**PDHonline Course C386 (3 PDH)**

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# Environmental Investigation and Remediation of a Hazardous Waste Site<br> Part 1 – Background and History Leading to Contract Award

*Instructor: Samir G. Khoury, Ph.D., P.G.*

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

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# Environmental Investigation and Remediation of a Hazardous Waste Site
# Part 1 – Background and History Leading to Contract Award

***Samir G. Khoury, Ph.D., P.G.***

## Course Content

## Course Introduction

A Research Institute ("Institute") had for many years used a variety of radioactive materials and numerous hazardous chemicals in conducting experiments in their laboratories. In order to dispose of the waste products of this research, the Institute operated a small shallow land burial facility on the grounds of its research campus. The liquid and solid wastes were placed in various types of containers which were then placed in narrow parallel trenches dug into the soil to a maximum depth of about 8 to 12 feet below the ground surface. Once a trench was nearly filled, dirt was placed over the waste, compacted, graded, fertilized and seeded. In areas where parts of older trenches subsided, due to breakage of containers or compaction of the waste, additional dirt was placed in the sunken areas and these parts were re-graded and re-seeded. In this case, the site itself slopes gently downhill, so that surface water would run off the burial area and into the woods down-slope of the landfill. The site is located in a part of the U.S. that receives a moderate amount of rainfall per year.

Shallow land burial at the site was carried out by the Institute for a period of 20 years, from the 1960s to the 1980s. The entire research facility is under a system of controlled access and admission to the research campus is through a guarded gate. In addition, the waste disposal site itself is fenced, padlocked and posted as shown on Figure 1.

Figure 1: Waste disposal site owned by the Research Institute

At this point it is important to note that shallow land burial of radioactive and chemical wastes at this site was conducted in accordance with the accepted federal and state standards that were in force

during the time of its operation. The Institute was never cited for improper disposal practices or other violations. Both the Institute and the Regulatory Agencies agreed that the site was managed and operated properly. After the site was decommissioned in the 1980s, only minor maintenance was completed, and the site and fence became overgrown with vegetation.

Since the late 1980s, however, public awareness of the dangers of contamination from landfills of all types was growing throughout the country. In response to this heightened awareness, regulatory agencies charged with the protection of public health and safety became increasingly concerned that disposal practices that were once considered acceptable may have long-term negative impacts on groundwater, surface water and soil. The US Environmental Protection Agency (USEPA) started to issue drinking water standards that specified minimum acceptable levels for a number of common industrial chemicals, including some radioisotopes. Federal and state legislations were promulgated requiring environmental regulatory agencies throughout the US to investigate operating, decommissioned and abandoned landfills of all types. The Superfund program was initiated at the federal level to help fund the cleanup of abandoned hazardous waste landfills of all types.

## Legislative Background

Hazardous wastes are defined as discarded substances that pose existing or potential danger to human beings or other biological organisms because they are toxic, flammable, radioactive, may explode or have some other properties that pause substantial risk to life. Although disposal of hazardous waste has been carried out in the U.S. since the beginning of the industrial revolution, it was not until the 1970s that the regulatory agencies promulgated regulations to address the problem of environmental contamination and promulgated acts to protect human health and safety. In fact the Environmental Protection Agency and the National Oceanic and Atmospheric Administration were created in 1970 and the Clean Air Act, the Clean Water Act, the Pesticide Control Act, the Endangered Species Act, and the Safe Drinking Water Act all became law by the end of 1974. A brief history of the legislative actions taken with respect to both nuclear and chemical wastes is presented in the following paragraphs.

### Low-Level Radioactive Waste

Low-level radioactive waste consists of ordinary objects that become contaminated by contact and use in the handling of radioactive materials. Low-level radioactive wastes do not include spent fuel rods from nuclear reactors or highly active radio nuclides. Almost all the radioactive waste generated in the U.S by universities, hospitals and research institutions, both federally and privately owned, are classified as low-level radioactive waste.

Starting in the mid-1940s, the beginning of the nuclear age, the United States used two methods for the disposal of low-level radioactive waste. The wastes were either 1) buried on land or 2) discarded into the ocean. In 1960, the Atomic Energy Commission (AEC) stopped issuing permits for ocean disposal and began opening government owned land burial sites. By 1962, most of the low-level radioactive waste was disposed of in shallow land burial facilities. Initially, the shallow land burial sites were licensed and operated under limited regulations and poorly defined performance criteria. The governing standards for the methods of disposal of low-level radioactive wastes were not promulgated

until 1981, when most of the commercially-owned and privately-owned disposal sites had begun to curtail their operations and close down. Presently, the official standards for the disposal of low-level radioactive waste are documented in Section 10 of the Code of Federal Regulations, Part 61 (10 CFR, Part 61). Since the early 1980s the disposal of radioactive waste has been regulated by the US Nuclear Regulatory Commission (USNRC). Only a few sites in the U.S. are licensed to receive and dispose of commercially generated low-level radioactive waste.

**Hazardous Chemical Waste**

Prior to the mid- to late-1960s, it was common practice to dispose of liquid hazardous chemical wastes in creeks, streams and open lagoons. The discarded chemicals in lagoons were left to evaporate and/or infiltrate into the ground. In some cases, both solid and liquid hazardous chemical wastes were placed in containers, such as metal drums, glass or plastic containers, and buried in trenches (shallow land burial). In some other cases these containers were just abandoned on top of the ground in commercial disposal facilities that had no operating procedures to monitor and check on the long-term integrity of the containers. Consequently, under constant exposure to the elements the containers deteriorated or broke and the contents leaked or spilled onto, and into, the ground.

The disposal of chemical wastes began to be controlled and regulated at the federal and state levels in 1969, with the promulgation of the National Environmental Policy Act (NEPA). Presently, the official standards for the disposal of hazardous chemical wastes are documented in Section 10 of the Code of Federal Regulations, Part 40 (10 CFR, Part 40). These regulations are periodically updated as more is learned about the properties of various chemicals. Since the early 1970s the disposal of hazardous chemical waste has been regulated by the US Environmental Protection Agency (USEPA).

## Initial Regulatory Interest in the Disposal Site

Although the waste disposal site, owned and operated by the Research Institute, was closed and decommissioned in the 1980s, it took time for it to appear on the radar screen of the State Regulatory Agencies. Because both radioactive and chemical wastes were buried on site, the State Radiation Protection Agency (State RPA) and the State Environmental Protection Agency (State EPA) were both interested in evaluating the status of the site. Existing protocols dictated that because of the presence of buried radioactive materials, the Radiation Protection Agency was to take the lead role in investigating the site. This was done in close coordination with the State EPA. The heightened interest of the regulatory agencies was motivated by the increased national public pressure to investigate possible sources of contamination from landfills.

For several years following closure, the State RPA had taken and tested soil, vegetation, and surface water samples from the area of the disposal site. During those years, the State RPA wrote in a letter addressed to the Research Institute that the waste disposal site had excessive vegetation growing on it, including small trees. The State RPA requested the Institute to maintain the site more actively by keeping the vegetation cut down, keeping the fence surrounding the site in good repair, maintaining a mowed ten-foot strip surrounding the fence and posting warning signs on the fence to limit access to the site by authorized personnel only. The State RPA wrote: "We want all the hazardous waste burial

grounds within the state to keep their identity and not be allowed to get overgrown and hidden from view by vegetation".

Later on, the State RPA and the State EPA wrote the Institute that: "We took soil, vegetation and water samples from the site to run them through the state laboratory. To date, we have not found any levels of radiation above background". The State RPA also noted that the Institute had made numerous improvements to the waste disposal site. The fence and site area had been cleaned up and looked good. The State RPA recommended that: "To keep the site looking good, it should be mowed several times a year and the fence should be cleaned and the posted signs kept legible".

Several years later, the State Radiation Protection Agency wrote a letter to the Institute requesting enhancements to the sampling and testing program that they have conducted till then. The State RPA recommended the installation of shallow monitoring wells at the site which would help demonstrate that contamination is not reaching the groundwater and moving with it offsite. The State RPA stated: "It should be noted that the issue of radioactive waste is foremost in the news and in the minds of many concerned citizens throughout the state. Other state and federal agencies, such as the State EPA, are also concerned about both the radioactive and chemical wastes. The State RPA thinks that it should consider every possible means to demonstrate that material is not moving off-site. People are becoming very concerned about groundwater contamination".

**Installation of Monitoring Wells**

In response to the written concerns of the State RPA the Institute installed five groundwater monitoring wells around the perimeter of the disposal site. This installation was done under the guidance of the State Groundwater Protection Agency (State GPA). The locations of these wells are shown on the following figure.

