automated Phase I ESA process will be cheaper in the long run.

4.6 Field test of the Automated Enhanced Phase I ESA Protocol

As a part of the project, the research team performed a field demonstration on the technology at a Chemical Waste Burial site located 7.5 mile southwest of ABC city. The objectives that the field demonstration were to accomplish were:

demonstrate compatibility of the software with

(a) a pen-based system,

(b) the GIS packages,

(c) a video camera driven by a PCMCIA card,

(d) pH meter and associated PCMCIA card

(e) DGPS and to

(2) verify whether the whole system could perform a site- specific Phase I ESA..

History of the Project Area: Chemicals that used in various laboratories in the city were disposed in various cells located at the burial site. There was an on-going release from one of the cells which affected the groundwater. The groundwater discharged to a nearby intermittent stream in which aquatic species were exposed to contaminants. The software determined a recognized environmental condition existed at that site. .

Result: The project team successfully demonstrated the capability of the handheld site characterization device. The software accepted all the pen-entry, GPS, pH and video inputs which proved compatibility. The software efficiently performed the Phase I environmental site assessment. The input forms that were generated during performing the assessment are shown in Appendix B. The manually generated report for the assessment is shown in Appendix C.

CHAPTER FIVE

SUMMARY, FINDINGS AND RECOMMENDATION

5.1 Summary

Environmental site assessments have been performed manually for the last 15 years or so. Often, these have been guided by checklists developed by individual practitioners (e.g., Hess (1993) and Cooper (1996)), in response to agency guidance documents, promulgated regulations, or standards issued by independent organizations such as the AGWSE (1992), ASTM (1993,1994), and ASCE (1996). Since those are time consuming, incomplete and expensive, attempts have been made to automate Phase I ESAs (Truby 1995 and MacNeill 1995)). Environmental site assessment which have been performed to date, using all of the above protocols, were of variable consistency and dubious quality. The lack of consistency is mainly due to the lack of a well-defined ESA protocol. The low quality is due, to the failure to incorporate sufficient site-specific data into environmental assessment. This research have tried to solve both of these deficiencies by developing a standard site assessment protocol. The Protocol for Automated Enhanced Phase I Site Assessment process has adopted ASTM standards ES 1527 & 1528 as a basis for the design and demonstration. It also incorporated all other site assessment guidance documents and publications and the lessons learned in the field practice by experienced site assessors. This research used GeoFirma: FieldPack Designer, version 2.2 for designing the Phase I ESA software. MapInfo, version 4.0 which is compatible with GeoFirma, is used as a GIS package. This integrated system (software) is then run in a handheld pen entry table computer. The computer is augmented with a number of PC cards which have the capabilities of capturing video, GPS time and position, measuring pH of the samples. At the completion of all real time data entries through keyboards, mice, pen, video, camera and GPS, the software will able to generate a text report or text report with embedded sound and video image, with links to

GIS maps and data tables. As a result, the automated enhanced Phase I ESA will not only increase the speed, efficiency, and accuracy of the site assessment process, but will also enhance the legal sufficiency of the ESA data.

5.2 Findings

Problems associated while developing the software: Research progress was hampered by several problems in using GeoFirma. These problems are discussed below.

1) Limited space availability: An open file in GeoFirma has 256 characters (one character means one check box or one text box or one GPS box), therefore a user cannot input more than 256 characters in one file. If more than 256 characters are inputted, the file cannot be opened in Fieldpack mobile. As a result, the assessor has to open four different files to input data during field demonstration which reduced the efficiency of the software.

2) Lack of user-friendliness: One of the objectives of this project is to develop a Graphical User-Interface (GUI) between different forms so that the software will lead the assessor to input data in those forms that are appropriate for the site. But the project team could not fulfill this objective using GeoFirma. In GeoFirma, one cannot create any context sensitive help features or screens, therefore it is not possible to define all terms used in the software or provide access to definitions.

3) Unable to generate report: In GeoFirma, one cannot open more than one file at a time. Since each file is independent of all others, the program cannot generate an output report automatically by using the data input into forms.

4) Editing problems: In GeoFirma, one can not move or delete more than one item or character at a time. This created problems in designing the software. For example, if one wants to add new information at a certain field, one has to move down each of the characters below that field.

5) Inability to make multiple DLL calls: The major limitation of GeoFirma is the inability to make multiple dynamically linked library (DLL) calls. Only a single DLL call could be processed within an individual project environment. For example, one cannot input more than one audio record, one GPS input and one video image in any one file.

Problems associated with MapInfo: A major limitation of the MapInfo software is that MapInfo can read or import a limited number of map or vector data formats. Other than MapInfo's own .mif format, the only map data format which MapInfo can import is AutoCad.dxf files. This limitation in import formats greatly restricts the ability of the software. While transferring the map, map features or vectors were transferred accurately but the attributes to the features were not. For example, the transferred maps showed both of the tributaries at the site, but it did not provide any information about the water quality of the tributaries.

Problems Associated with the Pen-Entry Based Computer:

1) Limited storage capacity of the battery.

2) Only two PC cards video and GPS cards can be plugged into the computer at a time. A number of additional cards such as pH, volatile organic analyzers, bar codes, audio, wireless communication etc. cards should be plugged into the computer to increase its effectiveness and efficiency.

3) It is very difficult to read the forms from the computer screens once the computer gets hot. As a result, during the demonstration day, the project team used an umbrella to protect it from direct exposure to sunlight. Otherwise, the screen would fade out.

5.3 Recommendation

Technical Approach: ESA can be made more effective, accurate and efficient through the use of a powerful handheld pen entry computer augmented with a larger number of additional PC Card slots and additional battery capacity (Roark and Focht 1996). The additional slots allows cards to be added to capture video, images, GPS time and position, audio, instrument measurements, bar codes, etc., in real time and store them in an object oriented data base. The additional slots will also allow the incorporation of wireless communications, and large amounts of storage. In particular, these slots will allow data entry for the rapidly growing array of instrumentation which is becoming available in PC card format. The concept of it is shown in figure 5.1. The device will then enable the skilled execution of a Phase I and Phase II ESA by an inexpert assessors that will provide sufficient information to allow a site manager to identify unacceptable risks and prioritize remediation activities based on risk comparison.

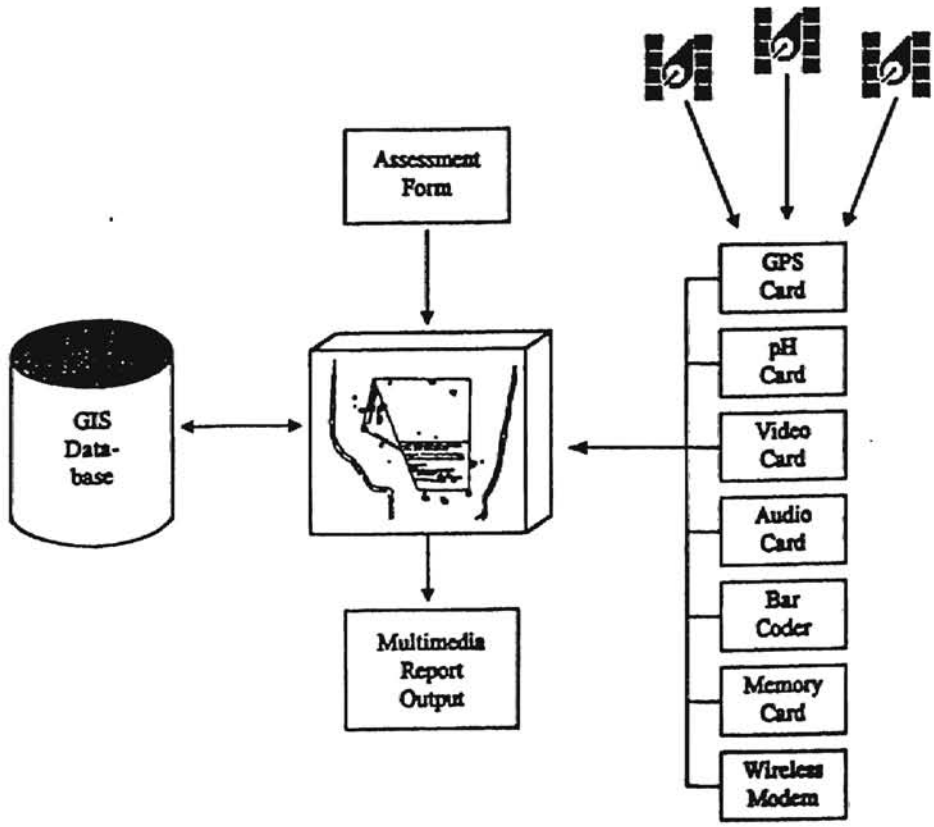

Figure 5.1 Concept of System

Design of Main Menu: A main menu will be created to facilitate selection of forms, track completed forms and incompleted forms and confirm the data entered in the forms. Basically, the main menu will monitor all forms that are required for completion of the site assessment.

GUI Input Forms: Microsoft Visual Basic (MS VB) version 4.0 can be used in place of GeoFirma for developing input forms. MS VB has graphical user interface (GUI) capability. Since GUI has become a standard for data entry processing, it will facilitate the entry of ESA data into the site characterization database. Microsoft Access which is compatible with MS VB, can be used as the primary database for the project and will be made compatible with the GIS database.

Help Features: In order to make this software more user-friendly, three different kinds of help features can be incorporated. These include context-sensitive help, tips and standard menu bar help features.

Geographic Information System: ESRI's ArcView 3.0 GIS software packages will be used in place of MapInfo 3.0 (with MapInfo Desktop and MapBasic) for transferring map features and their attributes. Since the ArcView 3.0 database is not compatible with Microsoft Access, a third drive-ODBC Driver Pack 3.0- will be required in order to build the interface between them.

Report Generation: The handheld site assessment device is unique and compelling in that it allows multi-modality information to be gathered in real time in the field. These data can be formatted easily and conveniently into reports using Microsoft Visual Basic. The creation of standard textual reports poses no problem. However, multi-media reports must be provided in order to truly capitalize on the system. This poses a problem because there is no clear consensus on how this to be done. One approach is to use the Hypertext Markup Language (HTML) developed for use on the World Wide Web on the Internet. Another option for report generation is a multimedia tool such as Macromedia Director. HTML has the advantage of being a widely-used standard. It also provides the opportunity to capitalize on the incredible growth and investment in the Internet. The project will evaluate these various approaches before choosing a software configuration.

