DOE/UMTRA--170

DE91 005848

UMTRA-DOE/ALO

Unlimited Release

ENGINEERING FEASIBILITY ANALYSIS FOR IN-SITU STABILIZATION OF CANONSBURG RESIDUES

January 1982

Prepared by
Roy F. Weston, Inc.
under contract
to
Sandia National Laboratories
Contract No. 74-2738
for the
UMTRA Project Office
Albuquerque Operations Office
Department of Energy

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Table of Contents

Page

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

List of Tables

LIST OF TABLES
(continued)

List of Figures

LIST OF FIGURES
(continued)

1 Executive Summary

1.1 INTRODUCTION

The U.S. Department of Energy is considering several methods for carrying out remedial actions in Canonsburg, Pennsylvania, at the site of an inactive uranium-processing mill. The main objective of this study is to determine the feasibility of in-situ stabilization as the remedial action. In-situ stabilization is an alternative to site decontamination and offsite disposal. The problems associated with offsite hauling of large quantities of contaminated material and with the location and development of a new disposal site could be avoided by the implementation of an in-situ stabilization concept. In addition, the in-situ approach would be more cost-effective than offsite disposal. This study will establish that a technically feasible and implementable in-situ stabilization concept can be developed that meets regulatory requirements and is cost effective. This study in no way commits the DOE to implement any specific actions described herein.

1.2 BACKGROUND

The Canonsburg site (Canon Industrial Park) is located in southwestern Pennsylvania, in northern Washington County, approximately 20 miles from downtown Pittsburgh. It is entirely contained within the urbanized Borough of Canonsburg.

If the stabilization-in-place option were to be implemented at the Canonsburg site, severe difficulties would be encountered in maintaining access to the residences on Wilson Avenue, the Georges Pottery property, and the residence at the end of George Street, both during and after remedial-action operations. For this reason and for other cogent health and safety concerns, this study is based on the premise that those properties would probably be acquired and would be incorporated into the disposal site.

The feasibility study area therefore covers a 30-acre area including 18.6 acres of the Canon Industrial Park (the original Canonsburg site), 6.1 acres of the Georges Pottery property, and 5.3 acres of residential property. It is bounded on the north, east, and west by Chartiers Creek, and on the south by the Conrail Washington Branch railroad. Two roadways (Strabane Avenue and Ward Street) traverse the industrial park, dividing it into three parcels, designated Areas A, B, and C. Areas B and C are undeveloped and relatively open, while Area A contains approximately ten structures. George Street borders the Georges Pottery area, which contains one large building and part of the residential area (one home), while six homes are located on Wilson Avenue.

Currently, portions of the site are being operated as an industrial park. There are 15 firms located on the site. These firms include a truck freight terminal, metal-work operations, machine shops, laundry operations, and various warehouses.

1.2.1 Radiation levels

Radiological surveys were made of the Canonsburg site in 1977 under the Atomic Energy Commission's 1974 "Formerly Utilized MED/AEC Sites Remedial Action Program." It was determined that significant amounts of contaminated material remain on the site and that the radiation levels measured in the buildings, soils, and ground water exceeded the proposed DOE guidelines for remedial action. Consequently, environmental and engineering analyses were made with respect to remedial action. The Canonsburg site was specifically identified in the 1978 Uranium Mill Tailings Radiation Control Act for remedial action consideration. The work at Canonsburg is a part of the Uranium Mill Tailings Remedial Action Program of the U.S. Department of Energy.

Radiological surveys of the Canonsburg site have been performed by several organizations, including the Oak Ridge National Laboratory (ORNL) and the Environmental Measurements Laboratory (EML). Concentrations of radium-226 and uranium-238 in surface soil samples from all three areas were found to be significantly greater than average natural background concentrations (1.2 and 1.3 picocuries per gram, respectively). Radium-226 values ranged up to 4200 picocuries per gram with over three-quarters of the samples exceeding 5 picocuries per gram. Concentrations of uranium-238 in some samples were greater than 172 picocuries per gram (the equivalent of source material), with values as high as 51,000 picocuries per gram. Measurements of the site's buildings show that all onsite buildings have extensive areas with gross alpha, gross beta-gamma, external gamma, and transferable alpha and beta contamination that exceed the appropriate limit.

Radiological ground-water quality was assessed at 40 of the onsite wells. With the exception of one extremely high radium-226 concentration of 4500 picocuries per liter in the western portion of Area A, the highest radium-226 concentration was found in the southeast corner of Area A (390 picocuries per liter). The lowest radium-226 concentration in any onsite well was <34 picocuries per liter. These results are above the existing standard of 30 picocuries per liter set by the U.S. Nuclear Regulatory Commission (NRC) and the proposed U.S. Environmental Protection Agency (EPA) standard of 5 picocuries per liter. All but two of the analysis results for uranium-238 were below the NRC standard of 40 picocuries per liter for this radionuclide; however, the majority of the results exceeded the EPA proposed standard of 10 picocuries per liter of total uranium.

In summary, surveys within Area A indicate that large quantities of the radioactive residue still remain on the site. Radium-bearing residues are present in soil beneath and adjacent to many of the buildings, as well as in the top few feet of soil over much of the area. Alpha contamination levels, beta-gamma dose rates, and external gamma radiation levels in some areas of the buildings and outdoors in Area A are above current Federal guidelines. Radon, radon daughter products, and thorium-230 levels in building air are also above current Federal guidelines in many instances. The ground water in Area A is also well above the current maximum permissible concentrations for radium and uranium.

Area B, although with lower contamination levels than Area A, is also above current Federal guidelines for radioactivity. Beta-gamma dose rates, external gamma radiation levels, radium in soil, and uranium and radium in ground water were all above the applicable guidelines. The 2- to 6-foot layer of contaminated soil on this area appears to be under approximately 8 to 9 feet of clean fill, which held surface contamination levels in this area lower than those of Area A.

Area C, a former lagoon area, was used as a depository for liquid wastes during uranium and radium recovery operations. The surface and subsurface soils are more contaminated than Areas A and B. A mucky material remains beneath the surface, with high concentrations of uranium and radium. Current Federal guidelines for soil radioactivity, ground-water radioactivity, and dose rates are exceeded in this area.

Radon and radon daughter products have been measured off the site at levels possibly in excess of current Federal guidelines.

1.2.2 Standards governing remedial action

The U.S. Environmental Protection Agency (EPA) has the primary responsibility for developing environmental standards for the disposal of wastes. In 1980, the EPA proposed standards for inactive uranium-processing sites under the Uranium Mill Tailings Radiation Control Act of 1978. These proposed standards are currently being revised, and may be made less stringent. For the sake of feasibility, however, the proposed remedial action has been designed to satisfy the proposed standards.

The EPA-proposed standards limit the annual average release of radon gas to the air from dispersed tailings to 2 picocuries per square meter per second, which is about twice the average for normal soils.

The performance standard for ground-water protection provides that selected contaminants from disposed tailings piles into ground water will not exceed specified levels. The contaminants specified are the same as those in the National Interim Primary Drinking Water Regulations. The only exception is the fluoride limitation. The EPA has omitted fluorides from the proposed standards because they are not important constituents in uranium mill tailings. If upstream ground-water levels exceed the specified concentration levels, then no further degradation is allowed. For existing sites, the EPA is proposing that the ground-water protection standards be applied starting 1.0 kilometer from the site.

The existing site conditions at Canonsburg and the proposed regulatory requirements for the safe disposal of wastes from inactive uranium processing sites define a unique set of considerations for onsite disposal.

1.2.3 Considerations for remedial action

With the radon and ground-water standards proposed by EPA, the 1000-year containment standard, and the long-term management objectives of NRC, the study of in-situ stabilization of the Canonsburg residues must deal with the following issues:

1. Heterogeneity -- Can a differentiation be made between various types and degrees of contamination, and can a spectrum of control strategies be developed to deal with them?

2. Excavation -- Is excavation (either partial or complete) a necessary part of the in-situ stabilization scenario? What is the extent of excavation required? If no excavation is required, can the areas of highest contamination levels be isolated to prevent public-health and environmental problems?

3. Area C materials -- Is it feasible to dispose of Area C materials on the site? How can this be accomplished?

4. Buildings -- What control measures are required to deal with the on-site buildings? If demolition is required, can the demolition rubble be disposed of on the site? Can any of the material be salvaged?

5. Multiple protection goals -- Can the contaminated material be isolated from storm-water infiltration while the radon flux rate from it is simultaneously held below regulatory levels?

6. Ground-water protection -- Can the ground-water flow regime and contaminant-leaching mechanisms be accurately established and control strategies developed to deal with the conditions? If these phenomena cannot be completely determined, can flexible strategies be developed to deal with the spectrum of uncertain conditions?

7. Newly generated wastes -- What management activities will be required for wastes created as a result of remedial-action activities (i.e., waste waters, dust, etc.)?

8. Flooding -- What flood protection measures might be required during and after construction?

9. Expected life -- Can an engineering design be developed for which the reasonably expected life is 1000 years? What historical or experimental basis is there for predicting the 1000-year life?

10. Cost -- Is there a cost-effective approach to in-situ stabilization at the Canonsburg site? Would there be a significant cost savings as a result of in-situ stabilization instead of decontamination and off-site disposal?

There are uncertainties in existing conditions such as the following:

1. Amount of contaminated materials.

2. Characteristics of contaminated materials.

3. Ground-water flow regime and potential for leaching of contaminants.

However, by using reasonable assumptions based on existing data and developing a flexible in-situ stabilization scenario, these uncertainties can be taken into consideration.

1.2.4 Conceptual approach for remedial action

This scenario is based on a conceptual approach that is conclusive in terms of feasibility and flexible enough to accommodate both the previously described uncertainties and the variations in regulatory requirements. The approach is modular, allowing various parts of the study called modules to be added or deleted depending on the results of further field study, changes in regulatory posture, or other design requirements.

The essential modules to be considered for in-situ stabilization at Canonsburg include the following:

1. Contaminated material handling.

2. Encapsulation of contaminated material.

3. Additional site work.

4. Environmental management.

1.3 CONTAMINATED-MATERIAL HANDLING

The contaminated-material module is required for assessing amounts and levels of contamination and sources and types of contaminated material. This is especially necessary at Canonsburg because of the heterogeneity of the contamination. This module covers the classification of contaminated material and the handling methods in terms of removal, excavation, decontamination, disposal, etc.

The existing data on surface and subsurface contamination at the site and knowledge of previous operating procedures indicate a large area of subsurface contamination in the lagoon portion of Area C, and a scattering of "hot spots" (contamination at levels of hundreds to thousands of picocuries per gram of radium-226) in Areas A and B. The hot spots in Area A are relatively close to the surface (0 to 8 feet), but in Area B they are deeper (8 to 14 feet).

The buildings in Area A have floors of contaminated soils or cracked concrete; these floors release radon gas and particulate daughter products.

Insufficient data exist to properly characterize the contaminated materials in Area C. Conflicting reports have been made concerning the characteristics of these materials, particularly pH and their potential for contaminant leaching. The uncertain chemical nature of the contaminated materials does not prevent the selection of a feasible in-situ stabilization concept as long as the construction materials used are resistant to wide variations in pH.

There are two basic conceptual approaches for in-situ stabilization. The first is to excavate and dispose of all contaminated materials in a specially designed repository. The second involves a judicious selection of some of the contaminated materials for excavation and disposal in this manner; the remainder would be stabilized in place, without excavation.

The problems with excavation of the entire site are many:

1. There is a logistics problem of secure handling and storage of large quantities of contaminated materials after they have been excavated.

2. Increased construction costs are involved in large excavations adjacent to Chartiers Creek.

3. Construction-worker exposure is increased.

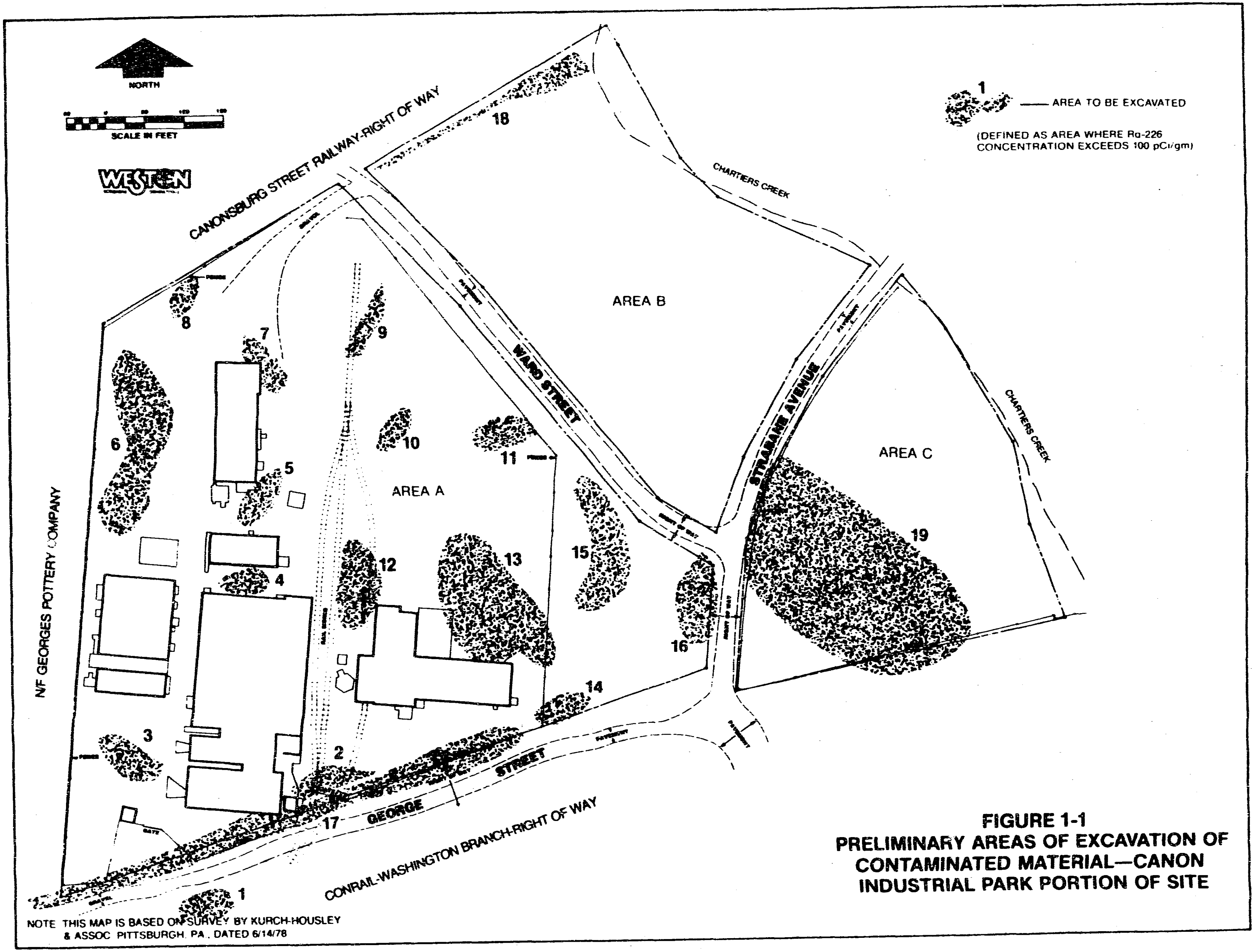
4. Massive construction efforts will increase the time required for construction which may delay the remedial-action schedule.

After consideration of the distribution of contaminated materials and their varying degrees of contamination and heterogeneity, it appears that the most feasible in-situ stabilization would involve a judicious selection of only some of the materials for excavation and disposal. The remaining materials would be stabilized in place using cover systems. This concept requires that all onsite buildings be decontaminated and demolished and that the more contaminated soils in Areas A and C be excavated. The building debris would be disposed of in the excavated portion of Area C, as well as other excavations, if possible. The more contaminated soils excavated from Areas A and C would be disposed of by placement in a specially designed cell which would totally encapsulate the material with a liner and a cover. Contaminated soils in Area B, located well below the surface, would receive additional soil cover (cap) over the entire area, as would areas surrounding the encapsulation structure.

Figure 1-1 shows the areas of excavation required to remove soils contaminated with radium-226 at concentrations of greater than 100 picocuries per gram in Areas A and C. Little excavation should be needed in Area B since the contamination is so deeply buried that the existing overburden, plus an additional soil cover, will be sufficient to control radon emanation and infiltration.

The physical and chemical properties of the Area C material have not been accurately quantified as yet. It has been described as "soup" or "yogurt" with pH values reportedly ranging from as low as 2 to as high as 13. In consideration of these uncertainties, it was decided to assume a worst-case condition of excavation by dragline to demonstrate the feasibility of the project concept. A sampling and analysis program to more fully characterize the Area C material is recommended before any excavation activity.

In some sections of Area C ground water is only 4 feet below the surface. Even during dry-weather periods, the ground water may only be 8 feet below the surface in Area C. Therefore, it may be necessary to dewater the area to facilitate excavation of contaminated material. Dewatering would simplify handling of the material after excavation as well.



1 — AREA TO BE EXCAVATED

(DEFINED AS AREA WHERE Ra-226 CONCENTRATION EXCEEDS 100 pCi/gm)

NOTE THIS MAP IS BASED ON SURVEY BY KURCH-HOUSLEY & ASSOC PITTSBURGH, PA., DATED 6/14/78

FIGURE 1-1
PRELIMINARY AREAS OF EXCAVATION OF CONTAMINATED MATERIAL—CANON INDUSTRIAL PARK PORTION OF SITE

1.4 ENCAPSULATION OF CONTAMINATED MATERIAL

The encapsulation-cell module is required for developing handling strategies for the most highly contaminated materials at the site. The source and character of these materials is developed in the contaminated-material module. The encapsulation-cell module addresses the evaluation, selection, and interaction of cover and liner materials and the conditioning and handling of these materials. The proposed location of the encapsulation cell is shown on Figure 1-2. The cover and liner configuration recommended for use is shown on Figure 1-3.

The encapsulation area is designed to contain the excavated more contaminated soils. It consists of a multilayer cover and a low-permeability liner. The cover is designed to limit radon flux from the encapsulated materials to 2 picocuries per square meter per second and to limit infiltration to as low as 1 percent of the annual average precipitation. The design of this cover represents a new approach in landfill design. Traditional designs allow water to penetrate the fill material and provide for long-term collection and possible treatment of leachate as it is generated. In the type of design proposed, the liner is essentially impermeable to ensure that no significant leachate escapes the cell. The multilayer cover is designed to minimize infiltration so that little leachate is generated. The liner then serves as a backup system to the cover. This type of design is essentially maintenance-free in application. The cover system should be constructed of entirely natural materials. The use of these materials is the best assurance of extended life because of their inherent structural stability and high resistance to biochemical degradation.

1.4.1 Multilayer cover system

A primary purpose of the cover system described in this subsection is to reduce radon fluxes at the surface of the covered Canonsburg disposal site to 2 picocuries per square meter per second or less. It is necessary to design the cover to accommodate the highest radon flux anticipated from the encapsulation area. The site characterization indicates that the highest radon flux could be 1000 to 1500 picocuries per square meter per second from the encapsulated material and up to several hundred picocuries per square meter per second from the remainder of the site.

Analyses of the effects of various cover configurations on radon flux rates were conducted using a computer model developed by Rogers Associates Engineering Corporation (RAECO, March 1981). The flux rate of 1000 to 1500 picocuries per square meter per second from the encapsulation area can be controlled to the specified regulatory level of 2 picocuries per square meter per second with the use of a 10-foot multilayer cover system (3 feet of clay, 1 foot of gravel, 6 feet of soil). The flux rate of several hundred picocuries per square meter per second flux from the remaining soils can be controlled to the specified level with the use of a 6-foot soil cover. Since contamination at several hundred picocuries per square meter per second and less can be adequately controlled by the 6-foot soil cover, it was determined that the excavation of soils contaminated with radium-226 at these lower concentrations would not be necessary.

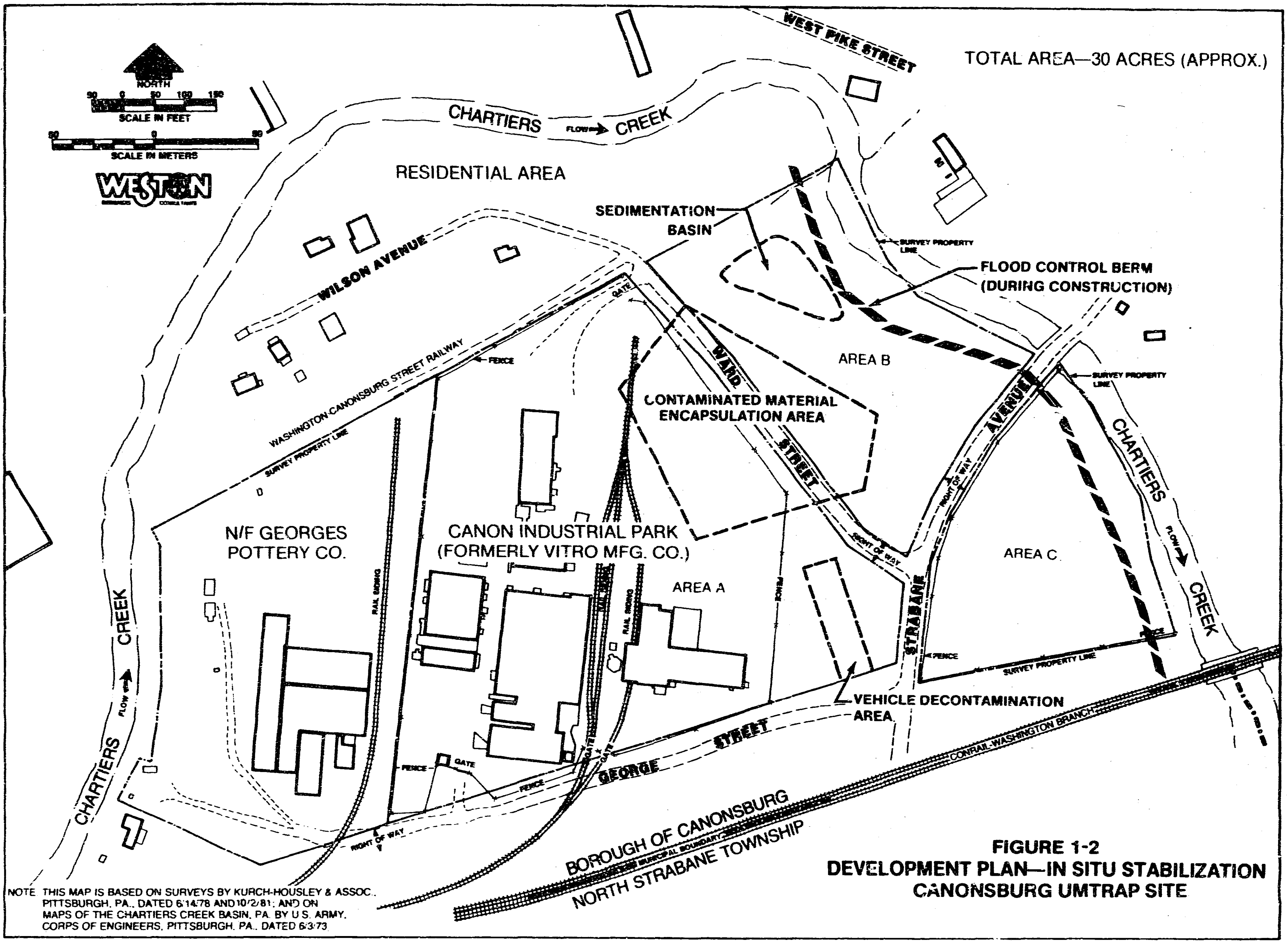


FIGURE 1-2
DEVELOPMENT PLAN—IN SITU STABILIZATION
CANONSBURG UMTRAP SITE

NOTE THIS MAP IS BASED ON SURVEYS BY KURCH-HOUSLEY & ASSOC., PITTSBURGH, PA., DATED 6/14/78 AND 10/2/81; AND ON MAPS OF THE CHARTIERS CREEK BASIN, PA. BY U.S. ARMY, CORPS OF ENGINEERS, PITTSBURGH, PA., DATED 6/3/73

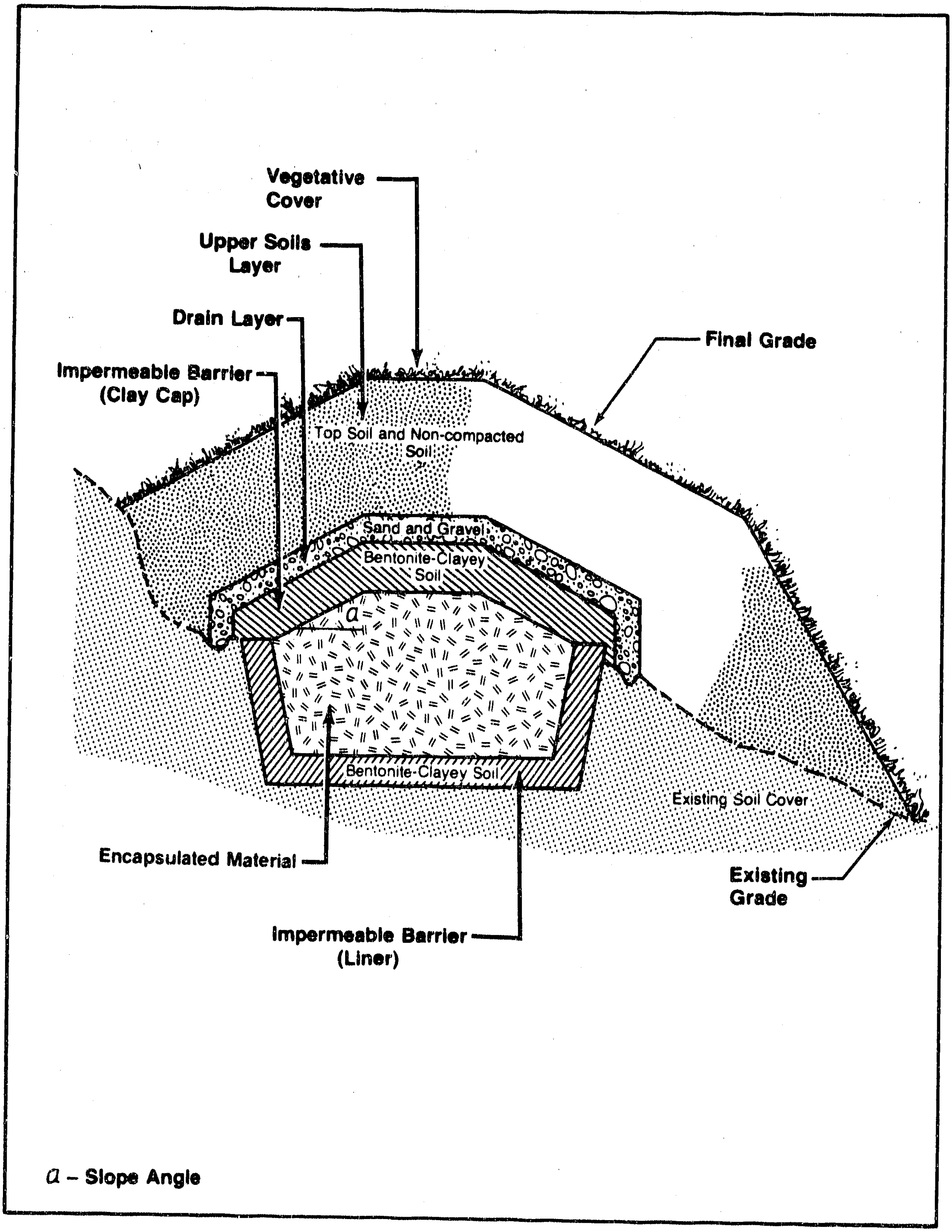


FIGURE 1-3 PROFILE OF RECOMMENDED ENCAPSULATION AND COVER CONFIGURATION—CANONSBURG UMTRAP SITE

A 6-foot multilayered cover system (3 feet of clay, 1 foot of gravel, 2 feet of soil) was considered an optional design for the encapsulation area due to the uncertain status of the EPA criteria. If the radon flux criterion was increased to 50 picocuries per square meter per second, this cover system would provide adequate radon control at a lower cost than the 10-foot-thick design. Similarly, the use of several thicknesses of soil was considered for cover for the remainder of the site in the event that the radon flux criteria become less stringent.

1.4.2 Liner system

The primary purpose and function of a liner system is to retard the physical movement of water into the natural environment. An optimal liner design would address the dual function of minimizing water (leachate) movement while passively treating any leachate that does migrate through the liner.

Upon reviewing the performance evaluation of various liner materials, it was determined that low-permeability native soils, admixtures of soil and bentonite, and bentonite itself are most suited to this application. The specific liner material, however, can only be selected once the readily available native soils are tested for permeability and cationic exchange capacity and the need for bentonite is established. The liner has been designed to be only as effective as the multilayered cover in terms of water control. Therefore, there should be no leachate or water buildup and no long-term maintenance requirements for leachate collection. Any water percolating through the liner will undergo ion-exchange attenuation through the clay.

1.4.3 Ion exchange

An ion-exchange barrier may be considered a means of controlling, if necessary, the migration of radionuclides in or into ground water. This type of system could be constructed as follows:

1. A curtain or barrier designed to intercept the flow of ground water around the periphery of the site.

2. A liner placed under the encapsulation cell designed to intercept any leachate that may be generated.

Ion-exchange material may be composed of the following:

1. Natural soils (clays generally have a high cation-exchange capacity).

2. Synthetic resins (zeolites, macroreticular polymers, gels, etc.).

The selection of the type of ion-exchange material will generally depend on the following factors:

1. Characteristics of the water or leachate that will be handled.
2. Presence and concentration of other ionic species.
3. Type of ionic species that must be removed.
4. Economic considerations.
5. Effective life.
6. Construction feasibility.

In addition, the ion-exchange function of a barrier or liner must be compatible with the other desired functions. For example, a primary purpose and function of a liner system is to retard the physical movement of water through the liner.

1.4.4 Waste conditioning

Waste conditioning is generally performed to meet one of the following three objectives:

1. To improve the handling and physical characteristics of the waste.

2. To decrease the surface area across which transfer and loss of contained contaminants can occur.

3. To limit the solubility of various contaminants within the waste.

Objectives 1 and 3 could be important at the Canonsburg site.

A number of fixation and conditioning methods were considered for application including the following:

1. Cement-based techniques.
2. Lime-based techniques.
3. Thermoplastic techniques.
4. Thermosetting resins.
5. Encapsulation techniques.
6. Glass and ceramic fixation techniques.
7. Thermal stabilization.
8. Acid extraction of contaminants.

They may be used in the event material excavated from Area C is found to have a low pH, which could damage a liner or cap made of bentonite clay and soil. Of the conditioning techniques considered, the lime-based techniques are the most applicable to the Area C material. Fixation techniques using lime-type products usually depend on the reaction of lime with a pozzolanic* material, water, and the waste to produce a concrete-type material. The most common pozzolanic materials used in waste fixation are cement-kiln dust, fly ash, and pulverized slag. These materials are readily available in the Pittsburgh area. The effectiveness of chemical fixation using this technique must also be demonstrated through bench-scale tests that simulate the actual process.

---

*The term pozzolanic applies to silicate-type material.

1.5 ADDITIONAL SITE WORK

The additional-site-work module is required for addressing those parts of the site other than the encapsulation cell. This module includes general site preparation such as flood control, dust control, and vehicle and worker decontamination, as well as handling strategies for contaminated materials other than those addressed in the encapsulation-cell module.

Additional site requirements which have been addressed as part of the in-situ-stabilization concept include the following:

1. Flood control and storm-water management, both during and after construction.
2. Site-access control and security.
3. Vehicle decontamination.
4. Fugitive-dust control.
5. Worker decontamination and health considerations.
6. Materials handling.

In addition, the areas of the site not included in the encapsulation cell must be addressed. They should be covered with a maximum of 5-1/2 feet of noncompacted fill and 6 inches of topsoil to support vegetation. Utilization of materials from the Burrell landfill site and from the vicinity proper as fill or cover materials is also feasible. Computer simulation efforts have shown that this should be sufficient to control radon flux to regulatory levels and to significantly reduce infiltration.

1.6 ENVIRONMENTAL MANAGEMENT

The environmental-management module is required for considering the environmental effects of construction activities. This module addresses environmental monitoring during construction, ground-water, surface-water, and waste-water management both during and after construction.

The cleanup strategy proposed for Area C could require initial dewatering of the soils in the area before excavation and the maintenance of a low groundwater table by continued pumping of the wells during the excavation. The waste waters, along with those generated during building decontamination and daily vehicle and worker decontamination, may require treatment for the removal of radioactive species before discharge to Chartiers Creek.

Storm runoff into the open excavation pits during construction should be collected and may require treatment before discharge. The waste-water treatment would include a sedimentation-and-surge basin followed by multimedia pressure filters for the treatment of suspended material. These could be followed by cation- and anion-exchange beds for the control of dissolved species, if necessary. Water softening may also be used in order to reduce the need for resin regeneration in the ion-exchange beds. Effluent quality should be monitored before discharge. The final design of waste-water treatment facilities would be determined by further characterization of the waste waters to be generated.