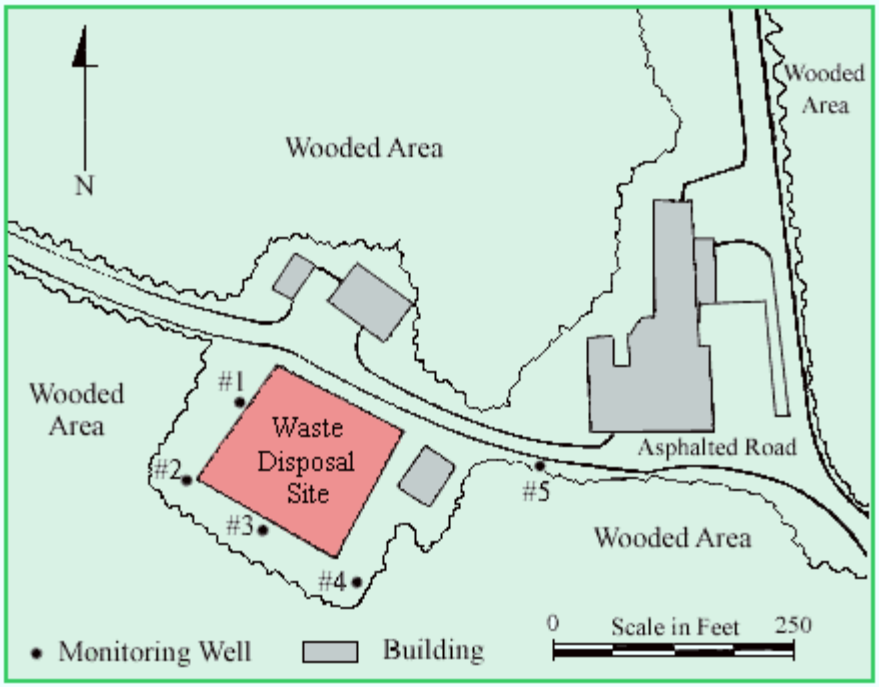


Figure 2: Location of initial groundwater monitoring wells installed around the waste disposal site

Wells numbered 1 through 4 were located just outside the fence surrounding the waste disposal area on the downhill side of the site. These wells were assumed to be down-gradient of the waste disposal site, so that any groundwater that was contaminated below the waste disposal area would likely flow in the general direction of these wells. Each of these wells was drilled to a depth of 50 feet. Well No. 5 was located uphill and away from the disposal site. This well was considered the background (or up-gradient) well and is used to sample the groundwater before it reaches the disposal site. Without an up-gradient well to establish the baseline chemistry of the groundwater, it is difficult to know if the waste disposal site is contributing contamination to the environment. Well No. 5 was drilled to a depth of 60 feet in anticipation that the groundwater table was deeper in that area of higher ground elevation.

Unfortunately, no geologic or well construction records were kept by the drilling contractor or by the Institute at the time these wells were installed. Initial groundwater levels were recorded as 25 ft. below ground surface in wells Nos. 1, 2, 3 and 4 and 48 ft. below ground surface in well No. 5. Groundwater levels were measured immediately after the borings were drilled. No records of well development exist. Wells are typically developed by pumping to remove residual drilling fluids and additives from the formation surrounding the well and to accelerate the equilibration of the water level in the well with that of the surrounding groundwater table. Consequently, these initial depth measurements are suspect and likely do not represent the top of the groundwater table under the site.

**Expression of Concern by the Regulators**

Following the installation, groundwater samples were collected from the five monitoring wells and analyzed by the State RPA. The State RPA wrote to the Institute that the analyses of the groundwater samples taken at the site revealed the presence of elevated concentrations of tritium and carbon-14. Subsequent chemical analyses also detected significant levels of several organic contaminants. The results of these analyses indicate that: “radioactive and chemical contaminants from the buried wastes were migrating away from the burial area through the near-surface groundwater”. However there was insufficient information at this point to determine the extent, rate and significance of this migration.

Based on these test results, the State RPA wrote to the Institute that: "It is necessary that you take immediate steps to develop, for our approval, a plan to assess and deal with this problem. You also need to develop a timetable for implementation and identify the qualifications and person(s) or firm(s) who will implement the plan. This plan should include, but not be limited to, the following:

- Identification of the source (locations, quantities and types of buried radioactivity and chemicals),
- Characterization of the plume of soil and groundwater contamination, including the rate and extent of horizontal and vertical movement,
- Characterization of burial site, including geology, hydrology, meteorology …etc., as necessary to predict future movement of contaminants,
- Evaluation of runoff and nearby surface water for radioactive and chemical contaminants,
- Identification of predictive mathematical or computer models which will be used,
- Identification and monitoring of off-site residential and other wells,
- Assessment of actual and potential impact on public health,
- Design and implementation of an ongoing monitoring program, and
- Development of a plan for mitigation of the impacts of offsite contamination".

The State RPA letter continued: "While the State Radiation Protection Agency is the lead regulatory agency, the Institute should note that the following additional state agencies have been contacted and they too have a regulatory interest in this matter: the State Waste Management Agency, Superfund Section, and the State Groundwater Protection Agency. The State Radiation Protection Agency activities in this matter will be closely coordinated with these other agencies to ensure that the plan and its implementation conform to any of their applicable regulatory requirements. Noting that the plans we are requiring you to develop are extensive, we will be pleased to meet with you to discuss our requirements in more detail at a mutually agreeable time. In this regard, it is our view that you should consider retaining an experienced commercial firm to assist you in your plan development and implementation. Your immediate attention to this matter is necessary".

It is important to note that with this letter, the relationship between the Institute and the State RPA changed. Prior to this time, the State RPA had implemented a minimal sampling and testing program around the waste disposal site once a year. Once contamination was identified in the groundwater, however, the State RPA directed the Institute to develop an extensive investigation program that included an assessment of impact on public health, the development of a mitigation plan and specified that their immediate attention to this matter was necessary. Note that the agency wrote: “we will be pleased to meet with you to discuss our requirements”. This phraseology indicated in no uncertain terms that there would be little room for the Institute to negotiate.

## Response to Regulatory Correspondence

In response to the expression of concern by the State RPA, the Institute issued a Request for Proposals (RFP) to qualified environmental and engineering consulting firms. The RFP included a brief history of disposal at the site, including the types of wastes that were buried there and the disposal practices used. The section on technical scope of work in the RFP included all the work plan items sent to the Institute by the State RPA. Also as part of the RFP, the Institute asked potential bidders to address:

- The types of testing to be done,
- A brief description of possible options that will be considered, and
- A schedule and cost estimate for the proposed work.

The RFP also included a request for qualifications and experience of the firm in completing similar projects, the qualifications and experience of the personnel to be assigned to the project, and proof that the firm has sufficient financial resources to complete the project. Each bidder was also requested to identify any subcontractors they intended to include on the project and their qualifications and experience. A project organization chart showing all key personnel and any subcontractor was also requested. Names and phone numbers of references for both the proposing firm and all subcontractors were requested. The Institute also asked for the assistance of the winning firm in seeking state regulatory approval of the proposed actions to be implemented in the final work plan.

## Pre-Proposal Site Visit

As part of the proposal process, the Institute invited representatives of interested firms to attend a pre-proposal site visit. For general information, the following map showing the 500, 1,000 and 1500 feet distances from the waste disposal site was provided by the Institute to all participants.

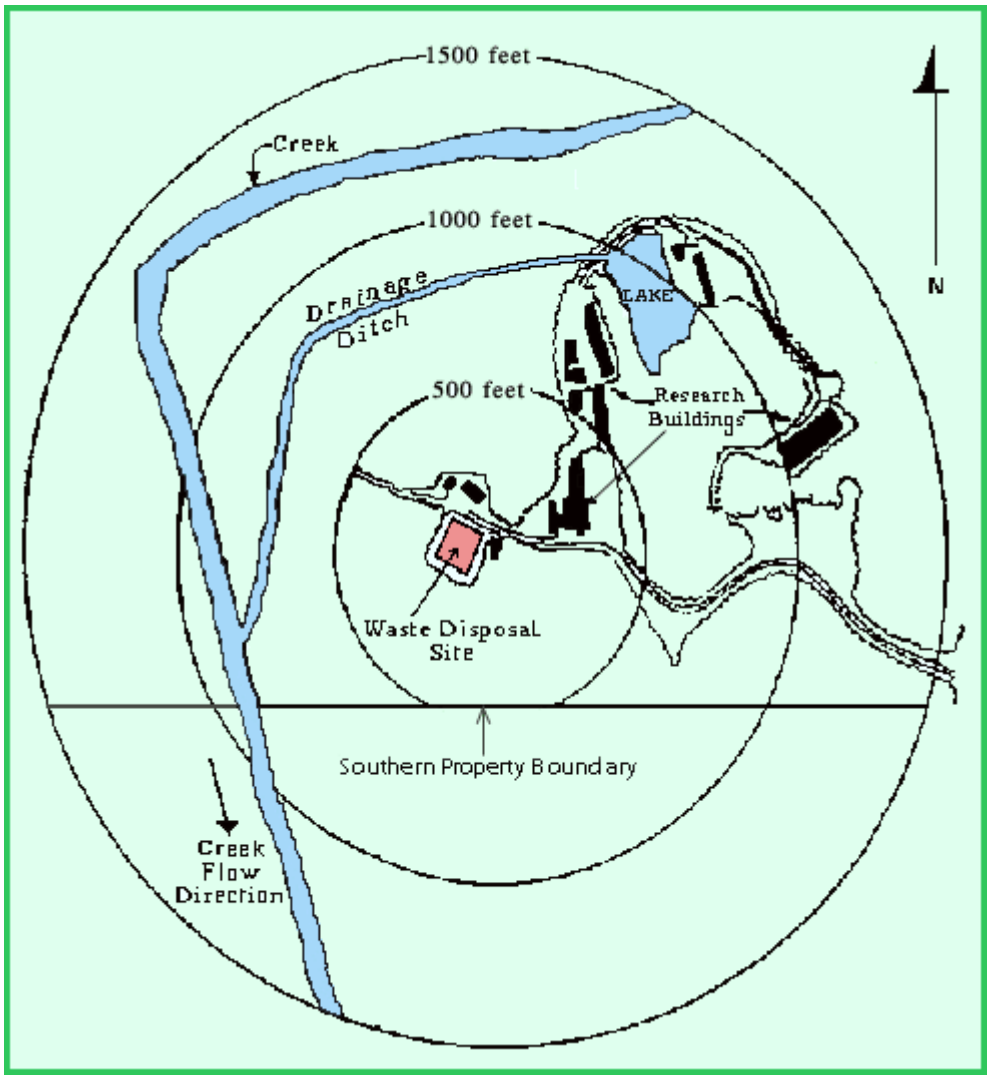


Figure 3: Map showing the 500-, 1,000- and 1500-feet distances from the waste disposal site

This site visit was very useful to all potential bidders. A number of questions were asked to clarify or expand on information provided in the RFP. Issues not addressed in the RFP were also raised. The visitors to the site learned that the waste appears to have been buried in a residual soil that was formed by the weathering of the underlying bedrock. The five monitoring wells installed around the waste disposal site by the Institute, at the request of the State RPA, were drilled to approximately the same depth. There was no indication from the available information whether the screened interval in each well was in the bedrock or the overlying soil or whether any geologic logs had been prepared during the drilling of the wells. The wells were apparently not developed, a process that is typically used to

remove residual drilling fluids from the surrounding formation to enhance the connection of a well to the groundwater system.