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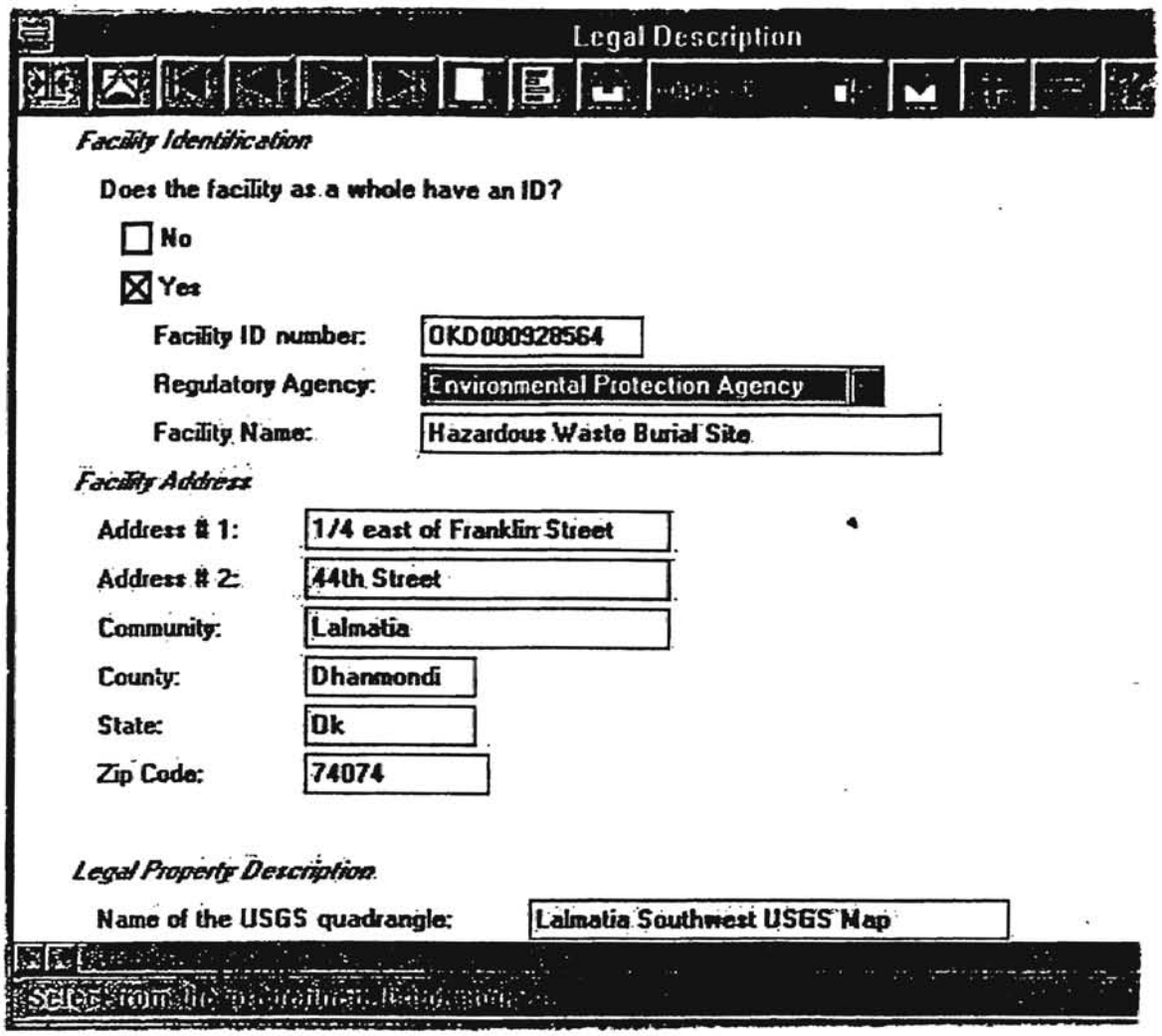
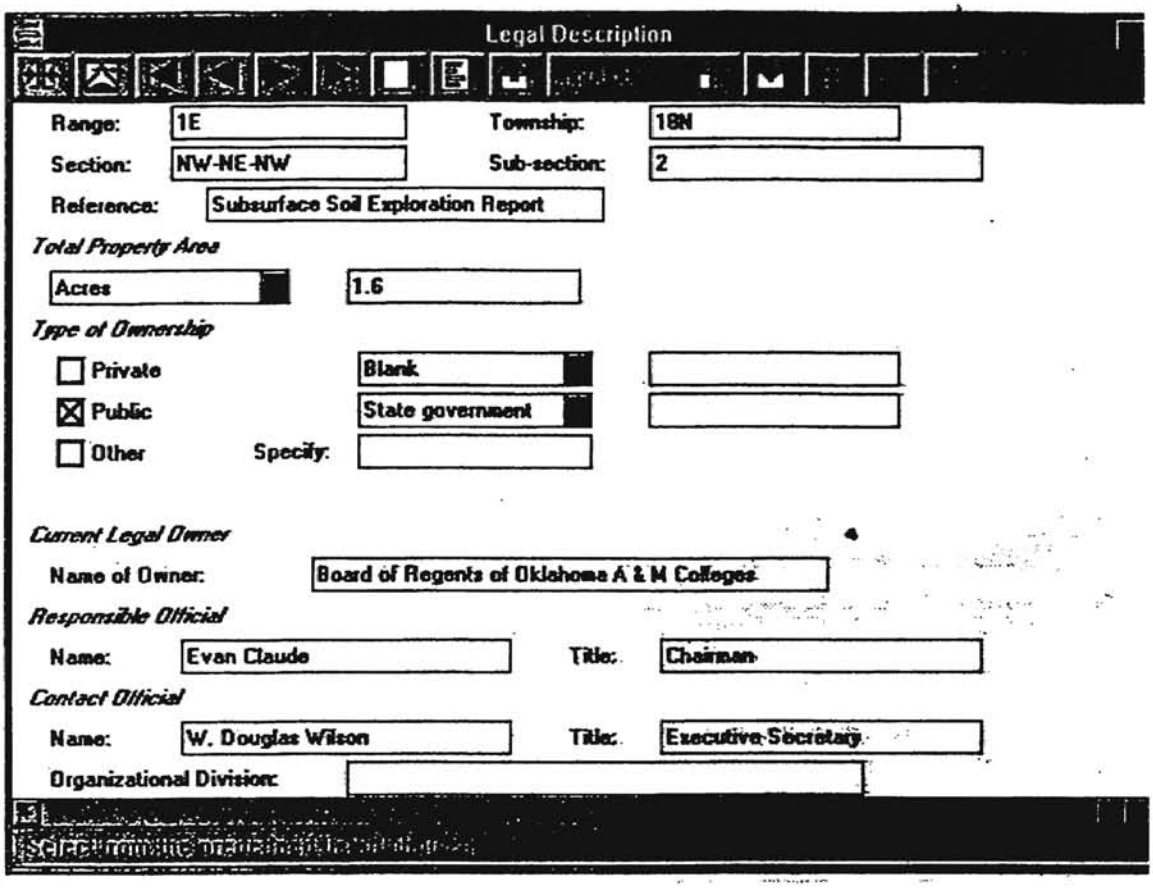
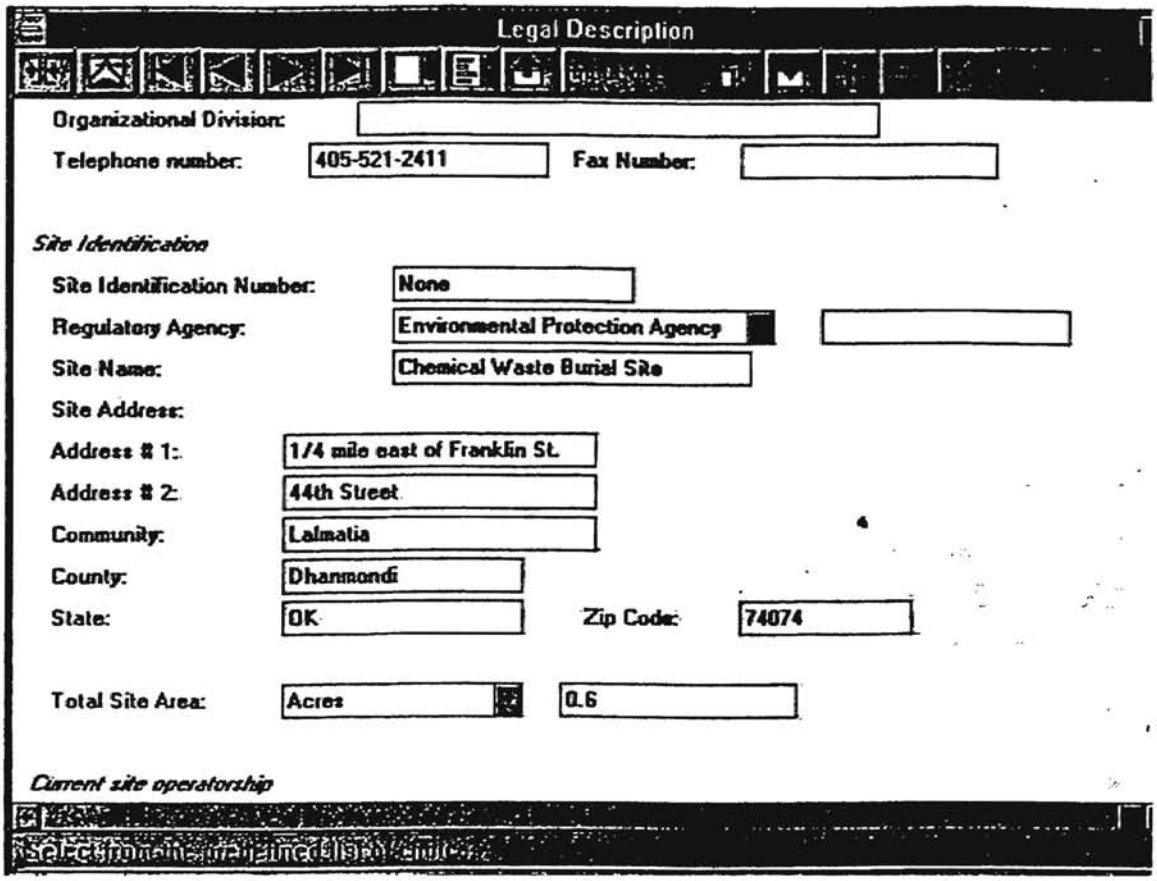
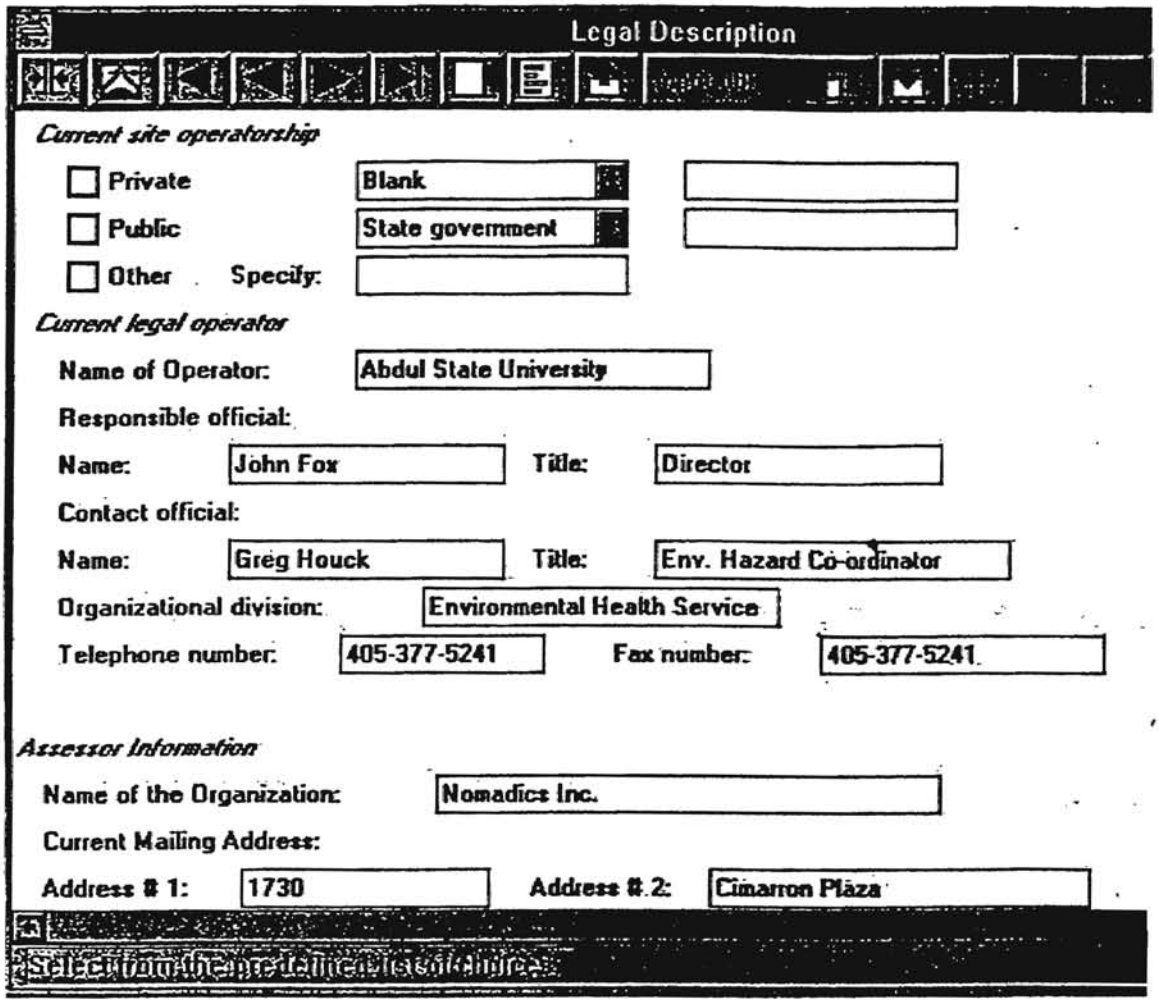
Appendix B