To control contamination in ground water, interim measures may be needed until complete natural renovation of the area is accomplished. Existing data on ground-water quality and the flow regime are not sufficient to precisely determine requirements and design parameters for such an interim measure. Offsite migration of ground-water contamination has not been identified yet. However, in order to establish the feasibility of the remedial-action concept a subsurface ion-exchange barrier was evaluated for application. If further confirmation studies establish the need for interim means of protecting the ground-water quality, this barrier, composed of a mixture of sand and natural zeolite, could provide a means of passive treatment for contaminated ground water flowing through the upper layer of unconsolidated material on the site. Within five to ten years the ion-exchange capability of the bed will be exceeded, but, by then, the effects of remedial action will have eliminated further contamination of the ground water. A water budget analysis of the proposed cover systems shows that 1 percent or less of the water impinging on the site will percolate through the waste.

1.7 APPROXIMATE COST ESTIMATE

An approximate cost estimate for in-situ stabilization of the Canonsburg site is given in Table 1-1. The costs are presented in a modular format to allow each element of the control concept (e.g., cover by itself, etc.) to be reviewed. It should be noted that this "approximate cost" is based on conservative assumptions. A preliminary cost estimate should be prepared as part of the detailed engineering phase of this project.

It should be noted that this cost estimate does not include site acquisition, cleaning offsite properties, and preparation of the Environmental Impact Statement (EIS). A significant reduction of the project cost could be realized by reducing the areas to be covered, reducing cover thickness, and verifying water quality conditions, to redefine the need for the ion-exchange barrier and portions of the waste-water treatment plant.

Table 1-1. Approximate cost[a]

Item	Approximate cost		
Encapsulation area (3 acres)			
Liner	$ 720,000		
Material filling	80,000		
Multilayer cover with vegetation	935,000		
Subtotal		$1,735,000	
Remainder of site (27 acres) 6-foot cover with vegetation		$1,790,000	
Contaminated soil excavation (23,985 cubic yards)			
Dewater Area C	60,000		
Excavation and material handling	215,000		
Subtotal		$275,000	
Building decontamination and demolition			
Building decontamination	200,000		
Salvageable-steel decontamination (4,700 tons)	30,000		
Building demolition	575,000		
Demolition-debris handling (18,000 cubic yards)	120,000		
Subtotal		$925,000	
Waste-water treatment		510,000	
Ion-exchange barrier (48,000 square feet)		500,000	
General site preparation			
Flood-control berm (2,400 feet)	240,000		
Fencing (7,000 feet)	100,000		
Remove railroad embankment and track (1,900 feet)	40,000		
Vehicle decontamination	30,000		
Worker facility	30,000		
Demobilization and cleanup	25,000		
Subtotal		$465,000	
Construction cost			$6,200,000
Contingency (15 percent)			930,000
Standby equipment and crew[b] (100 days at $5000 per day)			500,000
Engineering			713,000
Construction and environmental management			$1,500,000
TOTAL			$9,843,000

---

[a] Based on *Engineering News Record* cost index 3560; all individual cost items include 15 percent contingency for quantities, labor rate, etc.

[b] Cost of idle time for inspections, construction quality control, monitoring, and inclement weather.

1.8 CONCLUSIONS

The study of the Canonsburg site was initiated to ascertain the feasibility of onsite stabilization of all the radioactive contamination. Upon completion of this study, the following can be concluded:

1. An innovative remedial-action plan for in-situ stabilization has been developed that is both cost effective and feasible. Preliminary estimates are for a total cost of approximately $10 million.

2. A multilayered cover system has been developed. It is 10 feet thick, consisting of 3 feet of clay, 1 foot of gravel, and 6 feet of soil. It restricts water infiltration to 1 percent and controls radon flux rates to the regulatory levels of 2 picocuries per square meter per second.

3. All of the more contaminated materials (23,700 cubic yards of soil and 14,000 cubic yards of demolition rubble) on the site can be handled using demonstrated technologies.

4. The 80,000 cubic yards of material on the Burrell landfill site and the 5700 cubic yards of material on the vicinity properties can also be incorporated into this design.

5. These disposal technologies will satisfy proposed EPA and current NRC criteria for remedial action, and are flexible enough to handle a variety of future regulatory postures.

6. This plan will minimize impact to the public during construction (a period of approximately 18 months), and its implementation will ensure long-term stability.

2 Introduction

2.1 SCOPE AND OBJECTIVES

The purpose of this study is to assess the feasibility of in-situ stabilization as a remedial action at the Canonsburg site. General constraints on the study were the use of existing or easily obtainable data, and compliance with proposed Environmental Protection Agency (EPA) standards for remedial actions at inactive uranium-mill-tailings sites.

The objective of this study was to develop a feasible, cost-effective remedial-action plan to accomplish the following:

- Dispose of all contaminated materials on the site.
- Develop a plan that minimizes the impact on the public.
- Use demonstrated technologies.
- Ensure long-term stability.
- Satisfy EPA criteria for remedial action.
- Engineer a design flexible enough to handle a variety of regulatory postures.

2.2 SITE HISTORY

The Canonsburg site (Canon Industrial Park) is located in southwestern Pennsylvania, as indicated on Figure 2-1, in northern Washington County, approximately 20 miles from downtown Pittsburgh. It is entirely contained within the urbanized Borough of Canonsburg.

For the purposes of this study, the Canonsburg site (Figure 2-2) consists of the 30-acre area including 18.6 acres of the Canon Industrial Park, 6.1 acres of the Georges Pottery property, and 5.3 acres of residential property. It is bounded on the north, east, and west by Chartiers Creek, and on the south by the Conrail-Washington Branch railroad. Two roadways (Strabane Avenue and Ward Street) traverse the industrial park, dividing it into three parcels, designated Areas A, B, and C. Areas B and C are undeveloped and relatively open, while Area A contains approximately ten structures. George Street provides access to the Georges Pottery area and part of the residential area (one home). Now six homes are located on Wilson Avenue.

The Standard Chemical Company was the initial operator of the site during the period from 1911 to 1922, extracting radium from carnotite ore. Operations ceased from 1922 until 1930 when Vitro Manufacturing Company (Vitro) acquired the plant. Vitro extracted radium and uranium salts from onsite resi-

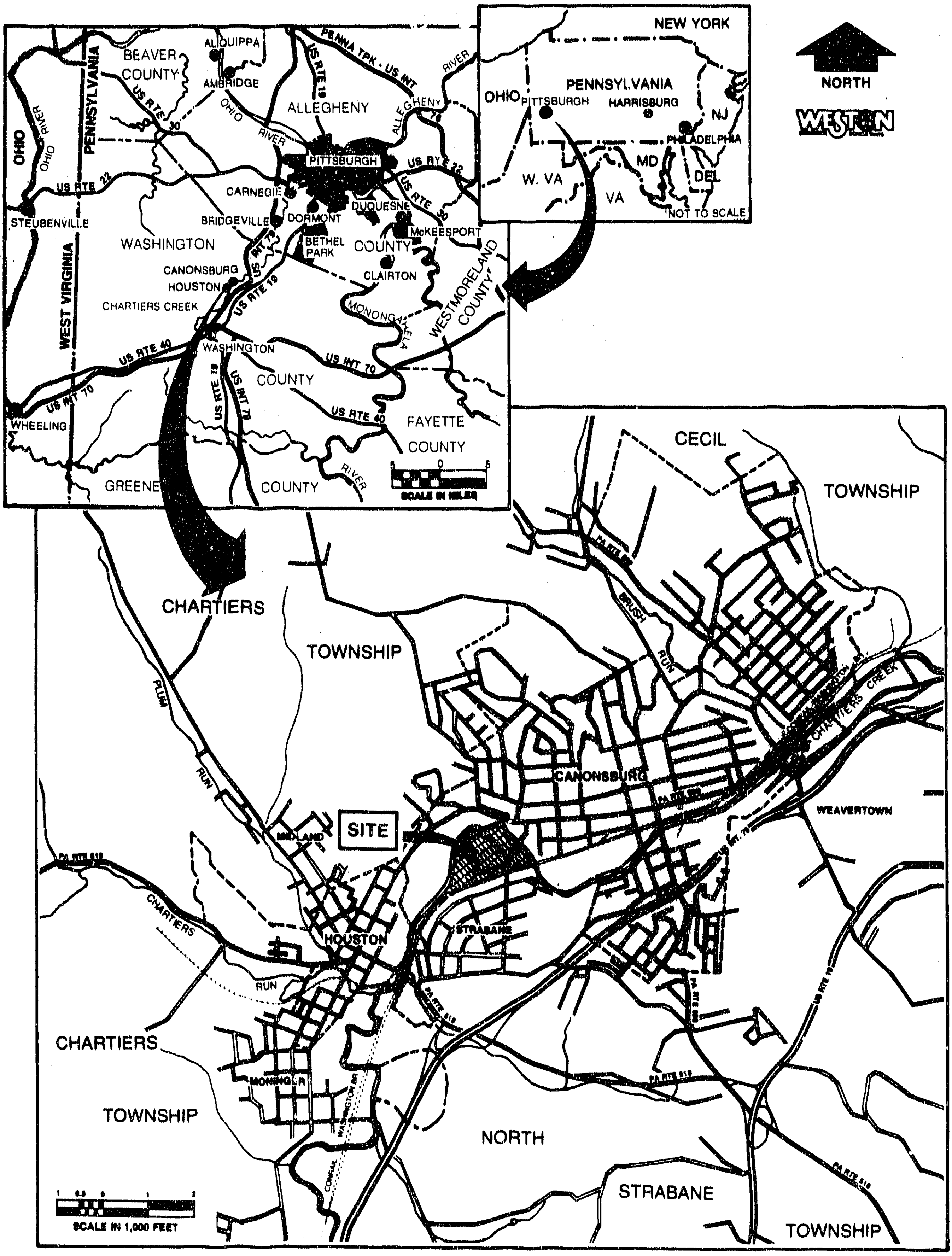
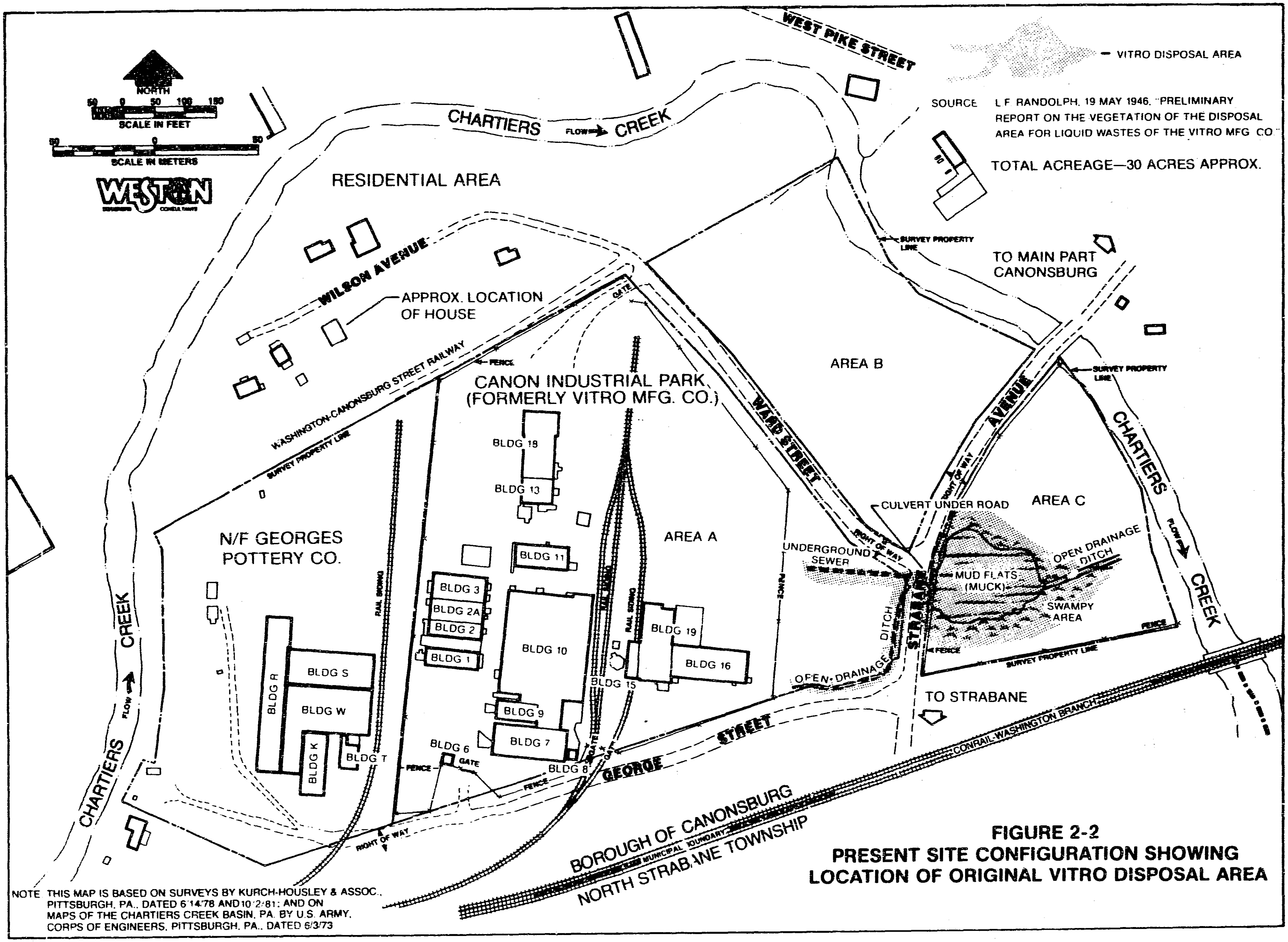


FIGURE 2-1 GENERAL LOCATION MAP OF THE SITE, CANONSBURG, PENNSYLVANIA



SOURCE L F RANDOLPH, 19 MAY 1946, "PRELIMINARY REPORT ON THE VEGETATION OF THE DISPOSAL AREA FOR LIQUID WASTES OF THE VITRO MFG CO"

TOTAL ACREAGE—30 ACRES APPROX.

NOTE THIS MAP IS BASED ON SURVEYS BY KURCH-HOUSLEY & ASSOC., PITTSBURGH, PA., DATED 6/14/78 AND 10/2/81; AND ON MAPS OF THE CHARTIERS CREEK BASIN, PA. BY U.S. ARMY, CORPS OF ENGINEERS, PITTSBURGH, PA., DATED 6/3/73

FIGURE 2-2
PRESENT SITE CONFIGURATION SHOWING LOCATION OF ORIGINAL VITRO DISPOSAL AREA

dues and carnotite ore from 1930 to 1942. In 1942, operations funded by Federal government contracts were directed to recover uranium from various ores, concentrates, and scrap materials. Vitro records show that in October 1948, approximately 30,000 pounds of uranium oxide (U_3O_8) were being extracted per month from 300,000 pounds of waste received from different AEC installations.

Liquid wastes were discharged through a drainage system beneath Strabane Avenue, which emptied into a swamp existing at that time. The swamp was connected by a drainage ditch to Chartiers Creek, which flows into the Ohio River west of Pittsburgh. The location of the swamp is shown in relation to the present site configuration on Figure 2-2.

Recovery operations at the Canonsburg site ceased in 1957. The remaining unprocessed residues and contaminated processing wastes remained stored on the site under an AEC "storage only" license. The real property was sold in 1962 to private individuals, while Vitro retained title to the uranium-containing materials. Before 1964, the immediate plant area was decontaminated, and all contaminated materials were moved to a main stockpile of uranium ores, located in Area A. In 1965, this pile was moved to the swamp in Area C, buried beneath an impermeable layer of "red dog" (a steel milling slag), and covered by clean fill material. Following this action, the site's source-material license was terminated. Currently, the site is being operated as an industrial park. Firms located on the site include a truck freight terminal, metal-work operations, machine shops, laundry operations, and various warehouses.

Radiological surveys were made of the Canonsburg site in 1977 under the AEC's 1974 "Formerly Utilized MED/AEC Sites Remedial Action Program" (FUSRAP). It was determined that the radiation levels measured in the buildings, soils, and ground water exceeded the proposed DOE guidelines for remedial action. Consequently, environmental and engineering analyses were made with respect to remedial action.

2.3 SITE DESCRIPTION

2.3.1 Radiological

Radiological surveys of the Canonsburg site have been performed by several organizations, including the Oak Ridge National Laboratory (ORNL) and the Environmental Measurements Laboratory (EML).

The maximum values measured and their locations are summarized in Table 2-1. The maximum permissible concentration (MPC) for radon-222 in air in unrestricted areas (pertaining to unrestricted access and use) is 3 picocuries per liter. This was exceeded in all of the onsite buildings as shown in Table 2-1. Daytime average radon-222 concentrations ranged from 2.6 to 106.5 picocuries per liter, while maximum radon-222 concentrations ranged from 6.5 to 300 picocuries per liter. Measurements of radon daughters in all but one of the buildings also exceeded the appropriate guidelines (0.033 working level), with an average daytime concentration from 0.02 to 0.51 working levels.

Table 2-1. Comparison of observations at the Canonsburg site with pertinent regulatory guidelines and standards

Pathway	Media	Type of contamination	Standard/ guideline	Source	Limit	Maximum value found	Location
Surface contamination	Building material	Gross alpha (from Ra-226)	Regulations guidelines 1.86 "Decontamination Guidelines for Facilities and Equipment"	USNRC, 1976	300 dpm/100 sq cm	40,000 dpm/100 sq cm	Block B6 -- Building 16
		Removable gross alpha (from Ra-226)			20 dpm/100 sq cm	400 dpm/100 sq cm	Block H4 -- Overhead beam in Building 18-
		Gross beta			0.2 mrad/hour at 1 cm	8.5 mrad/hour at 1 cm	Block B3 -- Building 7
External radiation	Not applicable	Not applicable	Dose Limits to Public Individuals	NCRP, 1971	500 mrem/year	4,000 mrem/year	2,000 hour/year at 2,000 μR/hour offsite south of Area A (2+50, R50)
			"Decontamination Guidelines for Facilities and Equipment"	USNRC, 1976	0.2 mrad/hour	8.5 mrad/hour	Block B3 -- Building 7, floor
						25 mrad/hour	Onsite inside, Area A (5+50 to 6+50, L250 to L300)
						15 mrad/hour	Offsite, south of Area A(1+50 to 2+50, R50 to R100)
			Clean-up Criteria for Uranium Mill Sites	USNRC, 1978	140 mrem/year	3,200 mrem/year	2,000 hour/year at 1,600 μR/hour onsite, Area A (6+50, L250)
Air	Concentration within buildings	Rn-222	10 CFR 20	USNRC, 1960	3 pCi/l	300 pCi/l	Building 9
		Rn-222 + daughters			0.033 WL	0.51 WL	Building 10
		Pb-210			4×10^{-3} pCi/l	1.3×10^{-4} pCi/l	Building 2
		Ra-226			3×10^{-3} pCi/l	8.1×10^{-5} pCi/l	Building 10
		Th-230			8×10^{-5} pCi/l	2.1×10^{-4} pCi/l	Buildings 10 and 16
		U-238			3×10^{-3} pCi/l	3.5×10^{-4} pCi/l	Buildings 11 and 19
	Ground emanation	Rn-222	40 CFR 192 (proposed)	USEPA, 1980	2 pCi/sq m/sec	No data	--
Ground water	Onsite	Ra-226 + 228	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/l	4,500 pCi/l	Western border, Area A, well 5
		Uranium, total			10 pCi/l	14,380 pCi/l (U-235 + 238)	
Soil	Floor drain sediments	U-238	10 CFR 40	USNRC, 1961	172 pCi/g	270 pCi/g	Building 1, drain 6
		Ra-226	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/g	310 pCi/g	Building 11, drain 2
	Surface onsite	U-238	10 CFR 40	USNRC, 1961	172 pCi/g	51,000 pCi/g	Southwest corner, Area A
		Ra-226	40 CFR 192 proposed)	USEPA, 1980	5 pCi/g	4,200 pCi/g	Southwest portion, Area A
	Surface offsite	U-238	10 CFR 40	USNRC, 1961	172 pCi/g	660 pCi/g	Chartiers Creek, south of Area C
		Ra-226	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/g	3,100 pCi/g	Chartiers Creek, southeast of Area C

External gamma radiation was measured in the buildings by the ORNL. The highest average value was 80 microroentgens per hour. The highest maximum value was 310 microroentgens per hour. These values could result in an individual receiving 160 millirems per year, and 620 millirems per year, respectively. The latter exceeds the 500 millirems per year limit for nonoccupationally-exposed individuals. Since the Canonsburg site represents an unrestricted property in private use, this limit applies to the onsite workers.

The ORNL measured surface contamination in the site's buildings. The results showed that all onsite buildings have extensive areas with gross alpha, gross beta-gamma, external gamma, and transferable alpha and beta contamination exceeding the appropriate limits.

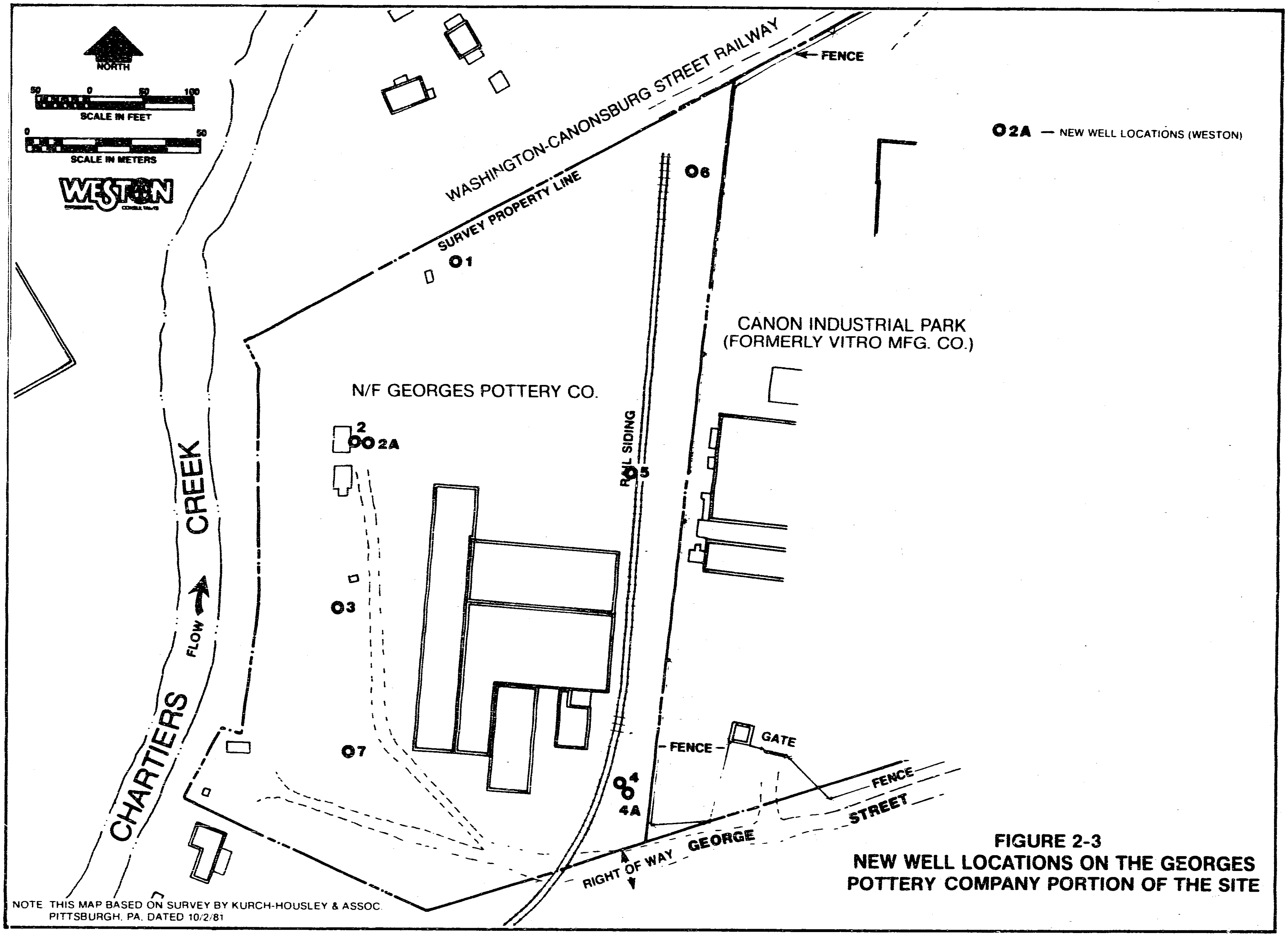
Measurements of radon-222 outside in Area A were taken at two locations by the ORNL and at four locations by the EML. These results ranged from 0.80 to 2.7 picocuries per liter. At one location, the ORNL measurements ranged from 2.5 picocuries per liter to a maximum of 10 picocuries per liter. At the other location, the average was 17 picocuries per liter with a maximum of 69 picocuries per liter.

Over 90 percent of the maximum beta-gamma dose-rate measurements at 1 centimeter heights in Area A exceed the 0.2 millirads per hour guideline, with some as high as 25 millirads per hour. Virtually all external gamma levels measured at 1 meter in Area A were greater than 100 microroentgens per hour. Values along the eastern portion ranged from 300 to 500 microroentgens per hour, with a maximum of 1600 microroentgens per hour. Values for beta-gamma and external gamma radiation also exceeded their respective guidelines at many locations in Areas B and C.

Concentrations of radium-226 and uranium-238 in surface soil samples from all three areas were found to be significantly greater than allowed under the proposed EPA standards. Radium-226 values ranged up to 6200 picocuries per gram with over half the samples exceeding 5 picocuries per gram. Concentrations of uranium-238 in some samples were greater than 172 picocuries per gram (the equivalent of source material), with values as high as 51,000 picocuries per gram.

Radiological water quality was assessed at all of the onsite wells. With the exception of one extremely high radium-226 concentration of 4500 picocuries per liter (it is suspected that this well was drilled into the drain system of an old building), the highest radium-226 concentration was found in the southeast corner of Area A (up to 390 picocuries per liter). The lowest radium-226 concentration in any onsite well was <34 picocuries per liter. This is above the existing standard of 30 picocuries per liter set by the NRC and the proposed EPA standard of 5 picocuries per liter. All of the analysis results for uranium-238 were below the NRC standard of 40,000 picocuries per liter for this radionuclide; however, the majority of the results exceeded the EPA proposed standard of 10 picocuries per liter of total uranium.

A ground-water sampling program in the Georges Pottery area was recently completed. Well locations are shown on Figure 2-3, and the results are tabulated in Table 2-2. The highest levels of contamination are consistently found in wells 4 and 4A, those closest to the industrial park.



NOTE THIS MAP BASED ON SURVEY BY KURCH-HOUSLEY & ASSOC.
PITTSBURGH, PA. DATED 10/2/81

FIGURE 2-3
NEW WELL LOCATIONS ON THE GEORGES
POTTERY COMPANY PORTION OF THE SITE

Table 2-2. Georges Pottery area ground-water analysis[a]

Well No.	Th-232	Th-230	Ra-226	Total uranium	Ac-227
1	< 0.418	< 0.725	< 0.167	93.5 ± 9.6	< 0.725
2	< 0.541	2.88 ± 1.70	0.594 ± 0.22	8.42 ± 2.4	< 0.764
2A	< 1.01	< 1.31	0.316 ± 0.18	3.11 ± 1.5	< 1.01
4	< 1.04	3.98 ± 1.88	18.3 ± 1.8	4570 ± 460	< 1.16
4A	< 0.899	< 1.27	--	291 ± 29	< 1.10
5	< 1.06	< 0.921	--	375 ± 38	< 0.752
6	< 0.642	< 1.28	--	4.96 ± 1.8	< 0.144
7	< 0.550	< 1.10	--	139 ± 14	< 0.777

---

[a] Results in picocuries per liter.

In summary, surveys within Area A indicate that large quantities of the radioactive wastes generated during radium and uranium recovery operations still remain on the site. Radium-bearing wastes are present in soil beneath and adjacent to many of the buildings, as well as in the top few feet of soil over much of the area. Alpha contamination levels, beta-gamma dose rates, and external gamma radiation levels in some areas of the buildings and outdoors in Area A are above current Federal guidelines. Radon, radon daughter products, and thorium-230 levels in building air are also above current Federal guidelines in many instances. The ground water in Area A is also well above the current maximum permissible concentrations for radium and uranium.

Area B, which has lower surface contamination levels than Area A, is also above current Federal guidelines for radioactivity. Beta-gamma dose rates, external gamma radiation levels, radium in soil, and uranium and radium in ground water were all above the applicable guidelines. There appeared to be a 2 to 6-foot layer of contaminated soil under approximately 8 to 9 feet of clean fill in this area which led to contamination levels in this area being lower than those of Area A.

Area C, the former lagoon area, was used as a depository for liquid wastes during uranium and radium recovery operations. The surface and subsurface soils are more contaminated than those in Areas A and B. A mucky material remains beneath the surface, with high concentrations of uranium and radium. Current Federal guidelines for soil radioactivity, ground-water radioactivity, and dose rates are exceeded in this area.

Radon and radon daughter products have been measured off the site at levels possibly in excess of current Federal guidelines.

2.3.2 Hydrological

2.3.2.1 Precipitation

Annual precipitation in the vicinity of the Canonsburg site is fairly well distributed throughout the year, and averages about 94 centimeters (37 inches) per year. The precipitation primarily results from cyclonic storms in winter, spring, and fall; from conventional (i.e., thunderstorm) activity in the summer; and infrequently from the remnants of hurricanes or tropical storms in late summer and fall. The highest monthly precipitation occurs in March and June, averaging about 9.7 centimeters (3.80 inches). Minimum precipitation totals in the Canonsburg area are normally observed in February or November and average about 6.1 centimeters (2.40 inches). Average annual snowfall at the Canonsburg site is about 89 centimeters (35 inches).

2.3.2.2 Surface water

The Canonsburg site lies in the Chartiers Creek Basin which drains an area of approximately 265 square miles. Chartiers Creek generally flows in a northeasterly direction and meets the Ohio River about 2.6 miles downstream of the point where the Monongahela and Allegheny Rivers merge to form the Ohio River. The site lies on the south bank of Chartiers Creek about 15 miles upstream from the mouth.

A portion of the plant properties encroach the 100-year and 500-year flood plains of Chartiers Creek. The flood plains are delineated on Figure 2-4; as shown on the map, portions of Area B and Area C lie in the flood plains.

Water quality data available from the Pennsylvania Department of Environmental Resource's (DER) STORET Retrieval System, USGS Water Resources Data for Pennsylvania (Water Year 1977), and WESTON's sampling program conducted in March and July 1979, were used to characterize the water quality in Chartiers Creek. In general, Chartiers Creek was found to be high in iron, sulfates, and fecal coliforms which are characteristic of streams receiving acid mine wastes, sewage, and industrial waste discharges.

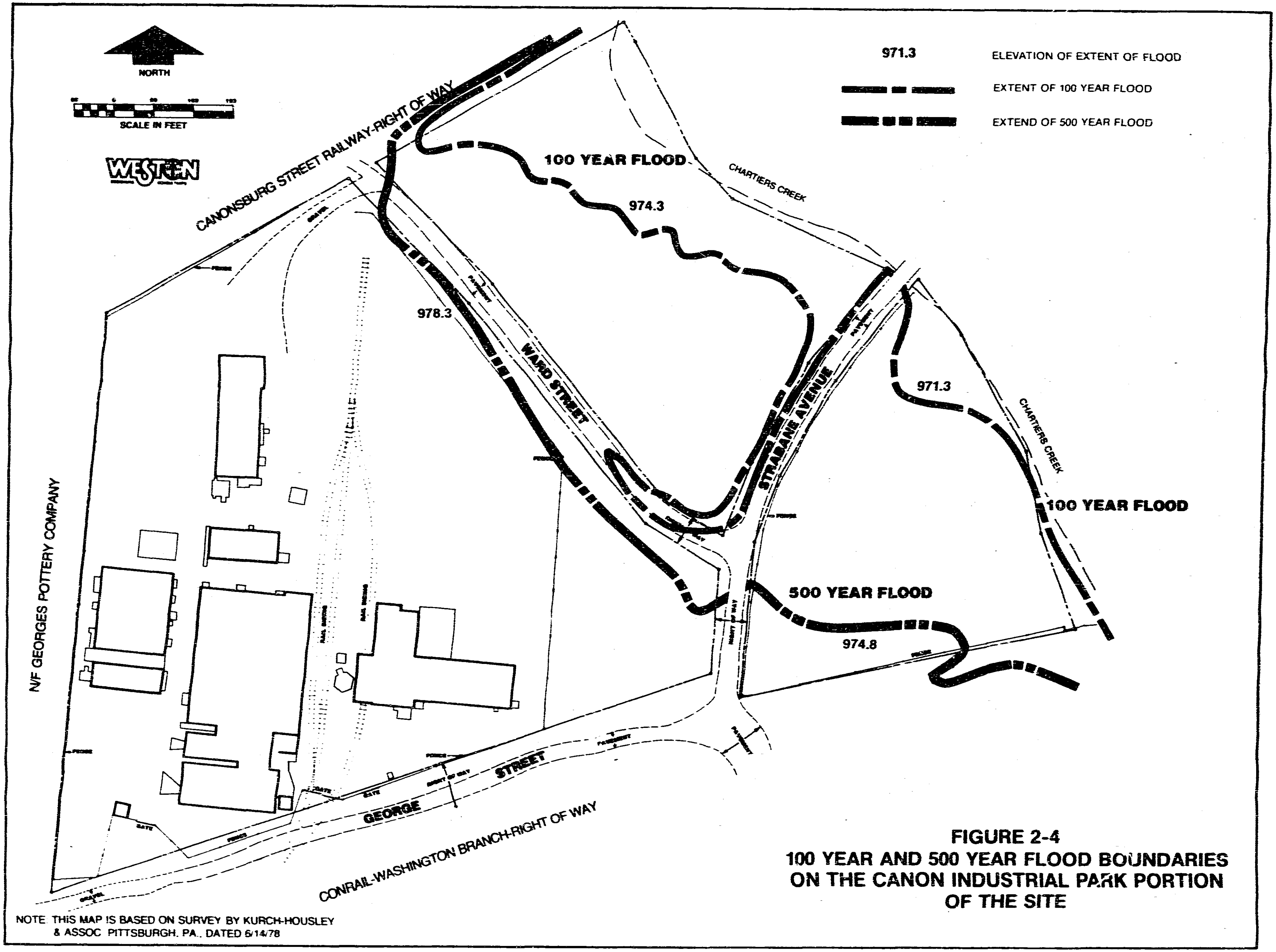
The site contributes high pollutant loads, particularly iron and sulfate, to the runoff to Chartiers Creek. With the possible exception of total organic carbon, however, these pollutant loads do not contribute to further degradation of water quality in the creek.