The visitors also learned that water levels in these wells were measured only once, shortly after the time of well installation. Since it may take days or weeks for a new monitoring well to equilibrate with the actual groundwater table, the existing information was considered by some to be of limited value and usefulness.

The site visit also allowed the participants to note the topography of the site, identify the property boundary and inspect the surrounding region to see what activities occurred in the site vicinity. The following topographic map illustrates the position of the waste disposal area within the local topography and in relation to the nearest creek.

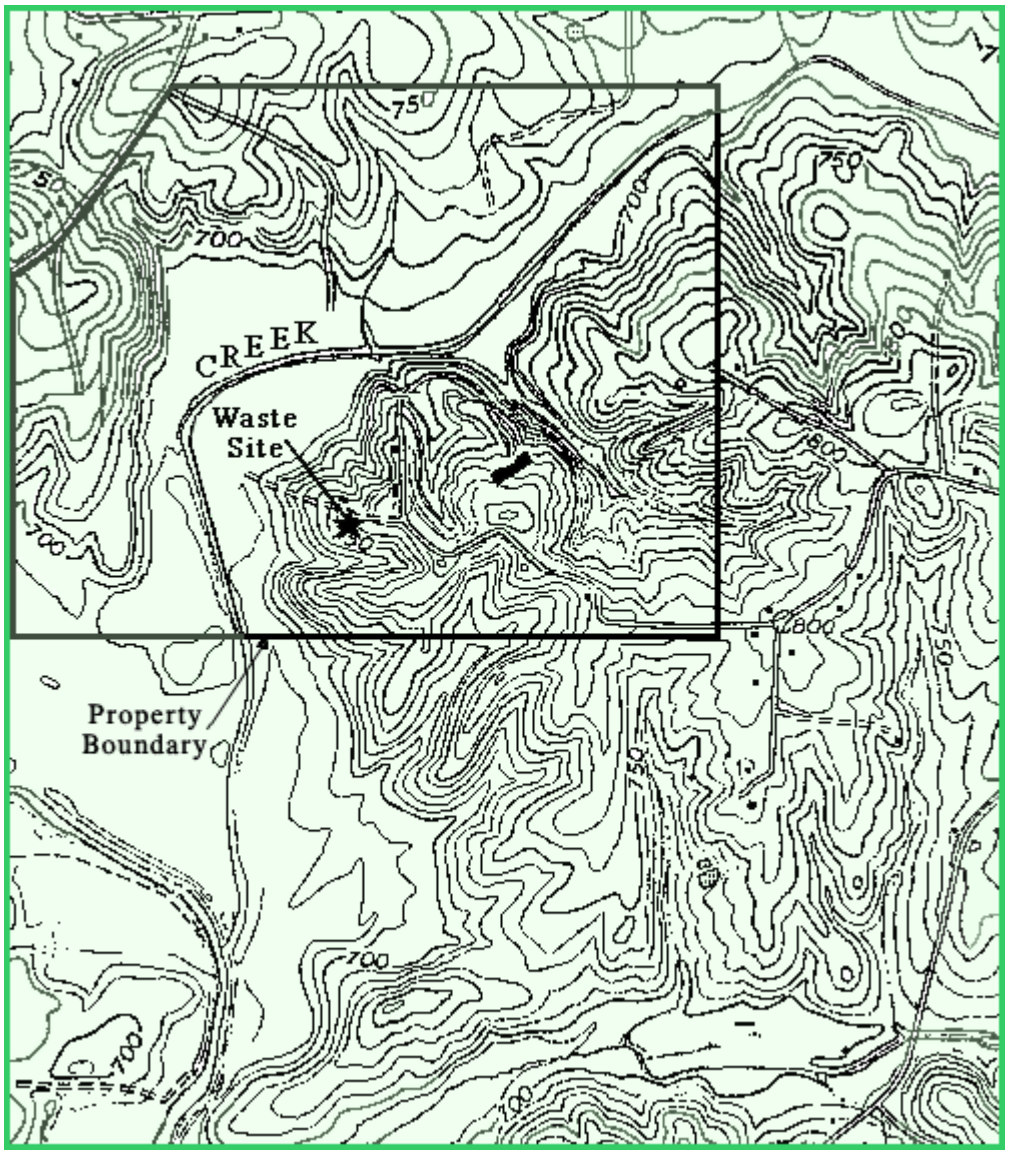


Figure 4: Topographic map of the area surrounding the waste disposal site, contour interval = 10 ft.

Based on the local topography, some preliminary inferences regarding surface water flow paths and groundwater flow directions could be made. The disposal site itself is located near the top of a small promontory that is primarily drained from east to west by a small draw, immediately to the south. This small surface water drainage channel joins a creek located about 1,000 feet to the West, across a flood plain. It was also noted during the pre-proposal site visit that corn was being cultivated on this portion of the flood plain. No mention of this land use had been made in the RFP.

In most areas of the country, the groundwater table mimics the topography, but in a more subdued fashion. Consequently, it was inferred that groundwater from beneath the waste disposal area likely moves down-slope to the west and southwest, in the direction of the flood plain.

The participants in the pre-proposal site visit were not required to identify themselves or their firms to each other, although they were required to sign in at the Institute. However, many of the participants knew each other from professional meetings and other encounters. As such, a secondary benefit of the site visit to potential bidders was an opportunity to see who would likely be competing for this project.

## Proposals from Interested Firms

The Institute received a number of proposals from interested firms. Since the scope of work was only generally defined, there was a broad spectrum of technical approaches, levels of detail, cost estimates, and schedules presented in the proposals that were received. The Institute recognized that a number of firms had the qualifications and depth of experience to implement the project. The selection of the winning bidder (“Consultant”) was based partially on one firm's incremental phased approach to the project, which recognized that the path the project would take could not be predicted in advance. The winning firm was also selected based on its qualification and experience on similar projects, and the fact that they had worked with the relevant state regulatory agencies in the past. Although cost was certainly a factor that was considered, the Institute felt that, in the long run, selecting a well qualified firm that proposed a reasonable technical approach and assigned well qualified staff to work on the project would ultimately minimize its total expenditures. Therefore, a low-bid was not the sole and primary criterion used for selection.

The phased technical approach presented by the winning bidder is presented graphically below.