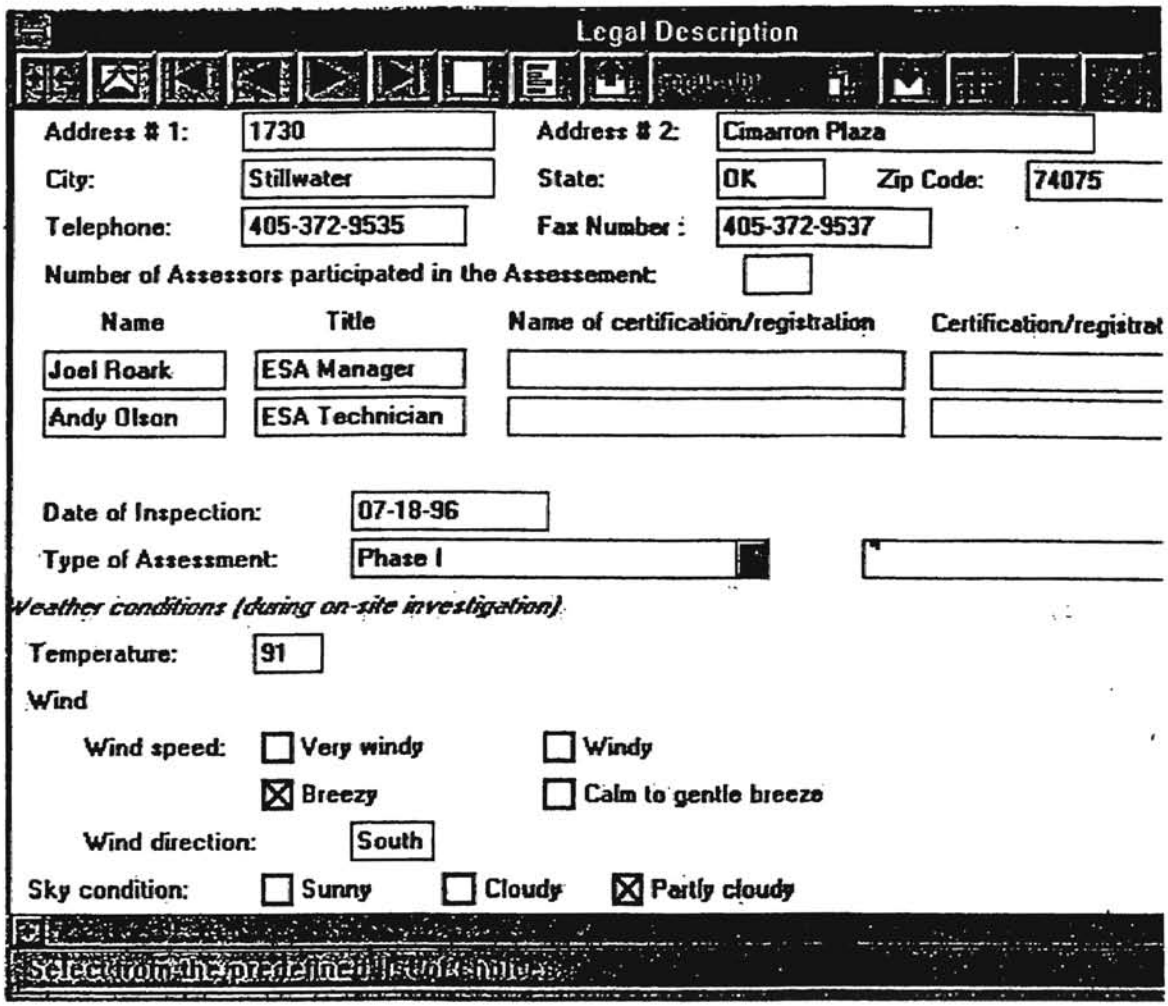
Field Demonstration Input Forms

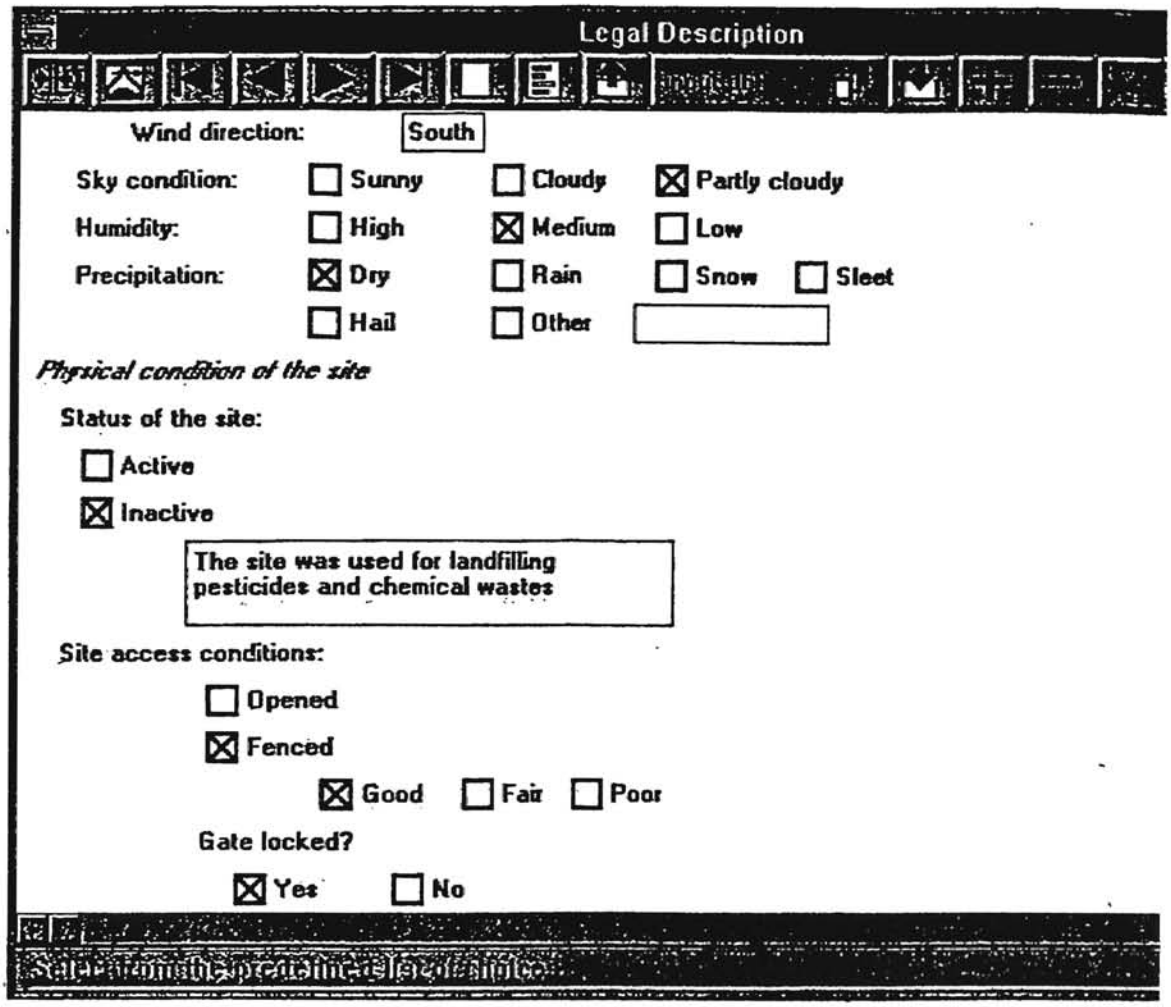

Legal Description
Facility Identification
Does the facility as a whole have an ID?
No
Yes
Facility ID number:
OKD000928564
Regulatory Agency:
Environmental Protection Agency
Facility Name:
Hazardous Waste Burial Site
Facility Address
Address # 1:
1/4 east of Franklin Street
Address # 2:
44th Street
Community:
Lalmatia
County:
Dhanmondi
State:
Dk
Zip Code:
74074
Legal Property Description
Name of the USGS quadrangle:
Lalmatia Southwest USGS Map


Legal Description
Range: 1E
Township: 18N
Section: NW-NE-NW
Sub-section: 2
Reference: Subsurface Soil Exploration Report
Total Property Area
Acres
1.6
Type of Ownership
Private
Public
Other
Specify:
Blank
State government
Current Legal Owner
Name of Owner: Board of Regents of Oklahoma A & M Colleges
Responsible Official
Name: Evan Claude
Title: Chairman
Contact Official
Name: W. Douglas Wilson
Title: Executive Secretary
Organizational Division:


Legal Description
Organizational Division:
Telephone number:
405-521-2411
Fax Number:
Site Identification
Site Identification Number:
None
Regulatory Agency:
Environmental Protection Agency
Site Name:
Chemical Waste Burial Site
Site Address:
Address # 1:
1/4 mile east of Franklin St.
Address # 2:
44th Street
Community:
Lalmatia
County:
Dhanmondi
State:
OK
Zip Code:
74074
Total Site Area:
Acres
0.6
Current site operatorship


Legal Description
Current site operatorship
Private
Public
Other
Specify:
Blank
State government
Current legal operator
Name of Operator:
Abdul State University
Responsible official:
Name:
John Fox
Title:
Director
Contact official:
Name:
Greg Houck
Title:
Env. Hazard Co-ordinator
Organizational division:
Environmental Health Service
Telephone number:
405-377-5241
Fax number:
405-377-5241
Assessor Information
Name of the Organization:
Nomadics Inc.
Current Mailing Address:
Address # 1:
1730
Address # 2:
Cimarron Plaza


Legal Description
Address # 1: 1730
Address # 2: Cimarron Plaza
City: Stillwater
State: OK
Zip Code: 74075
Telephone: 405-372-9535
Fax Number : 405-372-9537
Number of Assessors participated in the Assessement:
Name
Title
Name of certification/registration
Certification/registrat
Joel Roark
ESA Manager
Andy Olson
ESA Technician
Date of Inspection: 07-18-96
Type of Assessment: Phase I
Weather conditions (during on-site investigation)
Temperature: 91
Wind
Wind speed:
Very windy
Windy
Breezy
Calm to gentle breeze
Wind direction: South
Sky condition:
Sunny
Cloudy
Partly cloudy


Legal Description
Wind direction:
South
Sky condition:
Sunny
Cloudy
Partly cloudy
Humidity:
High
Medium
Low
Precipitation:
Dry
Rain
Snow
Sleet
Hail
Other
Physical condition of the site
Status of the site:
Active
Inactive
The site was used for landfilling pesticides and chemical wastes
Site access conditions:
Opened
Fenced
Good
Fair
Poor
Gate locked?
Yes
No

Current land uses

Current land uses on facility property:

- ☐ Industrial
- ☐ Commercial or retail
- ☐ Agricultural
- ☐ Unknown
- ☐ Park or recreational
- ☐ Undeveloped or underdeveloped
- ☒ Not zoned
- ☐ Other

Surrounding land uses:

- ☐ Industrial
- ☐ Commercial or retail
- ☒ Agricultural
- ☐ Unknown
- ☐ Park or recreational
- ☐ Undeveloped or underdeveloped
- ☒ Not zoned
- ☐ Other

Are there at least 50 contiguous acres of undeveloped or underdeveloped land present adjacent to the facility location?

- ☐ No
- ☒ Yes

Are these lands managed by any government agency?

- ☐ No
- ☒ Yes

Name of the agency: ASU

Purpose: Agricultural
cross-timber
experimental range
research

Previous Land Uses

Previous Land Uses

Previous land uses on facility property:

- ☐ Industrial
- ☐ Commercial or retail
- ☐ Agricultural
- ☐ Unknown
- ☐ Park or recreational
- ☐ Undeveloped or underdeveloped
- ☒ Not zoned
- ☐ Other

Surrounding land uses:

- ☐ Industrial
- ☐ Commercial or retail
- ☐ Agricultural
- ☐ Unknown
- ☐ Park or recreational
- ☐ Undeveloped or underdeveloped
- ☒ Not zoned
- ☐ Other

Regional Meteorology

Temperature

Mean annual temperature:	59
Mean seasonal minimum temperature:	15
Mean seasonal maximum temperature:	102

Average humidity:

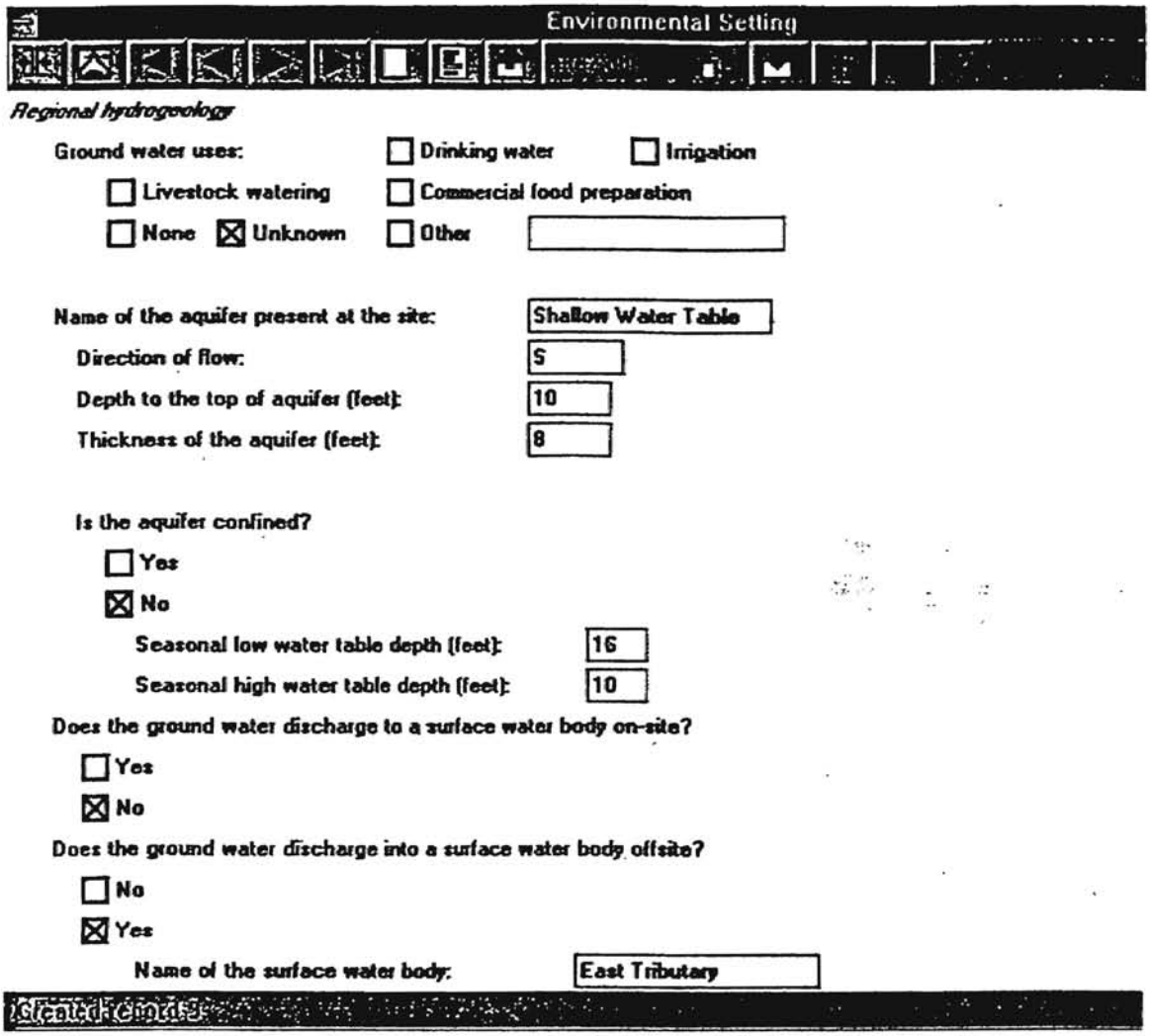
☐ High (>60%) ☒ Medium (30-60)% ☐ Low (<30%)