2.3.2.3 Ground water

Ground water in Washington County occurs both in unconsolidated alluvium that overlies bedrock and in the various bedrock formations. Figure 2-5 shows ground-water elevations in the unconsolidated material and flow directions for 23 July 1979, which is representative of the lowest water level of the period of record (April 1979 to January 1980). The same information for 11 October 1979 is shown on Figure 2-6, and is representative of the highest ground-water levels for the period of record. As seen on these figures, the primary ground-water flow is from the site to Chartiers Creek.

There is a small component of flow onto the former Georges Pottery property immediately adjacent to the western property line of the site. The flow pattern is through the Georges Pottery property to Chartiers Creek. There are internal components of flow towards Area C and Ward Street within Area B; these, however, become incorporated into the main flow system to Chartiers Creek.

The approximate rates of flow were computed for Areas A, B, and C individually. The rate of flow through Area C is approximately an order of magnitude lower than through the other areas.



NOTE THIS MAP IS BASED ON SURVEY BY KURCH-HOUSLEY & ASSOC PITTSBURGH, PA., DATED 6/14/78

FIGURE 2-4
100 YEAR AND 500 YEAR FLOOD BOUNDARIES ON THE CANON INDUSTRIAL PARK PORTION OF THE SITE

NOTE: 1. TOPOGRAPHY IS FROM PLAN OF SURVEY BY KURCH-HOUSLEY & ASSOC., ENGINEERS & SURVEYORS, PITTSBURGH, PENNSYLVANIA, REVISED TO 8/14/78. CONTOURS ARE SHOWN IN 2 FOOT INTERVALS AND REFER TO AN ASSUMED BENCHMARK (SEE ORIGINAL PLAN FOR LOCATION).

2. ON-SITE UTILITIES ARE NOT SHOWN ON THIS DRAWING. REFER TO PLAN OF SURVEY BY THE ABOVE SURVEYORS.

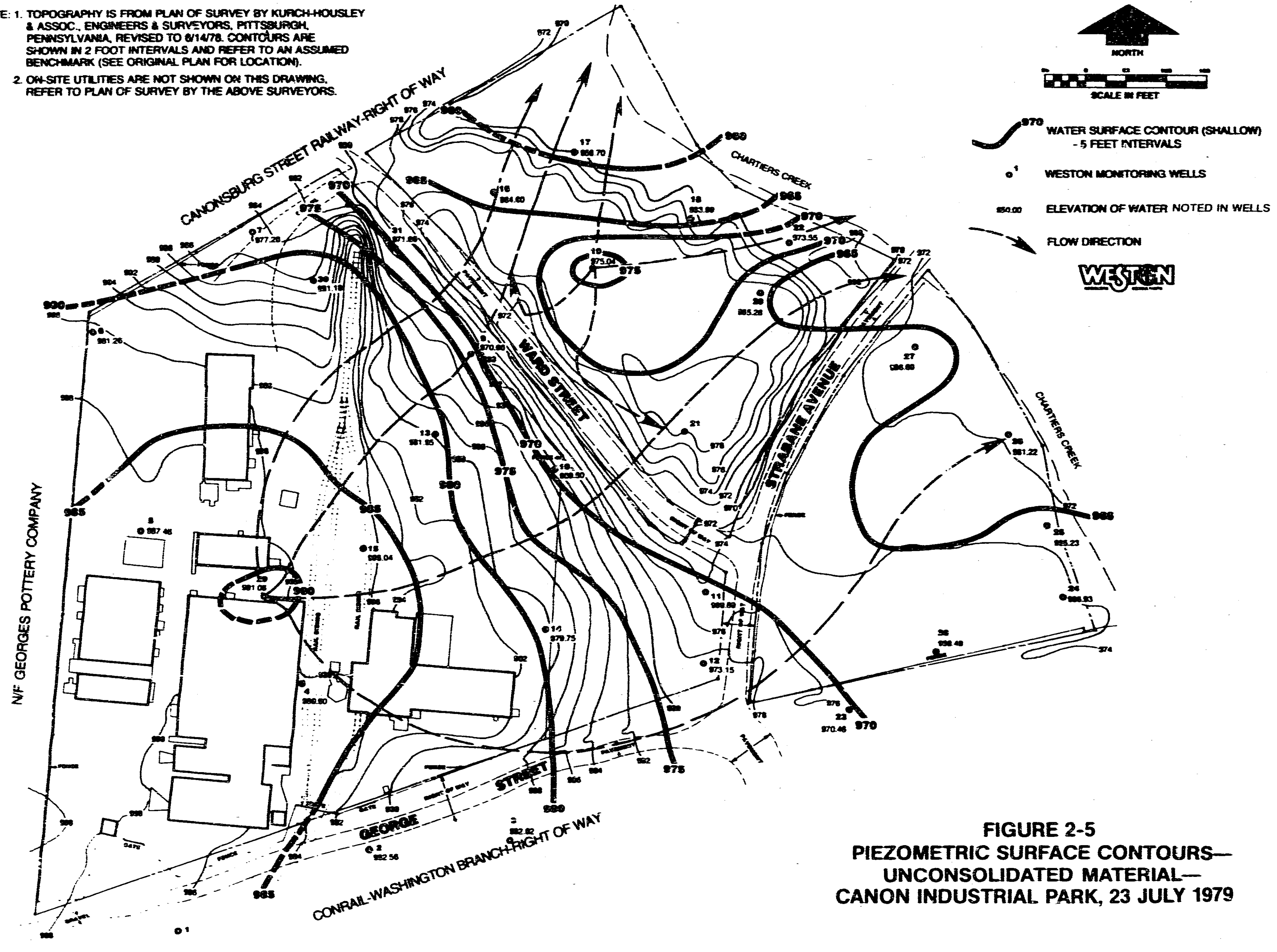
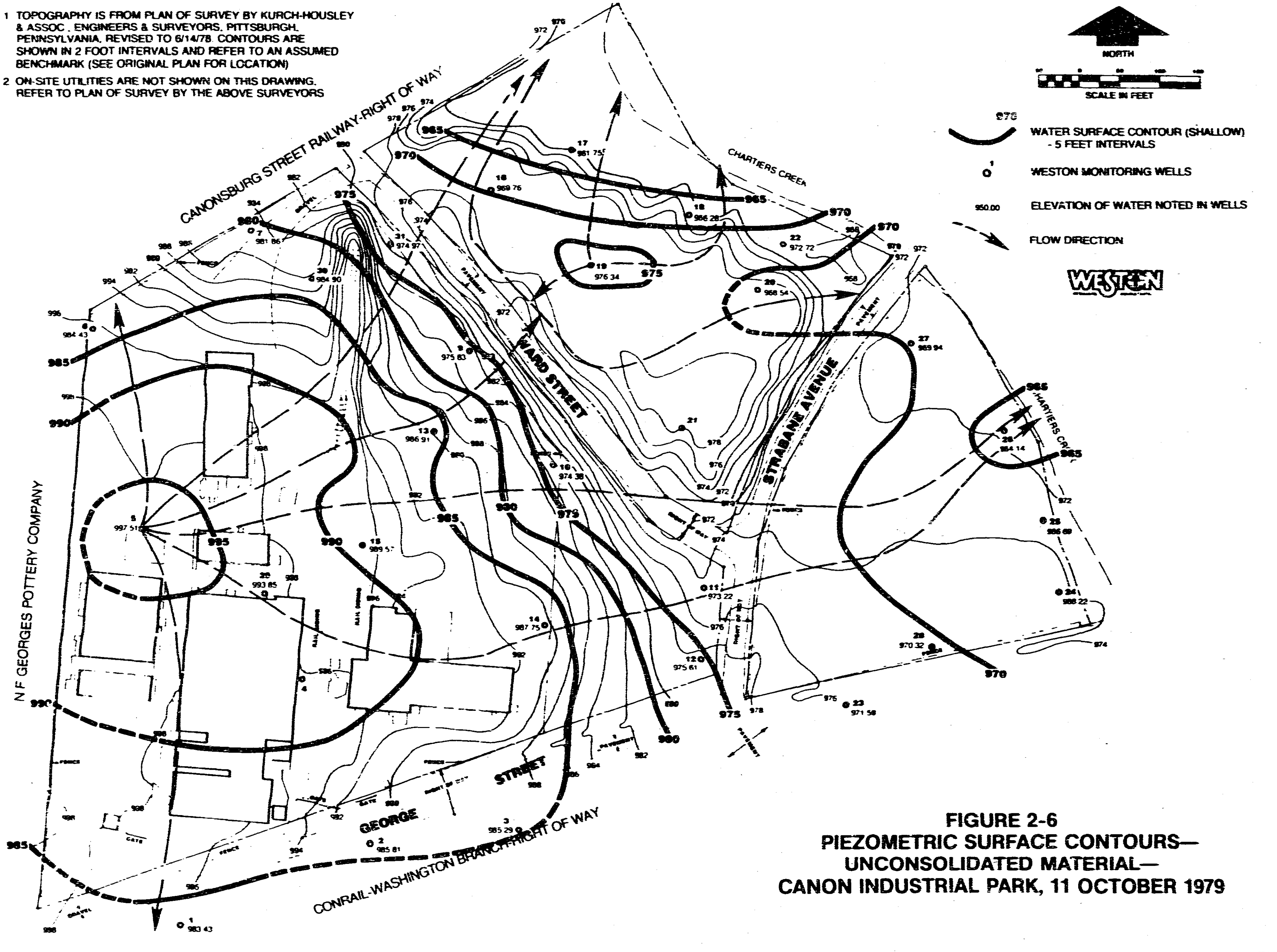


FIGURE 2-5
PIEZOMETRIC SURFACE CONTOURS—UNCONSOLIDATED MATERIAL—CANON INDUSTRIAL PARK, 23 JULY 1979



NOTE 1 TOPOGRAPHY IS FROM PLAN OF SURVEY BY KURCH-HOUSLEY & ASSOC. ENGINEERS & SURVEYORS, PITTSBURGH, PENNSYLVANIA, REVISED TO 6/14/78. CONTOURS ARE SHOWN IN 2 FOOT INTERVALS AND REFER TO AN ASSUMED BENCHMARK (SEE ORIGINAL PLAN FOR LOCATION)

2 ON-SITE UTILITIES ARE NOT SHOWN ON THIS DRAWING. REFER TO PLAN OF SURVEY BY THE ABOVE SURVEYORS

FIGURE 2-6
PIEZOMETRIC SURFACE CONTOURS—
UNCONSOLIDATED MATERIAL—
CANON INDUSTRIAL PARK, 11 OCTOBER 1979

)

Figures 2-7 and 2-8 show the ground-water elevations and flow directions in the bedrock system. The slope of the piezometric surface, and therefore, ground-water flow, is toward Chartiers Creek. As seen in the unconsolidated material, there appears to be a component of flow towards the creek, through the former Georges Pottery property. The bedrock system differs from the shallow ground-water system in that there does not appear to be a component of flow from Area B to Ward Street in the bedrock system. In addition, the ground-water high developed in Area B in the unconsolidated material is not present in the bedrock system. Ground-water contours show a rise in ground-water elevations that cross Area A and Area B in the northwest trend. The rise is unrelated to the ground-water mound in Area B in the unconsolidated material, but is south of and parallel to a minor ridge in the bedrock surface. Apparently the bedrock ridge is bordered by a fracture on the south side, and the rise in the ground-water elevations is the result of the increased porosity of the fracture zone. With several exceptions, water levels in the bedrock wells are below water levels in the adjacent shallow wells, indicating that most of the site is acting as a recharge area rather than a discharge area.

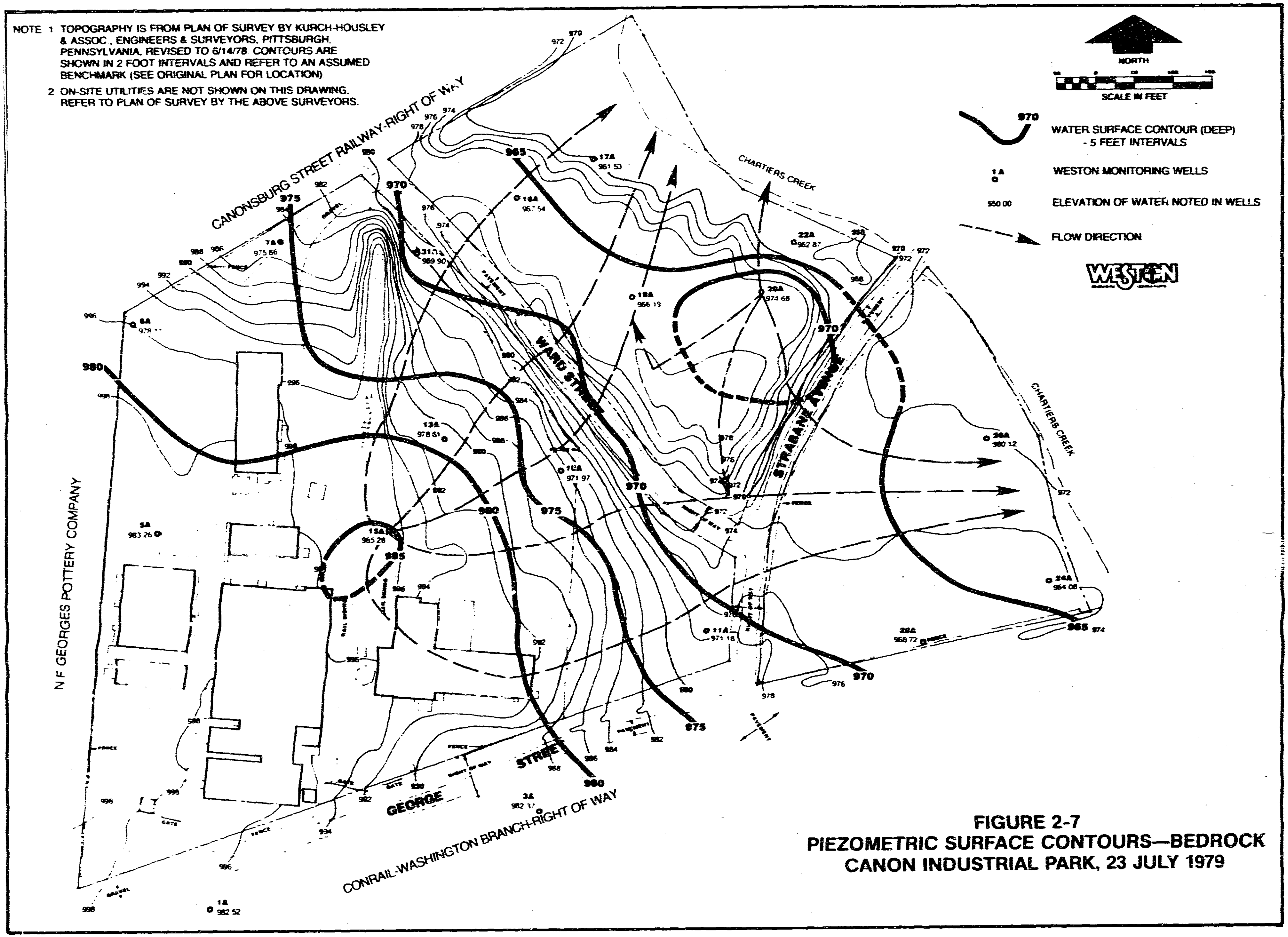
2.3.3 Geological

The Canon Industrial Park is located in a bend of Chartiers Creek, originally a part of the flood plain. Natural topographic relationships would place the site at a lower elevation than its surroundings; however, the site topography has been altered by filling and earth moving, and this relationship has been changed.

The general topographic trend on the site is from the southwest corner, on George Street, toward Chartiers Creek. Total relief on the site is approximately 9.1 meters (30 feet). Site topography is shown on Figure 2-9; the elevations shown are with respect to an assumed datum point.

Area A has the greatest amount of relief (approximately 7 meters), and the industrial park complex is located on the highest portion of Area A. Area B resembles a plateau, largely made up of dredged material from Chartiers Creek. The upper portion of the plateau is marked by several very shallow depressions, probably a result of differential compaction of the dredged materials. The upper portion lies 2.3 meters above its immediate surroundings. Area C, the lowest portion of the site, is relatively flat. Unlike Areas A and B, there are no significant topographic features on Area C. The Canon Industrial Park is underlain by four types of material: soil, fill, alluvium, and bedrock.

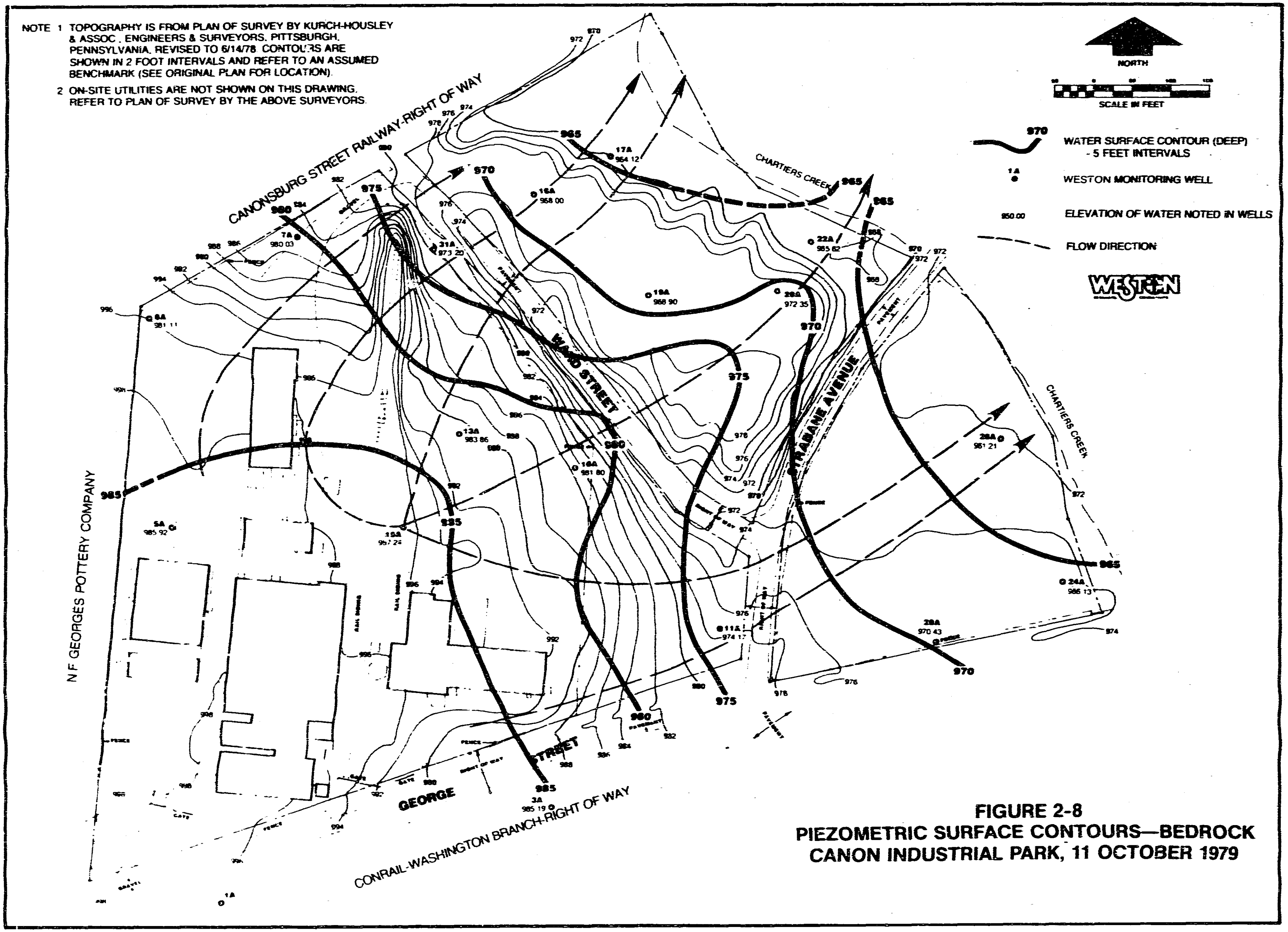
Fill is ubiquitous on the site. The thickness of the fill ranges from 2.7 meters (9 feet) to less than 0.3 meter (1 foot). The most common component of the fill is cinders. On Area A, along Ward Street, halfway between the north property line and George Street, there is a pocket of almost pure cinders roughly 3 meters thick, while over the remainder of the site, cinders are mixed with soil, stones, and building rubble.



NOTE 1 TOPOGRAPHY IS FROM PLAN OF SURVEY BY KURCH-HOUSLEY & ASSOC., ENGINEERS & SURVEYORS, PITTSBURGH, PENNSYLVANIA, REVISED TO 6/14/78. CONTOURS ARE SHOWN IN 2 FOOT INTERVALS AND REFER TO AN ASSUMED BENCHMARK (SEE ORIGINAL PLAN FOR LOCATION).

2 ON-SITE UTILITIES ARE NOT SHOWN ON THIS DRAWING. REFER TO PLAN OF SURVEY BY THE ABOVE SURVEYORS.

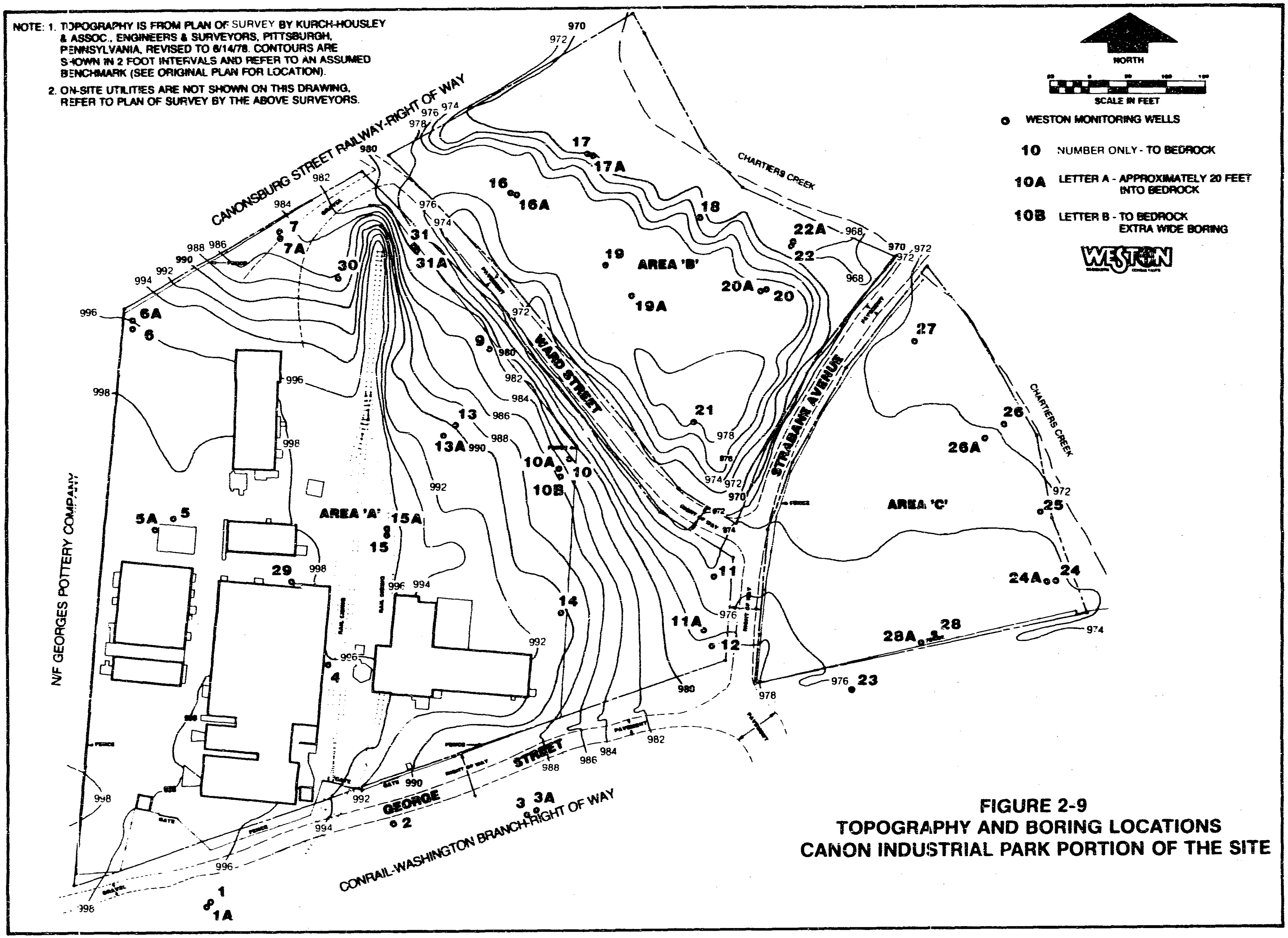
FIGURE 2-7
PIEZOMETRIC SURFACE CONTOURS—BEDROCK
CANON INDUSTRIAL PARK, 23 JULY 1979



NOTE 1 TOPOGRAPHY IS FROM PLAN OF SURVEY BY KURCH-HOUSLEY & ASSOC., ENGINEERS & SURVEYORS, PITTSBURGH, PENNSYLVANIA, REVISED TO 6/14/78. CONTOURS ARE SHOWN IN 2 FOOT INTERVALS AND REFER TO AN ASSUMED BENCHMARK (SEE ORIGINAL PLAN FOR LOCATION).

2 ON-SITE UTILITIES ARE NOT SHOWN ON THIS DRAWING. REFER TO PLAN OF SURVEY BY THE ABOVE SURVEYORS.

FIGURE 2-8
PIEZOMETRIC SURFACE CONTOURS—BEDROCK
CANON INDUSTRIAL PARK, 11 OCTOBER 1979



NOTE: 1. TOPOGRAPHY IS FROM PLAN OF SURVEY BY KURCH-HOUSLEY & ASSOC., ENGINEERS & SURVEYORS, PITTSBURGH, PENNSYLVANIA, REVISED TO 6/14/78. CONTOURS ARE SHOWN IN 2 FOOT INTERVALS AND REFER TO AN ASSUMED BENCHMARK (SEE ORIGINAL PLAN FOR LOCATION).

2. ON-SITE UTILITIES ARE NOT SHOWN ON THIS DRAWING, REFER TO PLAN OF SURVEY BY THE ABOVE SURVEYORS.

FIGURE 2-9
TOPOGRAPHY AND BORING LOCATIONS
CANON INDUSTRIAL PARK PORTION OF THE SITE

Area B has been filled with dredged material from Chartiers Creek. This material ranges in thickness from 1.2 to 6 meters, and is described as gray sandy silt. The dredged material has been deposited in the center of Area B, and forms a flat-topped mound of higher elevation than the surrounding area. On the eastern side of Area B the material was apparently deposited over alluvium. On the western (Ward Street) side, it was deposited over bedrock-derived soil and bedrock. It is difficult to distinguish the bottom limit of the fill from the original materials. On the eastern margins of Area B and Area C, along Chartiers Creek, alluvial materials deposited during flood stages of the creek are exposed on the surface.

Washington County has two primary industries that are based on geological resources: coal mining, and oil and gas development. The most significant source of coal in the Canonsburg area is the Pittsburgh coal seam. The most significant geologic hazard that could affect the Canon Industrial Park is land subsidence in adjacent coal mines. Although the Canon Industrial Park has not been undermined, the site could be affected by subsidence occurring in the vicinity. In mine-subsidence events, there have been instances in which subsidence in one area has resulted in uplift in adjacent areas. Subsidence events normally are accompanied by changes in the ground-water flow regime. Both of these effects could occur on the site as a result of subsidence in adjacent high-risk zones. However, the probability of these effects occurring in the immediate vicinity of the site is highly unlikely.

2.4 PROPOSED REGULATORY REQUIREMENTS

The EPA has a primary responsibility for developing environmental standards for the disposal of wastes. In 1980, the EPA proposed regulations for inactive uranium processing sites under the Uranium Mill Tailings Radiation Control Act of 1978. The regulations are currently being revised, and the proposed standards may be relaxed, possibly by 1983. For the sake of feasibility, however, the proposed remedial action has been designed to satisfy current criteria.

In the UMTRA program, Congress has recognized that uranium mill tailings are hazardous for a long time. They directed the EPA to set reasonable standards for their disposal. The EPA has proposed a requirement specifying 1000 years of protection. This means there must be a reasonable expectation that the disposal standards for radon emission and waste protection will be satisfied for at least 1000 years.

The EPA recognizes that institutional controls such as recordkeeping, maintenance, monitoring, and land-use restrictions are useful for adequate disposal systems and to provide greater protection. However, they do not believe that these methods should be relied on for periods longer than 100 years. Specific methods to implement the 1000-year containment standard will be evaluated on the basis of an analysis of the physical properties of the disposal system, and the potential effect of natural processes on this system. This, of necessity, will be on a case-by-case basis. Models, theories, and expert judgement will be the major tools in determining whether a disposal system will satisfy the standards.

This containment concept will be implemented through radon-emission and water-protection standards. These guidelines are discussed in the subsections that follow.

2.4.1 Radon emission

The EPA-proposed standards limit the disposal site's annual average release of radon gas to the air from dispersed tailings to 2 picocuries per square meter per second, which is about twice the average for normal soils.

2.4.2 Ground-water protection

The performance standard for ground-water protection provides that selected contaminants in disposed tailings piles will not exceed specified levels. The contaminants specified are the same as those in the National Interim Primary Drinking Water Regulations. The only exception is the fluoride limitation. The EPA has omitted fluorides from the proposed standards and added molybdenum and uranium. These standards are outlined in Table 2-3. The EPA chose these levels because they were believed to be adequate to ensure good-quality ground water for direct human consumption and for a wide variety of other purposes. If upstream ground-water levels exceed the specified concentration levels, then no further degradation is allowed. For existing sites, the EPA is proposing that the ground-water protection standards be applied starting 1.0 kilometer from the site.

If the contaminated materials are moved to a new disposal site, the EPA has proposed that the disposal standards for a new site be applied starting 0.1 kilometer from the site. This proposal acknowledges that total and complete containment is not possible, and that there is the potential for limited degradation. This "point-of-application" is an approach the EPA has proposed in the development of its national ground-water strategy. This may be modified when the national ground-water strategy is made final.

Table 2-3. Proposed ground-water protection standards

Contaminant	Level mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Molybdenum	0.05
Nitrogen (in nitrate)	10.0
Selenium	0.01
Silver	0.05
	pCi/l
Combined radium-226 and radium-228	5.0
Gross alpha particle activity (including radium-226, but excluding radon and uranium)	15.0
Uranium	10.0

2.4.3 Surface-water protection

The EPA has not developed a specific surface-water protection standard. The ground-water protection regulations, however, require limited water flow through a pile that would limit any contaminant movement to surface water, as well as to ground water. Therefore, it is expected that radon emissions and ground-water standards will protect surface water. The EPA, however, did propose that surface water not be degraded by tailings after disposal of the piles to ensure protection. This proposal means that after disposal, any contaminant releases from a disposal site should not increase the concentration of any harmful substances in the surface water.

2.4.4 Radium in soil

The EPA-proposed standard for radium-226 in soils to be released for public use is that the average concentration of radium-226 attributable to residual radioactive material from any designated processing site in any 5-centimeter thickness of soils or other materials on open land within 1 foot of the surface, or in any 15-centimeter thickness below 1 foot, shall not exceed 5 picocuries per gram. This level is between three and five times the average radium concentration in normal U.S. soils. The basis for the 5-picocuries-per-gram limit is intended to provide long-term protection and isolation of the radium in a dispersed form.

2.4.5 Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) is responsible for the licensing and regulation of nuclear facilities from the standpoint of public health and safety. The regulation 10 CFR 61 (proposed), gives the NRC the authority to regulate near-surface disposal of low-level radioactive wastes.

This proposed rule specifies licensing procedures, performance objectives, and minimum technical requirements in the areas of site suitability, site design, facility operations, site closure, environmental monitoring, waste classification, waste characteristics, waste labeling, land ownership, and institutional controls for near-surface disposal facilities. The performance objectives in the proposed rule relate to isolation of the low-level radioactive wastes and the stability of the disposal facility after closure. Isolation of the low-level radioactive wastes is defined as the controlled release of radionuclides from the near-surface disposal facility such that the applicable NRC and EPA standards will not be exceeded. The minimum technical requirements are intended to function collectively to help ensure that the performance objectives will be met at any licensable near-surface disposal facility for low-level radioactive wastes. Selected major performance and technical requirements of interest are discussed in the subsections that follow.