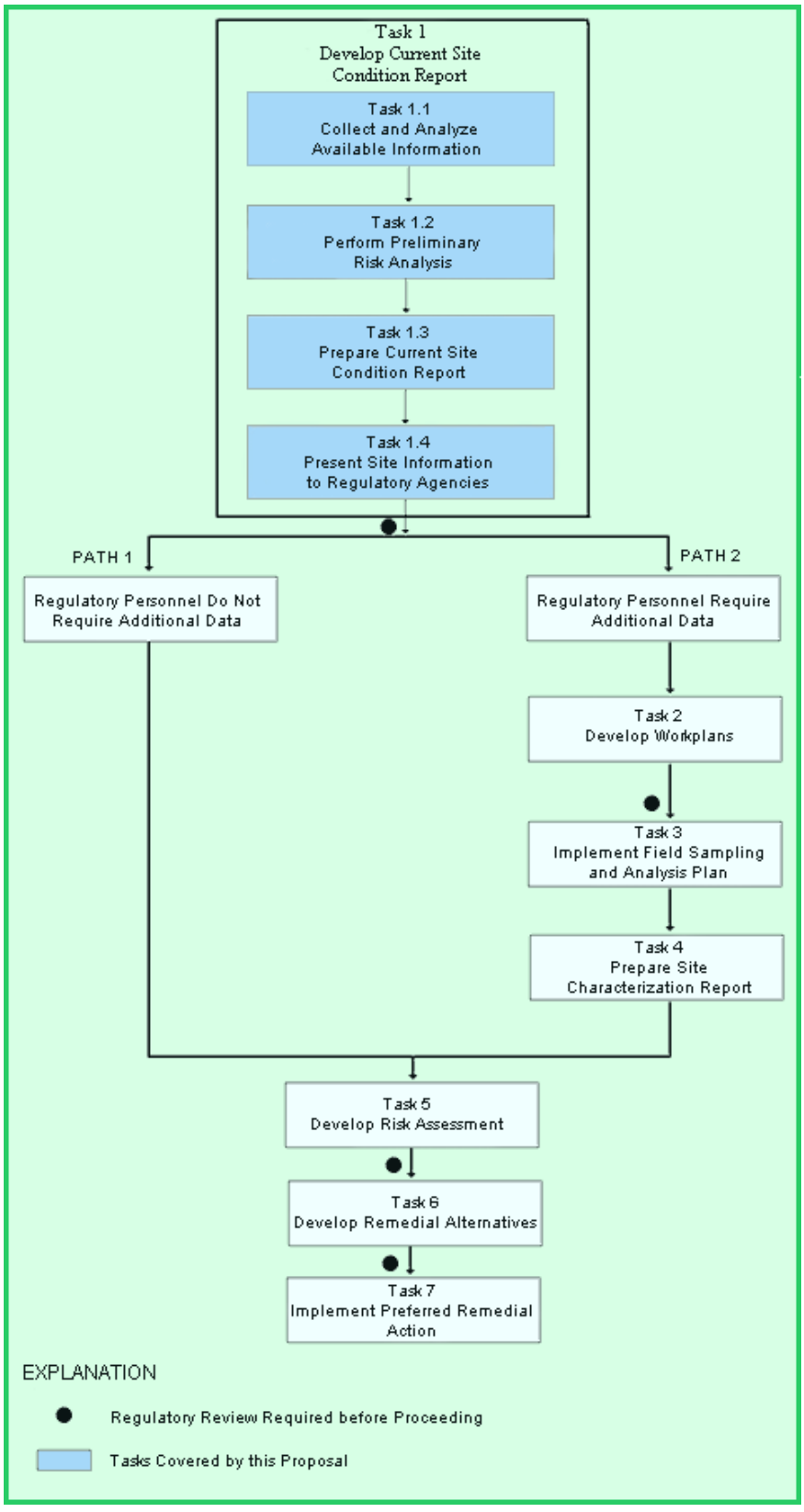


Figure 5: Flow chart of the Consultant's proposed approach to the investigation

Note that the figure specifically notes that only Task 1 was covered comprehensively in the proposal. As shown on the figure, Task 1 led to the preparation of a Current Site Condition Report (Task 1.3), which would be based solely on existing information. Except for measuring the groundwater level in existing monitoring wells, no new sampling, testing or installation of new monitoring wells was to be done in the preparation of that report. Depending on the review of the Current Site Condition Report by the regulatory agencies, one of two paths could be taken. Path 1 represents an optimistic scenario which leads to an expedited assessment of actual and potential impact on public health and the formulation of a remedial alternative on the basis of data collected and information analyzed for the Current Site Condition Report.

Path 2, on the other hand, represents a less optimistic scenario under which the results of Task 1 are not sufficient to perform an adequate assessment of actual and potential impact on public health or allow the identification of the best remedial alternative. Under this scenario, the acquisition of supplemental information and the preparation of a Site Characterization Report (Tasks 3 and 4) would be required. The Consultant's proposal provided technical, cost, and schedule information regarding the implementation of Task 1, that is the first step along either path. The Consultant estimated that it would require approximately eight weeks to complete Task 1. Until this task was completed and the required project path established, the Consultant felt that it would be premature to develop a full scope and cost estimate to perform the remaining tasks. Nonetheless, the Consultant developed a preliminary scope for this additional work for the benefit of the Institute, assuming the tasks under Path 2 were implemented. The full scope and schedule of Task 1 and the preliminary scope of Tasks 2 through 7 are presented below.

## Task 1 Scope & Schedule

The subtasks under task 1 deal with the compilation of existing information and the preparation of a Current Site Condition Report. The Consultant's proposal described this task in detail, as it was the first work to be done on the project. The Consultant's description of the activities under each subtask is presented below.

### Task 1.1 - Collect and Analyze Available Information

This study will address the types and quantities of materials disposed of at the site based on available records, the method of burial, the location and orientation of the burial trenches, past monitoring activities, and available radiological and chemical analyses of environmental media. The general geologic, hydrologic and meteorological conditions will be reported. The pre-proposal site visit provided the Consultant with an initial understanding of the local geology, site topography, location of existing groundwater monitoring wells, and general condition of the burial area. The Consultant will review the relevant information on the history of the site available in the files of the Institute and the records of the State RPA. The type of information to be reviewed will include:

- Burial inventory of waste materials, both radiological and chemical,
- History of activities at the waste burial site,
- Monitoring well installation records, and
- Analytical results of groundwater, surface water, soil, and vegetation sampling.

To aid in the determination of potential pathways to human receptors, the Consultant will also:

- Measure water levels in the existing groundwater monitoring wells to aid in determining the groundwater flow direction,
- Identify domestic drinking water wells within 2,000 feet of the waste disposal site,
- Identify the nearest downstream municipal surface water supply intake, and municipal water supply well, and
- Identify the end use of the agricultural crop(s) produced on the flood-plain down-slope and to the west of the waste disposal site.

**Task 1.2 - Preliminary Risk Analysis**

Based on the review of the available data, it may be possible to perform a preliminary risk evaluation. A simplified analysis of this type may provide a reconnaissance level assessment of the radiological and chemical risks to potential human receptors. This initial evaluation, together with the results of Task 1.1, may be sufficient to justify following Path 1 and avoid the cost of doing additional work at the site.

**Task 1.3 - Prepare Current Site Condition Report**

The Consultant will abstract and analyze, to the extent possible, the relevant information compiled during implementation of Task 1.1 and the results obtained from Task 1.2 to provide a report on the operational history and current conditions at the site. The Consultant will also summarize the geologic, hydrologic and meteorological information in the vicinity of the site from available published sources. The information will be compiled into a draft Current Site Condition Report. This report will enable the investigation team to plan any additional monitoring and sampling activities that may be needed. The report will also provide the active participants (the Research Institute, the State Regulatory Agencies and the Consultant) with a common base of information to evaluate any plans that are developed for the implementation of any follow-up work that would be required to address the concerns expressed by the State Regulators.

**Task 1.4 - Present Information to State Regulatory Agencies**

Upon submittal of the draft Current Site Condition Report, the Consultant will be prepared to discuss its findings and recommendations with the technical staff and legal counsel of the Institute. Based on comments from the Institute, the Consultant will update the report as needed and issue a Final Current Site Condition Report. This report will be distributed to both the Institute and the relevant State Regulatory Agencies. After a period of review, the Consultant proposes to hold a formal meeting with the State RPA and the other appropriate state regulatory agencies to answer their questions and obtain any necessary approvals to proceed. The Consultant will prepare the visual aids and handouts relating to the technical aspects of this presentation.

**Schedule for Task 1**

The Consultant proposed the following schedule for the Task 1 activities:

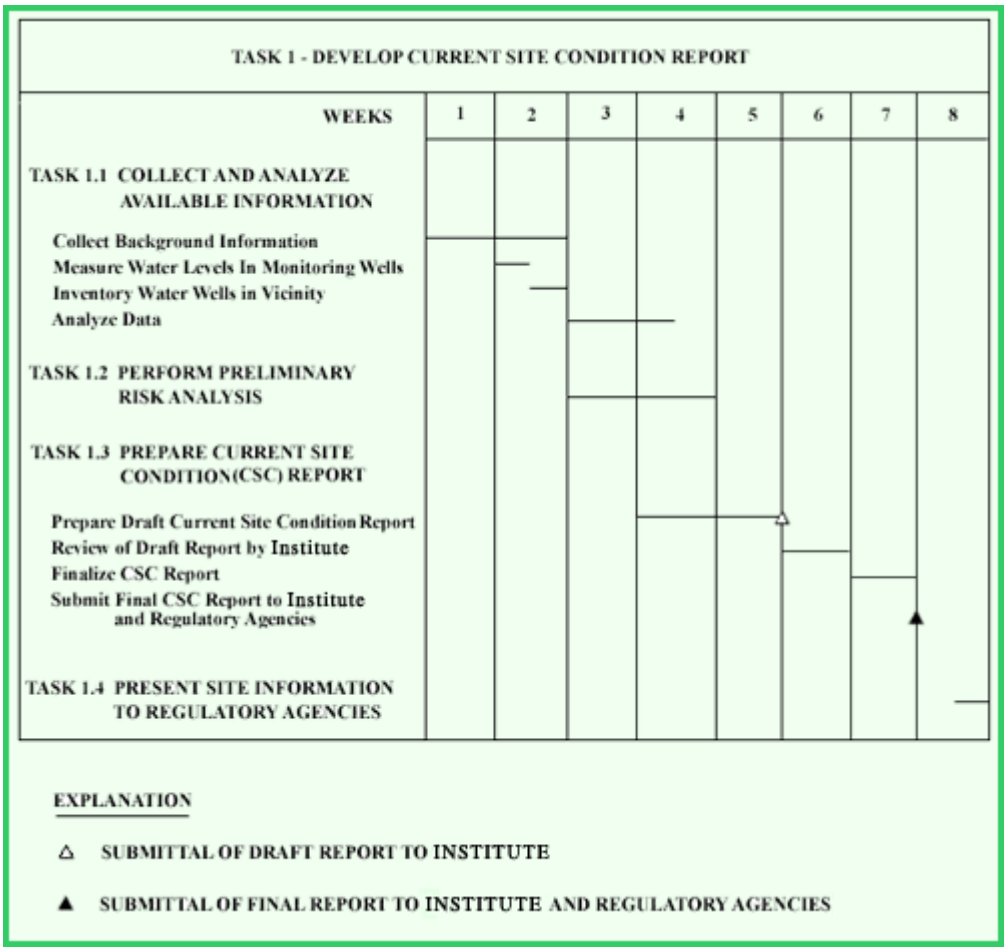


Figure 6: Proposed schedule for Task 1 Activities

Note in the schedule that some of the subtasks overlap because some could be started before the completion of earlier ones.