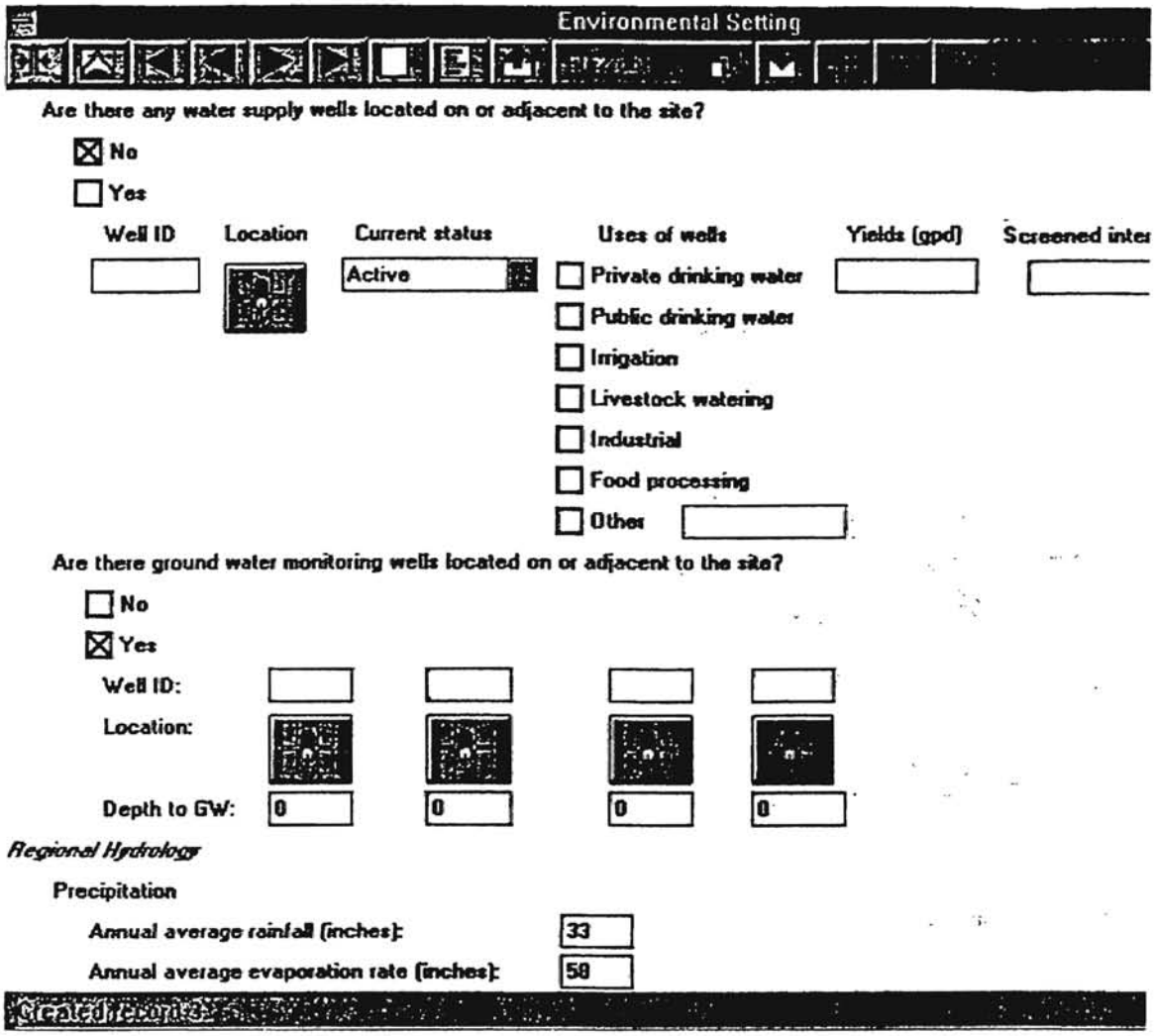
Wind

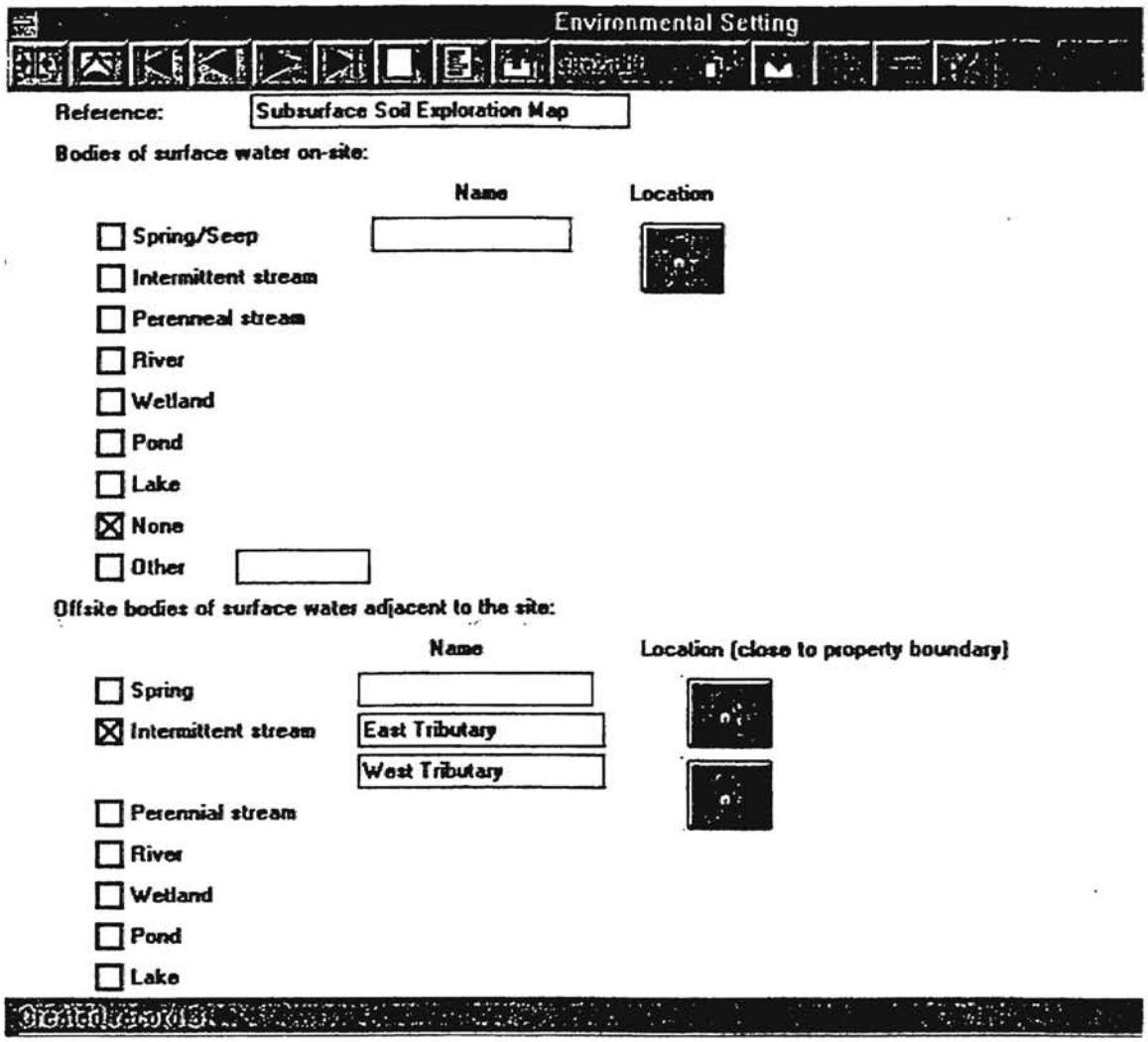
Average annual wind speed:	15
Predominant wind direction:	S

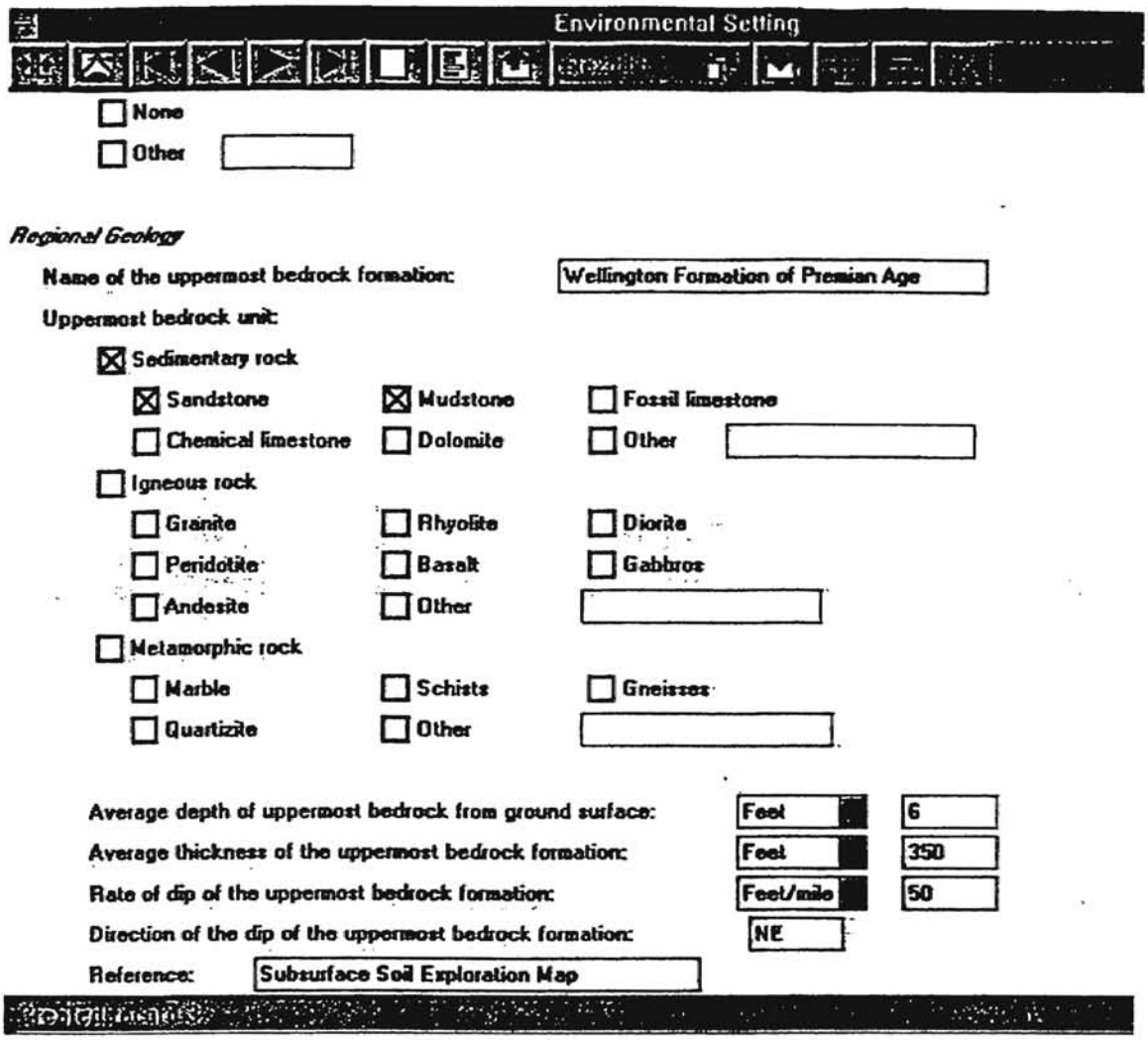
Reference: Soil Survey Map of Dhanmondi County