2.4.5.1 Performance requirements

Major performance requirements are as follows:

1. Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. In addition, concentrations of radioactive material in ground water must not exceed the maximum contaminant levels established in the National Primary Drinking Water Standards (40 CFR Part 141) at the nearest public drinking water supply (a limit of 10 picocuries per liter above background must be used for uranium and thorium).

2. Design, operation and closure of the land-disposal facility must not result in conditions where any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed, could receive a dose to the whole body in excess of 500 millirems per year.

3. The disposal facility must be designed, used, operated, and closed to achieve long-term stability of the disposed waste and the disposal site, and to eliminate the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

2.4.5.2 Technical requirements

Major technical requirements are as follows:

1. The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland.

2. Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or innundate waste disposal units.

3. The disposal site must provide sufficient depth to the water table so that ground-water intrusion, perennial or otherwise, into the waste will not occur.

4. Any ground-water discharge to the surface within the disposal site must not originate within the hydrogeologic unit used for disposal.

5. Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur.

6. Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur.

7. Covers must be designed to prevent water infiltration, to direct percolating or surface water away from the buried waste, and to resist degradation by surface geologic processes and biotic activity.

8. Surface features must direct surface-water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.

9. The disposal site must be designed to eliminate the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with waste after disposal.

These technical and performance requirements are generic for low-level radioactive waste disposal; there are currently no specific standards for tailings disposal at inactive sites.

The NRC has not issued and does not intend to issue regulations that apply to the cleanup and disposal of residual-radioactive materials at the inactive-uranium-processing sites covered by Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). In conformance with UMTRCA, NRC concurrence in proposed remedial actions and determinations as to the licensability of disposal sites for such materials will be to ensure compliance with the final EPA standards discussed in Section 4.1. On 3 October, 1980, however, the NRC did issue regulations governing the disposal of tailings from active-uranium-milling operations. These regulations (45 FR 65533-65536) are not applicable to UMTRAP remedial actions, but do contain technical criteria, primarily in the form of performance objectives, for the disposal of uranium-mill tailings. Though they will not be applied by the NRC to the inactive sites, the following is a summary of the NRC technical criteria that are most relevant to considerations of remedial-action alternatives for an UMTRCA Title I inactive site.

1. The disposal site should be remote from populated areas.
2. A proliferation of small disposal sites should be avoided.
3. Hydrogeologic and related environmental conditions at a site should favor isolating contaminants from humans and the environment for thousands of years; there should be no need to rely on ongoing, active maintenance to achieve isolation.
4. The prime option for tailings disposal is placement below grade.
5. Methods such as liners or dewatering, should be employed to reduce the seepage of toxic materials into ground waters.
6. Sufficient earth cover, but not less than 3 meters, should be placed over the tailings to reduce the radon-222 exhalation to not more than 2 picocuries per square meter per second above natural background levels.
7. A full self-sustaining vegetative cover or a rock cover should be established on the earth cover to reduce the potential for significant wind and water erosion of the earth cover. A rock cover is mandatory in arid and semi-arid regions where it is unlikely that vegetation will be fully self-sustaining.

2.5 PROBLEM DEFINITION

The existing site conditions at Canonsburg and the regulatory requirements proposed for the safe disposal of wastes from inactive uranium processing sites define a unique set of considerations for onsite disposal.

The radioactive materials on the site are heterogenous and widely distributed. They consist of unprocessed ores, contaminated soils, waste sludges, and building materials. The radioactivity and radionuclide concentrations vary from acceptable limits to thousands of times those limits. Area A contains the largest amount of surface and subsurface contamination, as well as all of the buildings. Area B has the largest amount of existing cover. Area C contains a large amount of buried sludges. The vertical deposition of radioactive materials varies from the surface to 18 feet below the surface.

The average annual rainfall of 37 inches per year requires consideration of infiltration through the waste material into the ground water, surface runoff carrying contaminants from the site during remedial action, and the long-term stability of waste sludges presently buried within the 100-year flood plain of Chartiers Creek.

Samples of the ground water indicate that it also contains radionuclides far in excess of background. The source of this contamination is not known at present, nor is it known whether ground water is flowing off the site.

The presence of abandoned mine shafts in the area may threaten the long-term geological integrity of the site, especially the ground-water flow regime.

With the radon and ground-water standards proposed by EPA, the 1000-year containment standard, and the long-term management objectives of NRC, the determination of in-situ stabilization of the Canonsburg residues must deal with the following issues:

1. Heterogeneity -- Can a differentiation be made between various types and degrees of contamination, and can a spectrum of control strategies be developed to deal with them?
2. Excavation -- Is excavation (either partial or complete) a necessary part of the in-situ stabilization scenario? What is the extent of excavation required? If no excavation is required, can the areas of highest contamination levels be isolated to prevent public-health and environmental problems?
3. Area C materials -- Is it feasible to dispose of Area C materials on the site? How can this be accomplished?
4. Buildings -- What control measures are required to deal with the on-site buildings? If demolition is required, can the demolition rubble be disposed of on the site?
5. Multiple protection goals -- Can the contaminated material be isolated from storm-water infiltration and simultaneously have the radon flux rate from the material controlled to regulatory levels?
6. Ground-water protection -- Can the ground-water flow regime and contaminant-leaching mechanisms be accurately established and control strategies developed to deal with the conditions? If these phenomena cannot be completely determined, can flexible strategies be developed to deal with the spectrum of uncertain conditions?
7. Newly generated wastes -- What management activities will be required for wastes created as a result of remedial-action activities (i.e., waste waters, dust, etc.)?
8. Flooding -- What flood protection measures might be required during and after construction?
9. Expected life -- Can an engineering design be developed for which the reasonably expected life is 1000 years? What historical or experimental basis is there for predicting the 1000-year life?
10. Cost -- Is there a cost-effective approach to in-situ stabilization at the Canonsburg site? Would there be a significant cost savings as a result of in-situ stabilization instead of decontamination and off-site disposal?

There are uncertainties in existing conditions such as the following:

1. Amount of contaminated materials.

2. Characteristics of contaminated materials.

3. Ground-water flow regime and potential for leaching of contaminants.

However, by using reasonable assumptions based on existing data and developing a flexible in-situ stabilization scenario, these uncertainties can be taken into consideration.

This scenario is based on a conceptual approach that is definitive in terms of feasibility and flexible enough to accommodate both the previously described uncertainties and the variations in regulatory requirements. The approach is modular, allowing various parts of the study called "modules" to be added or deleted based on the results of further field study, changes in regulatory posture, or other design requirements.

The essential modules to be considered for in-situ stabilization at Canonsburg include the following:

1. Contaminated-material handling.

2. Encapsulation of contaminated material.

3. Additional site work.

4. Environmental management.

The contaminated-material module is required for assessing amounts and levels of contamination and sources and types of contaminated material. It is especially necessary at Canonsburg because of the heterogeneity of the contamination. This module covers the classification of contaminated material and handling methods in terms of removal, excavation, decontamination, disposal, etc.

The encapsulation-cell module is required for developing handling strategies for the most highly contaminated materials at the site. The source and character of these materials is developed in the contaminated-material module. The encapsulation-cell module addresses the evaluation, selection, and interaction of cover and liner materials and the conditioning and handling of these materials.

The additional-site-work module is required for addressing those parts of the site other than the encapsulation cell. This includes general site preparation such as flood control, dust control, and vehicle and worker decontamination, as well as handling strategies for contaminated materials other than those addressed in the encapsulation-cell module.

The environmental-management module is required for considering the environmental effects of construction activities. This module addresses environmental monitoring during construction and the management of ground water, surface water, and waste water both during and after construction.

3 Contaminated Materials

3.1 INTRODUCTION

Recent surveys characterizing the radioactive-contaminated materials found at the Canonsburg site have shown that the contaminated materials are heterogeneous and randomly distributed and that there are uncertainties regarding the chemical characteristics of the materials.

The existing data on surface and subsurface contamination at the site and knowledge of previous operating procedures indicate a large area of subsurface contamination in the lagoon portion of Area C, and a scattering of "hot spots" (contamination at levels in hundreds to thousands of picocuries per gram of radium-226) in Areas A and B. The hot spots in Area A are relatively close to the surface (0 to 8 feet), but in Area B they are deeper (8 to 14 feet). Figures 3-1 and 3-2 show the gamma dose rate distribution and the areal concentrations of radium-226 found in surface soil samples.

The buildings in Area A have floors of contaminated soils or cracked concrete; these floors release radon gas and particulate daughter products.

Insufficient data exist to properly characterize the contaminated materials in Area C. Conflicting reports have been made concerning the characteristics of these materials, particularly pH and their potential for contaminant leaching.

The uncertain chemical nature of the contaminated materials does not prevent the selection of a feasible in-situ stabilization concept as long as the materials used to construct cap and liner systems are resistant to wide variations in pH.

There are two basic conceptual approaches for in-situ stabilization. The first is to excavate and dispose of all contaminated materials in a specially designed repository. The second involves a judicious selection of some of the contaminated materials for excavation and disposal in this manner. The remainder would be stabilized in place, without excavation.

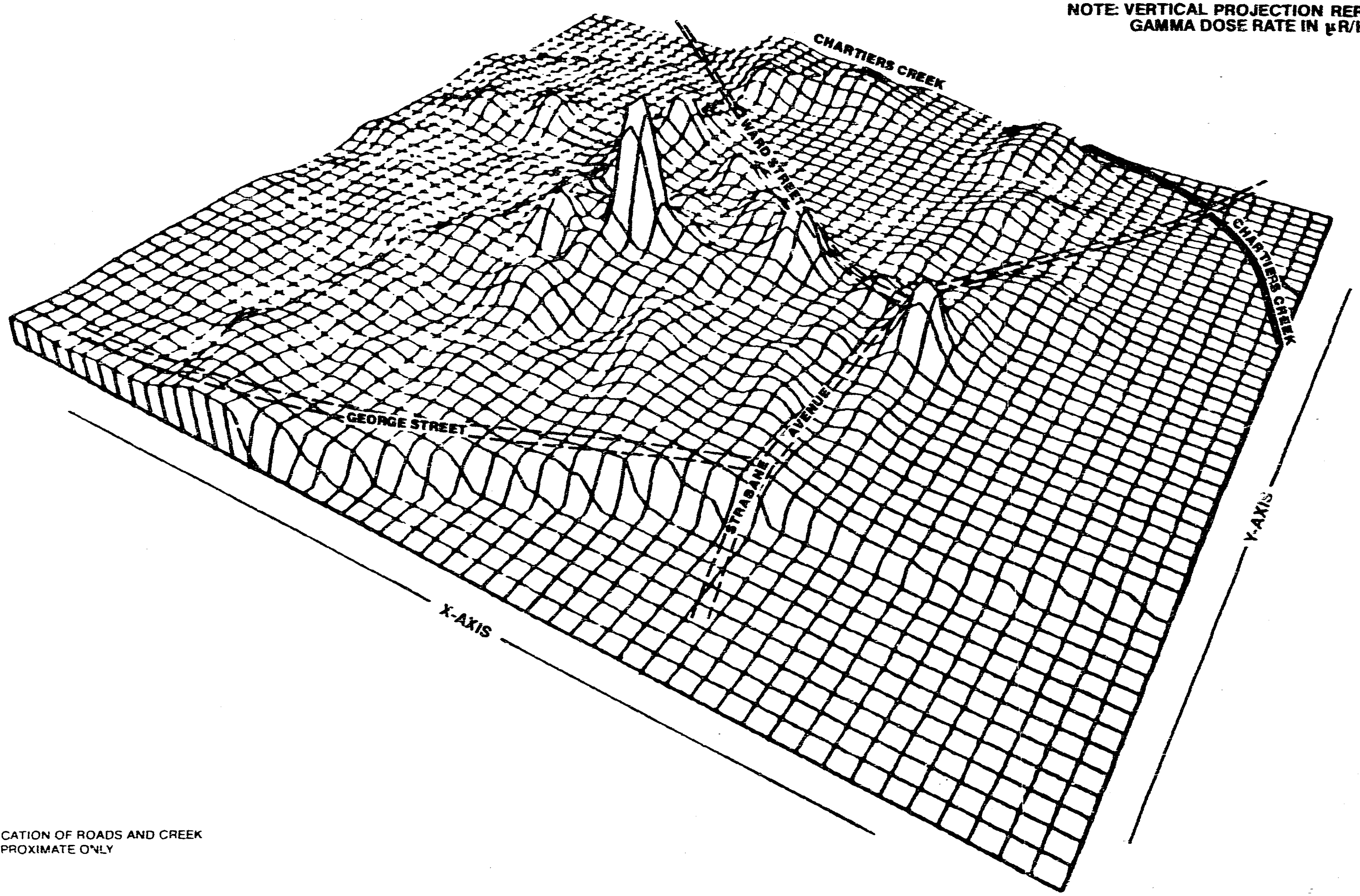
The problems with excavation of the entire site are many:

1. There is a logistics problem of secure handling and storage of large quantities of contaminated materials after they have been excavated.

2. Increased construction costs are involved in large excavations adjacent to Chartiers Creek.

3. Construction-worker exposure is increased.

4. Massive construction efforts will increase the time required for construction which may delay the remedial-action schedule.



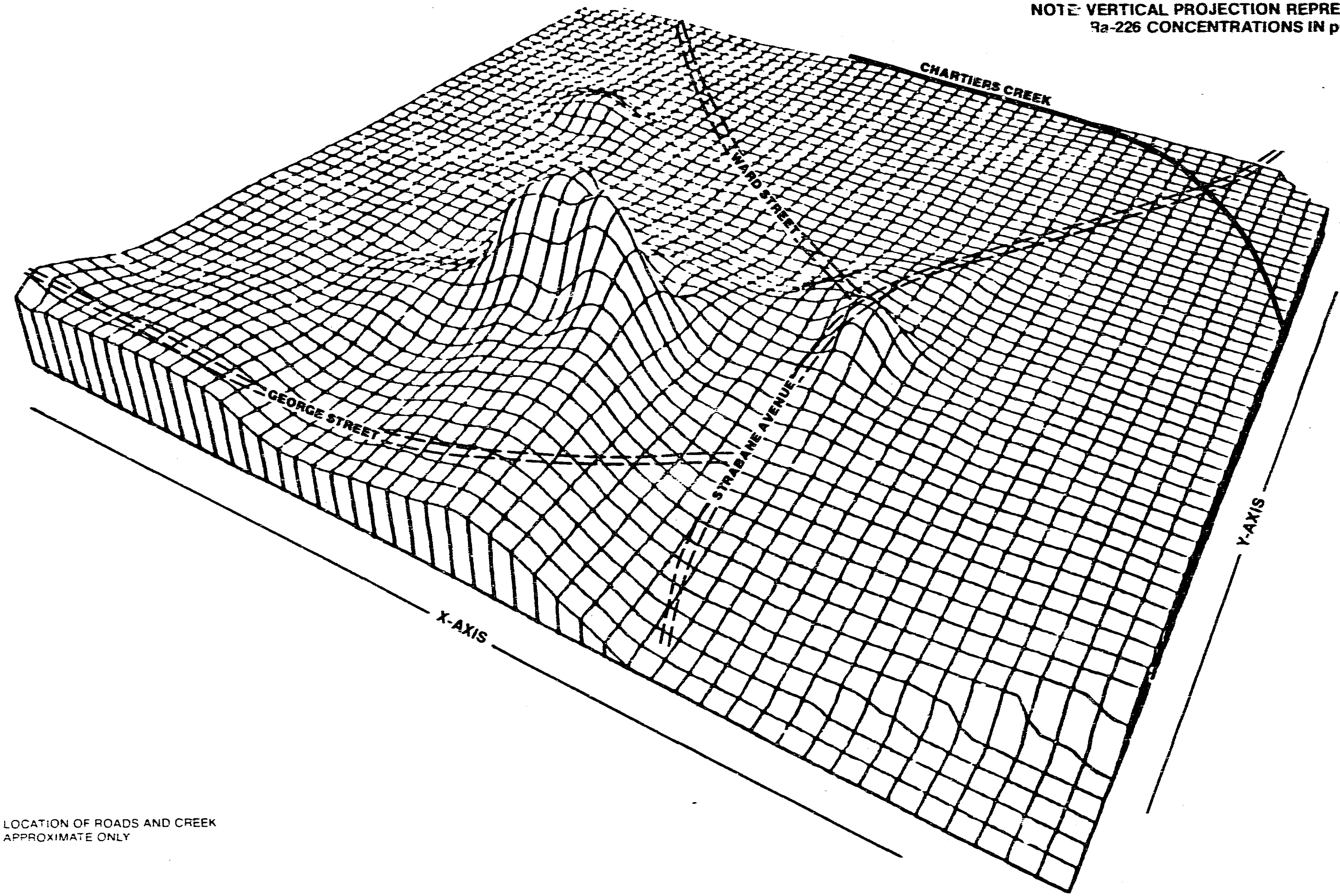
NOTE: VERTICAL PROJECTION REPRESENTS GAMMA DOSE RATE IN µR/Hr

LOCATION OF ROADS AND CREEK APPROXIMATE ONLY

FIGURE 3-1
PRELIMINARY THREE DIMENSIONAL INTERPRETATION
OF GAMMA DOSE RATE, ONE METER ABOVE THE SURFACE
CANON INDUSTRIAL PARK PORTION OF THE SITE

SOURCE QUARTERLY REPORT, ANL, 15 OCTOBER 1981

NOTE: VERTICAL PROJECTION REPRESENTS
Ra-226 CONCENTRATIONS IN pCi/gm



LOCATION OF ROADS AND CREEK
APPROXIMATE ONLY

SOURCE QUARTERLY REPORT ANL 15 OCTOBER 1981

FIGURE 3-2
PRELIMINARY THREE DIMENSIONAL INTERPRETATION
OF RADIUM—226 CONCENTRATIONS IN SURFACE SOIL
CANON INDUSTRIAL PARK PORTION OF THE SITE

After consideration of the distribution of contaminated materials and their varying degrees of contamination and heterogeneity, it appears that the most feasible in-situ stabilization would involve a judicious selection of only some of the materials for excavation and disposal. The remaining materials would be stabilized in place using cover systems. This concept requires that all onsite buildings be decontaminated and demolished and that the highly contaminated soils in Areas A and C be excavated. The building debris would be disposed of in the excavated portion of Area C, as well as other excavations or salvaged, if possible. More highly contaminated soils excavated from Areas A and C would be disposed of by encapsulation. Contaminated soils in Area B, located well below the surface, would receive additional soil cover (cap) over the entire area, as would areas surrounding the encapsulation structure.

The conceptual engineering design of the encapsulation system and an analysis of various soil-cover thickness requirements is given in Section 4.

3.2 EXCAVATION OF AREA A MATERIAL

Figure 3-3 shows the areas of excavation required to remove soils contaminated with radium-226 at concentrations greater than 100 picocuries per gram in Areas A and C. The reasons for selecting a level of 100 picocuries per gram is discussed in Subsection 4.2.3. Little excavation should be needed in Area B since contamination is so deeply buried that the existing overburden, plus an additional soil cover, will be sufficient to control radon and infiltration. Table 3-1 presents a summary of the volumes of excavation, both subsurface and surface, in Areas A and C.

Excavation in Area A should be relatively straightforward. The vertical extent of contamination is minimal and does not reach into the ground water. A backhoe should be sufficient for this work.

Figure 3-3 shows that much of the contaminated material at the Canonsburg site lies within Area C. This material extends deeper (18 feet) than any other pocket of contaminated material on the site. It is estimated that the total amount of material to be removed from the area is 12,500 cubic yards.

The physical and chemical properties of the Area C material have not been accurately quantified as yet. It has been described as "soup" or "yogurt" with pH values of either 2 or 13. In consideration of these uncertainties, it was decided to assume a worst-case condition of excavation by dragline to demonstrate the feasibility of the project concept. A sampling and analysis program to more fully characterize the Area C material is recommended before any excavation activity.

Figure 2-6 illustrates ground-water contours on 11 October 1979, a period of high ground-water elevation in the Canonsburg area. In some sections of Area C ground water is only 4 feet below the surface (wells 19 and 22). Even during dry weather periods, the ground water can be as high as 8 feet below the surface in Area C. Therefore, it may be necessary to dewater the area to facilitate the excavation of contaminated material. Dewatering would simplify handling of the material after excavation as well.

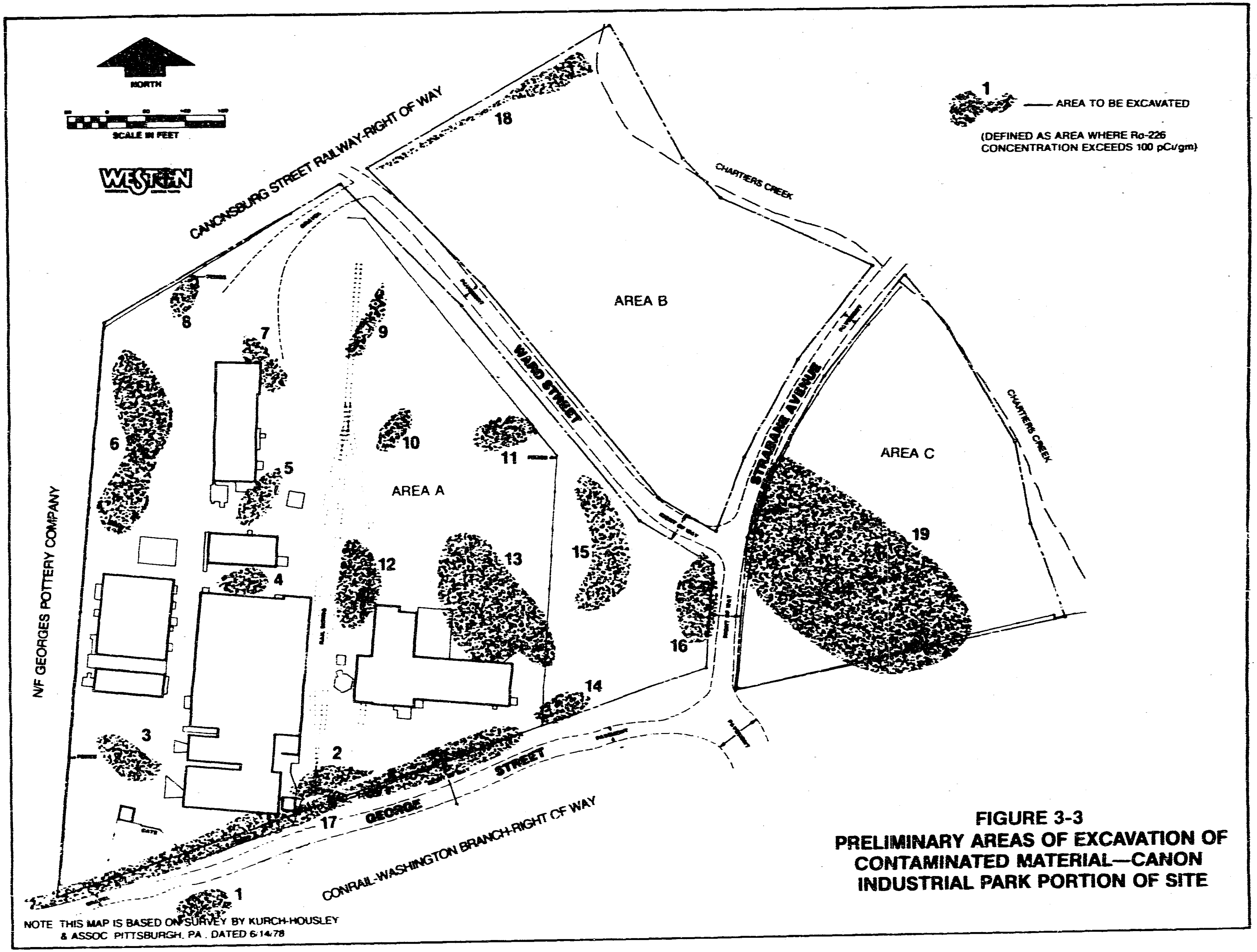


FIGURE 3-3
PRELIMINARY AREAS OF EXCAVATION OF CONTAMINATED MATERIAL—CANON INDUSTRIAL PARK PORTION OF SITE

Table 3-1. Volume estimate of contaminated soil to be excavated[a]

Area designation	Depth range (feet)	Volume (cubic yards)
A-1	2	145
2	2-4	510
3	2-8	635
4	3.5	200
5	2.5-3	350
6	1-4	1,395
7	3-3.5	450
8	2.5	180
9	2-3	380
10	2	230
11	3.5	555
12	5-7	1,600
13	3-4	2,880
14	3-6	460
15	0.5-5	850
16	0.5	75
17	0.5	340
18	0.5	250
19	0.5-18	12,500
	Total	23,985

[a] Concentration of radium-226 greater than or equal to 100 pCi/g.

It has been calculated that 288,000 gallons of ground water must be pumped to initially dewater the area to the degree required to allow excavation. This can be accomplished with 20 well points, each with a pumping capacity of 5 gallons per minute. To maintain the water table at the depressed level, 20,000 gallons must be removed each day. Pumped ground water may be contaminated with the radionuclides present in the soil; therefore, this water may have to be treated. The treatment process is described in Section 6 of this report. After the excavation in Area C is complete and the pit is backfilled with demolition debris, the well points should be removed or filled so they do not provide a pathway for any remaining low-level contamination to leave the site.

3.3 BUILDING DECONTAMINATION AND DEMOLITION

The building-demolition process will generate dust that may be contaminated and carried off the site by wind or other natural forces. Decontamination before demolition would minimize the amount of contaminated dust generated and yield a clean rubble which need not be placed in the encapsulation area for containment. Rubble should be back-filled into the holes created by contaminated soil excavation and supplemented with purchased clean fill as necessary. Placement of large chunks of building rubble, such as large steel beams, in the encapsulation area would endanger the area's stability (due to the potential for large differential settlement) in the long term (1000 years) and could damage the liner as well.

There are many considerations that must be examined before a specific decontamination method is chosen. These include cost-effectiveness, waste generation, ease of operation, and worker exposure. Other variables to be examined include the type of building material to be cleared, surface status (painted), level of contamination, and type of contamination.

There are a variety of surface-decontamination methods available, but for the purpose of this feasibility study, steam cleaning was the method considered most reasonable. The reasons for this choice include the following:

1. Ease of operation.
2. Speed of operation.
3. Low capital cost.
4. Compact, portable units available
5. Flexibility of units (can be used for wet sandblasting).
6. Availability of water supply and waste-water treatment.

The steam-cleaning operations can be carried out on one building at a time with two or three teams working at the same time, depending on the building size. All exposed surfaces should be cleaned with ceilings and walls done first. Scaffolding should be provided so that the nozzle would be no farther than one foot from the surface being cleaned. Motorized scaffolding could be used with hand hoses extending from the steam cleaners on the floor. The workers would need waterproof suits and boots and masks. The work can proceed in an orderly fashion, moving quickly through the building. The building should be sealed before cleaning begins to contain all spray. The doors and passageways can be blocked with sandbags in order to direct all the water to a sump area. All floor drains should also be sealed before steam cleaning by filling them with gravel to within 6 inches of the floor level, and then applying concrete to make them level with the surrounding concrete floor. The wet vacuums should be able to handle the flow from all operating steam cleaners, along with all sand and grit that would be generated. The water from the vacuum and sump can be pumped to the onsite sedimentation basin for storage and subsequent treatment. The roof and outside walls may have to be analyzed to see if they require decontamination. Where required, the decontamination process would be similar to the inside operation except for water collection. A trench could be dug around the building to contain all the cleaning runoff. From there it would be pumped to the sedimentation basin.

The calculated water usage is displayed in Table 3-2. This amount can easily be handled by the waste-water treatment plant. Sources of clean water are the Canonsburg public water supply or Chartiers Creek. Collection will be accomplished with one or more wet vacuums.

All the salvageable steel should be removed to a staging area, possibly the sealed and covered foundation of one of the buildings that has already been demolished. If further decontamination is needed, the steel would be steam cleaned a second time, followed by wet sandblasting, if necessary. Runoff would be contained and pumped to the sedimentation basin. When the steel is totally decontaminated it can be moved to a clean area, such as the Georges Pottery site, for transfer from the site.

After the buildings are decontaminated, as specified in the previous subsection, they will be demolished as soon as possible in order to prevent recontamination. Demolition should not be attempted unless weather conditions are favorable, i.e., a clear, dry day with little or no wind. A rainy day would not be acceptable because large amounts of water could cause runoff control problems. Any airborne contamination that is generated during the demolition should be controlled by the use of a water-mist system applied by a series of fire hoses. All runoff should be collected and pumped to the sedimentation basin for treatment.

Table 3-3 contains a list of possible demolition methods. Two relatively fast methods, controlled blasting and wrecking ball, were considered. Controlled blasting is recognized as the most reliable and fastest technique for demolition of massive, heavily-reinforced concrete structures. However, it is expensive and most of the buildings at the Canonsburg site have only thin concrete block walls. Thus, it was determined that the conventional wrecking ball and front-end loader method would be more appropriate because it is relatively fast and is less expensive. Demolition by wrecking ball is a more controlled process because there is a minimum of energy expended. If it is determined that an excessive amount of contamination is becoming airborne during demolition, a containment structure may have to be used. A large air-supported building is a possible solution; however, it is highly unlikely that this will be required, and it has not been included in the cost estimate. Demolition could continue inside an air-supported structure with any contamination filtered through exhaust fans.

Table 3-2. Steam-cleaning information[a]

Building	Total area cleaned (square feet)	Time to clean[b] (hours)	Water used (gallons)
1	19,833	99	23,760
2	11,074	55	13,200
2A	7,980	40	9,000
7	18,342	92	22,080
9A	5,768	30	7,200
9B	6,915	35	8,400
10	112,714	564	135,360
11	12,998	65	15,600
15	6,748	34	8,160
16	24,774	124	29,760
18 south	14,135	71	17,040
18 central	10,678	53	12,700
18 north	8,112	41	9,840
19	24,974	125	30,000
Total	295,027	1,478	354,730

[a] Cleaning rate is 200 square feet per hour at 4 gallons per minute.

[b] This time is calculated for one steam cleaner operating.

Table 3-3. Concrete removal methods -- summary of applications

Process	Application	Feasibility	Relative equipment cost
Controlled blasting	All concrete ≥2 ft	Excellent	High
Wrecking ball	All concrete ≤3 ft	Excellent	Low
Ram hoe (hydraulic ram)	Concrete ≤2 ft	Good	Low
Hobgobbler (air ram)	Concrete ≤2 ft	Good	Low
Flame cutting	Concrete ≤5 ft	Fair	Low
Thermic lance	Concrete ≤3 ft	Poor	Low
Rock splitter bristar	Concrete ≤12 ft	Good	Low
Demo compound	All concrete ≥1 ft	Fair	Low
Wall and floor sawing	All concrete ≤3 ft	Good	Low
Core stitch drilling	Concrete ≥2 ft	Poor	High
Paving breaker (pneumatic)	Concrete ≤1 ft	Poor	Low
Air hammer and chisel	Concrete ≤3 in	Poor	Low
Drill and spall	Concrete surface ≤2 in.	Excellent	Low
Scarifier	Concrete surface ≤1 in.	Excellent	Low
Water cannon	Concrete surface ≤2 in.	Fair	High
Needle scalers	Concrete surface ≤1/2 in.	Poor	Low
Grinding and sanding	Concrete surface ≤1/4 in.	Poor	Low

While most of the residential properties on the 30-acre site area have been designated as eligible for remedial action, there may be some structures on the Georges Pottery property and onsite streets that are not contaminated. These buildings would not require decontamination in any form, but the part of the Georges Pottery property that may be used to house the waste-water treatment equipment would need to undergo decontamination. The Georges Pottery buildings could be demolished in the same manner as the decontaminated buildings of the Canon Industrial Park. Less attention to dust and other contamination controls would be necessary if the buildings were uncontaminated. Salvageable steel could be immediately moved to the clean area. Rubble could be placed in Area C with the decontaminated rubble and covered with clean soil. The foundations would not be moved, but would be covered with clean soil. The residential buildings would simply be dropped into basements by the wrecking ball and then covered with clean soil.

Table 3-4 shows the volumes of material to be moved at the site.

Table 3-4. Material to be moved

To be excavated --	
Area A	11,235 cu yd
Area C	12,500 cu yd
	23,735 cu yd
To be filled --	
Building debris (including vicinity properties)	18,035 cu yd
Additional backfill	5,700 cu yd
	23,735 cu yd

4 Contaminated Material Encapsulation

4.1 INTRODUCTION

In order to securely contain the more contaminated soils, it is proposed that they be excavated and placed in an encapsulation cell. This cell would consist of an interconnected cover and liner which will totally encapsulate the waste. The encapsulation and containment design were formulated to meet the EPA criteria for remedial action at inactive uranium-mill-tailings sites. Criteria of primary importance in the design of the cell include those regulating radon gas emission and ground-water contamination. The proposed location of the encapsulation cell is shown on Figure 4-1. The cover and liner configuration recommended for use is shown on Figure 4-2.