**Proposed Type of Contract for Task 1**

The Consultant proposed to complete Task 1, including the preparation of the draft and final Current Site Condition Report and the formal meeting with the relevant state regulatory agencies, for a lump sum cost based on the level of effort estimated by the Project Manager. The prevailing corporate per-diem rates and estimated direct expenses were used to arrive at the proposed dollar amount. This type of contract is also called “fixed price” and means that the client would receive all the promised deliverables for a pre-determined price, independent of how many hours are spent by the consultant and without any added fees or reimbursement of expenses, beyond those estimated for the work listed in the proposal. The advantage of this type of contract to the client is that the Institute will know the exact price ahead of time and can include it in its budget process. The downside risk resides primarily with the Consultant. If the project manager has underestimated the time, effort and expenses required to complete the proposed tasks, losses could be incurred. However, the benefits of a lump sum bid include not having to prepare detailed itemized bills for the client and having the freedom to adjust

staff assignments as needed to expedite the work that has to be done. The Project Manager also felt that a lump sum bid was a low risk for this phase of work because no new field investigations were proposed and no subcontractors would be involved. For more information on how to estimate the cost of technical services the student is referred to the PDH course P-132 titled: "Managing Project Cost, Revenue and Profit".

## Preliminary Scope of Work for Tasks 2 through 7

In order to help the Institute understand the overall magnitude of the project and to demonstrate to the regulatory agencies that the Consultant and the Institute understood the goals of the program, the Consultant provided, as part of its proposal, a preliminary scope of work for Tasks 2 through 7. The implementation of these tasks presumes that additional field investigations and sampling and testing would be required (Path 2). A preliminary schedule was included, but no costs were estimated. Summaries of these tasks, as included in the Consultant's proposal, are presented below.

### Task 2 - Develop Work Procedures

Procedures to implement investigations at the Site will be prepared to guide the performance of work before undertaking any field activities at the site. The work procedures will include sections on:

- Project management,
- Sampling and analysis,
- Data management,
- Health and Safety plan, and
- Quality Assurance (QA) plan.

The Consultant is familiar with the preparation of these types of plans and procedures and will structure the format to facilitate review and approval by the regulatory agencies. It should be noted that the work procedures will be subject to periodic reviews and updates based on the site specific conditions that are encountered in the field. As necessary, the Consultant will periodically update the scope of the site investigation, the number and location of samples to be collected, the QA Plan, and/or the Health and Safety Plan. In all cases the rationale for recommending particular investigative methods and laboratory analyses that will be needed to support the goals of the program will be provided.

### Task 3 - Implement Field Sampling and Analysis Plan

This task may include the possible installation of additional ground water monitoring wells, the use of a variety of field environmental monitoring tools and the establishment of stream sampling stations. Additional vegetation, soil, ground water, and surface water samples may also be collected and analyzed. Health and Safety personnel will monitor all sampling and installation work to ensure that worker exposure to hazardous materials is minimized and that the work is performed in accordance with the Health and Safety Plan. The Quality Assurance Plan will be used to ensure the quality and reproducibility of the field measurements and laboratory analyses that are completed. For more

information about the concept of Quality Assurance the student is referred to the PDH course P-123 titled: “Quality Assurance”.

**Task 4 - Prepare Site Characterization Report**

After completion of the field surveys, and following the receipt and evaluation of the analytical results, a Site Characterization report will be prepared. This report will provide information on the:

- Geologic and hydrologic characteristics of the site,
- Source of any contamination,
- Concentration and extent of the contamination, and
- Rate of contaminant migration.

If requested by the Institute, a draft report will be prepared and submitted for review. Once comments are received, the Consultant will update the draft report and issue the Final Site Characterization Report.

**Task 5 - Develop Risk Assessment and Prepare Report**

Following the implementation of Tasks 2, 3 and 4, during which reliable chemical release and potential exposure data will be acquired, an environmental and public health risk assessment will be performed. In general, the type of site data needed for this assessment include:

- Contaminant identities,
- Contaminant concentrations in the source and media of interest,
- Characteristics of sources, especially information related to release potential, and
- Characteristics of the environmental setting that may affect transport, persistence and fate of contaminants,

The level of detail and confidence in the Risk Assessment Report will be higher if it is performed following the full characterization of site conditions.

**Task 6 - Develop Remedial Alternatives and Prepare Report**

Based on information collected and analyzed in previous tasks several remediation alternatives for the mitigation of any identified environmental problem at the site will be considered and evaluated. As required by the state regulations, the "no action" alternative will be evaluated together with a number of other proven remedial technologies in order to select the most suitable and cost effective one for implementation at the site. The Consultant’s knowledge of these technologies was gained from work at other decommissioned commercial low-level radioactive and hazardous waste disposal sites. In arriving at a recommendation, the Consultant will also consider the long-term land use of the site and adjacent areas.

**Task 7 - Implement Preferred Remedial Action**

The Consultant can provide design and construction management services for the selected remedial action during its implementation at the site, if the Institute so desires. The Consultant has extensive experience in the design and construction management of a wide range of remedial measures at contaminated sites across the country.

**Preliminary Schedule for Tasks 2 through 7**

The Consultant estimates that it would require approximately 8 additional months to implement the program that includes Tasks 2 through 6. The time required for Task 7, implementing the preferred remedial action, would depend on the remedial action selected and would require time for engineering and design work, review and approval by the Institute and regulatory agencies, and the required construction and installation activities at the site. At this point, a tentative installation schedule of two months was assumed.

A preliminary schedule for Tasks 1 through 7 is presented below. Note that the 12 months schedule is optimistic since it does not assign time for review of draft reports by the Institute or review of final reports by the state regulatory agencies. The turnaround time for laboratory analyses may also affect the schedule.

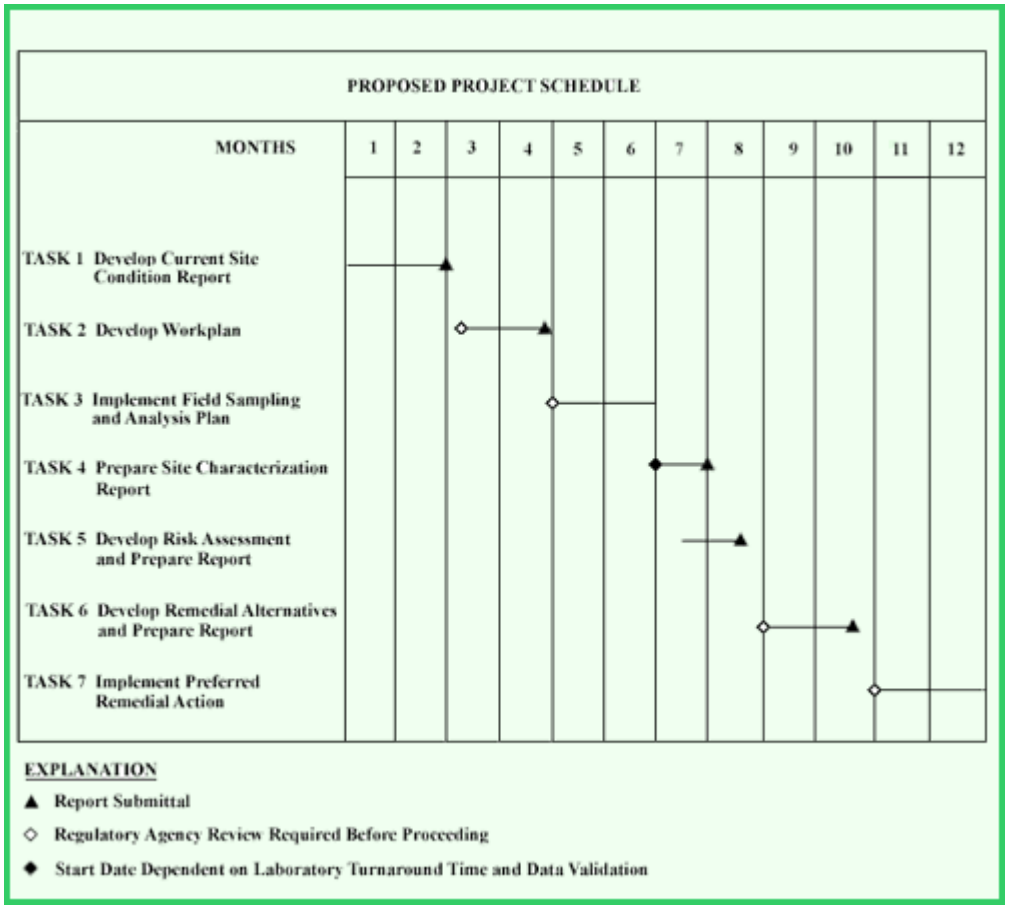


Figure 7: Preliminary Schedule of Tasks 1 through 7

## Award, Contract Negotiation and Project Initiation

The Institute notified the Consultant by letter of its acceptance of the proposal and its intention to proceed with the implementation of the work plan. At this point, the process of contract negotiation began. Simultaneously with the period of contract negotiation, the Institute and the Consultant agreed to hold a planning meeting to discuss how the project would be implemented. At the planning meeting the Consultant expressed that it would appreciate receiving from the Institute any information that may exist in its records concerning:

- Types, volumes, date of disposal and location within the waste disposal site where chemicals may have been placed,
- Number, location and dimensions of the waste trenches at the burial site,
- Any photos of disposal operations, including filling and closure of individual trenches,
- Available aerial photographs of the site, especially old aerial photos taken during operation of the facility,
- Available topographic or other maps and surveys of the site and vicinity,
- Available boring logs for the existing monitoring wells or other borings used for the foundation design of adjacent buildings,
- Land use over the past few years of the open field in the flood plain downhill of the waste disposal site, and
- The end use of any agricultural products grown in this open field.

At the same time, the Consultant agreed to proceed with the collection and compilation of available geologic, hydrologic, and meteorological data from published sources.