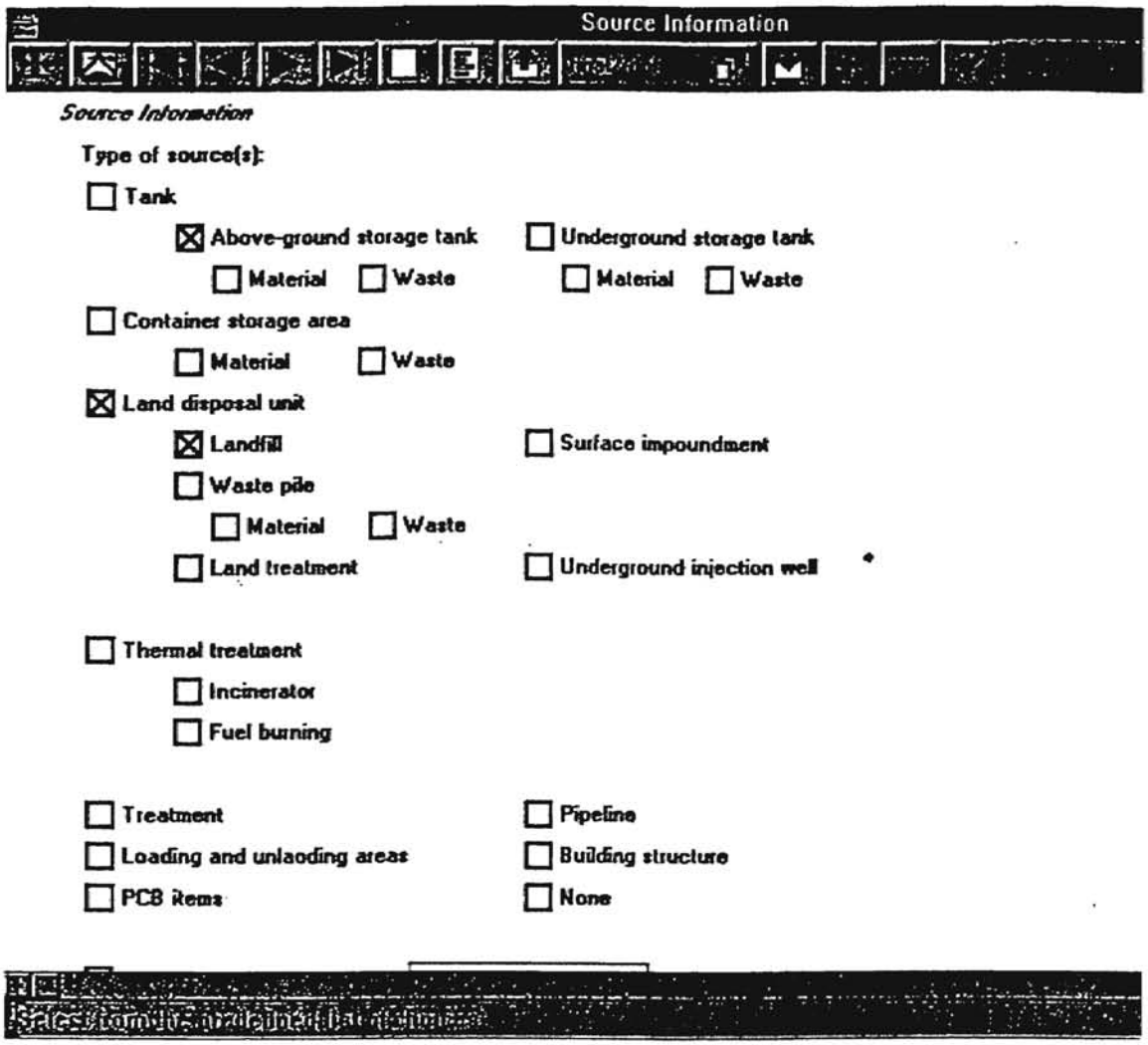
Regional hydrogeology

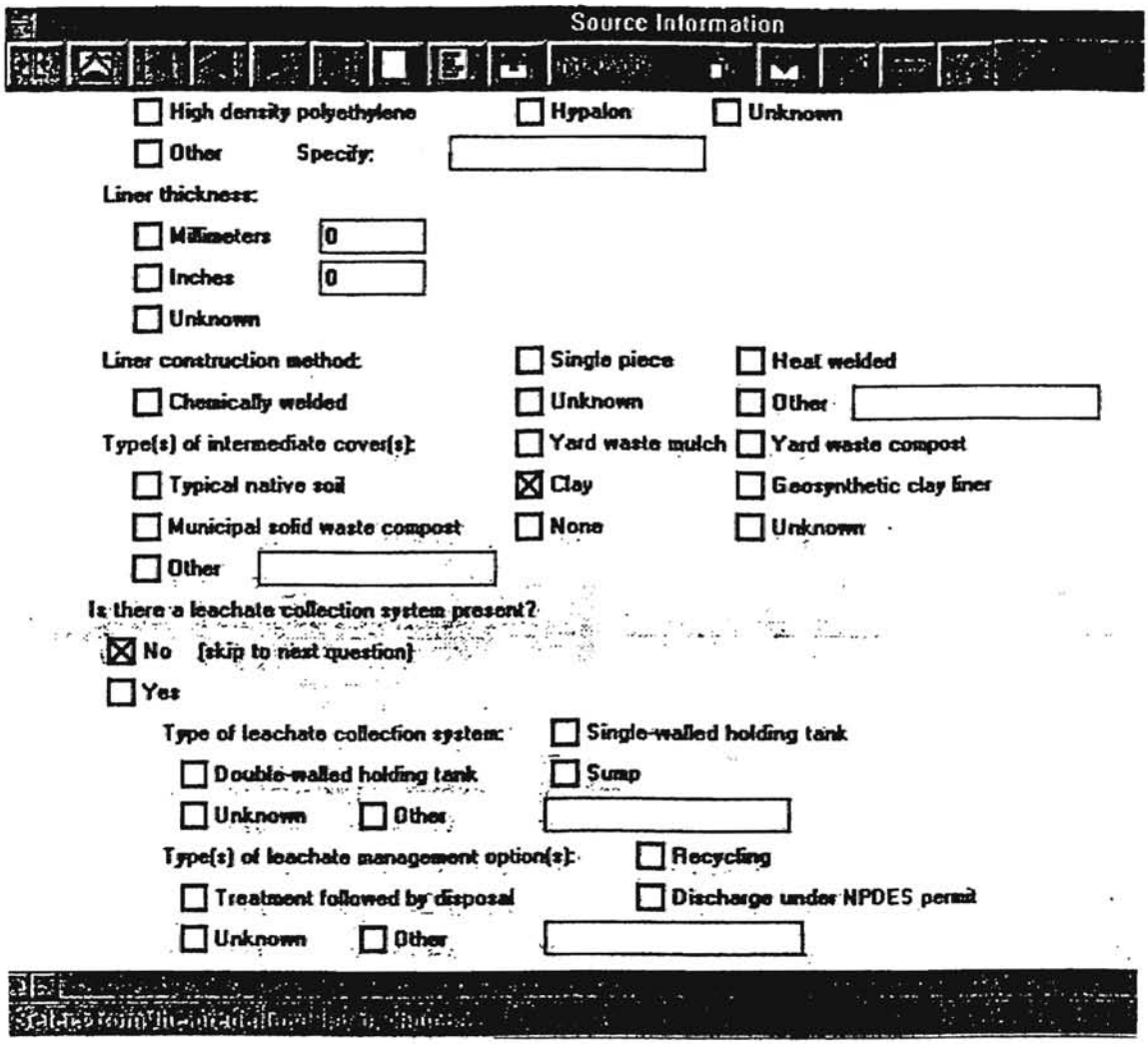

Environmental Setting
Regional hydrogeology
Ground water uses:
Drinking water
Irrigation
Livestock watering
Commercial food preparation
None
Unknown
Other
Name of the aquifer present at the site:
Shallow Water Table
Direction of flow:
S
Depth to the top of aquifer (feet):
10
Thickness of the aquifer (feet):
8
Is the aquifer confined?
Yes
No
Seasonal low water table depth (feet):
16
Seasonal high water table depth (feet):
10
Does the ground water discharge to a surface water body on-site?
Yes
No
Does the ground water discharge into a surface water body offsite?
No
Yes
Name of the surface water body:
East Tributary

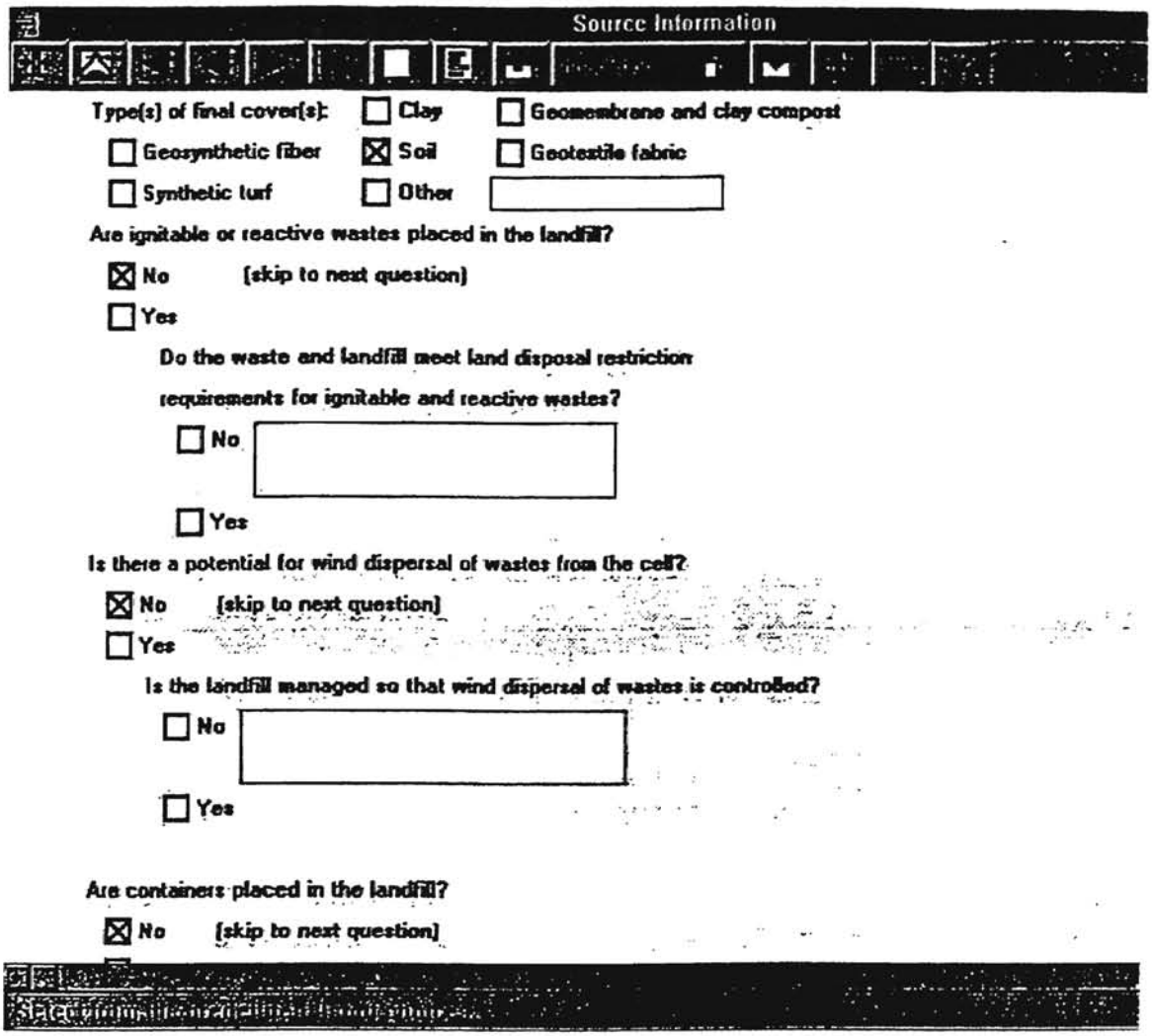

Environmental Setting
Are there any water supply wells located on or adjacent to the site?
No
Yes
Well ID
Location
Current status
Active
Uses of wells
Private drinking water
Public drinking water
Irrigation
Livestock watering
Industrial
Food processing
Other
Yields (gpd)
Screened inter
Are there ground water monitoring wells located on or adjacent to the site?
No
Yes
Well ID:
Location:
Depth to GW:
0
0
0
0
Regional Hydrology
Precipitation
Annual average rainfall (inches):
33
Annual average evaporation rate (inches):
58
Created records

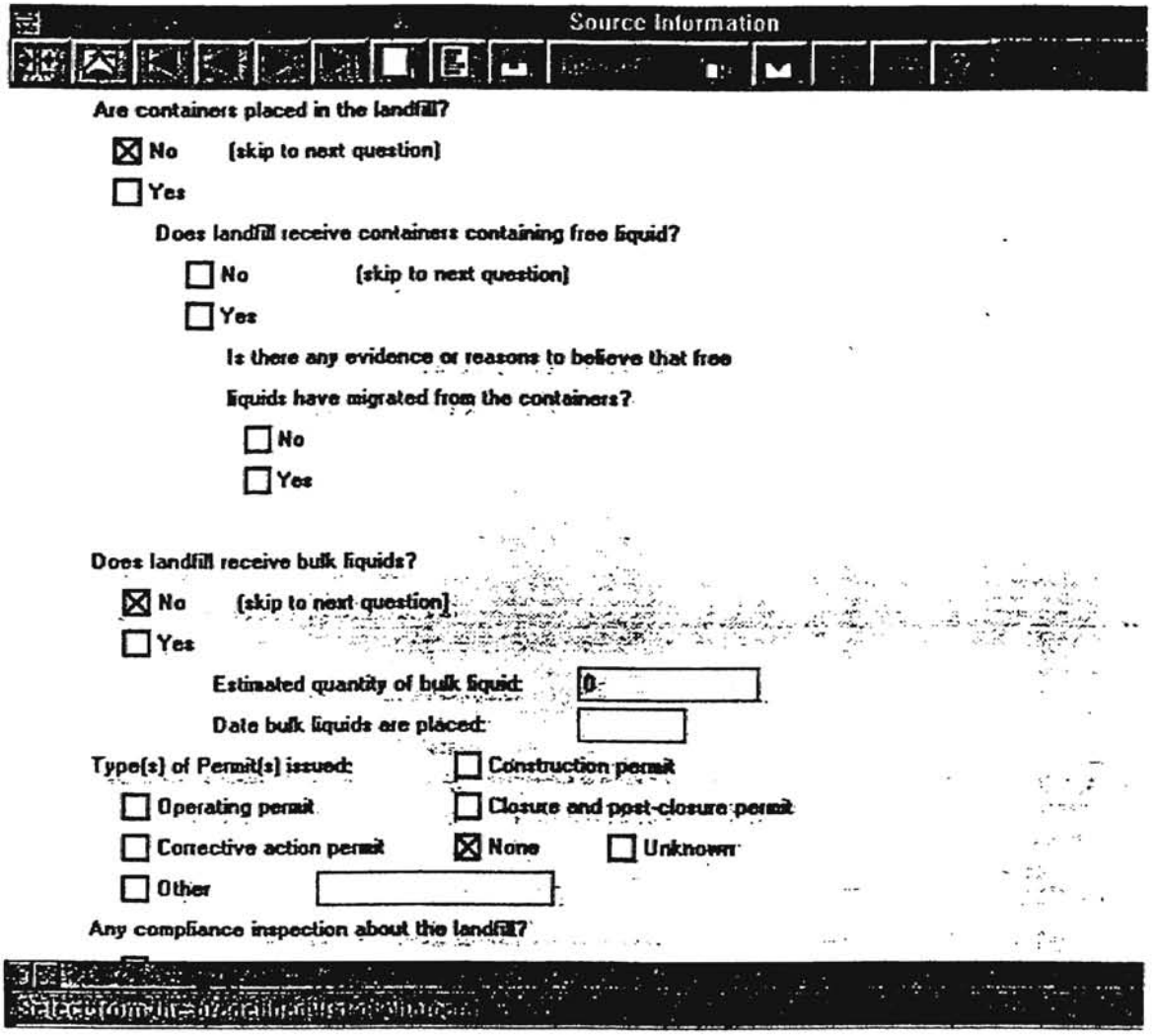

Environmental Setting
Reference:
Subsurface Soil Exploration Map
Bodies of surface water on-site:
Name
Location
Spring/Seep
Intermittent stream
Perenneal stream
River
Wetland
Pond
Lake
None
Other
Offsite bodies of surface water adjacent to the site:
Name
Location (close to property boundary)
Spring
Intermittent stream
East Tributary
West Tributary
Perennial stream
River
Wetland
Pond
Lake