4.2 COVER

4.2.1 Background

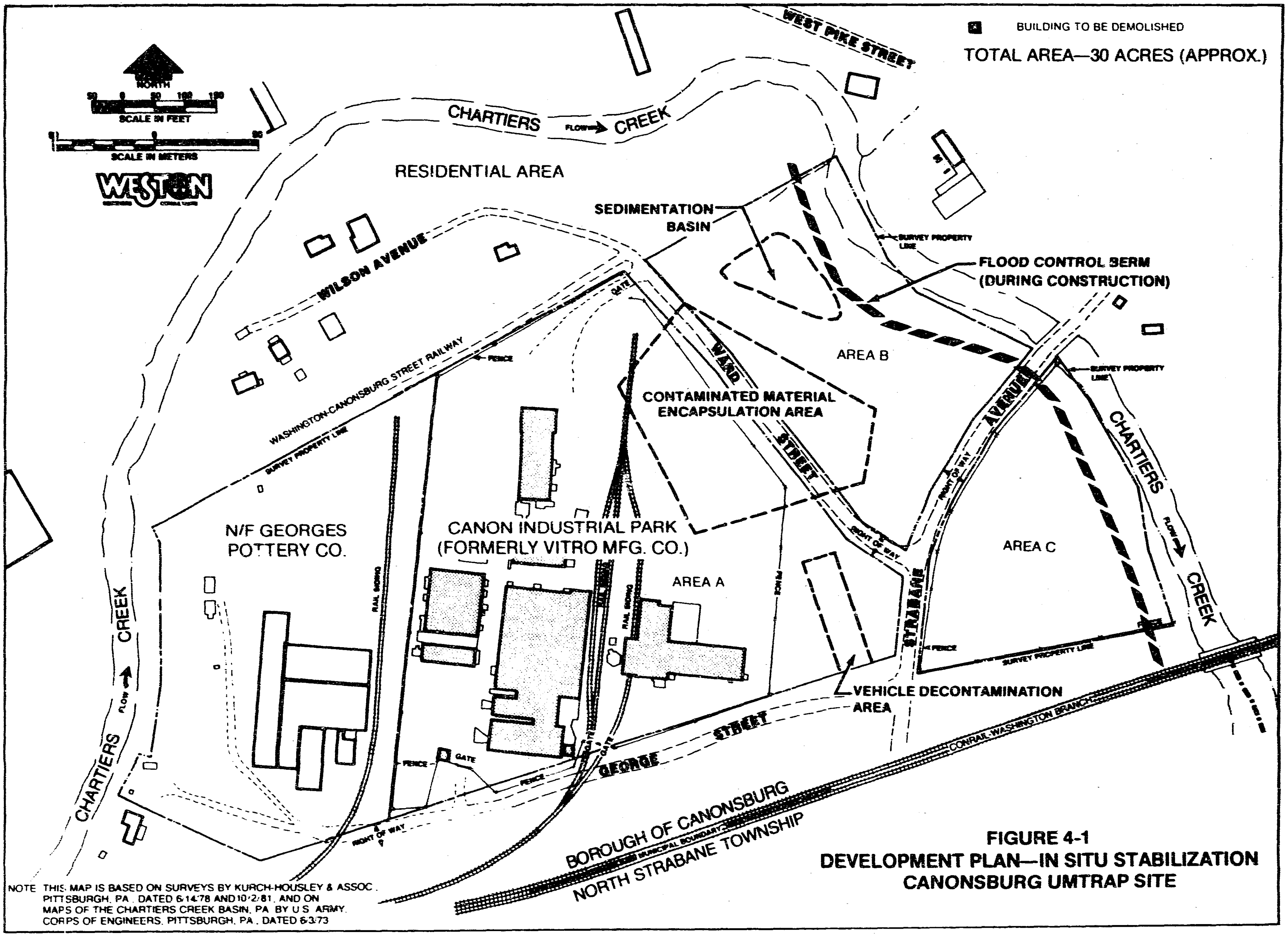
The cover, as an element of the encapsulation cell, plays a very important role in protecting the environment and public health. A properly selected, designed, and constructed cover system will control potential releases of radioactivity through air diffusion, surface and subsurface migration, and other physical transport pathways.

The evaluation and selection of cover systems for low-level radioactive waste is a function of various performance criteria and cover materials. A successful cover system will provide effective control of surface-water infiltration and radon gas emission, and will remain effective with minimum maintenance for 1000 years. The control of surface-water infiltration will minimize radionuclide leaching and subsequent transport.

4.2.2 Cover material evaluation

Eighteen cover types have been systematically evaluated based on 20 performance criteria. The covers were then ranked based on these criteria, and the best performer was identified. Six major classes of covers were evaluated, and are as follows:

1. Multilayer.
2. Asphalts.
3. Concrete.
4. Synthetics.
5. Natural soils.



NOTE THIS MAP IS BASED ON SURVEYS BY KURCH-HOUSLEY & ASSOC., PITTSBURGH, PA. DATED 6/14/78 AND 10/2/81. AND ON MAPS OF THE CHARTIERS CREEK BASIN, PA BY U.S. ARMY CORPS OF ENGINEERS, PITTSBURGH, PA., DATED 6/3/73

FIGURE 4-1
DEVELOPMENT PLAN—IN SITU STABILIZATION
CANONSBURG UMTRAP SITE

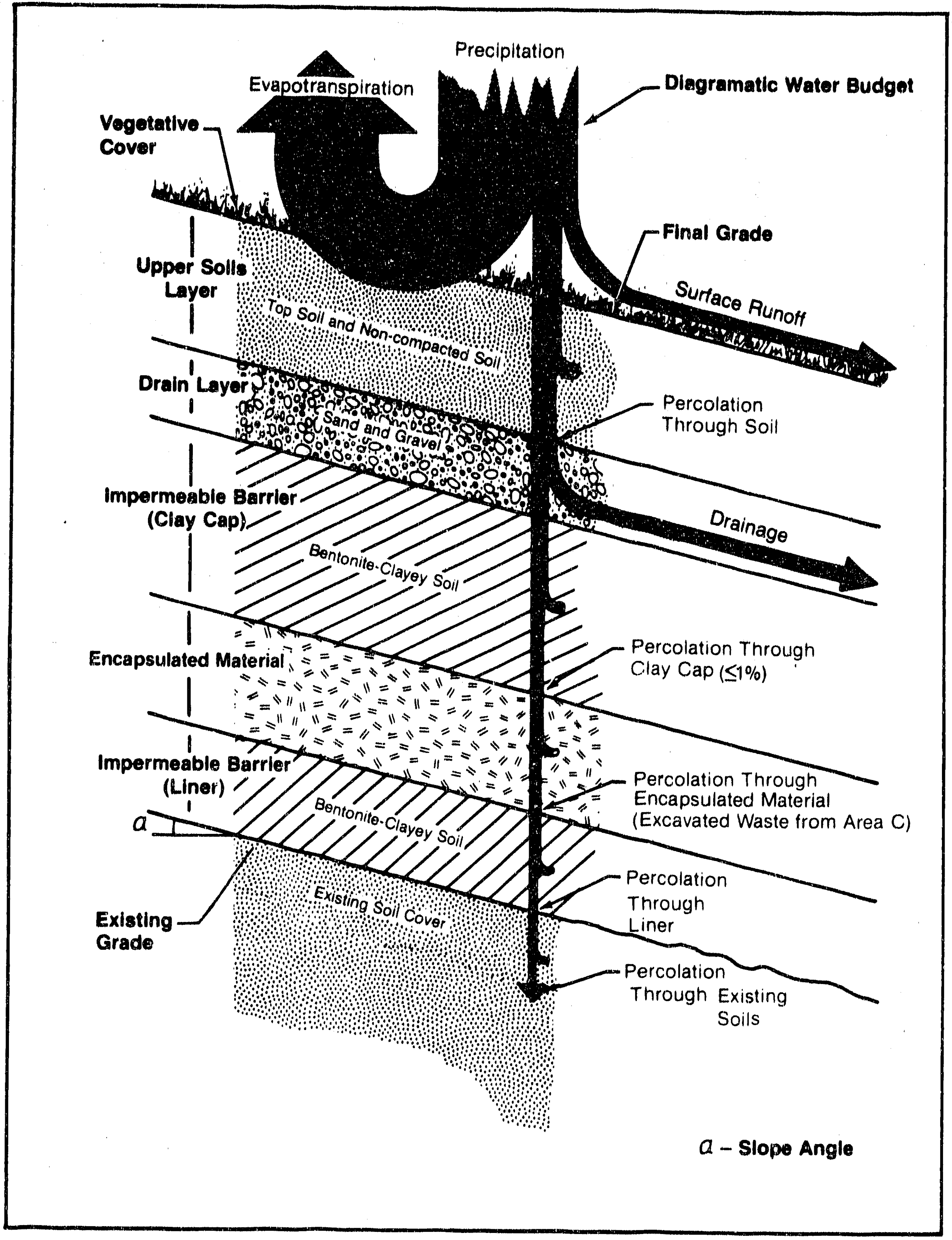


FIGURE 4-2 PROFILE OF RECOMMENDED ENCAPSULATION AND COVER CONFIGURATION—CANONSBURG UMTRAP SITE

6. Soil admixtures.

Table 4-1 illustrates the evaluation process for the various cover materials.

If a cover material was given a positive performance rating, a plus sign appears in that criteria column. If a negative performance rating was given, a minus sign appears in the criteria column. It is clearly seen that the multilayered cover system shows the best performance. No single cover material meets all of the required performance criteria. In addition to the limitations inherent in the cover materials themselves, which are different for different materials, all mono-layer covers have common disadvantages, as follows:

1. Limited protection from wind and water erosion.

2. Susceptibility to surficial cracking during periods of drought.

3. Lack of any backup protection against sudden failure which might result in a total loss of integrity.

The recommended multilayer cover system for the low-level radioactive residues is shown on Figure 4-3; an optional system is shown on Figure 4-4. The system consists of the following:

1. Top layer of noncompacted soil which will support vegetation.

2. A middle layer of coarse gravel or crushed rock.

3. A bottom layer of clay.

4.2.3 Cover specifications for radon control

A primary purpose of the cover system described in this subsection is to reduce radon fluxes at the surface of the covered Canonsburg disposal site to 2 picocuries per square meter per second or less. It is necessary to design the cover to accommodate the highest radon flux anticipated from the encapsulation area. The site characterization indicates that the highest radon flux would be 1000 to 1500 picocuries per square meter per second from the encapsulation area and up to several hundred picocuries per square meter per second from the remainder of the site.

Table 4-1. Cover material general performance criteria evaluation

Cover material	Historical applications as a cover material	Trafficability	Impede water percolation	Radon gas control	Erosion control	Aid surface runoff	Desiccation	Freeze/thaw stability	Seismic stability	Crack resistance	Side-slope stability	Potential for side-slope seepage	Discourages rodent burrowing	Supports vegetation	Ease of construction	Probable 1000-year life	Cost of placement	Biological deterioration	Root penetration	Wave radiation gamma penetration
Spray asphalt emulsion	–	–	+	+	+	+	+	+	–	–	–	+	–	–	–	–	+	–	–	–
Hydraulic asphalt	–	+	+	+	+	+	+	+	–	+	+	+	+	–	–	–	–	–	–	+
Synthetic -- CSPE	–	–	+	–	+	+	+	+	–	–	–	+	–	–	–	–	–	–	–	–
Synthetic -- PVC	–	–	+	–	+	+	+	+	–	–	–	+	–	–	–	–	–	–	–	–
Synthetic -- neoprene	–	–	+	–	+	+	+	+	–	–	–	+	–	–	–	–	–	–	–	–
Synthetic -- CPE	–	–	+	–	+	+	+	+	–	–	–	+	–	–	–	–	–	–	–	–
Concrete	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–	–	–	–	+	+
Low permeability native soils	+	–	+	+	–	+	–	–	–	–	+	+	–	+	+	+	+	+	–	+
Onsite soils	+	+	–	+	–	–	–	–	–	–	+	+	–	+	+	+	+	+	–	+
Soil admixtures (bentonite)	+	–	+	+	–	+	–	–	–	–	+	+	–	+	+	+	+	+	–	+
Bentonite	+	–	+	+	–	+	–	+	–	–	+	+	–	–	+	+	–	+	–	+
Well-graded gravel	+	+	–	–	+	–	+	+	+	+	+	–	+	–	+	+	+	+	–	+
Riprap	+	+	–	–	+	–	+	+	+	+	+	–	+	–	+	+	+	+	–	+
Silty-sand (soil)	+	+	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	–	+
Clayey-sand (soil)	+	–	+	+	–	+	–	+	–	–	+	+	–	+	+	+	+	+	–	+
Soil cement	–	–	+	+	+	+	+	+	–	+	+	+	+	–	–	–	–	+	–	+
Soil asphalt	–	–	+	+	+	+	+	+	–	+	+	+	+	–	–	–	–	–	–	+
Multilayered -- grass/ topsoil/gravel/clay/soil	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	+	–	+

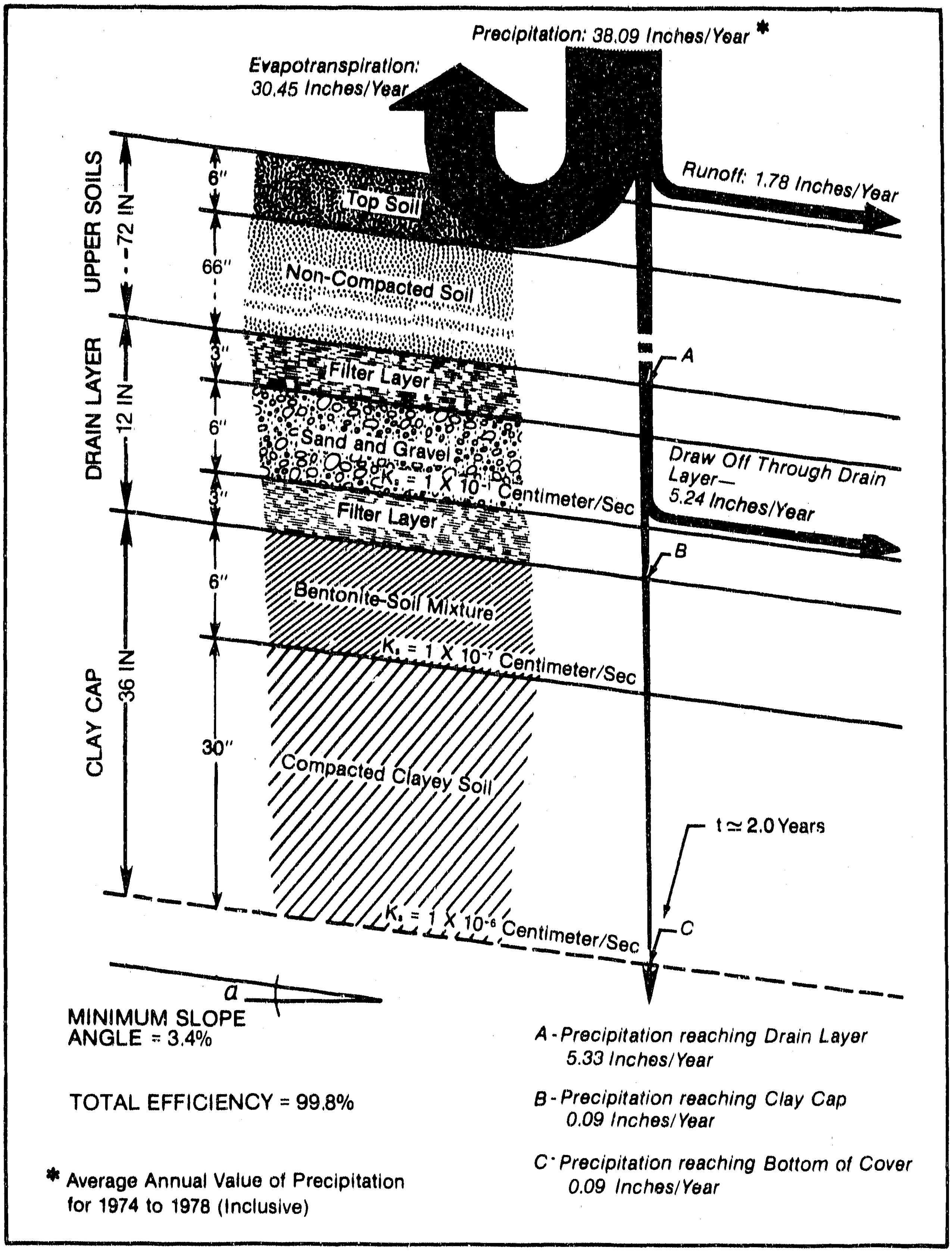
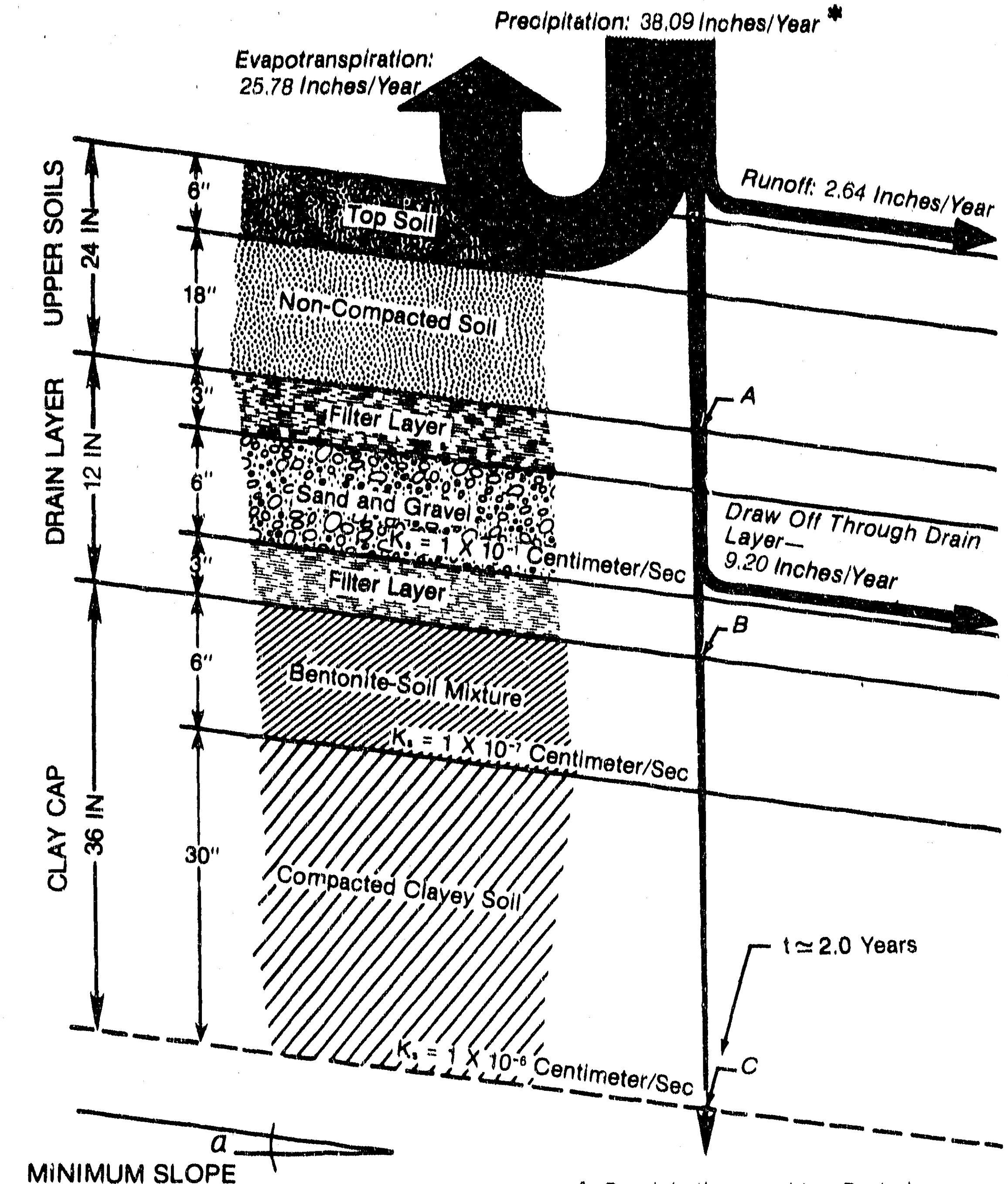


FIGURE 4-3 WATER BUDGET RESULTS FOR RECOMMENDED COVER SYSTEM—CANONSBURG UMTRAP SITE



MINIMUM SLOPE
ANGLE = 3.4%

TOTAL EFFICIENCY = 99.7%

A - Precipitation reaching Drain Layer
9.33 Inches/Year

B - Precipitation reaching Clay Cap
0.13 Inches/Year

C - Precipitation reaching Bottom of Cover
0.13 Inches/Year

* Average Annual Value of Precipitation for 1974 to 1978 (Inclusive)

FIGURE 4-4 WATER BUDGET RESULTS FOR OPTIONAL COVER SYSTEM—CANONSBURG UMTRAP SITE

The design cover thickness to reduce the design base flux to the 2 picocuries per square meter per second specification can be computed using equation (4-1) (RAECO, March 1981):

$$x_1 = -\ln\left(\frac{J_1}{J_o}\right)\frac{1}{\sqrt{\frac{\lambda \times p}{Dh}}} \qquad (4\text{-}1)$$

Where: x_1 = Required cover thickness.
J_1 = Radon flux rate from covered materials.
J_o = Radon flux rate from uncovered materials.
λ = Radon decay constant ($2.1 \times 10^{-6} sec^{-1}$).
p = Porosity of the cover material.
D = Effective radon diffusion coefficient for the cover material.
h = Dimensionless coefficient (~ 1 when $J_1 \ll J_o$)

Analyses of the effects of various cover configurations on radon flux rates were conducted using a computer model developed by Rogers Associates Engineering Corporation (RAECO, March 1981). Pertinent results are displayed in Table 4-2. From this table it can be seen that the 1000 to 1500 picocuries per square meter per second flux rate from the encapsulation area can be controlled to the specified regulatory level of 2 picocuries per square meter per second with the use of a 10-foot multilayer cover system as shown on Figure 4-3 (3 feet of clay, 1 foot of gravel, 6 feet of soil), and that the several hundred picocuries per square meter per second flux from the remaining soils can be controlled to the specified-level with the use of a 6-foot soil cover. Since the contamination (several hundred picocuries per square meter per second and less) could be adequately controlled by the 6-foot soil cover, it was determined that excavation of soils contaminated with radium-226 at these lower concentrations would not be necessary.

The 6-foot multilayered cover system as shown on Figure 4-4 (3 feet of clay, 1 foot of gravel, 2 feet of soil) was considered an optional design for the encapsulation area due to the uncertain status of the EPA criteria. If the radon flux criteria were increased to 50 picocuries per square meter per second, this cover system would provide adequate radon control at a lower cost than the 10-foot thick design. Similarly, the use of several thicknesses of soil was considered for cover for the remainder of the site in the event that the radon flux criteria become less stringent.

4.2.4 Functional components of the cover system

4.2.4.1 Vegetation and upper soils

Vegetation controls erosion and encourages soil water loss by evapotranspiration. Otherwise, erosion will ultimately degrade the cover and seriously reduce its effectiveness. A "fair" vegetation rating is used in the concept

Table 4-2. Radon attenuation by various covers

Cover	Base radon flux (pCi/m^2/s) 100	500	1000	1500
	Radon emanation through cover system (pCi/m^2/s)			
3 ft soil	14.25	70.55	140.9	211.3
6 ft soil	1.173	5.175	10.18	15.18
3 ft clay/1 ft gravel/2 ft soil	2.354	11.10	22.22	33.25
3 ft clay/1 ft gravel/6 ft soil	0.2363	0.4940	0.8162	1.138

design as opposed to "good" or "excellent" ratings. The "fair" rating is considered representative of the as-built system.

The effect of vegetation quality on resultant percolation through the topsoil and underlying noncompacted soil was examined. The results for good grasses as opposed to poor grasses are shown on Figure 4-5. They were computed using the Hydrologic Simulation and Solid Waste Disposal Sites (HSSWDS) model developed by the EPA with the U.S. Army Corps of Engineers (Perrier and Gibson, 1980). This one-dimensional (vertical) model is presently in draft form. It represents a state-of-the-art methodology for performing water budget analyses on complex cover systems. Since it is a one-dimensional simulation, the results are insensitive to surface slope and area. For the Canonsburg site, however, the cover is modest in size (3 acres) and surface slope (5 percent or less). Therefore, water budget results are considered the best engineering estimates. A two-dimensional model has been developed as Version II of HSSWDS. The EPA expects to release Version II in spring of 1982.

In Figure 4-5, the dynamic interaction between surface runoff, evapotranspiration and percolation is evident. Note that for good grass with a 66-inch noncompacted soil layer, evapotranspiration is greater, runoff is less, and the resultant percolation is less than that for poor grass. Therefore, the net soil water change for good grass is less than that for poor grass. Also, because of its adverse water erosion effects, poor grass is unacceptable.

Topsoil thickness will be limited to 6 inches because of its relatively high cost. If adequate quality topsoil is not available, it may be necessary to supplement existing soil with fertilizers, conditioners, etc. Vegetation characteristics which almost universally should be given precedence are the following:

1. Low-growing and limited penetration of plant roots.

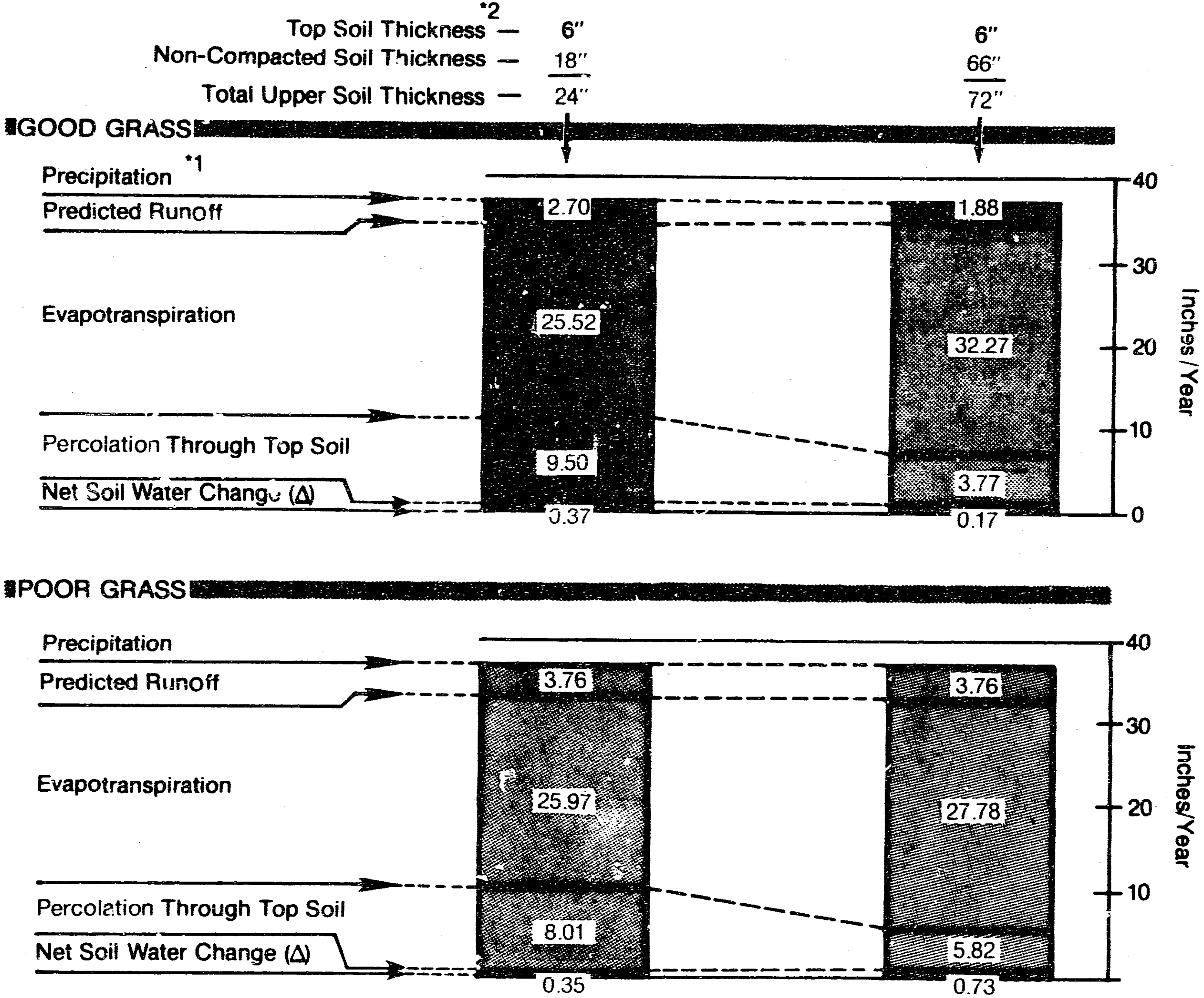
2. Rapid germination and development.

3. Resistance to fire, insects, and disease.

Rapid establishment and maintenance of vegetation can be accomplished by carefully addressing soil type, nutrient and pH levels, climate, species selection, mulching, and seeding time. Local agronomists or county agricultural agents could provide guidance with respect to specific requirements.

Beneath the topsoil, a noncompacted soil native to the area will be used. The noncompacted soil layer supports vegetation primarily through its increased water-holding capacity. This soil layer typically lacks the general composition and macronutrients needed to adequately support vegetation.

Slope stability will be maintained by limiting slopes to a ratio of 1 vertical to 4 horizontal (1V on 4H). This is the maximum slope on which vegetation can be established and maintained, assuming an ideal soil with low erodibility and adequate moisture-holding capacity. Optimum vegetative stability generally requires slopes of 1 vertical on 4 horizontal or flatter. Wind erosion is insignificant for slopes less than 1 percent, however, it is significant for slopes greater than 10 percent. This can be minimized by adequate vegetation cover.



*1. Average Annual Value Precipitation for 1974 to 1978 (Inclusive) — 38.09 Inches /Year

*2. Top Soil—Silt Loam, Non-Compacted Soil—Clay as per USDA Soils Textural Classification

FIGURE 4-5 COMPARATIVE WATER BUDGET RESULTS FOR VEGETATIVE COVERING USING 'GOOD' GRASS AND 'POOR' GRASS

Annual percolation through the upper soils from 1974 through 1978, inclusive, are given in Tables 4-3 and 4-4. Water budget results were computed by HSSWDS (Perrier and Gibson, 1980).

A "default" climatological data input option in HSSWDS was used for the analysis. This option permits the use of climatological data for approximately 90 cities across the country. The program used has a second option of manually loading climatological data that may be more specific to a study area. The climatological input includes parameters such as precipitation, solar radiation, and leaf area index (LAI) for the city requested. Climatological data for Pittsburgh, Pennsylvania were felt to be representative of Canonsburg.

Greater attenuation of percolation through the upper soil layers is achieved with greater total thickness as shown on Figure 4-6. Note that there is a significant reduction in percolation as a function of increased total thickness. Water budget results for the drain and clay layers follow.

4.2.4.2 Drain layer

The drain layer will consist of crushed rock or coarse gravel having a relatively large permeability, K_s, of 1×10^{-1} cubic meter per second. A drain layer thickness of 1 foot will be used. The thickness requirement is a function of the following:

1. Annual percolation rate.
2. Drain length.
3. Permeability.
4. Drain slope.

The assumed conditions for calculating flow through the drain layer are given on Figure 4-7 (Moore, 1980). This figure shows a drain layer of thickness d(cm) overlying a low permeability material. The drain layer extends over distance, L. The saturated permeability of the drain layer is given by K_s. The annual percolation rate, e, is the amount of water, annually, that impinges on the drain layer. It is assumed that the percolation rate is constant with time. This is a valid assumption since seepage fluxes do not change rapidly with respect to time.

The height of the saturated water surface for the limiting case when $\alpha = 0$ is given by (Moore, 1980), as follows:

$$h = \left(\frac{e}{K_s} \quad (L-x) \enspace x\right)^{1/2} \tag{4-2}$$

The maximum height of water in the drain layer, h_{max}, is given as:

$$h_{max} = \left(\frac{eL^2}{4K_s}\right)^{1/2} \tag{4-3}$$

Table 4-3. Results of water budget computed using HSSWDS for the recommended cover system

Vegetation classification: "Fair" grass

Topsoil: Silt loam[a]

Noncompacted soil: Clay[a]

Year	Rain (in.)	Runoff (in.)	Evapotranspiration (in.)	Percolation (in.)	Soil water (in.)	
					Initial	Final
1974	41.83	1.36	32.41	5.27	5.37	8.16
1975	46.42	4.06	32.09	9.47	8.16	8.96
1976	31.78	0.52	28.26	6.69	8.96	5.27
1977	33.20	0.96	28.92	2.24	5.27	6.36
1978	37.24	2.00	30.55	2.99	6.36	8.05
Average	38.09	1.78	30.45	5.33		

Note:		
	Topsoil layer thickness:	6 inches
	Noncompacted soil layer thickness:	66 inches
	Total upper soil thickness:	72 inches

---

[a] U.S. Department of Agriculture textural classification.