In addition, the Consultant requested a meeting with the long-time groundskeeper at the waste disposal site. This request was made to discuss his recollections regarding disposal practices such as the number, location and disposition of the trenches within the fenced area of the waste disposal site and the frequency of disposal. While meeting with the groundskeeper in the field, the Consultant planned to measure the ground water level in the five existing monitoring wells. No sampling would take place at this time.

The Consultant also recommended that the Institute schedule a coordination meeting with the State RPA and the other interested State Regulatory Agencies to ensure that at the onset everyone understood the concerns and expectations of the other parties involved. By the time the Institute and the Consultant met with the state regulators, the Consultant had compiled general observations about the waste disposal site, which it shared with the meeting participants, as explained below.

## Meeting Between the Institute, Consultant and Regulatory Agencies

Representatives of three regulatory agencies participated in the coordination meeting. These were the State RPA, the State WMA, Superfund Section and the State GPA. The Consultant made the following formal presentation at this meeting summarizing the existing background information it had collected to date:

**Burial History at the Site**

- Burial of wastes at the site took place between 1960 and 1980,
- The fenced area of the disposal site is approximately 0.65 acre,
- Wastes were buried in narrow trenches,
- Records of wastes buried between November 1973 and June 1979 are missing, and
- Initial review of the inventory records suggests that less than 2 Curies of radioactive materials were buried at the site.

**Past Environmental Monitoring**

- Monitoring of soil, vegetation, and surface water began after decommissioning,
- The first five ground water monitoring wells were installed ten years after decommissioning,
- Ground water monitoring began when the five monitoring wells were installed, and
- One round of water level readings was completed soon after the installation of the wells.

**Sampling Results from Existing Records**

- Analytical results of soil, vegetation and surface water samples taken between the site decommissioning and the installation of the five monitoring wells did not indicate any migration of radioactive material,
- Analytical results of ground water samples taken from the five monitoring wells indicate that tritium (H-3) is present in wells 1, 2, 3, and possibly in 4 but not in well 5, and
- Re-sampling of well No. 3 a year later indicated the presence of tritium (H-3), carbon-14 (C-14) plus some organic chemical compounds: chloroform, carbon tetrachloride, p-Dioxane (1, 4-Dioxane) and isopropyl-ether.

After the presentation by the Consultant, the representatives of the state regulatory agencies were asked to express their opinions and explain their concerns relative to the waste disposal site. The representative of the State RPA, the lead state regulatory agency, indicated that he does not believe that the waste disposal site poses a radiological risk to the public at this time. He indicated that the driving regulations will be those dealing with the chemical contamination. He is satisfied with the Institute's estimate that the total radioactivity disposed at the site does not exceed two Curies. His concern is with the chemicals that were used in association with the radioactive elements and disposed of at the site.

The representatives of the other two State Regulatory Agencies (the State WMA, Superfund Section and the State GPA) indicated that they were interested in the characterization of the chemicals that are present, and in the definition of the vertical and horizontal rates and direction of groundwater movement. They will also want to define the chemical contamination levels at various distances from the disposal site and from the Institute's property boundary. The state regulations are framed with respect to distance from point of contamination to adjacent properties, which is not necessarily the fence line surrounding the disposal site itself. The goal should be containment of the source of contamination and continued monitoring of environmental parameters. The ultimate purpose is to prevent further degradation of the environment.

Based on these discussions, the Consultant and the Institute agreed that the Task 1 scope of work presented in the Consultant's proposal would need to be revised. The Institute and the Consultant decided also that the revisions should be targeted specifically to the expressed desires of the regulatory agencies. Therefore, it became apparent that the work that the Consultant had originally proposed needed to be supplemented with an initial round of field investigations to, at least, independently verify the identity of the contaminants and their concentration in the soil and groundwater immediately down-gradient of the site. The revised Task 1 and additions to the scope and schedule, in the form of new tasks 2, 3, and 4 are presented in the following section.

## Revision to the Scope of Work

The following changes to the Task 1 scope of work and the addition of new tasks 2, 3 and 4 were prepared by the Consultant:

### Task 1.1 - Collect and Analyze Available Information

This task was intended to collect as much available information as possible concerning the inventory of waste buried on site, disposal practices and the configuration of the trenches in the waste disposal area. Information from the surrounding area, including locations of water wells within 2,000 feet of the site, the location of the nearest municipal water supply well and surface water intake will be identified. No changes were made to the scope or cost of this task.

### Task 1.2 - Develop Understanding of Groundwater Conditions

In the original proposal Task 1.2 was entitled "Preliminary Risk Assessment". The original intent of this task was to complete an initial evaluation of potential risks to human receptors. The Consultant had proposed that the results of Task 1.1 and this preliminary risk assessment could be sufficient to satisfy the regulatory agencies and no additional field investigations would be required (Path 1 in the original proposal). It was obvious after the coordination meeting with the regulatory agencies that additional monitoring wells would be required and a site characterization program would be expected.

Therefore, this task was re-scoped to start the process of site characterization by developing a generalized geologic profile of the site, and estimating porosity and permeability of the local soils and bedrock. The Consultant would also estimate local groundwater gradients and flow directions within the upper portion of the water table. At this stage, this work would be completed based on existing information and the experience of the Consultant. It would be used primarily to help design the field investigation program and the selection of locations for the installation of new monitoring wells.

The major change in the focus and scope of this subtask required an adjustment to the cost for the performance of these services.

### Task 1.3 - Prepare Preliminary Site Condition Report

This task was essentially unchanged, except that it would now include the results of the revised Task 1.2. The Consultant felt that the change in the scope of this task was small enough to not impact the total cost.

**Task 1.4 - Present Site Information to the Institute**

This task was originally entitled "Present Information to State Regulatory Agencies". The Institute requested that the Consultant deal with it only at this stage of the project, and not to plan on making presentations to the state regulatory agencies. It became obvious that the Institute was starting to realize that the regulatory agencies would likely be requiring a significant amount of work to be done at the site and decided to be more cautious in their dealings with them. The Institute also clarified that the Consultant's presentation would be made not only to the technical and managerial staff of the Institute, but also to its legal counsel, and that legal and liability issues would likely be considered and discussed.

The Consultant did not request any change in the cost of this subtask.

**New Task 2 - Develop Initial Work Plans**

This is a modified version of the original Task 2 scope, provided under the path 2 option (see Figure 5). Before collecting this initial and restricted set of samples from the site for analysis, the Consultant will prepare site specific project procedures incorporating the requirements of both a Health and Safety Plan and a Quality Assurance Plan. These initial project procedures will include:

- Management Plan,
- Scope of Sampling Program,
- Preparation of Sampling Containers,
- Equipment Decontamination,
- Water Level and Well Depth Measurement,
- Groundwater Sampling, and
- Soil Sampling

These procedures will be updated periodically as necessitated by changes and additions to the scope of work. This task required an adjustment to the cost and schedule of the contract.

**New Task 3 - Implement the Field Sampling and Analysis Plan**

This is a modified version of the original Task 3 scope, provided under the path 2 option (see Figure 5). All five existing monitoring wells that surround the disposal site will be sampled for chemical analysis by approved Environmental Protection Agency (EPA) methodologies as follows:

- Full organic analysis, including volatile and semi-volatile organic compounds,
- Priority pollutants metals,
- Radiological analysis for tritium (H-3) and carbon-14 (C-14), and
- Gamma scan

Four soil samples at different elevations from the east-west drainage, south of the site, will also be analyzed for volatile organic compounds and tritium.

This task required an adjustment to the cost and schedule of the contract.

**New Task 4 - Prepare Current Site Condition Report**

This is a modified version of the original Task 4 scope, provided under the path 2 option (see Figure 5). The results of the chemical analyses, from samples tested in Task 3, above, will be used to update the Preliminary Site Condition Report. Based on this update, the Consultant will recommend an appropriate course of action to the Institute.

This task required an adjustment to the cost and schedule of the contract.

## Revised Schedule of New Scope

The original schedule for Task 1 was 8 weeks (2 months). The revised Task 1 maintained the same schedule, but with the addition of new tasks 2, 3 and 4, the overall schedule was lengthened by three months, and the cost adjusted accordingly. The revised schedule for the work to be implemented during the first stage of this project is shown on the following figure.