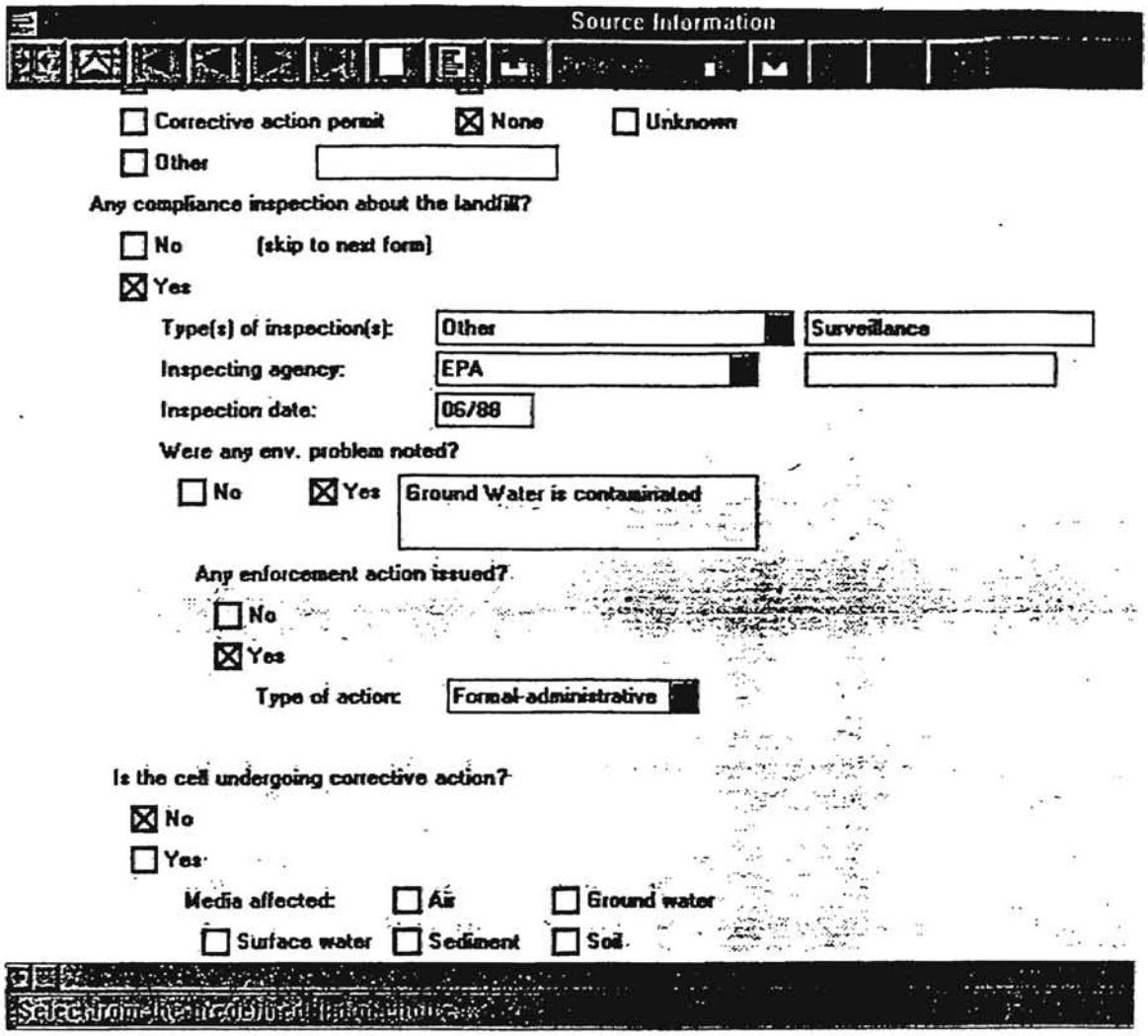

Environmental Setting
None
Other
Regional Geology
Name of the uppermost bedrock formation:
Wellington Formation of Premian Age
Uppermost bedrock unit:
Sedimentary rock
Sandstone
Mudstone
Fossil limestone
Chemical limestone
Dolomite
Other
Igneous rock
Granite
Rhyolite
Diorite
Peridotite
Basalt
Gabbros
Andesite
Other
Metamorphic rock
Marble
Schists
Gneisses
Quartizite
Other
Average depth of uppermost bedrock from ground surface:
Feet
6
Average thickness of the uppermost bedrock formation:
Feet
350
Rate of dip of the uppermost bedrock formation:
Feet/mile
50
Direction of the dip of the uppermost bedrock formation:
NE
Reference:
Subsurface Soil Exploration Map

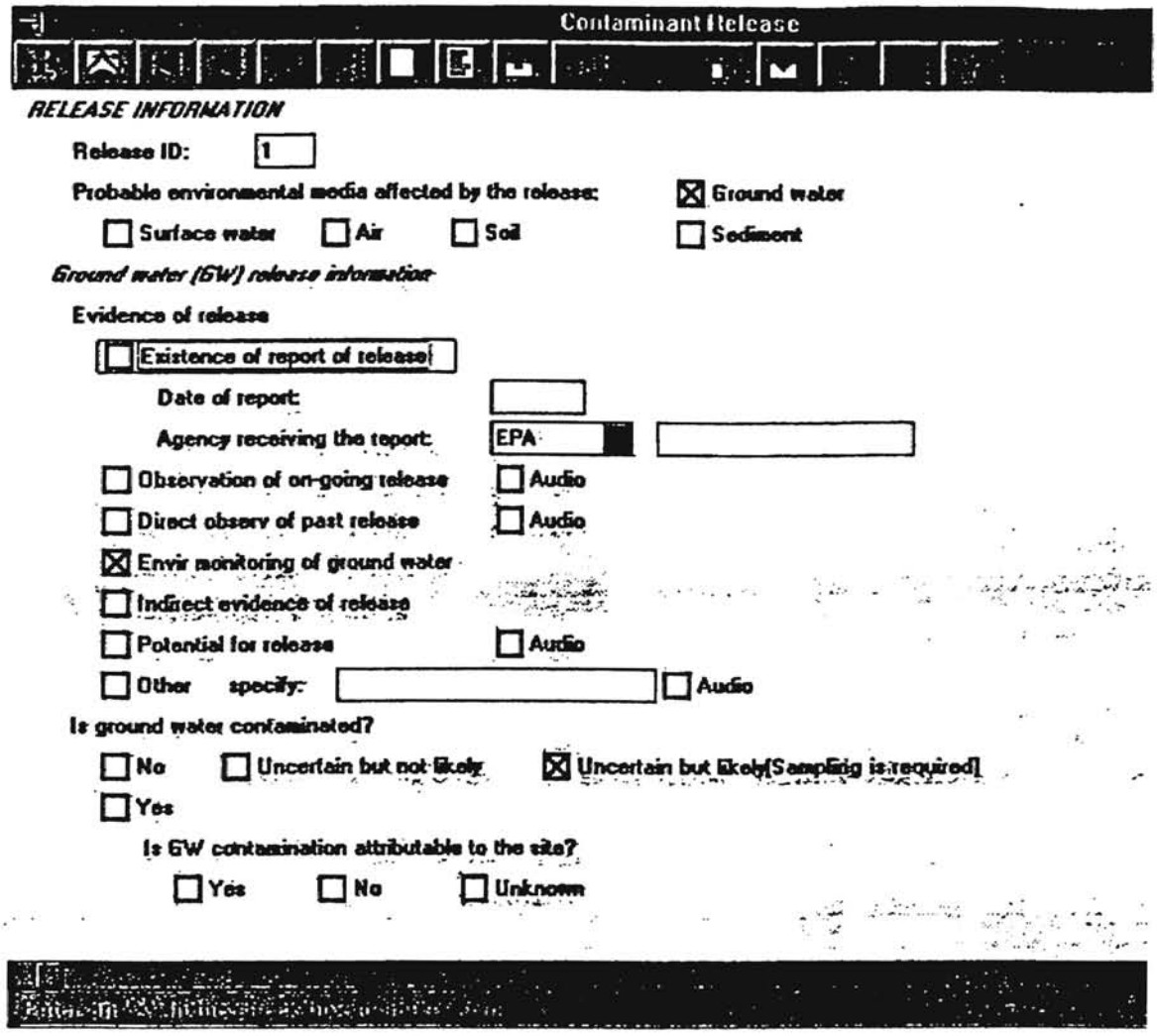

Source Information
Source Information
Type of source(s):
Tank
Above-ground storage tank
Material
Waste
Underground storage tank
Material
Waste
Container storage area
Material
Waste
Land disposal unit
Landfill
Surface impoundment
Waste pile
Material
Waste
Land treatment
Underground injection well
Thermal treatment
Incinerator
Fuel burning
Treatment
Pipeline
Loading and unloading areas
Building structure
PCB items
None