Table 4-4. Results of water budget computed using HSSWDS for the optional cover system

Vegetation classification: "Fair" grass

Topsoil: Silt loam[a]

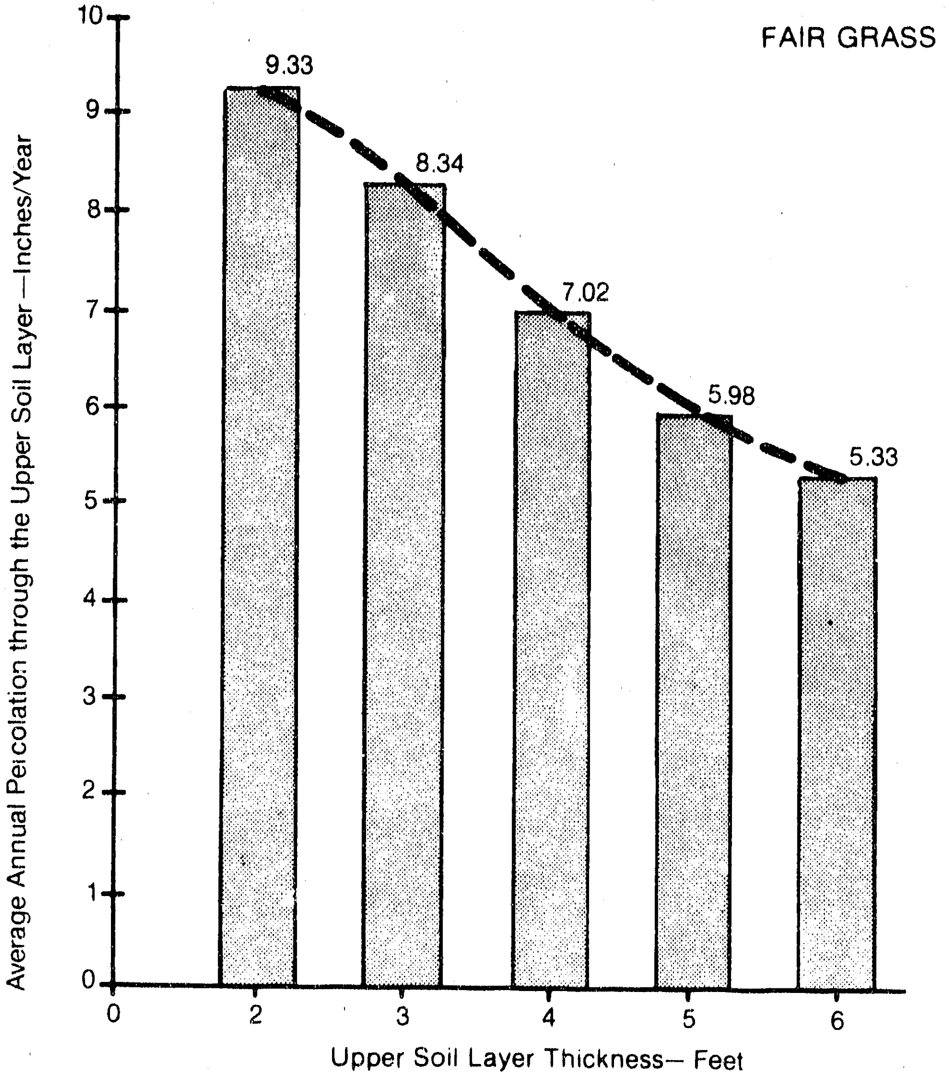
Noncompacted soil: Clay[a]

Year	Rain (in.)	Runoff (in.)	Evapotranspiration (in.)	Percolation (in.)	Soil water Initial (in.)	Soil water Final (in.)
1974	41.83	1.81	28.22	10.52	1.45	2.73
1975	46.42	6.00	28.61	11.64	2.73	2.90
1976	31.78	0.77	22.75	8.51	2.90	2.65
1977	33.20	1.14	23.37	8.51	2.65	2.83
1978	37.24	3.73	25.96	7.48	2.83	2.90
Average	38.09	2.64	25.78	9.33		

Note:		
	Topsoil layer thickness:	6 inches
	Noncompacted soil layer thickness:	18 inches
	Total upper soil thickness:	24 inches

---

[a] U.S. Department of Agriculture textural classification.

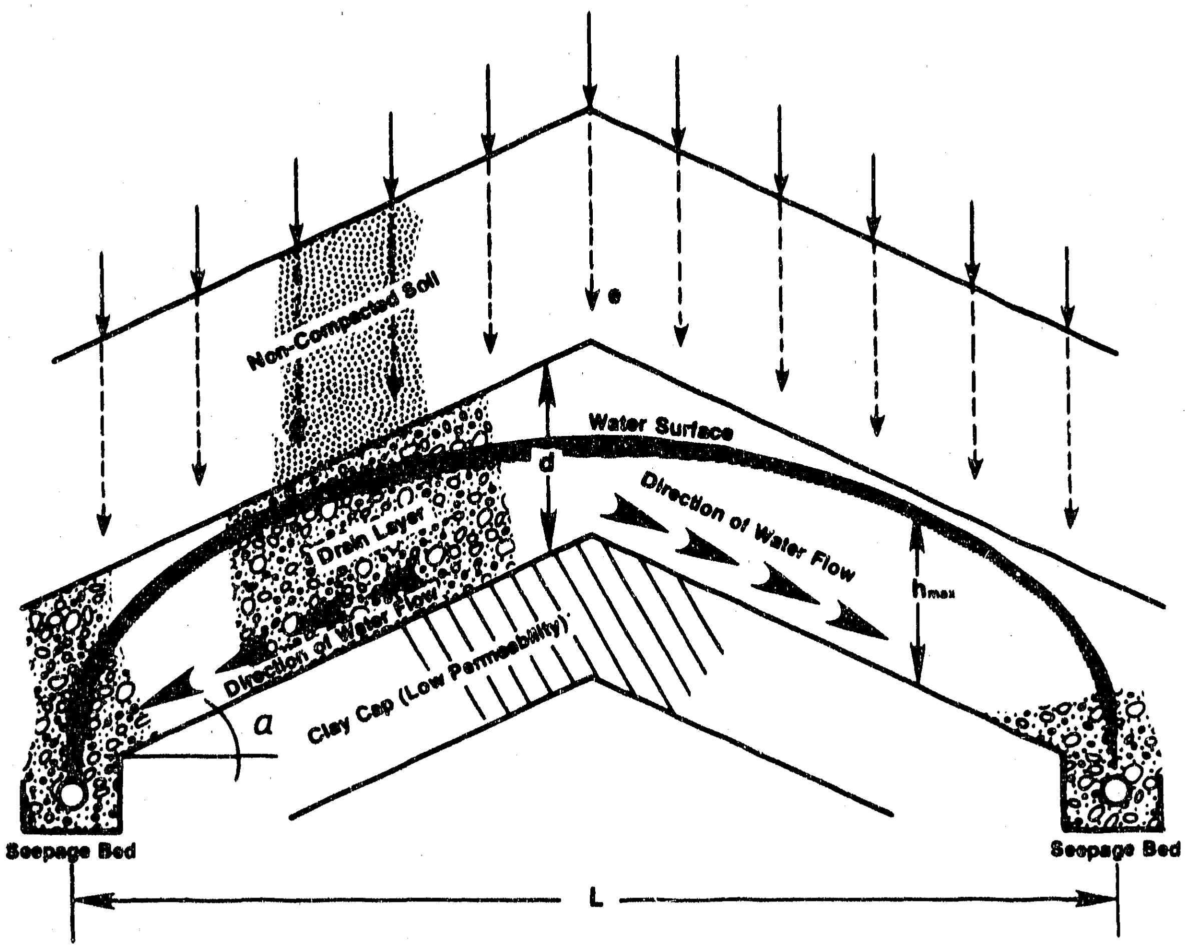


1. Upper Soils Layer Consists of top soil (a constant thickness of 6 inches) and non-compacted soils

2. As per USDA Soils Textural Classification
   Top Soil—Silt Loam
   Non-Compacted Soil—Clay

3. Precipitation value (38.09 inches/ year) is the Average Annual Value Precipitation for 1974 to 1978 (inclusive).

FIGURE 4-6 **GRAPH OF AMOUNT OF ANNUAL PRECIPITATION PERCOLATING THROUGH INCREASING THICKNESS OF UPPER SOILS LAYER**



h_{max} — Maximum height of water standing in the Drain Layer

d — Drain Layer thickness

L — Distance between opposing laterals or seepage beds

e — Rate of water flow impinging on drain layer, equal to percolation rate

a — Slope angle

SOURCE: MOORE, 1980

FIGURE 4-7 DIAGRAM OF ASSUMED WATER SURFACE PROFILE IN DRAIN LAYER.

Setting the slope at some value greater than 0 ($\alpha > 0$) will accelerate the flow toward the collector system. h_{max} for $\alpha > 0$ is given by:

$$h_{max} = \frac{L\sqrt{C}}{2}\left[\frac{\tan^2\alpha}{C} + 1 - \frac{\tan\alpha}{C}\sqrt{\tan^2\alpha + C}\right] \qquad (4\text{-}4a)$$

Where:

$$C \equiv \frac{e}{K_s} \qquad (4\text{-}4b)$$

Having a slope α, greater than zero is critical since in this case, if water were to cease impinging on the drain layer, the water would completely drain in a finite amount of time. If $\alpha = 0$ the drainage time is infinitely long.

The results of a sensitivity analysis are given in Table 4-5 to examine the effects of percolation rate, drainage length and slope, and saturated permeability on the maximum height of water standing in the drain layer. Drain thickness requirements will increase as a function of an increase in annual percolation rate and decrease in permeability. Other parameters being equal, drain thickness requirements will decrease as a function of increasing slope. The most critical parameter for a given annual percolation rate is drain permeability. A drain saturated permeability of 1×10^{-1} centimeters per second is specified. Gradation of particle sizes is required above and below the drain layer to prevent the tendency for fine particles to penetrate the coarser layer.

Equally important, "internal" erosion or differential settlement will result. In time, this will result in deep cracks. Such discontinuities are aggravated by depressions in the vegetated topsoils which provide surface storage, thus, further encouraging deep percolation. Increased percolation through the upper soils will then, in time, overload the hydraulic capacity of the drain layer.

The interaction of particle size and drain slope and length are more critical with respect to drain layer efficiency. Drain efficiency is a measure of the drain's capacity to divert water laterally that is percolating vertically. Efficiencies that exceed 60 percent are recommended.

The minimum drain layer thickness requirement was computed using equation (4-4a). The drain layer is 200 feet long, and has a slope of 3.4 percent. A drain layer thickness of 12 inches was selected. This thickness is considered practical from a construction standpoint, and, in addition, provides a safety factor that exceeds the minimum drain layer thickness requirement by several hundred percent as shown in Table 4-5. This can be achieved for a very modest additional construction cost.

Table 4-5. Results of sensitivity analysis

Drain layer length: 200 ft
$L = 2 \times$ drainage length = 400 ft = 121.92 m

Vegetation cover: "Fair" grass

Upper soil thickness	Maximum annual percolation rate	Slope 1%	5%	10%	15%
		Drain layer thickness (in.)			
($K_s = 1 \times 10^{-1}$ cm/sec)					
24 inches	11.64 in./yr 9.4×10^{-9} m/sec	3.76	3.68	3.68	3.68
72 inches	9.47 in./yr 7.6×10^{-9} m/sec	3.37	3.31	3.31	3.31
($K_s = 1 \times 10^{-2}$ cm/sec)					
24 inches	11.64 in./yr 9.4×10^{-9} m/sec	13.54	11.74	11.66	11.65
72 inches	9.47 in./yr 7.6×10^{-9} m/sec	11.93	10.54	10.48	10.47

The approach for estimating drain layer efficiency is based on saturated Darcy flow in both the drain layer and clay cap. The assumed geometry is given on Figure 4-8a, at some time, t (Moore, 1980).

This approach postulates that at some initial time a rectangular slug of liquid is placed on the saturated liner to a depth, h_o. The liquid flows both horizontally along the slope of the system, and vertically into the clay liner. The fraction of liquid moving into the collector drain system at time, t, is given (Moore, 1980), as follows:

$$\frac{S}{S_o} = 1 - \frac{t}{t_1} \tag{4-5}$$

and the fraction of liquid seeping into the clay liner is given by:

$$\frac{h}{h_o} = \left(1 + \frac{d}{h_o \cos \alpha}\right) e^{-Ct/t_1} - \frac{d}{h_o \cos \alpha} \quad 0 \leq t \leq t_1 \tag{4-6}$$

Where:

$$t_1 = \frac{S_o}{K_{s1} \sin \alpha} \tag{4-7}$$

$$C = \left(\frac{S_o}{d}\right)\left(\frac{K_{s2}}{K_{s1}}\right) \cot \alpha \tag{4-8}$$

and

S = Length of saturated volume at time, t (cm).

h = Thickness of saturated volume at time, t (cm).

S_o = Initial length of saturated volume = L/2 sec (centimeters).

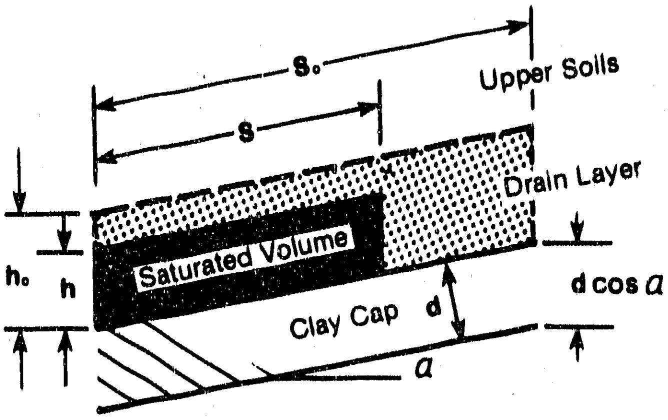
h_o = Initial thickness of saturated volume (centimeters).

K_{s1} = Saturated permeability of the material above clay liner (centimeter per second).

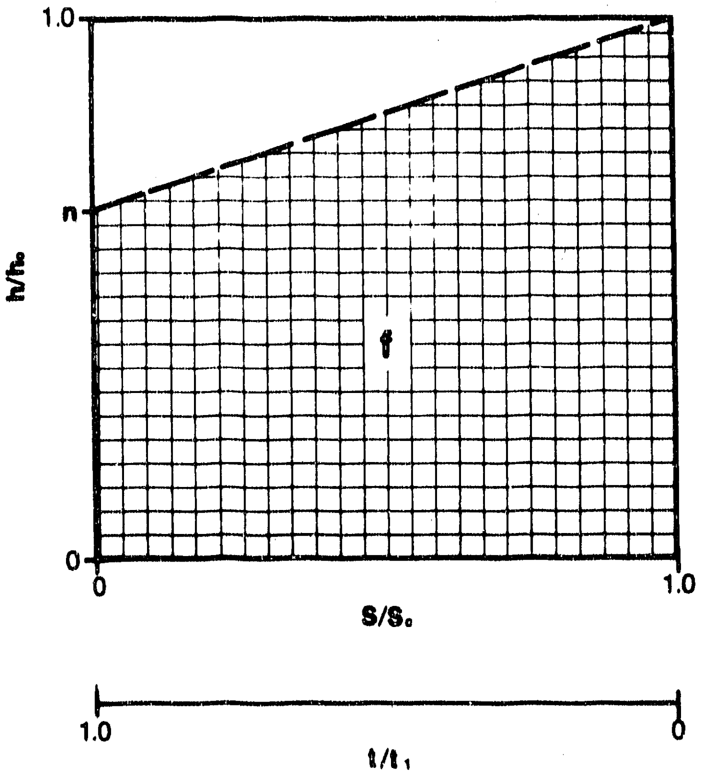
K_{s2} = Saturated permeability of the clay liner (centimeter per second).

α = Slope angle of the system (degrees).

d = Thickness of the clay liner (centimeters).



a GEOMETRY FOR CALCULATING EFFICIENCY OF DRAIN LAYER



b DIAGRAM FOR COMPUTING EFFICIENCY OF DRAIN LAYER

SOURCE MOORE. 1980

FIGURE 4-8 **ASSUMED GEOMETRY FOR COMPUTING DRAIN LAYER EFFICIENCY**

The efficiency of the liner is easily determined with reference to Figure 4-8b which plots h/h_o versus S/S_o and t/t_1. Equations (4-5) and (4-6) can be solved parametrically in t/t_1, to yield the line shown on the figure. (The line is actually a curve, however, for practical liner and drain layer configurations it can be approximated as a straight line.) In this case, the efficiency of the system is given by the area labelled "f." This area is most easily determined by calculating the value of h/h_o when $t/t_1 = 1.0$ (or $S/S_o = 0$). The term h/h_o is set equal to n and can be obtained by solving equation (4-9) with $t/t_1 = 1.0$:

$$n = \left(1 + \frac{d}{h_o \cos \alpha}\right) e^{-C} - \frac{d}{h_o \cos \alpha} \tag{4-9}$$

The value of n can be either positive or negative, however, most efficient designs will have $n > 0$. The efficiency is given by either:

$$f = \frac{1+n}{2} \quad \text{for } n > 0 \tag{4-10a}$$

or

$$f = \frac{1}{2(1-n)} \quad \text{for } n < 0 \tag{4-10b}$$

Thus, the efficiency varies from 0 to 1.0.

The quantity of liquid draining out of the system is given by:

Amount collected in drains $= f \times h_o$

and the quantity of liquid seeping into the clay cap or liner is given by:

Amount seeping into liner $= (1-f) \times h_o$

The amounts of water impinging on the clay cap are summarized in Table 4-6.

Water will be diverted into seepage pits. This was done, as opposed to drainage at the soil surface, to contain radon that may diffuse through the impermeable barrier. Thus, the upper soils provide an added safety factor for radon containment.

4.2.4.3 Impermeable barrier (clay cap)

The clay cap is constructed either of one layer of compacted soil; or two layers, compacted soil overlaid by a compacted soil and bentonite mixture. The criterion for barrier selection is permeability. Permeabilities of 10^{-6} to 10^{-8} centimeters per second are required for attenuation of radon as well as water. A clay cap thickness of 3 feet was selected.

Table 4-6. Water impinging on drain layer and clay cap

Minimum slope: 3.4%
Drain layer length: 200 ft

	Precipitation (in./yr)	Water impinging on drain layer (in./yr)	Water impinging on clay cap (in./yr)
Cover description: 10 ft total thickness consisting of 6 ft of noncompacted soil, a 1-ft drain layer, and a 3-ft clay cap.			
Average 1974 to 1978, inclusive	38.09	5.33	0.091
Maximum	46.42	9.47	0.133
Minimum	33.20	2.24	0.054
Cover description: 6 ft total thickness consisting of 2 ft of noncompacted soil, a 1-ft drain layer, and a 3-ft clay cap. (Optional multilayer cover system.)			
Average 1974 to 1978, inclusive	38.09	9.33	0.131
Maximum	46.42	11.64	0.151
Minimum	33.20	7.43	0.111

All water that permeates the clay layer will, in time, ultimately percolate downward through the waste material and the liner. The times required to permeate the barrier are given in Table 4-7 (using equation (4-16)). These time estimates are conservative since they assume a constantly saturated upper boundary. The initial water content will be approximately 15 percent, a water content that is about optimum for soil compaction. During the time that water permeates the cap, the moisture content will increase from 15 to 40 percent. The water-holding capacity of the clay soil is approximately 40 percent by weight.

In the early stages, the wetting process is described by equation (4-11) where the first term on the right side dominates, shown as follows:

$$\frac{\partial \tilde{\theta}}{\partial t} = D^* \frac{\partial^2 \tilde{\theta}}{\partial Z^2} - K^* \frac{\partial \theta}{\partial Z} \tag{4-11}$$

Thus,

$$\frac{\partial \tilde{\theta}}{\partial t} \cong D^* \frac{\partial^2 \theta}{\partial Z^2} \tag{4-12}$$

The D* term represents capillary attraction. During this stage of the wetting process, gravitational forces are negligible as compared to capillary forces.

Imposing the following initial and boundary conditions:

Initial Condition

$\tilde{\theta} = \theta$; for $Z > 0$ and $t = 0$

(Z is positive, downward)

At initial time ($t = 0$), assume that the moisture content is equal to θ, throughout the depth of the liner.

Boundary Condition

$\theta = \theta_s$ for $Z = 0$ and $t \geq 0$

At all times at the boundary ($Z = 0$), the moisture content is held at the saturation moisture content, θ_s.

The solution of equation (4-12), having the initial and boundary conditions just given, is as follows:

$$\tilde{\theta} = \theta_i + (\theta_s - \theta_i) \operatorname{erfc} \frac{Z}{2\sqrt{D^* t}} \tag{4-13}$$

The relationship for the cumulative amount of water enter [illegible]e barrier soil at time, t, is as follows:

$$M_t = 2 (\theta_s - \theta_i)\sqrt{\frac{D^* t}{\pi}} \tag{4-14}$$

and the quantity of liquid required to saturate the barrier to a depth, d, is given by:

$$M_t = (\theta_s - \theta_i) \quad d \qquad (4\text{-}15)$$

Equating equations (4-14) and (4-15) yields:

$$t = \frac{\pi d^2}{4D^*} \qquad (4\text{-}16)$$

Table 4-7. Time required for water to completely permeate a clay cap or liner consisting of a soil and bentonite mixture, plus compacted soil

Assumptions:

Diffusivity, D* (square centimeter per second), of the compacted soil is from one to two orders of magnitude greater than in-situ permeability.

Compacted soil permeability is one order of magnitude greater than soil and bentonite mixture permeability.

Time required to permeate (years)

Soil and bentonite mixture (Thickness 0.5 ft)			Compacted soil (Thickness 2.5 ft)			Total time (yrs)
K_s (cm/sec)	D* (sq cm/sec)	Time (yrs)	K_s (cm/sec)	D* (sq cm/sec)	Time (yrs)	
10^{-6}	10^{-4}	0.058	10^{-5}	10^{-3}	0.145	0.203
10^{-7}	10^{-5}	0.578	10^{-6}	10^{-4}	1.446	2.024
10^{-8}	10^{-6}	5.784	10^{-7}	10^{-5}	14.461	20.245

K_s = Coefficient of permeability.

4.3 LINER SYSTEM

4.3.1 Background

The use of natural and synthetic materials of low permeability to line waste storage and disposal impoundments has been demonstrated to be a useful means of preventing leachate and waste liquid components from leaking and subsequently polluting ground and surface waters. These liner materials can also serve to prevent the migration of dangerous concentrations of radon and other gases from a waste containment site. Many liner materials are available from which the containment system for specific wastes may be chosen.

Two types of liner systems exist, active and passive. Active liner systems employ the use of leachate collection, and generally require considerable post-closure maintenance. An active liner system must also be constructed of highly impervious materials, and include a backup liner for quality assurance. Active liner systems have restricted life expectancies, and typically cannot be expected to provide a low maintenance 1000-year life.

A significant amount of information exists regarding the water resistance of lining materials, regardless of whether they are soils, asphalts, or polymeric membranes. The contaminated materials at the Canonsburg site may also contain other ingredients which could affect lining materials. Since waste leachates are generally not the aggressive agents in waste liquids and usually are of relatively low concentrations, it is necessary to consider the totality of all constituents in a waste in assessing a liner material for a given application; the chemical composition of both the waste and the lining material must be considered.

This subsection will only consider passive liner systems because with their use, a low maintenance 1000-year service life, can reasonably be expected. A variety of liner systems was considered for the encapsulation area, including asphalts, concrete, synthetics, natural soils, and soil admixtures. Table 4-8 illustrates the systematic performance evaluation of these materials. The natural soils with possible soil admixtures (bentonite clay) were again chosen based on past experience and long service life. They are also desirable for their ability to provide controlled hydraulic flux and radiological attenuation. The cost of placement and ease of construction are favorable characteristics.

4.3.2 Functions of the liner

The primary purpose and function of a liner system is to retard the physical movement of water into the natural environment. An optimal liner design would address the dual function of minimizing water (leachate) movement while passively treating any leachate that does migrate through the liner.

Water that permeates the clay cap will, in time, permeate the waste material and liner. The rate of water movement through the liner will, at saturation, equal that of the clay cap. Thus, water will not accumulate between the liner and the cap.

Table 4-8. Liner material general performance criteria evaluation

Liner material	Permits hydraulic controlled flux	Historical application as liner material	Seismic stability (2)	Crack resistance (3)	Radionuclide attenuation (5)	Vegetation penetration	Potential for damage to liner during placement	Ease of construction	Probable 1000-year life	Biochemical deterioration	Cost of placement
Spray asphalt emulsion	-	+	-	-	-	-	+	-	-	-	+
Hydraulic asphalt	-	+	-	+	-	+	+	+	-	-	-
Synthetic -- Hypalon	-	+	-	+	-	-	-	+	-	-	-
Synthetic -- PVC	-	+	-	+	-	-	-	+	-	-	-
Synthetic -- Neoprene	-	+	-	+	-	-	-	+	-	-	-
Synthetic -- CPE	-	+	-	+	-	-	-	+	-	-	-
Concrete	-	+	+	+	-	+	+	-	+	+	-
Low permeability/native soils (1)	+	+	+	-	-	-	+	+	+	+	+
Soil admixtures (4) (bentonite)	+	+	+	-	+	-	+	+	+	+	+
Bentonite (4)	+	+	+	-	+	-	+	+	+	+	-
Soil cement	+	-	-	-	-	+	+	-	-	+	-
Soil asphalt	+	-	-	+	-	+	+	-	-	-	-

An ion-exchange barrier may be considered a means of controlling the migration of radionuclides in or into ground water. This type of system could be constructed as follows:

1. A curtain or barrier designed to intercept the flow of ground water from a contaminated area.

2. A liner to be placed under a waste area designed to intercept any leachate that may be generated.

Ion-exchange material may be comprised of the following:

1. Natural soils (clays generally have a high cation exchange capacity.).

2. Synthetic resins (zeolites, macroreticular polymers, gels, etc.).

Selection of the type of ion-exchange material will generally depend on the following factors:

1. Characteristics of the water or leachate that will be handled.

2. Presence and concentration of other ionic species.

3. Type of ionic species that must be removed.

4. Economic considerations.

5. Effective life.

6. Construction viability.

In addition, the ion-exchange function of a barrier or liner must be compatible with the other desired functions of that barrier. For example, a primary purpose and function of a liner system is to retard the physical movement of water through the liner. An optimum liner design would address the dual function of restricting water (leachate) movement while treating any leachate that does migrate through the liner by the ion-exchange process.

The use of ion-exchange materials for control of radioactive wastes has been proposed in the literature (Benson, 1980, and Northrup, 1980). The performance of various natural materials, e.g., expandable clays and zeolites, for adsorbing specific radioactive species has been reported. A recent literature search (Benson, 1980) for ion-exchange data associated with clays, zeolites, and basalt identified 92 references to ion-exchange data on clays, 22 references for zeolites, and 6 references on basalt.

Nowak (1979) has proposed a model for radionuclide migration through an ion-exchange backfill barrier system. This type of modeling effort may also be applied to a liner. Nowak (1979) presented his model, beginning with its differential form, as follows:

$$\epsilon \frac{\partial C}{\partial t} + \frac{\partial S}{\partial t} + \epsilon v_g \frac{\partial C}{\partial x} - \epsilon D_L \frac{\partial^2 C}{\partial x^2} = 0 \qquad (4\text{-}17)$$

Where: C = Liquid phase concentration, quantity of sorbing species per unit volume of liquid.

S = Concentration of species sorbed on the solid phase (quantity of sorbed species per unit volume of bed liquid plus solid volumes).

ϵ = Effective porosity of bed (fraction of bed volume containing flowing liquid).

v_g = Average <u>interstitial</u> velocity of flowing liquid.

x = Distance in bed along direction of flow and longitudinal diffusion.

D_L = Coefficient of longitudinal dispersion and diffusion combined.

t = Time.

For the boundary condition,

$C = C_O,\ X = 0,\ T > 0$

and for the initial condition,

$C = 0,\ X > 0,\ T = 0,$

Crank (1956) gives the solution for equation (4-17) as follows:

$$\frac{C}{C_o} = 1 - \text{erf}\left\{\frac{x}{2\left(\frac{D_f t}{\sqrt{2R_f}}\right)^{1/2}}\right\} \qquad (4\text{-}18)$$

Where: D_f = Liquid phase molecular diffusivity.

$R_f = 1 + \frac{\rho B K d}{\epsilon}$

ρB = Bulk packing density of solid sorbent, mass of solid per unit bed volume.

K_d = Distribution coefficient for a linear-sorption isotherm, the ratio of quantity of sorbed species per unit mass of solids to quantity of mobile species in the liquid phase per unit volume of liquid.

Typical values for the parameters used in equation (4-18) are presented in Table 4-9. The time to "breakthrough" for barrier walls with various characteristics is given on Figure 4-9. In developing these estimates, "breakthough" is defined as $C/C^o = 0.01$. As Figure 4-9 indicates, for those parameter values used, a barrier thickness ranging from less than 1.0 foot to approximately 6.5 feet would be necessary to attain a 1000-year design (i.e., at 1000 years of barrier life, the breakthough concentration ratio, C/C^o would be less than or equal to 0.01.

Table 4-9. Typical values of physical and chemical properties for the ion-exchange barrier

K_d = 100 to 5000 milliliters per gram

B = 2 grams per cubic centimeter

D_f = 10^{-4} to 10^{-6} square centimeters per second

ϵ = 0.25 to 0.40

X = 1 to 10 feet

The results for a clay barrier wall can be roughly applied to a clay liner system as well. A clay of the type to be used for the encapsulation-cell liner at the Canonsburg site should have a K_D of about 500 milliliters per gram and a D_f of about 10^{-5} square centimeters per second. As shown on Figure 4-9, this produces a time to breakthrough of 1000 years for a 1-foot thick liner, or almost 10,000 years for a 3-foot thick liner.

4.3.3 Liner-system description

Three feet is the recommended thickness for the clay liner. This choice was made for several reasons, as follows:

1. Constructability.
2. Long-term ion-exchange capacity.
3. Compactability.

Bentonite combined with natural soils to produce a mixture of low permeability, or a native clayey soil may be used. The specific liner material can only be selected once the native soils are tested for permeability and cationic exchange capacity. The time required for water to completely permeate the liner is given in Table 4-7.

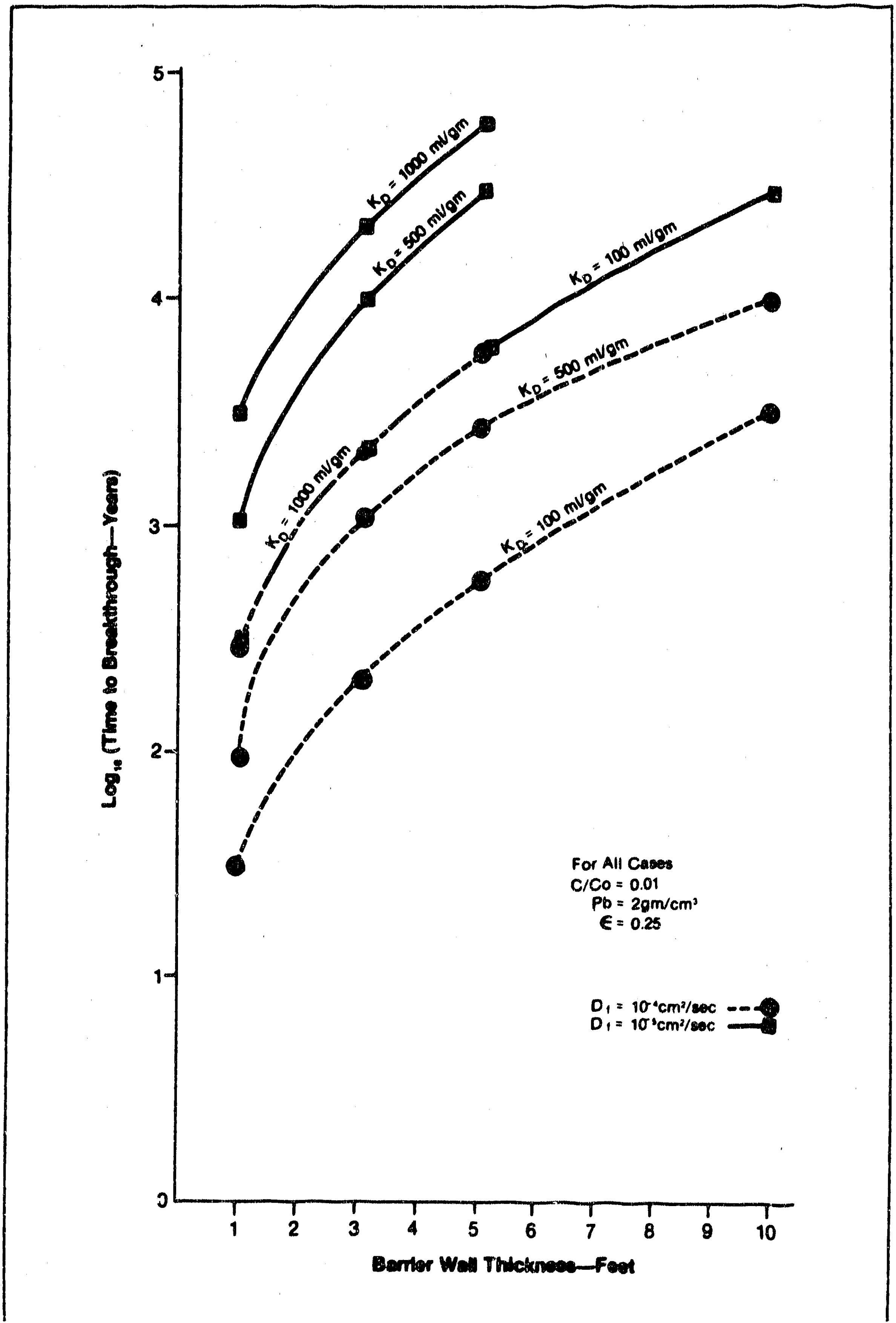


FIGURE 4-9 GRAPH OF BREAKTHROUGH TIME AS A FUNCTION OF BARRIER WALL CHARACTERISTICS—HIGH AND LOW DIFFUSION RATES (D$_f$)

It should be noted that standard bentonite is susceptible to deterioration in an excessively low pH environment (Crim, 1979; Morrison, 1981; and van Zyl, 1978). The pH effects can only be assessed once the low-level radioactive waste of concern is tested. The pH effects, however, are expected to be minimal because the waste material has been leached by rainwater for many years. Subsection 4.4 will discuss material-handling procedures to address any potential problems of this nature.