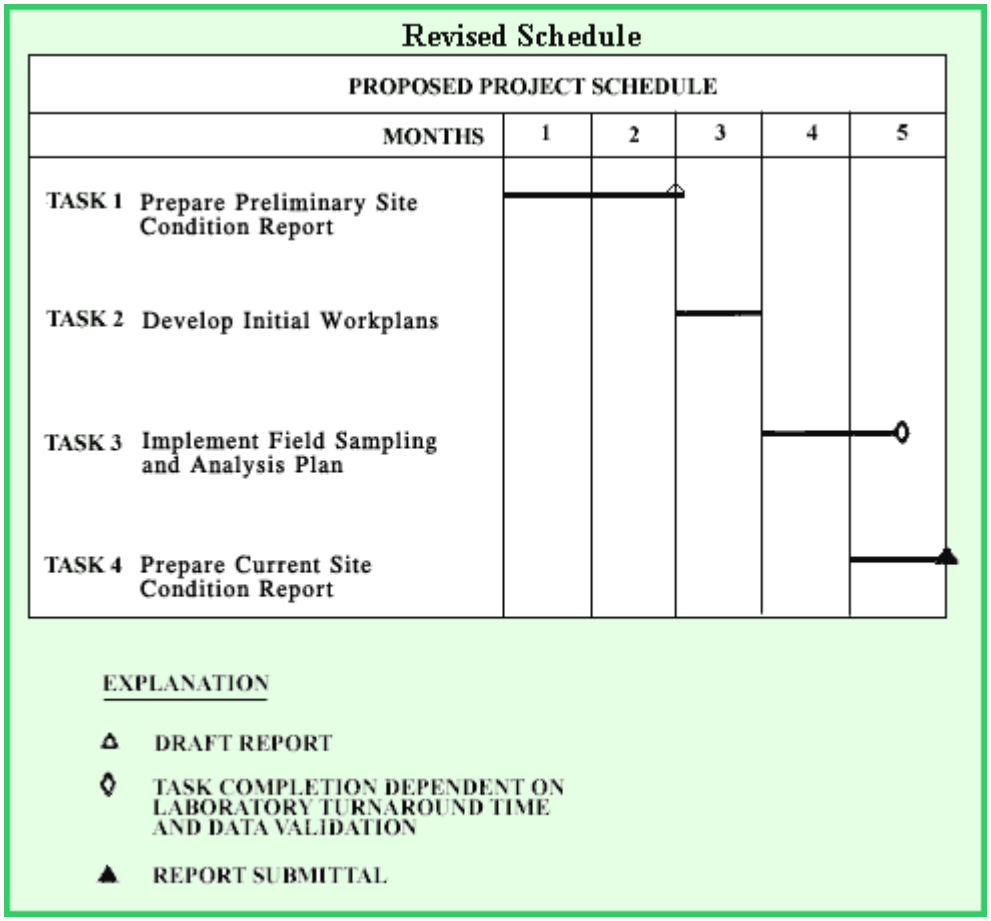


Figure 8: Revised Schedule of First Stage of Work

## Contract Negotiation

The activities completed thus far on the project, including the coordination meeting with the regulatory agencies and revisions to the scope of work for Task 1,2,3 and 4, were done by the Consultant prior to having a signed contract in place. Since there was no signed contract, the Consultant completed this work "at risk". The Consultant felt that establishing goodwill early in the project was a good business practice and that the Institute's contract award and letter of intent was a sufficient basis to initiate some work on the project.

However, the Consultant was unwilling to start field activities at the site or begin in-depth analyses of existing data until a signed contract was in place. The Institute assumed that the contract negotiation was likely to be short, with little to no impact on the overall schedule. This assumption proved to be incorrect. The negotiation of acceptable contractual terms between the Institute and the Consultant turned out to be a long and complex process in which each party attempted to protect its perceived interests and limit its liability and financial exposure. Each party played to its strengths, but had to take into consideration the views and pressures of other parties, including those of the regulators and the general public. Interestingly, the technical scope of work was not a significant part of the contract negotiation. Most of the time was spent on the so-called "Terms and Conditions" which defined the legal and contractual relationship between the Institute and the Consultant. It is instructive to review the highlights of the contract negotiation process, as it is typical of similar projects where regulatory agencies are involved. The highlights of the negotiation process and the final version of the terms and conditions are presented in the following sections.

### Leverage, Goals and Agendas of the Interested Parties

Once the State RPA found contamination in the monitoring wells, the regulatory agencies immediately exerted pressure on the Institute to investigate many aspects of the site, including the geologic and hydrologic setting and type and extent of contamination to determine what, if any, remedial measures were needed. As with all regulatory agencies, issues of schedule and cost were not their concern. However, the Institute clearly recognized that addressing the requirements of the regulatory agencies would likely be expensive, and that there was no guarantee that they would be satisfied with the results of the proposed investigation. The Consultant was put in the difficult position of trying to design and implement a program that it felt, on the basis of past experience, would satisfy the regulators and remain within a budget and schedule that the Institute would consider reasonable.

At the same time, the Consultant could not guarantee that its proposed program would, without doubt, satisfy the regulators. Through experience on other projects, the Consultant knew that regulatory agencies often requested more detailed information once new data became available. Other issues would likely come up, based on the new data or changes in the regulatory agencies' staff assigned to monitor the project. Also based on past experience, the Consultant knew that the regulators would be unwilling to state that the requirements expressed to date were complete and all-inclusive.

In entering the phase of contract negotiation, the obvious leverage the Institute had was financial. The Institute wanted to spend the minimum amount necessary to satisfy the regulators. However, it was not possible to estimate, with any level of certainty, what that minimum amount was likely to be.

The leverage the Consultant had in the negotiation was prior experience with the regulatory process, the ability to translate the concerns expressed by the regulatory agencies into specific work items and the ability to deliver on the contracted services. On the whole, it was in the best interest of both parties – the Institute and the Consultant - to reach an equitable agreement to ensure the successful completion of the work with the least amount of delay and interruption. Nonetheless, following submittal of the revised scope of work, it took an additional three months to negotiate an acceptable contract between the Institute and the Consultant. This time was taken mostly in reviews of the terms and conditions by the legal counsels of both parties and obtaining the necessary signatures of the executives of both the Institute and the Consulting firm. Highlights of the final negotiated terms and conditions are presented in the following sections.

**Terms and Conditions**

Both the Institute and the Consultant wanted to develop a contract that would cover not only the initial scope of work, but also all other subsequent activities that could develop as well. Efforts were made to identify potentially controversial issues in order to resolve them to the satisfaction of both parties during the contract negotiation period. This approach was desirable, from the Institute's point of view, to ensure that no schedule delays or re-negotiations would be required once the work started.

Following is the list of terms and conditions that were formulated into the final contract for providing professional environmental and engineering services to the Institute:

- Definitions,
- Equipment and access to site,
- Billing,
- Responsibility for services,
- Indemnification,
- Insurance,
- Special Liability,
- Consequential damages,
- Delays,
- Third party interests,
- Changes and termination,
- Precedence and divisibility, and
- Concluding statement.

Each of these is briefly described in the following subsections.

**Definitions**

This was the introductory section of the contract. It defined whom the Institute and Consultant were, and described the working relationship between them. It also defined what was meant by the scope of technical services and stated that the scope of work was included as an attachment to the contract. The scope for the initial work was provided in detail, while the scope of the remaining work was left general since it would have to be revised and updated based on the ongoing reviews and requests of the

regulators. Provisions were also made in this section for the modifications and/or additions to the initial scope of work to be treated as an extension to the ongoing work, provided they were mutually accepted and ratified by both the Institute and Consultant.

The word "contract" was also defined in this section to include the terms and conditions contained in the remainder of the document. A statement was also inserted in this section to the effect that these terms and conditions supersede any other agreement reached between the parties.

**Equipment and Access to the Site**

This section stated that the Institute would provide site access to the Consultant and its sub-contractors whenever requested so that the Consultant could perform the scope of work efficiently. It also included reference to existing records, analyses and other documentation relating to waste disposal at the site that the Institute was to provide to the Consultant to enable it to perform the promised services.

Arrangements were also spelled out for the appropriate and timely access of heavy equipment to the site, such as drill rigs, excavators, trucks, surveying and well sampling gear.

**Billing**

This section spelled out the elements of the financial agreement between the Institute and the Consultant. It defined that the contract was to be implemented on a fixed price (“lump sum”) basis for a pre-defined portion of the scope (Tasks 1, 2, 3 and 4). A schedule of progress payments related to defined milestones within the scope of work was set up, as the Consultant did not want to wait until the final submittal of the updated Current Site Condition Report (Task 4) to be paid. Other charges for reimbursement were also specified, such as cost for laboratory testing and travel expenses. The fixed cost was developed on the basis of the Consultant’s published corporate per-diem rates for the year in which the work was implemented. The wording of this section was reviewed quite carefully by the Consultant to ensure that a reasonable cash flow was established during the project in return for the services provided. Although this first phase of work was only scheduled for five months, the wording in this section would set the precedent for payment throughout the remainder of the contract. As such, this was an important section of the contract for the Consultant.

**Responsibility for services**

This section established the fact that the services were to be performed by the Consultant and other qualified parties, such as subcontractors, on behalf of the Institute. A statement was included in this section explaining that the services were to be performed with the care and skill ordinarily exercised by the members of the engineering profession practicing under similar conditions. No other offers of guarantees or warranties for the services were offered. Although it is tempting to offer “state-of-the-art” services, it is contractually safer to offer “state-of-the-practice” services.

The right of the Consultant to rely on information provided by the Institute and the Institute's advisors and consultants was addressed here as well. The Consultant expected to be able to accept such information at face value and without independent verification. If such information was not available,

the Consultant retained the right to propose a modification to the scope, schedule and cost of services to check the existing information or acquire new and necessary data.

A statement was included in this section to limit the total liability of the Consultant in performing the referenced services. Liability was confined to the re-performance of any defective services plus limited compensation for time lost. The period of liability exposure was also specified.

Importantly, the liability language in this section specifically did not guarantee that the regulatory agencies would consider the work completed by the Consultant to be sufficient to address all their requirements or concerns. The Institute wanted assurances from the Consultant that all the regulators' issues would be resolved completely. The Consultant, however, had sufficient experience to realize that once new information is presented to the regulators, they often request additional work to be done to provide more detail or address a "new" issue. The Consultant did not want, and could not afford, to be caught in this potentially endless loop without being fairly compensated. For more information on the rationale behind the wording of the clauses in this section the student is referred to the PDH course P-122: "Professional Liability".

**Indemnification**

The Institute requested the Consultant to indemnify and hold them harmless of claims and liabilities arising from negligence or intentional misconduct during the performance of work. This liability exposure affected not only the Consultant, but also the Consultant's agents, subcontractors and employees.

To offset this exposure, the Consultant requested the inclusion of a similar clause that would indemnify and hold it harmless from negligence and intentional misconduct of the Institute and its agents. For example, if the Consultant relies on information provided by the Institute and that information turns out to be defective or erroneous, the Consultant would be entitled to an equitable relief, and could not be held liable for re-performance of the work.