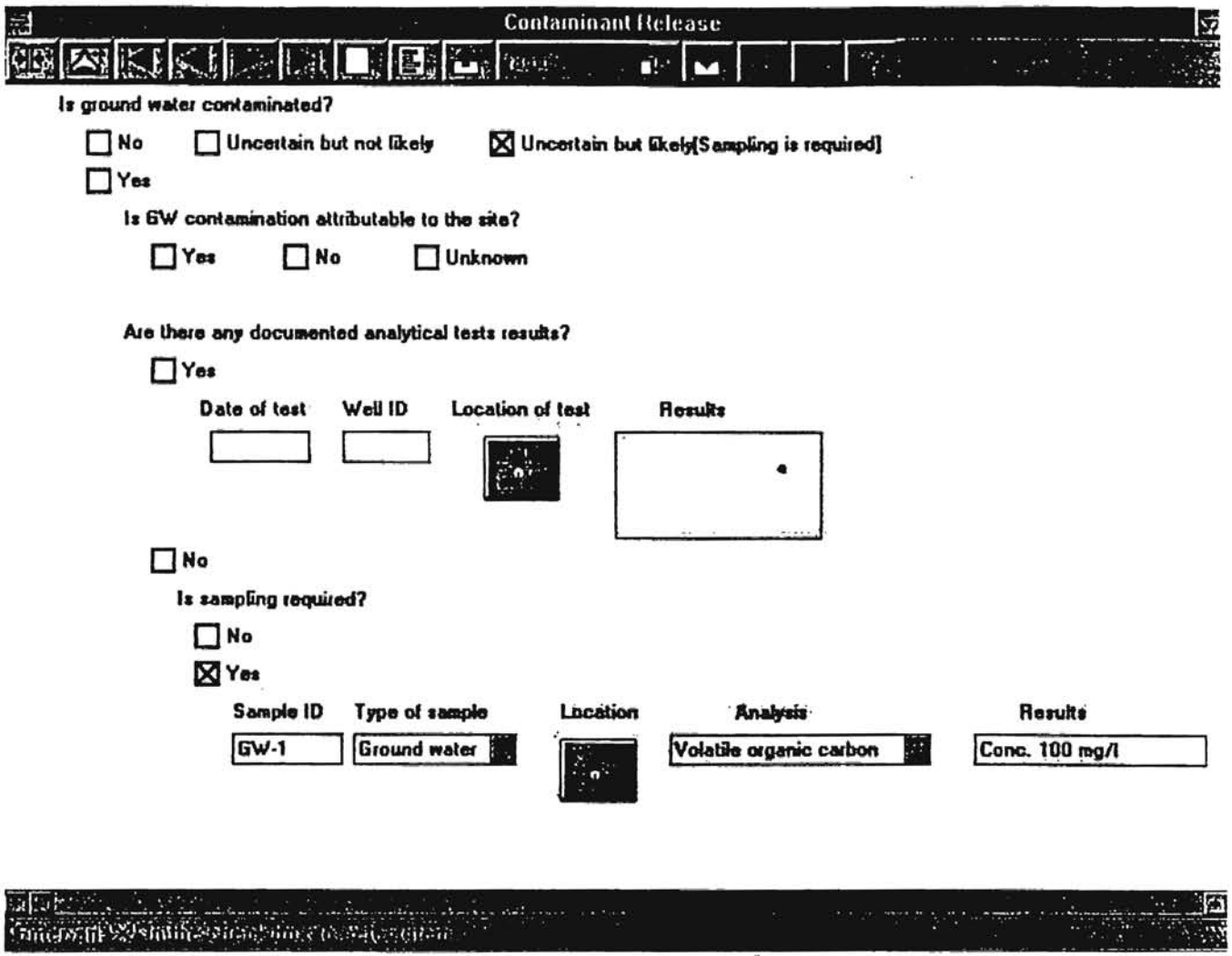

Source Information
☐ High density polyethylene
☐ Hypalon
☐ Unknown
☐ Other
Specify:
Liner thickness:
☐ Millimeters
0
☐ Inches
0
☐ Unknown
Liner construction method:
☐ Single piece
☐ Heat welded
☐ Chemically welded
☐ Unknown
☐ Other
Type(s) of intermediate cover(s):
☐ Yard waste mulch
☐ Yard waste compost
☐ Typical native soil
☒ Clay
☐ Geosynthetic clay liner
☐ Municipal solid waste compost
☐ None
☐ Unknown
☐ Other
Is there a leachate collection system present?
☒ No (skip to next question)
☐ Yes
Type of leachate collection system:
☐ Single-walled holding tank
☐ Double-walled holding tank
☐ Sump
☐ Unknown
☐ Other
Type(s) of leachate management option(s):
☐ Recycling
☐ Treatment followed by disposal
☐ Discharge under NPDES permit
☐ Unknown
☐ Other

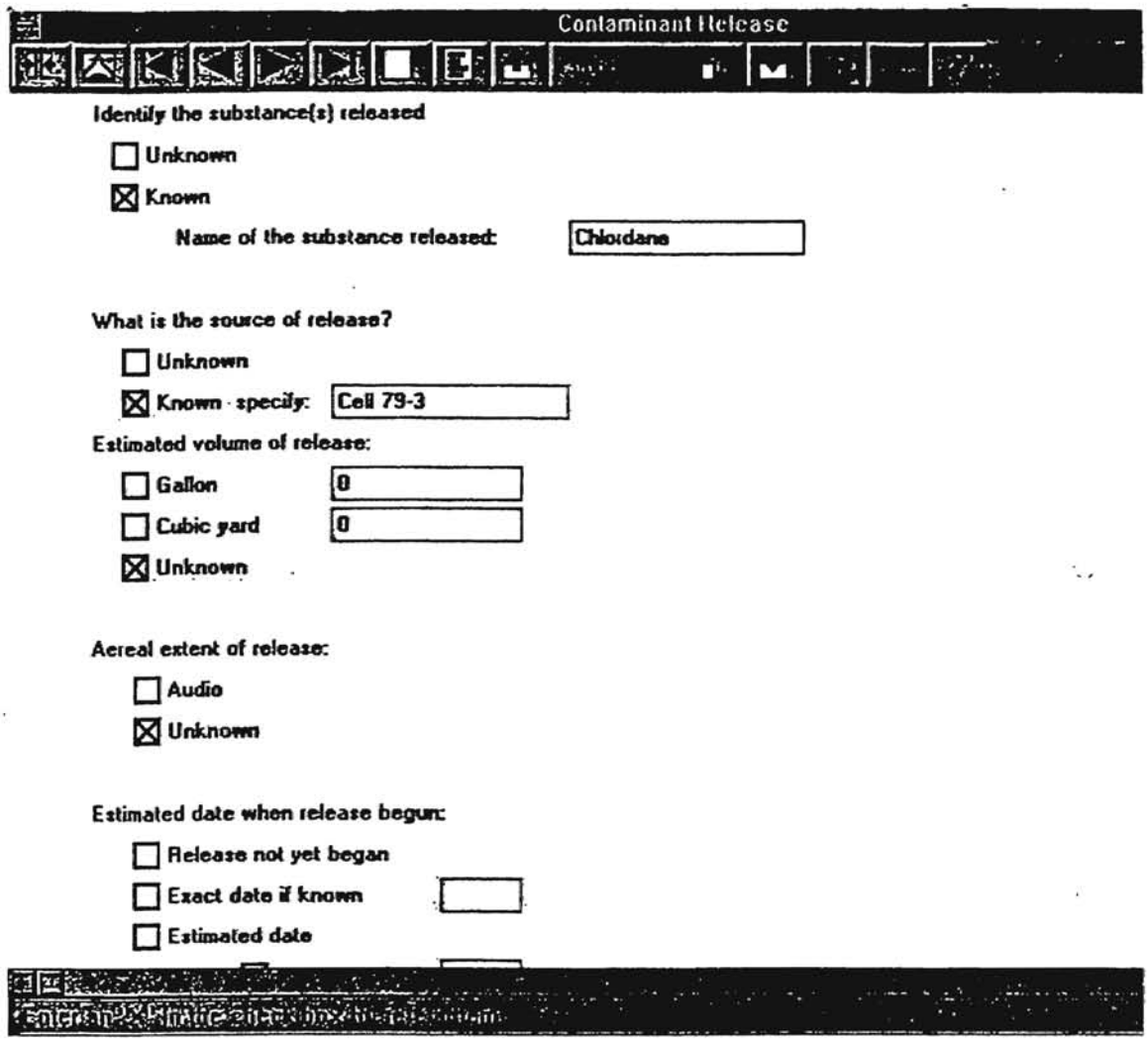

Source Information
Type(s) of final cover(s):
Clay
Geomembrane and clay compost
Geosynthetic fiber
Soil
Geotextile fabric
Synthetic turf
Other
Are ignitable or reactive wastes placed in the landfill?
No
(skip to next question)
Yes
Do the waste and landfill meet land disposal restriction
requirements for ignitable and reactive wastes?
No
Yes
Is there a potential for wind dispersal of wastes from the cell?
No
(skip to next question)
Yes
Is the landfill managed so that wind dispersal of wastes is controlled?
No
Yes
Are containers placed in the landfill?
No
(skip to next question)

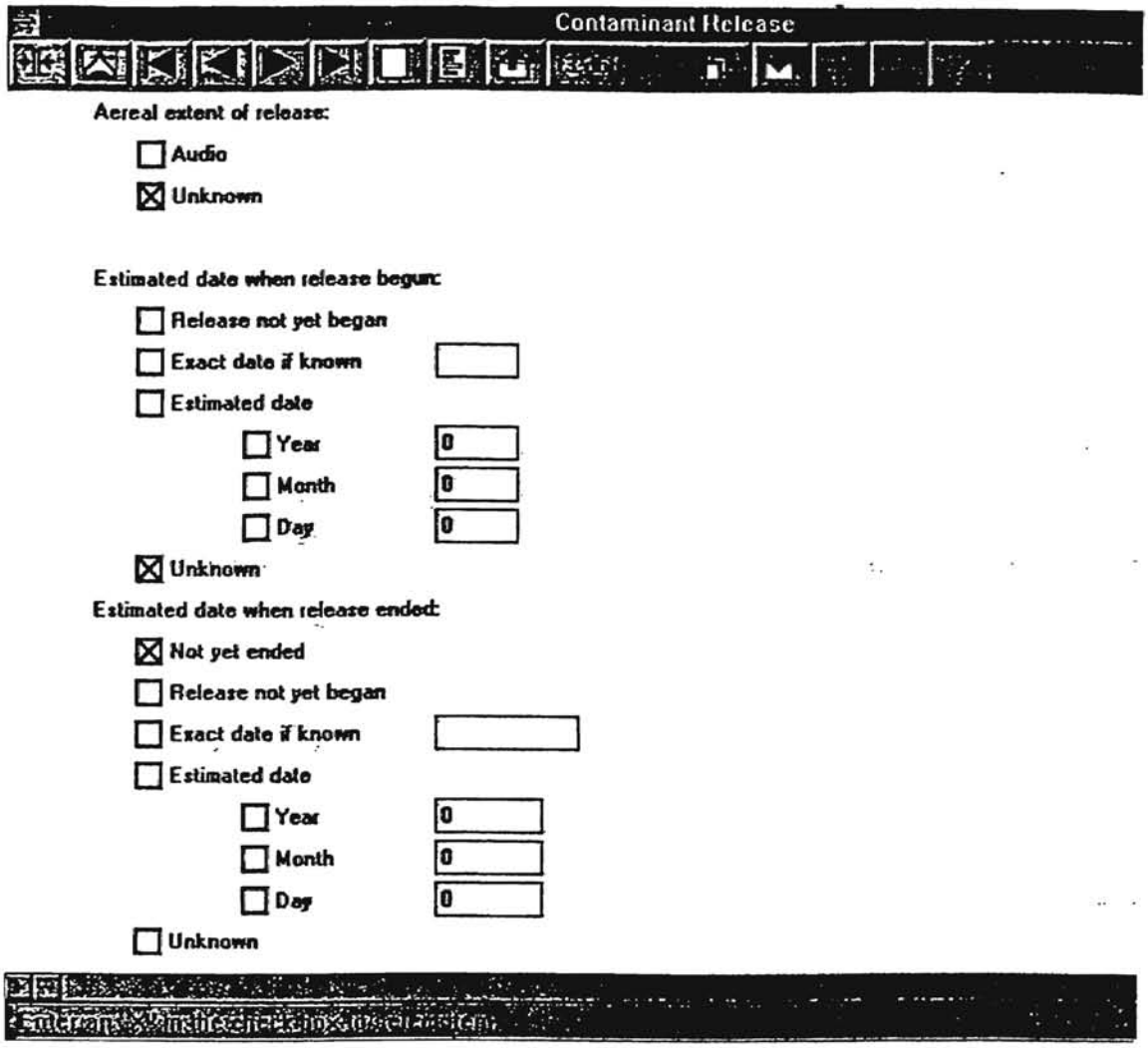

Source Information
Are containers placed in the landfill?
No (skip to next question)
Yes
Does landfill receive containers containing free liquid?
No (skip to next question)
Yes
Is there any evidence or reasons to believe that free liquids have migrated from the containers?
No
Yes
Does landfill receive bulk liquids?
No (skip to next question)
Yes
Estimated quantity of bulk liquid:
0
Date bulk liquids are placed:
Type(s) of Permit(s) issued:
Construction permit
Operating permit
Closure and post-closure permit
Corrective action permit
None
Unknown
Other
Any compliance inspection about the landfill?


Source Information
Corrective action permit
None
Unknown
Other
Any compliance inspection about the landfill?
No
(skip to next form)
Yes
Type(s) of inspection(s):
Other
Surveillance
Inspecting agency:
EPA
Inspection date:
06/88
Were any env. problem noted?
No
Yes
Ground Water is contaminated
Any enforcement action issued?
No
Yes
Type of action:
Formal-administrative
Is the cell undergoing corrective action?
No
Yes
Media affected:
Air
Ground water
Surface water
Sediment
Soil


Contaminant Release
RELEASE INFORMATION
Release ID: 1
Probable environmental media affected by the release:
Ground water
Surface water
Air
Soil
Sediment
Ground water (GW) release information
Evidence of release
Existence of report of release
Date of report:
Agency receiving the report:
EPA
Observation of on-going release
Audio
Direct observ of past release
Audio
Envir monitoring of ground water
Indirect evidence of release
Potential for release
Audio
Other specify:
Audio
Is ground water contaminated?
No
Uncertain but not likely
Uncertain but likely[Sampling is required]
Yes
Is GW contamination attributable to the site?
Yes
No
Unknown


Contaminant Release
Is ground water contaminated?
No
Uncertain but not likely
Uncertain but likely[Sampling is required]
Yes
Is GW contamination attributable to the site?
Yes
No
Unknown
Are there any documented analytical tests results?
Yes
Date of test
Well ID
Location of test
Results
No
Is sampling required?
No
Yes
Sample ID
Type of sample
Location
Analysis
Results
GW-1
Ground water
Volatile organic carbon
Conc. 100 mg/l


Contaminant Release
Identify the substance(s) released
Unknown
Known
Name of the substance released:
Chlordane
What is the source of release?
Unknown
Known - specify:
Cell 79-3
Estimated volume of release:
Gallon
0
Cubic yard
0
Unknown
Aereal extent of release:
Audio
Unknown
Estimated date when release begun:
Release not yet began
Exact date if known
Estimated date


Contaminant Release
Aereal extent of release:
Audio
Unknown
Estimated date when release begun:
Release not yet began
Exact date if known
Estimated date
Year
Month
Day
Unknown
Estimated date when release ended:
Not yet ended
Release not yet began
Exact date if known
Estimated date
Year
Month
Day
Unknown

Is there any receptors present on or adjacent to the site?

☐ No (No risk exists)

☒ Yes

Is there any citizen environmental complaints about the release?

☒ No (skip to next question)

☐ Yes

Date of complaint:

Nature of complaint:

Were complaint resolved?