A liner system used with a cover has the additional benefit of providing waste encapsulation. By tying the cover and liner systems together the buried low-level radioactive wastes can be completely sealed. Encapsulation allows more complete isolation of the disposed wastes, and therefore lessens any environmental impacts.

The radionuclide-attenuating capabilities and inherent long-term structural and physiochemical stability of soils are their outstanding characteristics. Relatively simple construction techniques, along with ready availability and accessibility, make soil an obvious choice as a liner material.

4.4 WASTE CONDITIONING

Waste conditioning is generally performed to meet one of the following three objectives:

1. To improve the handling and physical characteristics of the waste.
2. To decrease the surface area across which transfer and loss of contained contaminants can occur.
3. To limit the solubility of various contaminants within the waste.

Objectives 1 and 3 could be important at the Canonsburg site.

A number of fixation and conditioning methodologies were considered for application including the following:

1. Cement-based techniques.
2. Lime-based techniques.
3. Thermoplastic techniques.
4. Thermosetting resins.
5. Encapsulation techniques.
6. Glass and ceramic-fixation techniques.
7. Thermal stabilization.
8. Acid extraction of contaminants.

These techniques are all chemical (as opposed to physical). They may be used in the event material excavated from Area C is found to have a low pH, which could damage a liner or cap made of bentonite clay and soil. Of the conditioning techniques considered, the lime-based techniques are the most applicable to the Area C material. Fixation techniques using lime-type products usually depend on the reaction of lime with a pozzolanic* material, water, and the waste to produce a concrete-type material. The most common pozzolanic materials used in waste fixation are cement-kiln dust, fly ash, and pulverized slag. These materials are readily available in the Pittsburgh area. The effectiveness of chemical fixation using this technique must also be demonstrated through bench-scale tests that simulate the actual process.

The advantages of the lime-based techniques include the use of well-known chemistry involving lime-pozzolanic reactions, in addition to the fact that no specialized equipment would be required for this type of processing.

Waste conditioning may also imply physical conditioning to improve the physical properties (such as bearing strength, etc.) of the contaminated materials. This may be necessary at Canonsburg if the Area C materials are found to be "soupy." In that case, these materials should be physically mixed with the relatively dry soils excavated from Area A. This mixing could take place within the encapsulation cell itself. It should result in a compactable material of optimum moisture content and density which is strong enough to support both the multilayered cover system and the temporary load of construction vehicles. Adequate support of the cover system from below is essential to promote long-term stability and integrity of the cover. Physical mixing may also produce some beneficial chemical results by means of Area A materials partially neutralizing Area C materials.

4.5 SUMMARY

In conclusion, the encapsulation cell would consist of the following:

1. A multilayered cover system designed to control water infiltration and radon emanation.
2. A clay liner to provide physical containment and ion-exchange capability to passively treat leachate.

These will be combined to effectively isolate the more contaminated soils from the surrounding environment.

---

*The term pozzolanic applies to silicate-type material.

REFERENCES FOR SECTION 4

Benson, L.V., 1980. "A Tabulation and Evaluation of Ion Exchange Data on Smectites, Certain Zeolites, and Basalt," U.S. Department of Energy Contract No. W-7405-ENG-48, Lawrence Berkeley Laboratory, University of California.

Crank, J., 1956. The Mathematics of Dispersion, Oxford Press, London, pp. 18-19 and 121-122.

Crim, R.G., 1979. "Stability of Natural Clay Liners in a Low pH Environment," Symposium on Uranium Mill Tailings Management, Fort Collins, Colorado, 19-20 November.

Moore, C.A., September 1980. Landfill and Surface Impoundment Performance Evaluation Manual, U.S. Environmental Protection Agency, Solid and Hazardous Waste Research Division, Cincinnati, Ohio.

Morrison, A., July 1981. "Can Clay Liners Prevent Migration of Toxic Leachate?" Civil Engineering, American Society of Civil Engineers, New York.

Northrup, C.J.M., Jr., editor, 1980. Scientific Basis for Nuclear Waste Management, Volume 2, Plenum Press, New York.

Nowak, E.J., 1979. "The Backfill Barrier as a Component in a Multiple Barrier Nuclear Waste Isolation System," Sandia Laboratories Report, SAND 79-1109.

Perrier, E.R. and A.C. Gibson, September 1980. Hydrologic Simulation on Solid Waste Disposal Sites, SW-868, U.S. Environmental Protection Agency, Solid and Hazardous Waste Research Division, Cincinnati, Ohio.

Rogers, V.C., G.M. Sandquist, and K.K. Nielson, March 1981. "Radon Attenuation Effectiveness and Cost Optimization of Composite Covers for Uranium Mill Tailings," Rogers and Associates Engineering Corporation (RAECO).

van Zyl, D., and J.A. Caldwell, 1978. "Efficiency of a Natural Clay Liner for High Acidity Tailings Impoundment," Symposium on Uranium Mill Tailings Management, Fort Collins, Colorado, 20-21 November.

5 Additional Site Requirements

5.1 SITE PREPARATION

5.1.1 Flood control

Since the site lies partially within the 100- and 500-year flood plains of Chartiers Creek, it is necessary to protect it from the effects of flooding during the construction period. This can be accomplished by the construction of a flood control berm as illustrated on Figure 5-1. At a height of five feet this berm would protect the site from a 500-year flood. The berm should be constructed of clean fill and riprapped on the stream side for stability.

5.1.2 Storm-water management

Surface runoff and drainage control prevent the transport of contaminated materials away from the site during the construction period, and aid in preserving the final cover integrity in the post-construction years. The objectives of a storm-water control plan for the Canonsburg site are as follows:

1. Divert clean storm-water runoff around contaminated parts of the site.
2. Retain and treat (if necessary) potentially contaminated storm-water runoff from the site itself.
3. Minimize both disturbed areas and time of exposure or erosion factors (wind, water, etc.).
4. Stabilize disturbed areas immediately.
5. Retain sediment on the site.

Storm-water runoff should be managed by means of a network of structural control measures such as the following:

1. Drainage ditches and conduits.
2. Diversions (berms).
3. Sedimentation basin.

Prior to any excavation activities, a small earthen berm should be constructed around the area to be excavated. Only rainfall which falls directly into the pits will be considered contaminated. Storm water which falls directly into excavated pits should be pumped to a sedimentation basin (described more fully in Subsection 6.1) from which it would flow to the waste-water treatment plant.

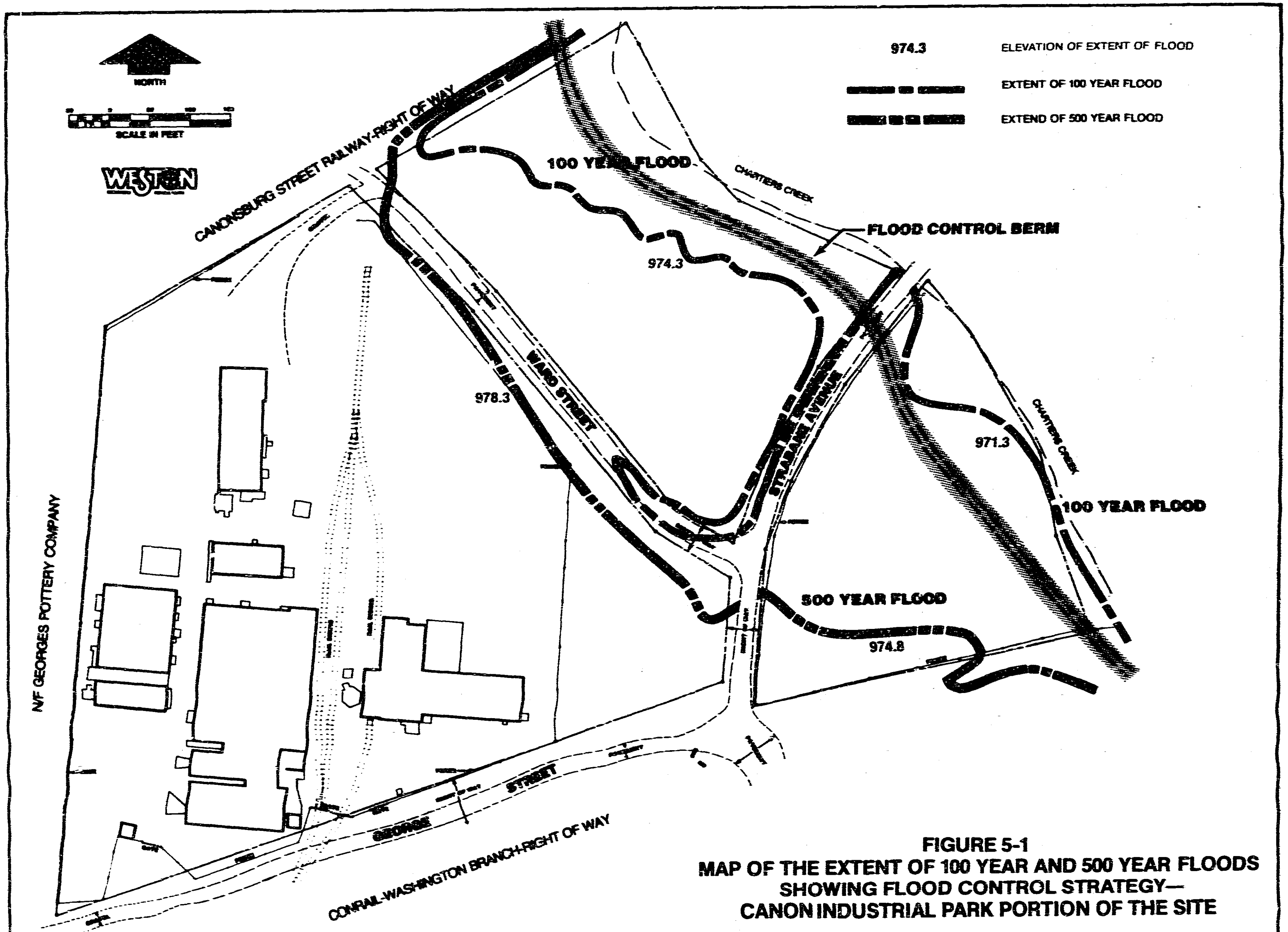


FIGURE 5-1
MAP OF THE EXTENT OF 100 YEAR AND 500 YEAR FLOODS
SHOWING FLOOD CONTROL STRATEGY—
CANON INDUSTRIAL PARK PORTION OF THE SITE

NOTE: THIS MAP IS BASED ON SURVEY BY KURCH-HOUSLEY
& ASSOC. PITTSBURGH, PA., DATED 6/14/78

Temporary seeding of fast growing grasses should be used to reduce erosion in areas which are disturbed for periods of up to one year, or until a permanent vegetative cover is established. This seeding might be applicable in channels, diversions, sedimentation basins, and other temporarily-disturbed areas of the site.

Temporary mulching without seeding can be used for the protection of critical areas which have been graded or cleared and may be subject to erosion for six months or less (since seedings may not have a growing season in which to become established).

An erosion control plan should be developed by the construction contractor and submitted to the project engineer before any site activity begins. The plan should provide erosion control measures for all disturbed areas of the site. Sediment barriers should be provided at storm-drain inlets, across minor swales and ditches, along property lines, at discharge points to Chartiers Creek, etc. They will prevent sediment from leaving the site and entering natural drainage-ways by slowing storm-water runoff and causing deposition of sediment.

5.1.3 Site security

Fencing is required to ensure site security during the construction period. Although there is currently fencing around portions of the site, much of it is in poor condition. For the purpose of this study, it has been assumed that any existing fence will be removed and replaced with an 8-foot high chain-link fence topped with three strands of barbed wire. This new fence should surround the entire site (site being defined as the Canon Industrial Park, Georges Pottery area, and Wilson Street residential area), and be furnished with two 12-foot gates.

5.1.4 Material handling

Large quantities of soil, gravel, clay, and other construction materials will be required onsite for various phases of the remedial action. To facilitate transport and delivery of these materials as well as take full advantage of the existing railroad siding on the site, it is proposed that all construction materials be delivered to the site by rail and stockpiled until needed. When all materials have been delivered, the railroad siding can be removed and the railroad grade demolished to conform to the surrounding topography.

5.2 BALANCE OF SITE

The areas of the site not included in the encapsulation portion will be covered with a maximum of 5-1/2 feet of noncompacted soil and 6 inches of topsoil to support vegetation. Computer modeling efforts have shown that this will be sufficient to restrict radon flux to 2 picocuries per square meter per second, and to significantly reduce infiltration, assuming that all remaining contamination is at the surface. However, since much of the remaining contamination is buried at depths up to 18 feet, many areas may require significantly less cover or no cover at all. In addition, the regulatory limit on radon flux level may be raised. Table 5-1 lists a possible scenario for required amounts of cover. To demonstrate the feasibility of this remedial-action concept, the cost estimate assumes a 6-foot cover over the balance of the site.

The final site configuration is shown on Figure 5-2. This assumes a cover of 6 feet of soil over the balance of the site. Except where the edges of the clay caps require a 20-percent slope, gentle slopes are incorporated to carry drainage off the site with a minimum possibility for erosion. As can be seen on the figure, there are channels north and south of the encapsulation area to direct runoff around it and toward Chartiers Creek.

The 80,000 cubic yards of material on the Burrell landfill site as well as the 5700 cubic yards of material on the vicinity properties may also be disposed of here. These materials can be used either as fill or cover materials, and the integrity of the site will be maintained.

Table 5-1. Reduced cover thickness scenario

Area designation		Area (acres)	Cover thickness (feet)	Cover volume (cubic yards)
A	11	3 encapsulation	--	--
		8 remainder	3	38,700
B		4.5	2	14,500
C		3.1	4	20,000
Georges Pottery	6	2 surface contaminated	3	9,700
		4 clean	1	6,500
Residential areas		5.4 clean	1	8,700
	Total	30		98,000

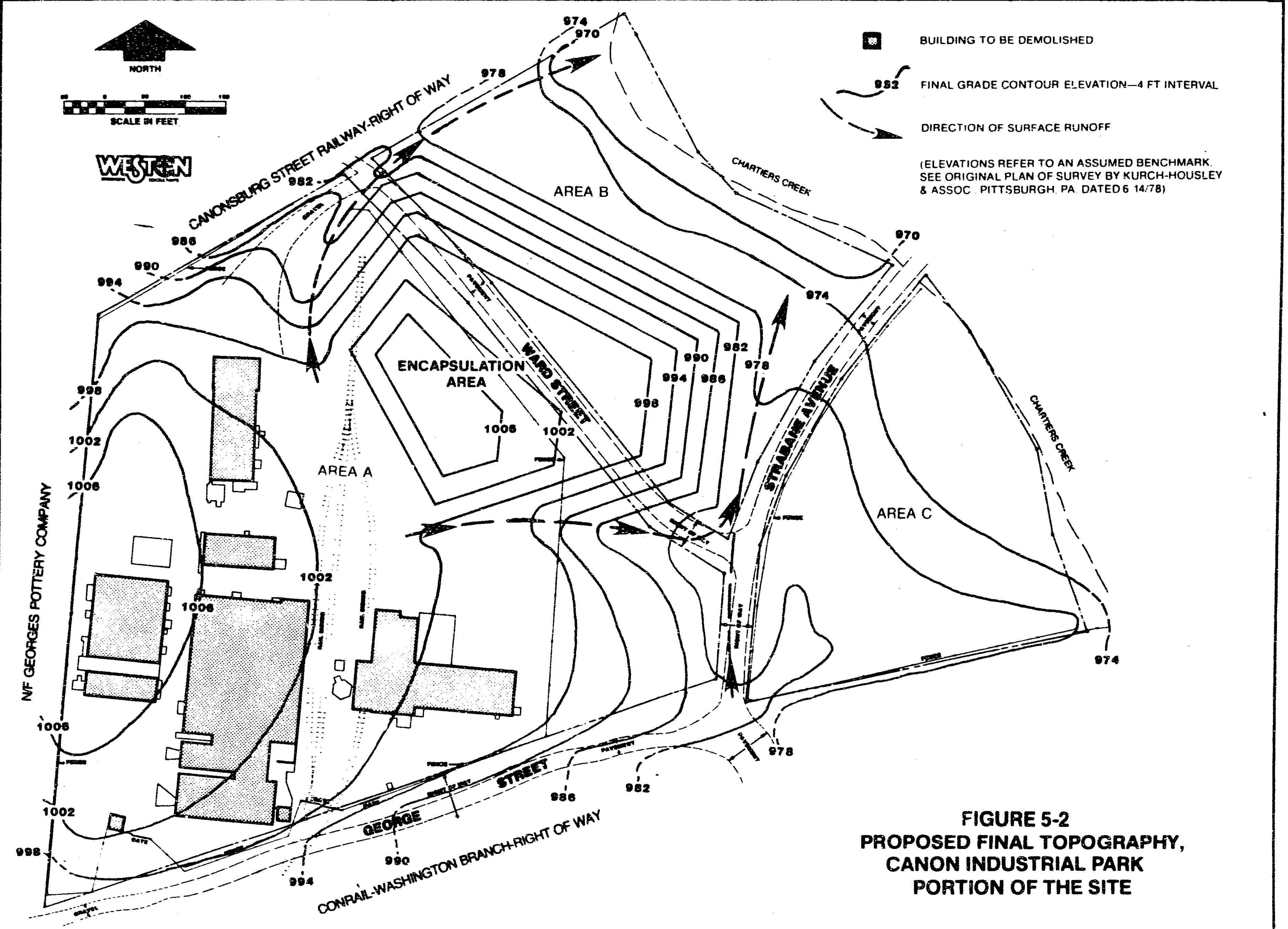


FIGURE 5-2
PROPOSED FINAL TOPOGRAPHY, CANON INDUSTRIAL PARK PORTION OF THE SITE

NOTE. THIS MAP IS BASED ON SURVEY BY KURCH-HOUSLEY & ASSOC. PITTSBURGH, PA., DATED 6/14/78

6 Environmental Management

Throughout the construction period, proper environmental management of the site is essential. This includes handling contaminated waste water, including treatment if necessary, and monitoring both the site and people working on it. The need for waste-water treatment has not been fully documented, or has the potential water quality been determined. To demonstrate the feasibility of the concept, however, a complete waste-water treatment scheme has been developed, along with a site-monitoring plan.

6.1 WATER MANAGEMENT

6.1.1 Waste-water sources

Throughout the implementation of the remedial-action program proposed for the Canonsburg site, various waste waters could be generated which could require treatment for removal of radioactive species prior to discharge to Chartiers Creek. Some of these waste waters would be the result of specific decontamination activities. It is estimated that approximately 6000 gallons per day of waste water would be generated from various steam-cleaning activities, including equipment washing, building washing, and wet sandblasting. In addition, the cleanup strategy proposed for Area C could require initial dewatering of the soils in this area prior to their excavation, and during the excavation activities, maintenance of a low ground-water table by continuing to pump the wells. It is estimated that during the initial dewatering activities, approximately 300,000 gallons per day of water would be generated, and that subsequently, 20,000 gallons per day would have to be pumped to maintain the depressed ground-water table.

In addition to these quantities of waste water generated from cleanup activities on the site, storm runoff which ponds in any of the subsurface contamination excavations (Figure 3-3) should be collected and treated prior to discharge. Clean runoff should be prevented from entering the open pits by means of diversion berms constructed around the perimeter of each pit. From the total area of all the excavations of subsurface contamination, approximately 247,000 gallons of runoff would be collected. Again, for the purpose of design, it is assumed that this volume of runoff would be treated over a ten-day period, resulting in a daily flow of 24,700 gallons per day. Estimated quantities of waste water that may be generated from the site are given in Table 6-1.

Table 6-1. Quantities of waste water generated at the Canonsburg site

Source	Quantity (gal/day)
Steam cleaning for equipment and building washing and wet sandblasting	5,760
Groundwater controls for Area C	
With dewatering	288,000
Without dewatering	20,000
Runoff (assuming 100-year storm, 12-hour duration, 247,000 gallons) volume to be treated in ten days	24,700
Summary of daily volumes	
With dewatering (wet weather)	319,000
Without dewatering (wet weather)	50,500
Without dewatering (dry weather)	25,800

6.1.2 Waste-water treatment

In developing the design basis for the waste-water treatment facility, it was assumed that, under normal conditions, the facility would be operated six hours per day, allowing two hours per day for normal maintenance of equipment, etc. It was further assumed that, during this six-hour period, the facility should be capable of treating the volume of waste water generated under dry weather conditions, after the dewatering of Area C has been completed. As indicated in Table 6-1, this volume of waste water was estimated at 25,800 gallons per day or 72 gallons per minute.

To allow for uncertainties in the estimates of waste-water quantities, 100 gallons per minute was chosen as the nominal design capacity for the treatment facility. It should be noted that larger daily quantities of waste water could be treated at this facility by extending its hours of operation, and, if necessary, allowing excess quantities of waste water to accumulate temporarily in a sedimentation basin included in the facility. For the purpose of design, a 100-year storm of 12 hours duration has been assumed for sizing the sedimentation basin.

Flow through the waste-water treatment plant at 100 gallons per minute will allow accumulation of waste water in the 450,000-gallon sedimentation basin without overflow during the initial dewatering of Area C. This dewatering would occur at a rate of 288,000 gallons per day; approximately seven to ten days would be required.

Data are presented in Table 6-2 (Oak Ridge National Laboratory, December 1980) which characterize the runoff from the Canonsburg site. While site cleanup activities will influence these characteristics, a review of the data in these tables indicates that the waste-water treatment strategy, developed for the Canonsburg site, would require provisions for the control of suspended material as well as dissolved species found in the waste water. These requirements were felt to be consistent with those for treating the waste waters generated by the various decontamination activities. Further waste-water characterization and treatability studies may well show that only selected portions of the process design are necessary to obtain adequate treatment.

Using the available information described in the previous subsection, a waste-water treatment strategy was developed which includes a sedimentation basin for collection of runoff and other waste waters generated at a rate in excess of the capacity of the treatment facility, followed by multimedia pressure filters for control of suspended material, followed by cation and anion ion-exchange beds for control of dissolved species. A simplified process flow diagram for the proposed facility is presented on Figure 6-1.

For ultimate disposal of the spent regenerant and backwash solids, the use of this waste as an ingredient for mixing concrete has been considered. Assuming 10,000 gallons per week of waste solution generated from backwashing and regeneration, a water to cement ratio of 9 gallons per sack of cement (94 pounds), and a cement to sand to aggregate ratio of 1:3:5 by volume, approximately 50 cubic yards of concrete per day would be produced. This concrete could be poured into 55-gallon drums, for example, at approximately 1100 pounds per drum, and buried on the Canonsburg site.

Table 6-2. Range of concentrations of pollutants in runoff from various locations on the site (Oak Ridge National Laboratory, December 1980)

Parameter	Concentration (mg/l)
BOD_5	1 - 5
Suspended solids	15 - 753
NH_3-N	0.4 - 0.8
NO_3-N	0.76 - 6.7
Total phosphorus	0.61 - 1.21
TOC	5 - 13
Lead	0.02 - 0.44
Turbidity	13 - 860

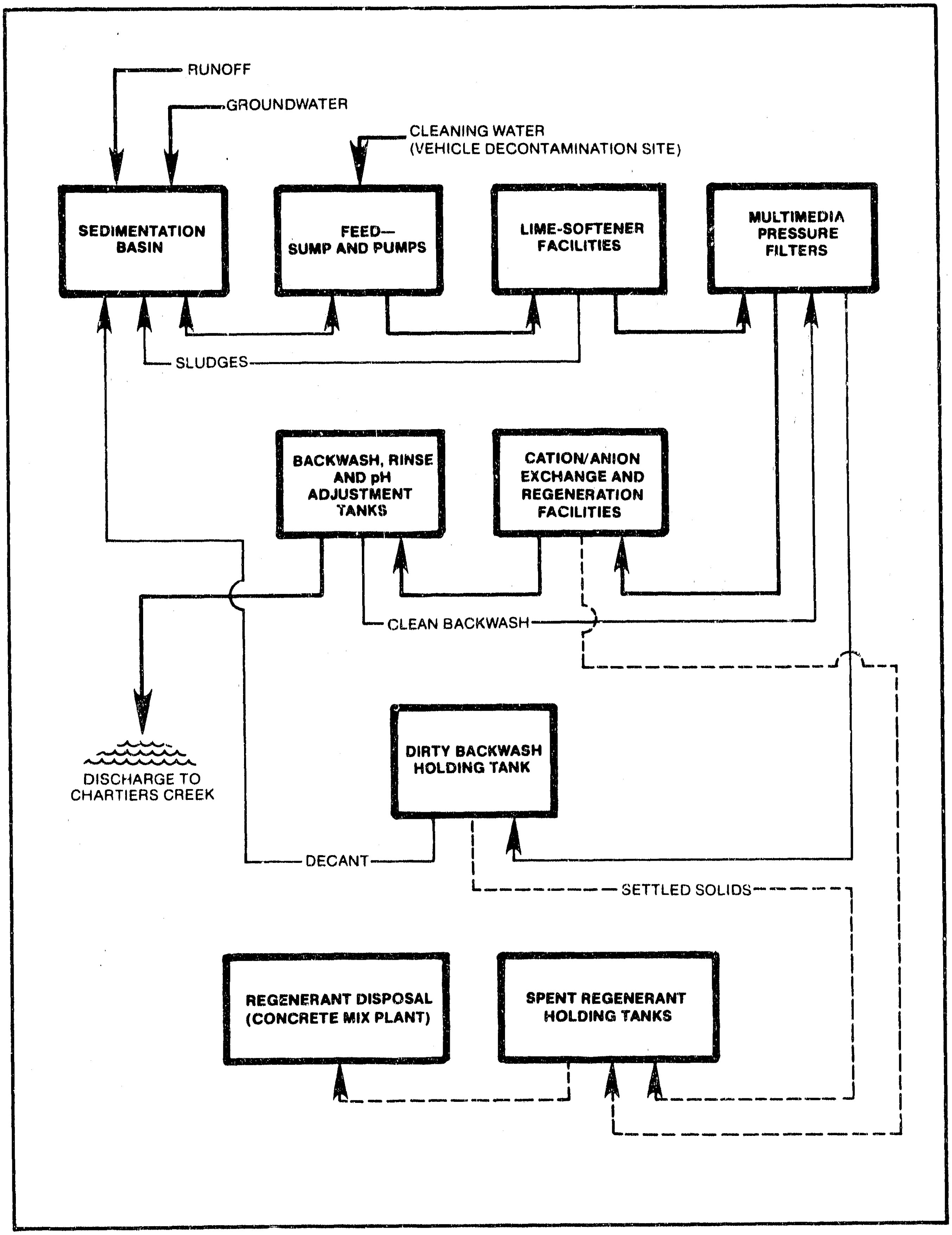


FIGURE 6-1 PROCESS FLOW DIAGRAM—PROPOSED WASTEWATER TREATMENT FACILITY—CANONSBURG UMTRAP SITE

During the design of the proposed facility, various factors were taken into consideration in an attempt to minimize the overall costs, i.e., capital plus operating costs, for the facility. Wherever possible, the use of equipment that is modular and portable in design, and readily available from vendors, is recommended so that at the completion of the cleanup program at the Canonsburg site, the equipment would be available for potential use at other sites.

6.1.3 Ground water

Figure 2-6 depicts contours in the unconsolidated upper layer of the site at the time of highest water table levels. Figure 2-8 shows ground-water contours in the bedrock. It can be seen that ground water is flowing toward Chartiers Creek from all directions.

Wells 22 and 27, located adjacent to Chartiers Creek, show elevated levels of radium-226 and uranium-238. Wells 24 and 24A show elevated levels of uranium-238. Other wells in the vicinity of the creek have low amounts of contamination. The movement of contamination with the ground water cannot be accurately established with the existing data.

Movement in a horizontal direction in the unconsolidated material would be expected to carry contamination to Chartiers Creek, and yet water quality data from the creek show no evidence of contamination, possibly due to dilution effects. Markos, et al. (May 1981, pp. 5-15) states that "equilibrium of the (radium and uranium) isotopes in the waters indicates the contamination is from contact of the interstitial waters with the solid material rather than migration and transport from a removed source," and "thermodynamic calculations suggest that interstitial waters are supersaturated with most contaminants and will either precipitate, forming their own minerals, coprecipitate, or become adsorbed by an iron precipitate" (May 1981, pp. 5-23). Basically, the question of contaminant migration via ground water has yet to be resolved, therefore, the worst-case potential for migration by means of ground water must be assumed.

Water flow from the unconsolidated material into the shallow bedrock could carry contamination in a vertical direction. Limited data have shown lower levels of contamination in shallow bedrock than in unconsolidated material immediately above it. No data exist concerning contamination in deep bedrock.

No sampling has been done on the other side of Chartiers Creek to document the ground-water flow regime or extent of contamination, if any.

Contamination encapsulation is the primary means of cleaning up the ground water at the Canonsburg site. This will eliminate any additional contamination although it will not affect existing levels of contamination. The regulatory requirements detailed in Section 2 specify that drinking-water standards must be met in the ground water at distances greater than 1.0 kilometer from the site. Natural attenuation effects may be sufficient to meet these requirements in the long term, however, until these effects dominate, additional treatment may be required. To accomplish this, a passive subsurface ion-exchange barrier could be used. The need for this barrier must be established by means of verification of existing ground-water data, obtaining additional data, and the possible computer simulation of the ground-water flow regime. The barrier would be located along the Chartiers Creek portion of the site perimeter, as shown on Figure 6-2, in the unconsolidated material, approximately 15 to 20 feet in depth. It would be constructed of a sand and natural zeolite mixture to provide ion-exchange capabilities without affecting the natural flow regime. Zeolites have been used at the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho, and in the General Electric Company operations near Morris, Illinois to decontaminate low-level radioactive wastes from irradiated fuel storage basins.

Depending on specific design parameters, the barrier can be expected to be effective for approximately 5 to 10 years. Based on Canonsburg water quality data, the barrier would have the capacity to treat up to 7200 gallons per square foot. Many ion-exchange sites in the barrier would be used by species other than the radionuclides of concern, such as heavy metals, because of the poor overall ground-water quality in the area. The short service life would be sufficient since the barrier is to serve only as an interim measure until natural flushing has been accomplished.

6.2 MONITORING PROGRAMS

6.2.1 Introduction

Monitoring activities at the Canonsburg site fall into two basic categories, as follows:

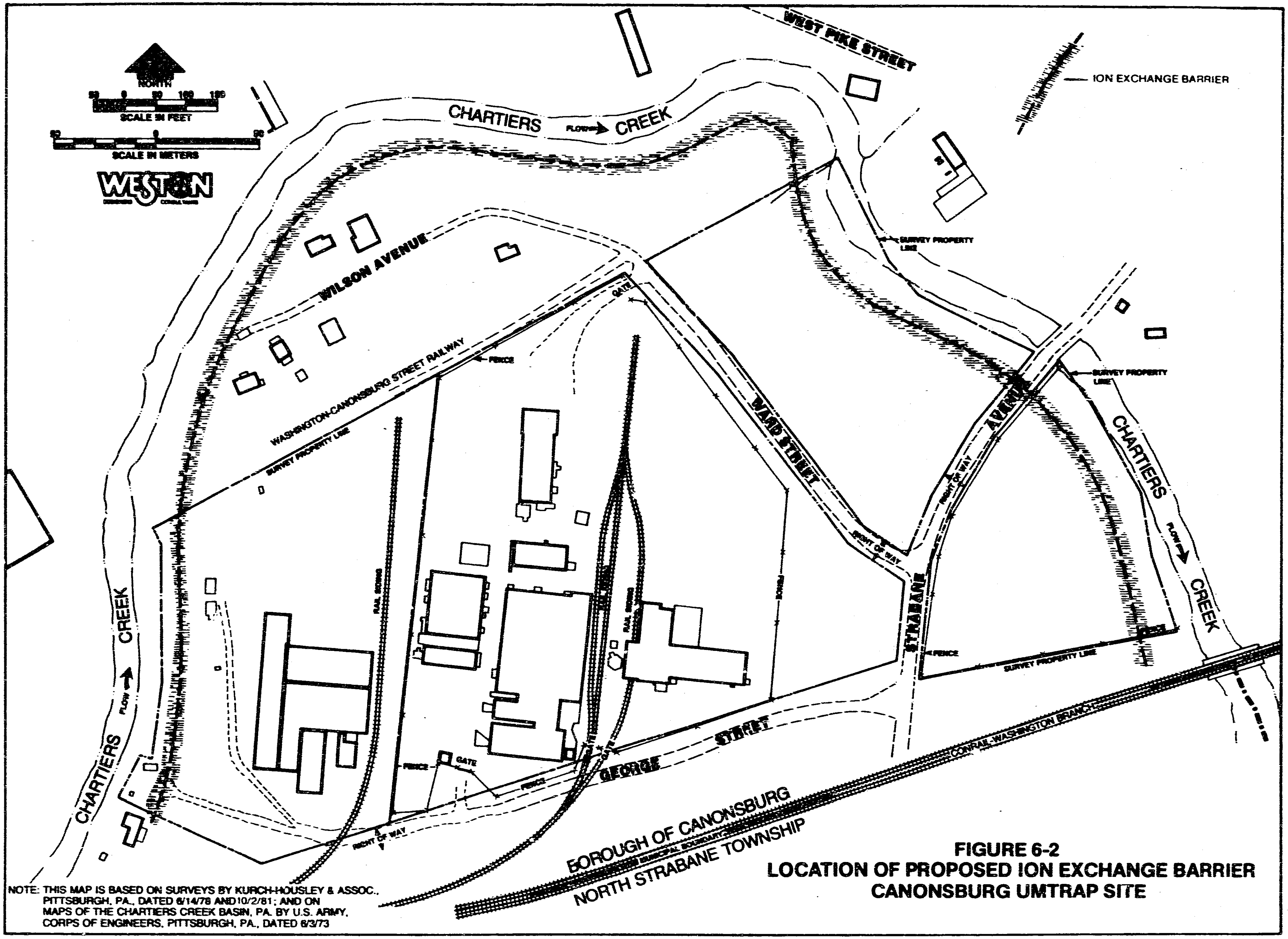
1. Radiological environmental monitoring.
2. Personnel and workplace monitoring.