Damages that may result from pre-existing conditions, despite the high standards of professional care and caution exercised by the Consultant, were mentioned specifically in this clause and excluded from consideration. This meant that the Institute would not be entitled to indemnification if the alleged damages were caused by pre-existing conditions that were beyond the control of the Consultant.

**Insurance**

The Institute requested the Consultant to secure various types of insurance coverage before starting work on any of the contracted services. These types of insurance coverage are listed below:

- Workers' compensation and employers liability,
- Comprehensive general liability, including protective coverage for property damage, and
- Automobile, public liability and property damage, including rental car coverage.

In each case, the Institute accepted the recommended statutory limits of coverage. These limits were also satisfactory to the Consultant.

**Special Liability**

The Consultant specifically mentioned that the Institute would be responsible to defend any claim, action or legal procedure that may be brought against the Consultant or its agents as a result of alleged improper disposal of hazardous substances on or within the site. The Institute will be responsible for the proper disposal of the small volume of waste that would be generated as part of the sampling and testing activities conducted by the Consultant at the site.

The Consultant also exempted itself from responsibility arising from the improper characterization of site conditions prior to its arrival on the scene. In such cases, reimbursement of expenses related to schedule delays and/or court litigation costs plus expenses of attorneys were also addressed. In addition, if during the performance of its work the Consultant was, for any reason, summoned by a court of law to disclose information prepared under the contract, the Institute would be notified as soon as possible. In such a case, the Institute would be expected to lead and cover the costs of the ensuing legal proceedings, schedule delays and other associated expenses.

**Consequential Damages**

Under this section, the Consultant wanted to specifically exclude from consideration indirect and consequential damages that may be brought against it. Examples of such damages included: loss of profits or revenue, loss of full or partial use of any equipment or facility, cost of capital, loss of goodwill, and claims brought by the Institute's customers and/or other third parties. This clause was included to discourage the filing of frivolous claims that are not directly related to the performance of the technical services.

**Delays**

This clause specified that neither party would be considered in default of performing its obligations to the extent that the performance of such obligations was prevented or delayed by any cause beyond the reasonable control of the affected party. In such a case, the time of performance for either party would be extended by a period equal to the time lost. Compensation would also be equitably adjusted to account for the effects of such delay. For example, the occurrence of a natural disaster in which neither the client nor contractor had a role would trigger the provision of this clause.

**Third Party Interests**

This clause stated specifically that the contract was not intended for the benefit of or construed as creating rights in favor of any third party. It essentially ensured that the contract was entered into by the Institute and the Consultant without the involvement, intervention or participation of a third party that may claim later on to have some interest in any aspect of the agreement.

**Changes and Termination**

This section established the right of the Institute to make changes and/or additions to the Consultant's scope of work. These changes would become effective upon execution of a mutually accepted change

order to the contract. Any change order agreed upon by the two parties became an extension to the original scope of work and was legally binding. If the proposed changes affected the ability of the Consultant to deliver on any aspect of the original agreement, some schedule accommodation and compensation adjustment would be negotiated to the satisfaction of both parties.

This clause also reserved the right of the Institute to terminate the contract at any time, including the ability to do so prior to the completion of the contracted services. In such a case, the Consultant would reserve its right to receive reasonable notice in writing of the Institute's intent. The Consultant also specified that it was entitled to be paid for work completed as of the time it received such notice. The Consultant would also be reimbursed for reasonable costs incurred in terminating the remainder of the services described in the contract, including storage and archiving of information collected to date.

**Precedence and Divisibility**

This clause was included to clarify that the provisions of the contract would fully govern any and all services furnished by the Consultant and would prevail over and render void any inconsistent or conflicting provision contained in the Institute's initial Request for Proposal and the Consultant's submitted proposal. Also, if any term, condition or provision of the contract was to be declared by a court of law to be void or unenforceable or limited in its application or effect, such an event would not affect or invalidate any other provision of the contract. In such a case, all other provisions were to remain fully enforceable and the parties could negotiate an equitable adjustment in the affected provisions with the purpose of implementing the intent of the contract.

**Concluding Statement**

This clause contained a final statement that reiterated that the contract in question contained the entire agreement between the parties as to the services to be rendered. All previous or contemporaneous agreements, representations, warranties, promises, and relating conditions concluded earlier were expressly superseded by this contract.

**Final Considerations**

As you undoubtedly noted, very little of the contract negotiations addressed the actual technical scope of work. The three-month negotiation process was taken mostly in reviews by the legal counsels and obtaining the signatures of the executives of both parties. No field work at the site was scheduled or initiated before the contract was ratified and signed by both parties.

Close to the end of the negotiations, and based on a letter of intent from the Institute to implement the scope of work, the Consultant began to prepare the project specific procedures that would guide the implementation of various aspects of this project. These plans and procedures were prepared to satisfy the project's Quality Assurance (QA) and Health and Safety (H&S) requirements. The project plans and procedures are presented in the third course of this series entitled: "Part 3 – Preparation of Project Plans and Procedures."

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## Summary

The disposal of hazardous waste in shallow trenches within the Institute's campus was conducted in accordance with the prevailing federal and state standards and regulations of the time (1960s and 1970s). This did not, however, prevent the State Environmental Regulators in the 1990s from requiring the Institute to prepare an investigation plan to assess existing conditions at its decommissioned waste disposal site. This course has taken you through:

- A brief history of waste disposal at the burial site,
- The changes in public awareness leading to federal legislation regarding waste disposal,
- Initial concerns expressed by the State Radiation Protection Agency,
- The contents of the Request for Proposals issued by the Institute,
- Observations made during the pre-proposal site visit,
- The technical approach presented in the successful proposal,
- A clarification of the Regulators' concerns at an initial coordination meeting,
- Preparation and submittal of a revised scope and schedule of work, and
- Negotiation of satisfactory Terms and Conditions for a final contract.

At this point, work began in earnest at the site. The results of the compilation and review of existing information are presented in the second course of this series entitled: "Part 2 – Analysis of Existing Information and Regulatory Concerns". The project plans and procedures that were developed to guide the implementation of new field activities, including those prepared to address requirements of the Quality Assurance Plan and the Health and Safety Plan are presented in the third course of this series.

## Glossary of Terms and Acronyms used in this Course Series

| | |
|---|---|
| 1,4-Dioxane | para-Dioxane (p-Dioxane), a hazardous chemical |
| AEC | Atomic Energy Commission |
| adsorption coefficient | measure of adherence of ions in solution to the surface of solids with which they come in contact |
| alluvial soil | a young soil on flood plains that is being actively deposited by streams |
| ASTM | American Society for Testing and Materials |
| bailer | cylindrical container designed to remove water from a well |
| C-14 | Carbon-14, a radioactive form of carbon. Stable carbon is C-12 |
| CFR | Code of Federal Regulations |
| cm/sec | Centimeter per second |
| Curie | A unit of measurement of radioactivity, which is approximately equal to the decay rate of one gram of pure radium. |
| DOT | Department of Transportation |
| Down-gradient | A direction towards which groundwater is likely to flow |
| draw | A small natural watercourse or gully, also a dry streambed whose water runs from periodic rainfall. |
| EPA | Environmental Protection Agency |
| ft. | feet |
| GC/MS | Gas Chromatograph/Mass Spectrometer |

| | |
|---|---|
| H&S | Health and Safety |
| HASP | Health and Safety Plan |
| H2SO4 | Chemical formula of sulfuric acid |
| H-3 | tritium, a radioactive form of hydrogen |
| HCL | Chemical formula of hydrochloric acid |
| HNO3 | Chemical formula of nitric acid |
| in. | inches |
| LLRW | Low Level Radioactive Waste |
| mafic rock | igneous rock composed mainly of dark-colored minerals |
| mCi | milli-Curie, a measurement of radioactivity = 1/1000 Curie |
| my | million years |
| NaOH | Chemical formula of sodium Hydroxide |
| OVA | organic vapor analyzer |
| pCi/L | pico-Curie/liter, a measurement of radioactivity in liquids (one trillionth) |
| pCi/gr | pico-Curie/gram, a measurement of radioactivity in solids (one trillionth) |
| permeability | capacity of a porous rock to transmit a fluid, ease of fluid flow |
| pH | hydrogen-ion activity in solution, a measure of acidity/alkalinity |
| pluton | A geologic igneous intrusion |
| potentiometric surface | a surface representing the total head of water in an aquifer |
| ppb | parts per billion |
| ppm | parts per million |
| purging | volume of water extracted from a well prior to sampling |
| QA/QC | Quality Assurance/Quality Control |
| Saprolite | A thoroughly decomposed rock, formed in place by the weathering of igneous, sedimentary or metamorphic rocks. |
| SCS | Soil Conservation Service |
| State RPA | State Radiation Protection Agency |
| State EPA | State Environmental Protection Agency |
| State GPA | State Groundwater Protection Agency |
| State WMA | State Waste Management Agency |
| Superfund | Acronym referring to the resources allocated by Federal or State Agencies for the clean-up of decommissioned waste disposal sites. The funds are disbursed by priority based on the degree of hazard |
| total head | the height of a column of water above a datum plane |
| ug/L | micro-gram/Liter |
| ug/kg | micro-gram/kilogram |
| uS/cm | microsiemens per centimeter, a measure of specific conductivity |
| Up-gradient | A direction opposite to that in which groundwater is likely to flow |
| USDA | United States Department of Agriculture |
| US-DOT | United States Department of Transportation |
| USEPA | United States Environmental Protection Agency |
| USNRC | United States Nuclear Regulatory Commission |
| USGS | United States Geological Survey |
| well screen | section of well casing perforated or slotted to allow water inflow |