☐ No

☐ Yes

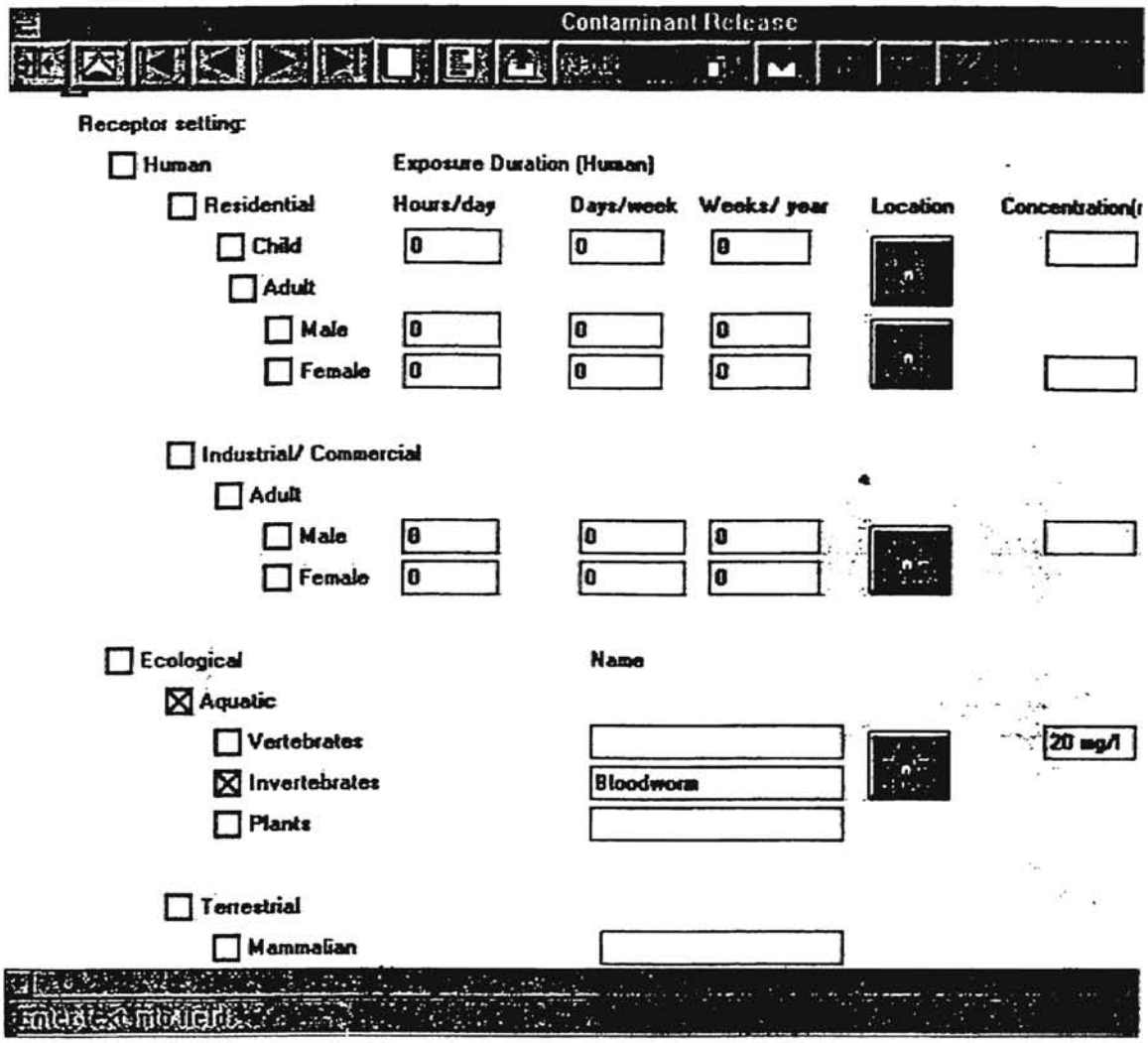
☐ Audio

RECEPTOR INFORMATION

Is there any specific evidence that the receptor is exposed to this migration pathway from the above release?

☐ No (Low risk exists for the receptors)

☒ Yes


Contaminant Release
Receptor setting:
Human
Exposure Duration (Human)
Residential
Hours/day
Days/week
Weeks/ year
Location
Concentration(
Child
Adult
Male
Female
Industrial/ Commercial
Adult
Male
Female
Ecological
Name
Aquatic
Vertebrates
Invertebrates
Bloodworm
Plants
20 mg/l
Terrestrial
Mammalian

ENVIRONMENTAL FINDINGS

Release	Source		Affected media		Receptor
☒ Yes	☐ Unknown		☒ Ground water	☐ Surface water	☐ Human
☐ No	☒ Known	Cell 79-3	☐ Air	☐ Soil	☒ Ecological
			☐ None		☐ None

☐ The site is Not recommended for further study. There is no evidence that the site is impacted by any environmental hazards.

☒ The site IS recommended for further study to quantify the risks associated with the following hazards.

- ☒ The environmental hazards that were produced due to the release affected the environmental media which then affected the receptors. A recognized environmental conditions exists at the site.
- ☐ There is a potential release opportunity exist at the site which may create a recognized environmental condition at the site.

Appendix C

Site Assessment Report

ENVIRONMENTAL SITE ASSESSMENT

PHASE 1

Chemical Waste Burial Site

Dhanmondi County, Oklahoma

EPA ID No: OKD 000928564

Prepared for

Abdul State University

Prepared by

Nomadics, Inc.

Stillwater, Oklahoma

Date of Submission

07-18-96

Table Of Content

PHASE I ENVIRONMENTAL SITE ASSESSMENT

1. INTRODUCTION

Nomadics, Inc. has conducted a Phase I Environmental Site Assessment (ESA) of the Chemical Waste Burial Site for Abdul State University. The purpose of this assessment is to determine the presence or likely presence of any presence of any hazardous substances on the site under conditions that indicate an existing release, a past release or a material threat of a release of any hazardous substances into structures or into environment of the site that may threaten human health, welfare and environment. The investigation included the review of archival information, site reconnaissance, environmental sampling and interviews site management personnel.

The ESA investigation team (Joel Roark and Andy Olson) visited the site on 18th July 1996. The sky was partly cloudy. The temperature was 108^{0}F, the humidity was medium (30-60)% and the wind speed was 5-15 miles per hour form the south. There was no precipitation during the site reconnaissance.

2. SITE LEGAL DESCRIPTION

2.3 Location

The Chemical Waste Burial Site is located at ¼ mile west of Franklin Road on 44th Street, Dhanmondi County, Oklahoma. It is located on a 1.6 acre facility in the NW ¼ NE ¼ NW1/4 Section 2, Township 18 North, Range 1 East, Dhanmondi, Oklahoma. The site has been used for landfilling pesticides and laboratory wastes. The perimeter of the site was fenced and the fencing appears to be in good condition. There are two gates to the facility which were locked.

2.2 **Ownership**

Currently, the facility is under the ownership of the state government of Oklahoma. The Board of Regents for Oklahoma A & M Colleges is the owner of the facility. Claude Evan, Chairman, is the responsible official for the facility. W. Douglas Wilson, Executive Secretary, is the contact official for the site.

2.3 **Operatorship**

Currently, the facility is under the operatorship of the state government of Oklahoma. Abdul State University is the operator of the facility. John Fox, Director of the Physical Plant, is the responsible official for the facility. Greg Houck, Environmental Hazard Coordinator, is the contact official for the site.

4. **ENVIRONMENTAL SETTING**

3.5 **Land Uses**

The site area is approximately 0.6 acres. The current dominant land use on the property is not zoned but is used for land disposal. The current surrounding land uses within 1 mile of the property boundary are zoned as agricultural. There are at least 50 contiguous acres of undeveloped or underdeveloped land located adjacent to the facility boundary which are used for cross-timber experimental ranch research. The surrounding land was previously zoned as agricultural.

3.2 **Regional Geology**

The uppermost bedrock formation beneath the waste disposal site is the Wellington Formation of Permian age. This formation is about 350 feet thick. It is composed of interbedded sandstones and mudstones. Average depth of it from the ground surface is 10 feet. The beds dip approximately 50 feet per mile to the west.

3.3 **Regional Hydrology**

There is no surface water body located on site. There are two intermittent streams within one mile of the site which drain into Wild Horse Creek. The annual average rainfall for the region where the site is located is 33 inches and the annual average evapotranspiration rate is 58 inches.

3.4 **Regional Hydrogeology**

A shallow water table aquifer is located at an average depth of 10 feet from the ground surface. The thickness of the aquifer is 6 feet. Water in the aquifer flows to the south. The aquifer is not confined. The seasonal low water table depth and seasonal high water depth of the aquifer are 16 feet and 10 feet respectively. The ground water does not discharge to a surface water body on-site. It discharges to the east tributary, located 50 feet from the property boundary. There are 7 monitoring wells present on or adjacent to the site. They were installed to determine the quality of ground water under the facility.

3.5 **Regional Meteorology**

The mean annual temperature is 79^0F. The mean minimum temperature is 15^0F and the mean maximum temperature is 102^0F. Average humidity at the site is medium (30-60)% and the annual average wind speed is 15 miles per hour predominantly from the south.

3.6 **Regional Soil**

The site is located on Harrah soils which are loamy, which the Pulaski soils being located in the adjoining sites. The Harrah soil is low to medium in natural fertility and medium in organic content. Slope ranges from 3 to 8 percent. Permeability is moderate and surface runoff is medium.

4. SOURCE INFORMATION

4.5 **Physical Description**

There is one landfill present that is composed of 30 cells. Landfill cell 79-3 is located at 36^0 4'19.14665" latitude and $97^0$10'17.7291 longitude. The capacity of this cell is 225 cubic feet. Wastes were first added to that cell on 06/86. Wastes were last added to the cell on 05/88. The cell was closed on 06/88. The total quantity of wastes disposed in the cell is unknown.

4.2 **Cell Construction**

There is no liner used in Cell 79-3. An intermediate cover of soil were used to cover wastes. No leachate collection system was installed in the cell. The final covers of the cell are clay, topsoil and vegetation. There are no wind disposal of wastes from the cell.

4.3 **Types of Wastes Disposed**

Chlordane (pesticide), butylamine and aluminum chloride wastes were disposed in the cell. No ignitable or reactive waste was buried in the cell. No container was buried in the cell. No bulk liquids were buried in the cell.

4.4 **Regulatory History**

Cell 79-3 is not permitted. There was a surveillance inspection of the landfill by Environmental Protection Agency on 06/88. There was an environmental problem noted. A formal administrative enforcement action was issued that requiring ground water monitoring. Corrective action to address ground water contamination has not yet begun.

5. **HAZARD IDENTIFICATION**

5.6 **Release Information**

There is a release from Cell # 79-3 to the ground water. Sampling of ground water was performed at monitoring well 4 during the site reconnaissance. Chlordane was detected at a concentration of 100 µg/l.

5.2 **Receptor Information**

There are ecological receptors present in the east tributary of Wild Horse Creek. Names of the ecological receptors found in the tributary include aquatic macro-invertebrates, such as bloodworm, oligochetes. Since ground water flows from the site to the east tributary, the ecological receptors are exposed to the release. Analysis of a sample of the water in the tributary during the site reconnaissance revealed a concentration of 20 µg/l, a concentration toxic to the micro-invertebrates. None of these macro-invertebrates were found in the tributary.

6. **SUMMARY AND CONCLUSION**

Phase I of the Environmental Site Assessment for the Chemical Waste Burial Site attempted to determine the presence or likely presence of any hazardous substances on the site under conditions that indicate an existing release, a past release or a material threat of a release of any hazardous substances into the structures or into the environment of the site which may threaten to human health, welfare and the environment. All federal, state and local and site

records were reviewed, a site reconnaissance was performed, interviews were conducted with the site operators and environmental samples were collected and analyzed to characterize the types and concentrations of substances released from the site and potential migration pathways to bioreceptors.

Based on all the information obtained, it is concluded that an environmental hazard exists due to the release form the Cell 79-3 which migrates through the ground water and impacted the aquatic macro-invertebrates in the east tributary to the Wild Horse Creek. A recognized environmental condition exists at the site.

7. RECOMMENDATION

A Phase II ESA is recommended to further characterize (1) sources of contamination, (2) the ground water monitoring pathway; (3) exposures of other ecological receptors to ground water contamination, and (4) risk to ecological receptors. Specifically, further ground water, surface water and sediment analysis should be conducted, additional receptors should be identified, and risk estimates should be developed.

VITA

Md Mahmudur Rahman

Candidate for the Degree of

Master of Science

Thesis: AUTOMATED ENHANCED PHASE I ENVIRONMENTAL SITE ASSESSMENT PROTOCOL

Major Field: Environmental Science

Biographical:

Personal Data: Born in Dhaka, Bangladesh, February 11'1967, the son of late Md Mojibur Rahman and Nurul Naher.

Education: Received Secondary School Certificate Degree from Dhanmondi Government Boys High School in April'1983: Received Higher Secondary School Certificate Degree from Dhaka College, Dhaka in July'1985; Received Bachelor of Science Degree in Mechanical Engineering from Bangladesh University of Engineering & Technology, Dhaka, Bangladesh in August' 1992.

Professional Experienced:

Worked as a Assistant Mechanical Engineer in Industrial Credit Division, Janata Bank, Bangladesh from February 1993 to Mid. August 1993.

Working as a Research Assistant, Oklahoma State University, School of Geology, from January 1996.