6.2.2 Radiological environmental monitoring

Table 6-3 presents radiological criteria for the predominant pathways and isotopes at the site. This information led to the development of a two-phase monitoring program, as follows:

1. Phase I -- During construction and closure activities.

2. Phase II -- Immediately after closure.



NOTE: THIS MAP IS BASED ON SURVEYS BY KURCH-HOUSLEY & ASSOC., PITTSBURGH, PA., DATED 6/14/78 AND 10/2/81; AND ON MAPS OF THE CHARTIERS CREEK BASIN, PA. BY U.S. ARMY, CORPS OF ENGINEERS, PITTSBURGH, PA., DATED 6/3/73

FIGURE 6-2
LOCATION OF PROPOSED ION EXCHANGE BARRIER
CANONSBURG UMTRAP SITE

Table 6-3. Radiological criteria for the predominant pathways and isotopes

Pathway	Media	Type of contamination	Standard/ guideline	Source	Limit
Surface contamination	Building material	Gross alpha (from Ra-226)	Regulations guidelines 1.86 "Decontamination Guidelines for Facilities and Equipment"	USNRC, 1976	300 dpm/100 sq cm
		Removable gross alpha (from Ra-226)			20 dpm/100 sq cm
		Gross beta			0.2 mrad/hour at 1 cm
External radiation	Not applicable	Not applicable	Dose Limits to Public Individuals	NCRP, 1971	500 mrem/year
			"Decontamination Guidelines for Facilities and Equipment"	USNRC, 1976	0.2 mrad/hour
			Clean-up Criteria for Uranium Mill Sites	USNRC, 1978	140 mrem/year
Air	Concentration within buildings	Rn-222	10 CFR 20	USNRC, 1960	3 pCi/l
		Rn-222 + daughters			0.033 WL
		Pb-210			4×10^{-3} pCi/l
		Ra-226			3×10^{-3} pCi/l
		Th-230			8×10^{-5} pCi/l
		U-238			3×10^{-3} pCi/l
	Ground emanation	Rn-222	40 CFR 192 (proposed)	USEPA, 1980	2 pCi/sq m/sec
Ground water	Onsite	Ra-226 + 228	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/l
		Uranium, total			10 pCi/l
Soil	Floor drain sediments	U-238	10 CFR 40	USNRC, 1961	172 pCi/g
		Ra-226	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/g
	Surface onsite	U-238	10 CFR 40	USNRC, 1961	172 pCi/g
		Ra-226	40 CFR 192 proposed)	USEPA, 1980	5 pCi/g
	Surface offsite	U-238	10 CFR 40	USNRC, 1961	172 pCi/g
		Ra-226	40 CFR 192 (proposed)	USEPA, 1980	5 pCi/g

The Phase I program is described in Table 6-4. This program will be in effect for the duration of the remedial-action period, and is geared toward environmental protection and confirming the results of the personnel and workplace monitoring program.

The Phase II program will be conducted immediately after closure, and has as its primary objective determination of the remedial action's effectiveness. This will be accomplished as follows:

1. Measuring and evaluating the beta gamma and gamma dose rates at 1-centimeter and 1-meter heights, respectively, over the entire site.
2. Measuring and evaluating the radon flux rates from the site.
3. Measuring and evaluating the alpha, beta, radium-226, and uranium-238 levels in upgradient, midgradient, and downgradient wells.
4. Measuring and evaluating the alpha, beta, radium-226, and uranium-238 levels in Chartiers Creek water and sediment samples upstream of the site, in the site discharge area, and downstream.
5. Measuring and evaluating the alpha, beta, radon-222, and radon daughter product levels in the air environment on the site and immediately off the site in the downwind direction using high-volume sampling techniques.

6.2.3 Decontamination of construction equipment

Vehicles and equipment which are only operating on the site may not have to be decontaminated until ready to leave the site. All onsite vehicles, however, will be monitored routinely to determine if the operator's cab or cab entry is contaminated. Decontamination of the vehicle operator's cab and cab entry point will be carried out as needed.

Vehicles or equipment preparing to leave the site will be monitored prior to leaving. If contamination is found, the equipment will be decontaminated. This may consist of dry removal followed by steam cleaning, and then washing as required on the decontamination pads as shown on Figure 6-3.

6.2.4 Worker decontamination

To prevent any contamination from leaving the site on construction workers, inspectors, or other personnel, a workers' facility may be required. This facility would serve as a barrier between clean and contaminated areas of the site. At the beginning of a working shift a worker would enter the facility from the "clean side," don his protective clothing, and leave the facility on the "contaminated side." At the end of the shift, the process would be reversed, with the protective clothing left behind in the facility. Personnel

Table 6-4. Construction monitoring program

Sample type	Number of sampling locations	Analyses	Frequency of sampling and analysis
External radiation			
Thermoluminescent dosimeters	Locations to be determined	Gamma dose	Monthly
Ground water	Monitoring wells as available (one up-gradient, one mid-gradient, three down-gradient)	Gross alpha and beta, Ra-226, U-238	Monthly
Surface water	Chartiers Creek (upstream, discharge area, and downstream)	Gross alpha and beta, Ra-226, U-238	Monthly (continuous composite)
Particulates			
AP filters	Locations to be determined	Gross alpha and beta	Weekly (continuous composite)
Radon in air	Locations to be determined	Rn-222 and daughters	Continuous
Sediment and surface soils	Onsite areas for soil Chartiers Creek sediments (upstream, discharge area, and downstream)	Ra-226, U-238	Monthly
Waste-water treatment	To be determined	Gross alpha, gross gamma, Ra-226, U-238	Monthly and continuous

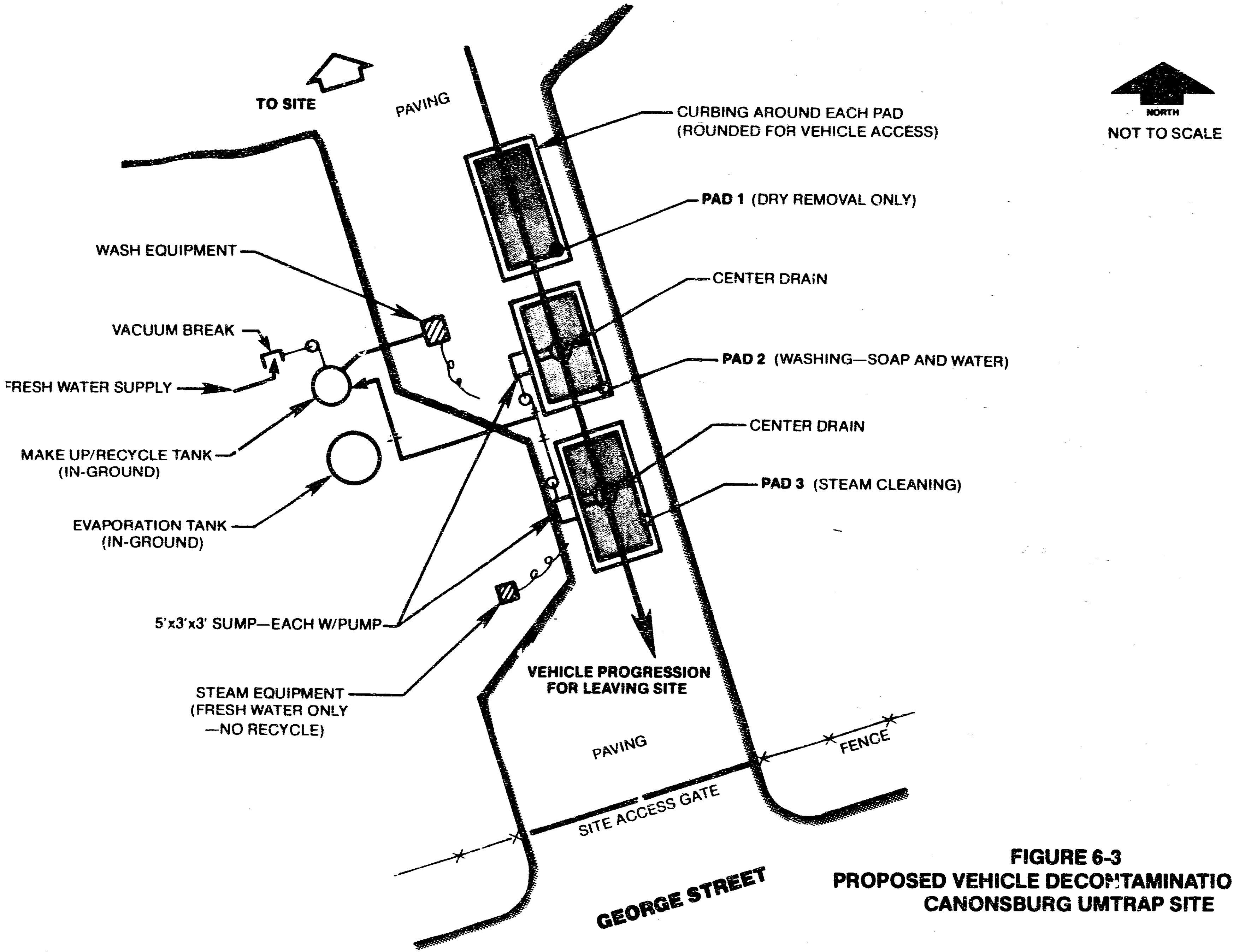


FIGURE 6-3
PROPOSED VEHICLE DECONTAMINATION AREA
CANONSBURG UMTRAP SITE

may be required to shower prior to leaving the site, and all protective clothing would be laundered in the facility. Waste waters from showers and laundry would flow to the waste-water treatment plant for treatment prior to discharge. Lockers and sanitary facilities (discharged to existing sanitary sewer system) would also be provided in the workers' facility.

A health and safety plan for the protection of employees, subcontractor personnel, and the general public has been developed. The health and safety plan initially requires all personnel to attend a four-hour orientation session. Here they will receive instruction on the following:

1. Potential hazards associated with the job.
2. Measures that can and will be taken to ameliorate these hazards.
3. Purpose and types of radiation monitoring that will be performed.
4. Individual and collective responsibilities in radiation safety.
5. Specific safety procedures that will be followed, including:

    a. Description of the entry and exit procedures.
    b. Dosimetry.
    c. Special clothing.
    d. Use of the employees' shelter.

The purpose is to sensitize employees to potential hazards, to make them aware that safety procedures, although at times burdensome, have been put in place for their protection and that they should maximize the use of these procedures and minimize exposure.

In order to properly implement the health and safety plan, all personnel must submit pre- and post-job urine samples for radiological analysis, and wear radiation dosimeters at all times when on the job site. These steps are necessary in order to evaluate any potential radiation exposures, which by design, are to be kept as low as reasonably achievable.

Radiation exposure of personnel on the job site would be minimized if necessary by having all employees report to the employee shelter where they would be issued, and would put on, appropriate protective clothing prior to entering the job site. They would then report to their specific job locations. Any time personnel leave the site, or at the end of the work day, they must report to the employee shelter and return all protective clothing and be monitored for radiation exposure. Additionally, eating and smoking would only be permitted within the confines of the employee shelter. Members of the general public that have a need to enter the job site would follow the same procedures.

Radiation exposure of the offsite general public will be prevented by monitoring and cleaning all equipment prior to it leaving the job site. Exposure will also be prevented by conducting decontamination processes in a manner which mitigates the spread of contaminated materials off the site. This includes stopping all work under adverse environmental conditions.

REFERENCES FOR SECTION 6

Markos, G., K.J. Bush, and T. Freeman, May 1981. Geochemical Investigation of UMTRAP Designated Site at Canonsburg, Pennsylvania, Geochemistry and Environmental Chemistry Research, Inc., prepared for the U.S. Department of Energy.

7 Implementation Guidelines

7.1 FINAL ENGINEERING DESIGN

The selected concepts were carefully evaluated for feasibility of design and construction. However, many items and details must be investigated further for the final design. The major items that will require in-depth analyses are the following:

1. The composition and consistency of the material in Area C is uncertain at the present time. More specific data on this material must be obtained with a program of field testing, sampling, and laboratory analyses. Material-handling details will be resolved using the results of these analyses.

2. Refinements of the cover and liner composition to ensure the desired performance are needed. Detailed testing and evaluation of cover and liner materials are required to determine properties which control water movement into and out of the system.

7.2 CONSTRUCTION SEQUENCE

The physical size of the site will place some constraints on the construction sequence. The encapsulation area covers the central portion of the site, as may be seen in the preliminary site development plan, Figure 4-1. Simultaneous construction would result in mutual interference.

The recommended construction schedule is presented on the milestone chart on Figure 7-1. To protect the site from flooding and prevent contamination from being carried off the site by surface water, the flood control berm should be constructed before excavation of any contaminated materials begins. The sedimentation basin (described in Section 6 of this report) should be installed simultaneously.

Building decontamination and demolition should begin in the vicinity of the encapsulation area to facilitate filling the Ward Street cut, and support berm construction and installation of the liner. Limited amounts of contaminated soils in the area should be excavated and stockpiled prior to liner installation. When the liner is completely in place, soil excavation should continue along with building decontamination and demolition. As excavation of the various hot spots is completed, the holes should be backfilled with decontaminated building rubble. Further sequencing is not critical except that high priority should be given completing the cap in the encapsulation area to avoid collection of excess quantities of rain water in the liner.

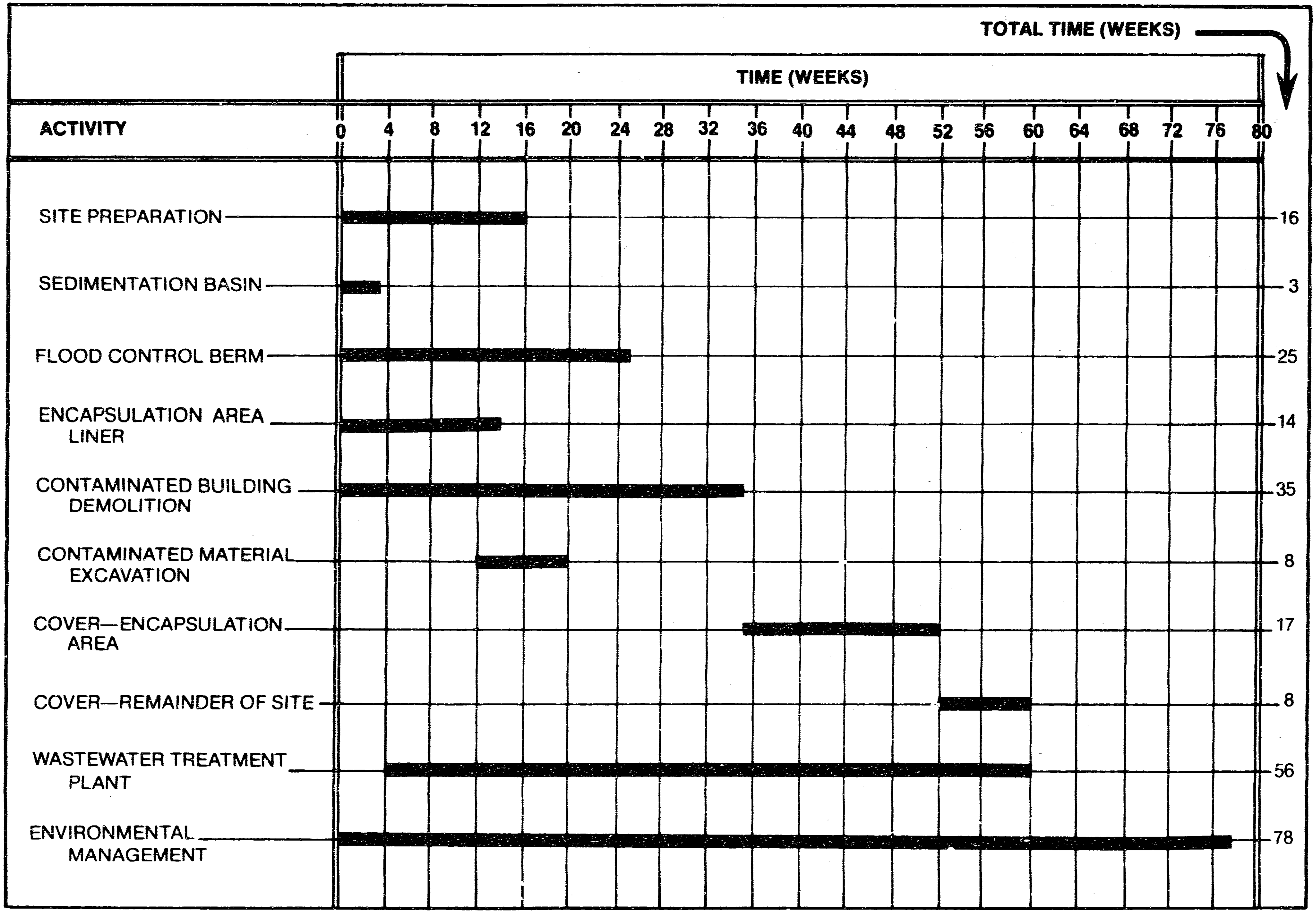


FIGURE 7-1 PRELIMINARY CONSTRUCTION SCHEDULE
CANONSBURG UMTRAP SITE

7.3 MATERIAL AVAILABILITY

7.3.1 Fill soil and topsoil

Conversations with a local contractor have revealed that a large quantity of good quality fill soil can be found within 4 miles of the site. This soil can be used as cover material over the majority of the site and as a component of the multilayer cover (encapsulation area). It is estimated that a total of 286,000 cubic yards would be needed to provide 6 feet of cover over areas other than the encapsulation cell. As detailed in Section 5, this amount could be reduced to 100,000 cubic yards, depending on regulatory requirements and the depth of contamination. Some of this material may be obtained from clean areas on the site, from areas such as the Georges Pottery site, and the residential area.

It is expected that the fill soil would retain any radon gas at least for the duration of its half life (3.8 days). This should prevent any contamination of the surface soil. Fill soil can also be used for construction of the flood levees, and any other necessary site grading.

A 6-inch layer of topsoil would be required over the entire site in order to promote the growth of grasses and other small vegetation. This topsoil should be fertile, friable, and neither excessively acid nor alkaline. A total of 24,200 cubic yards would be required. This amount is available at a distance of 4 miles from the site. Time-released herbicides are currently being researched by Pacific Northwest Laboratories, and could be used to provide a biological barrier to any deep-rooted vegetation if demonstration projects prove that this is feasible. The herbicides would be strategically placed in the upper soils to allow the growth of small vegetation, but exclude any deep-rooting vegetation. Since these herbicides are in the developmental stage, the application cost has not been included in this report.

7.3.2 Impermeable material

A natural clay is available within 10 miles of the Canonsburg site. A local contractor has been successful in using it to control seepage, and he believes it would be suitable for use as a secure liner. It would be used in the encapsulation-cell liner and cap. Other uses could include liners for the equipment decontamination area, the salvageable steel decontamination area, and the sedimentation basin. The total amount of clay required is estimated at 27,500 cubic yards.

If tests prove this soil is unsuitable for the specified uses, a mixture of bentonite and native soil would be specified. Since this mixture would be more costly than a native clay, the cost estimate (Subsection 8.1) was prepared with the assumption that a natural clay would be unavailable.

7.3.3 Gravel

Gravel and sand would be used in the multilayer cover system to provide a drainage medium for infiltration from precipitation. It would also provide a barrier against burrowing rodents. Some crushed stone would also be used in the truck-washing area, and for pipe bedding and erosion control. Crushed and graded slag is available from a local site. An estimated 2000 cubic yards would be required for the 6-inch drainage layer of the contaminated material encapsulation area.

Fine-grained sand could also be obtained from a local source. A total of 2000 cubic yards would be required for the 3-inch upper and lower layers of the drainage system.

7.4 TRAFFIC PATTERNS AND CONTROL

Before any construction begins at the Canonsburg site, Strabane Avenue and Ward Street will be closed to all traffic. Construction vehicles would obtain access to the site at the Strabane Avenue and George Street intersection. No vehicle should be allowed to exit the site without stopping at the decontamination station located at this intersection. All vehicles should be monitored for contamination at the decontamination station and cleaned, if necessary. Rail hauling may be utilized in some instances, specifically for transporting fill material, clay, etc.

During construction the Ward Street location would be used as part of the waste encapsulation site.

After all construction is completed, Strabane Avenue would be swept clean and repaved. A fence would be placed along each side of Strabane Avenue to prevent vehicular traffic on the site. Once Strabane Avenue has been monitored and found to be clean of any radiological contamination, it would be reopened to public transportation.

8 Feasibility Analysis

8.1 FEASIBILITY CRITERIA

The feasibility of in-situ stabilization as a remedial action at the Canonsburg site was evaluated using a set of nine criteria. These criteria are as follows:

1. Satisfaction of regulatory requirements.
2. Use of demonstrated technology.
3. Long-term stability.
4. Public acceptability.
5. Constructability and scheduling.
6. Implementability.
7. Flexibility of control elements.
8. Impact on other UMTRAP sites.
9. Cost-effectiveness.

The proposed remedial-action plan was considered in light of each of these criteria, which are discussed in the subsections that follow.

8.2 SATISFACTION OF REGULATORY REQUIREMENTS

It is difficult to determine if the EPA criteria of a 1000-year service life could be met. Through the use of low- and no-maintenance structures and natural materials, a long service life is ensured, although it is not possible to predict the actual length at this time. A multilayer encapsulation area cover and the soil cover for the remainder of the site would reduce radon gas flux to the regulatory level of 2 picocuries per square meter per second, as demonstrated through computer modeling efforts. Although it is believed that removal of highly-contaminated soils and natural attenuation processes may adequately control ground-water quality to regulatory levels as listed in Section 2, the installation of an ion-exchange barrier along Chartiers Creek is being proposed to serve as a passive backup system, ensuring the satisfaction of ground-water quality criteria. It has been calculated that levels of radium-226 of approximately 100 picocuries per gram could be left in the soil in Areas A and C and higher levels in Area B since the exposure potential from these levels can be controlled by means other than removal, such as cover and passive ground-water treatment. In addition, the NRC guideline of no need for long-term maintenance has been addressed by the use of passive systems.

8.3 USE OF DEMONSTRATED TECHNOLOGY

The creation of a secure encapsulation cell on the site would use proven technologies developed for hazardous waste handling. Building decontamination techniques used in this concept are adaptations of techniques used at other sites contaminated with radioactive elements. Ion-exchange processes for waste-water treatment are currently being used at nuclear generating stations and for other radioactive waste waters.

8.4 LONG-TERM STABILITY

As previously stated, the use of natural construction materials and low- and no-maintenance structures would provide long-term stability for the site.

8.5 PUBLIC ACCEPTABILITY

Public opinion in the Canonsburg area seems to favor in-situ stabilization over site decontamination and disposal elsewhere as a remedial action for the industrial park area. The appearance of the site when the remedial action is complete should not be objectionable since the general topography will be preserved in higher elevation.

Disposal of treated waste water in Chartiers Creek, though feasible from technical and regulatory standpoints, may be unacceptable to local residents. If it is unacceptable, an alternative discharge option may be required. The treated effluent could be injected into the remainder of the site (outside the encapsulation cell) for the purpose of refluxing and recovering additional contaminants. The expense of such an option would be minimal, but is not included in the cost estimate at this time.

8.6 CONSTRUCTABILITY AND SCHEDULING

Table 8-1 illustrates an approximate construction schedule under which remedial action would be completed within 18 months. This schedule assumes no delays for weather, monitoring activities, etc. All of the required construction activities could be performed by most large general contractors, without the use of highly specialized equipment.

Table 8-1. Preliminary construction schedule

Activity	Start (week number)	Finish
Sedimentation basin	1	3
Flood control berm	1	25
Encapsulation area liner	1	14
Site preparation	1	16
Building decontamination and demolition	1	35
Contaminated material excavation	12	20
Encapsulation area cover	35	52
Remainder of site cover	52	60
Waste-water treatment plant	4	60
Environmental management	1	78

8.7 IMPLEMENTABILITY

There are several items that must be evaluated before implementation to assure the effectiveness of the remedial action. These include the following:

1. Refinements of the cover and liner designs to ensure the desired performance. Detailed testing and evaluation of cover and liner materials is required.
2. Analysis of the effectiveness of pelletized herbicides to control vegetative growth to desired levels for an extended period of time.
3. Detailed analysis of locations of contaminated soils both on and in the vicinity of the industrial park property.
4. Analysis of traffic volume generated by transport of construction materials to the site. The volumes of material required could necessitate a sizeable amount of truck traffic through the Borough of Canonsburg. Rail haul is a possibility if material sources can be located near existing rail lines. Reduction of material requirements as discussed in Section 5, and use of onsite clean soils should be investigated.

8.8 FLEXIBILITY OF CONTROL ELEMENTS

The feasibility design presented for the remedial action at Canonsburg is flexible. The encapsulation area has presently been sized to contain all contaminated soils now known to exist on the site. During studies performed before implementation, if it is found that the quantity of contaminated soil changes, the design can be modified for the appropriate capacity. The effectiveness of optional cover designs for the encapsulation area and the remainder of the site has been analyzed in the event that regulatory requirements are relaxed. In general, the conceptual design could be adapted to any set of regulatory criteria imposed during the final design phase.

8.9 IMPACT ON OTHER UMTRAP SITES

The contamination problems encountered at the Canonsburg site are numerous and complex. They include problems found at most other UMTRAP sites; therefore, control methods developed for remedial action at Canonsburg can be applied to these other sites. Equipment purchased for the waste-water treatment plant could be transported and used at the other sites, if required.

8.10 COST-EFFECTIVENESS

Table 8-2 lists approximate cost estimates for in-situ stabilization of the Canonsburg site. The costs are presented in a modular format so that each element of the control concept can be reviewed.

The cost-effectiveness of the proposed remedial action is based on the encapsulation concept. All other costs associated with this particular program of remedial action would be incurred as a part of any other remedial-action program. For example, if the contaminated soils were chemically stabilized rather than encapsulated, costs for excavation, building decontamination and demolition, waste-water treatment, site preparation, and covering the remainder of the site would not change. The cost for chemical stabilization and subsequent handling should be compared only to the cost of the encapsulation area, $1,735,000. Other cost estimates for the cleanup of the Canonsburg site have not considered these constant costs separately from the costs of handling the contaminated soils. In addition, the cost estimation has considered the "worst-case" scenario, so that no additional costs would arise during implementation. The cost estimate is, therefore, a maximum estimate; actual costs could be significantly lower if the actual case is not the "worst case." The modular analysis developed clearly illustrates the cost effectiveness of in-situ stabilization. Cost reductions can be achieved by the following means:

1. Relaxed regulatory requirements -- If the regulatory level for radon flux was relaxed, considerable savings could be realized. For example, if a 6-foot multilayer cover (3 feet of clay, 1 foot of gravel, 2 feet of soil) was used instead of the 10-foot design, and 3 feet of soil rather than 6 feet over the remainder of the site, a saving of $1.1 million would result. Additional savings of $59,000 would be realized by implementing the cover scenario described in Table 5-1.

2. Ion-exchange barrier -- The need for the ion-exchange barrier has not been established at this time. If ground-water studies show that it is not required, approximately $500,000 in savings could be realized.

3. Waste-water treatment -- Detailed waste-water characterization and treatability studies may show that little or no waste-water treatment is required, thus providing significant cost savings.

4. Building decontamination -- The specified levels of building decontamination may be excessive. Lower levels of decontamination could generate cost savings up to $250,000.

Table 8-2. Approximate cost[a]

Item	Approximate cost		
Encapsulation area (3 acres)			
Liner	$ 720,000		
Material filling	80,000		
Multilayer cover with vegetation	935,000		
Subtotal		$1,735,000	
Remainder of site (27 acres) 6-foot cover with vegetation		$1,790,000	
Contaminated soil excavation (23,985 cubic yards)			
Dewater Area C	60,000		
Excavation and material handling	215,000		
Subtotal		$275,000	
Building decontamination and demolition			
Building decontamination	200,000		
Salvageable-steel decontamination (4,700 tons)	30,000		
Building demolition	575,000		
Demolition-debris handling (18,000 cubic yards)	120,000		
Subtotal		$925,000	
Waste-water treatment		510,000	
Ion-exchange barrier (48,000 square feet)		500,000	
General site preparation			
Flood-control berm (2,400 feet)	240,000		
Fencing (7,000 feet)	100,000		
Remove railroad embankment and track (1,900 feet)	40,000		
Vehicle decontamination	30,000		
Worker facility	30,000		
Demobilization and cleanup	25,000		
Subtotal		$465,000	
Construction cost			$6,200,000
Contingency (15 percent)			930,000
Standby equipment and crew[b] (100 days at $5000 per day)			500,000
Engineering			713,000
Construction and environmental management			$1,500,000
TOTAL			$9,843,000

---

[a] Based on Engineering News Record cost index 3560; all individual cost items include 15 percent contingency for quantities, labor rate, etc.

[b] Cost of idle time for inspections, construction quality control, monitoring, and inclement weather.

9 Conclusions and Recommendations

9.1 CONCLUSIONS

The study of the Canonsburg site was initiated to ascertain the feasibility of onsite stabilization of all the radioactive contamination to satisfy the following objectives:

1. Prevention of ground-water and surface-water contamination.
2. Minimization of radon emanation from the site due to buried radioactivity.
3. Minimization of radiation exposure to persons working on, living near, or using the site.
4. Application of feasible engineering techniques such that a 1000-year life could be reasonably assured for the site after stabilization.

Upon completion of this study, the conclusions that can be drawn are the following:

1. An innovative remedial-action plan for in-situ stabilization has been developed that is both cost effective and feasible. Preliminary estimates are for a total cost of approximately $10 million.
2. A multilayered cover system has been developed. It is 10 feet deep (consisting of 3 feet of clay, 1 foot of gravel, 6 feet of soil) which restricts infiltration to 1 percent of precipitation, and controls radon flux rates to the regulatory levels of 2 picocuries per square meter per second.
3. All of the more highly contaminated materials (23,700 cubic yards of soil and 14,000 cubic yards of demolition rubble) on the site can be handled using demonstrated technologies.
4. The 80,000 cubic yards of material on the Burrell landfill site and the 5700 cubic yards of material on the vicinity properties can also be incorporated into this design.
5. These disposal technologies will satisfy proposed EPA and current NRC criteria for remedial action, and are flexible enough to handle a variety of future regulatory postures.
6. This plan will minimize impacts on the public during construction (a period of approximately 18 months), and its implementation will ensure long-term stability.

9.2 RECOMMENDATIONS

Recommendations were carefully evaluated for their feasibility and cost-effectiveness; there are three technical uncertainties that should be addressed before the implementation of a detailed stabilization plan. It is recommended that the following items be analyzed in depth:

1. The composition of the soil, and bentonite cap, and liner layers for the encapsulation-cell site must be determined by laboratory testing to determine the mixtures of site soil and bentonite that will have the desired permeability.
2. A more accurate determination of the extent of subsurface soil contamination must be made before construction.
3. A more complete evaluation of ground-water quality and flow regime must be completed in order to evaluate the need for the ion-exchange barrier.

Numerous other design and construction details must be resolved before implementing the final engineering design, such as the following:

1. Preconstruction monitoring to verify the final engineering design.
2. Analysis of the radon flux rates through the indigenous soils to be used as fill and cover materials.
3. Final construction-cost estimates.

It has been concluded that the implementation of these recommendations will achieve the following:

1. A cost-effective plan for in-situ stabilization.
2. An innovative, environmentally sound solution to the unique conditions and problems present at the Canonsburg site.
3. A set of control concepts that can be applied at other sites in the Uranium Mill Tailings Remedial Action Program.
4. Satisfaction of current or future revised regulatory requirements.

In order to meet the stated objectives for the stabilization of the Canonsburg site, recommendations are made as follows:

1. Area A hot spots and Area C contaminated soils should be placed in an encapsulation system. The encapsulation system should have a multilayer cover and a full liner.
2. The multilayer cover should be used for lowering the external direct dose, for ground-water protection, and for the control of radon emanation. This cover would be composed of upper layers of noncompacted soil (72 inches), coarse gravel, and crushed rock (12 inches) and a bottom layer of clay (36 inches).

3. An ion-exchange barrier may be necessary on the site along the creek as an interim ground-water protection measure until the natural attenuation resulting from encapsulating contamination source material controls ground-water quality.

4. The buildings on the site should be decontaminated before demolition in order to minimize possible airborne contamination. Structural steel should be decontaminated and salvaged. After demolition, building rubble, along with debris from vicinity properties and clean fill, should be used as fill in pits excavated to remove the more contaminated soils.

5. The remainder of the site should be covered with a layer of soil of up to 6 feet to properly adjust drainage patterns and further ensure site integrity.

6. All final grading on the site should be to levels above the 100-year flood elevation.

7. An erosion-control plan should be developed by the construction contractor.

END

DATE FILMED

02 / 12 / 91