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SUMMARY REPORT ON THE LOW-LEVEL RADIOACTIVE WASTE BURIAL SITE, WEST VALLEY, NEW YORK (1963 - 1975)

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II
REGIONAL OFFICE OF RADIATION PROGRAMS
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

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FOREWORD

Since the discovery of x-rays in 1895, man has sought to exploit the many benefits that radiation can provide to human welfare. Since that time, the sources of radiation have expanded at a very rapid rate both in scope and quantity. As the sources of radiation have increased so have the amount of radioactive wastes. Because these radioactive wastes have long half-lives, releases to the environment must be restricted over thousands of years.

EPA's objective for the management of radioactive wastes is to assure that no unwarranted risks are imposed upon present or future generations from exposure to radiation from this source. This will be done by ensuring that all radioactive waste materials are isolated from the biosphere during their hazardous lifetimes.

EPA is responsible for establishing environmental standards which must be met in connection with waste management activities. EPA will coordinate its efforts with ERDA, NRC, and USGS through an interagency working group established by EPA.

As a first step, EPA will establish environmental criteria for radioactive waste management which will provide environmental and public health guidance to Federal agencies responsible for developing radioactive waste disposal alternatives. In parallel EPA will develop numeric environmental standards for high-level waste disposal. Subsequent efforts will be devoted to developing environmental standards for other types of wastes and disposal options. The two most immediate problems are the disposal of high-level wastes and low-level wastes; interim standards are anticipated for these two classes of waste by 1977 and 1979 respectively. In order to accomplish these national goals, EPA's regional offices serve as a focal point for collection of operational and surveillance data for existing sites.

This report discusses the disposal of low-level radioactive wastes at a specific site, West Valley, New York. The report has three goals. The first is to summarize results of a migration study performed for EPA by various New York State agencies at the West Valley site. The second goal is to provide a data base for the development of criteria, guidelines, and standards for future low-level waste burial sites by compiling pertinent West Valley data into a single document. The third goal is to make available to others interested in the siting and operation of radioactive waste burial sites some of the more important experiences, problems, and corrective actions encountered during the operation of the West Valley site. Considerable assistance has been received from various New York State agencies involved with the West Valley site as well as EPA's Office of Radiation Programs.

I believe this report will be valuable to readers concerned with low-level radioactive waste burial. I encourage users of this report to inform the Region II Office of omissions or errors. Your additional comments or requests for further information are also solicited.

Gerald M. Hansler, P.E.
Regional Administrator

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EXECUTIVE SUMMARY

In 1973, the New York State Department of Environmental Conservation (NYSDEC) asked the U.S. Environmental Protection Agency (EPA) for assistance in determining whether radionuclides were migrating from the Nuclear Fuel Services' (NFS) West Valley low-level radioactive waste burial area through the subsurface to the surrounding environment. A lithological boring study was performed in 1973 and 1974 showing tritium contamination of the surface area and of the first 10 to 15 feet of strata immediately adjacent to the trenches used for burial. Although the results were inconclusive, the study indicated several sources of tritium contamination were possible. Downward migration resulting from fallout from the nearby nuclear fuel reprocessing plant, or from spillage occuring during burial operations are potential sources of the contamination. Lateral migration in certain geologic areas directly from the burial trenches is another potential source of the contamination. While the data is insufficient to indicate which way the tritium is moving, it can be surmised that no significant lateral migration has taken place to date.

Extensive water infiltration has also occurred in some of the trenches, and in March 1975, water containing radionuclides seeped through two of the trench caps, contaminating the adjacent surface area, and entered a nearby stream. Burial operations were terminated by NFS shortly after this seepage was detected by NYSDEC. The New York State Energy Research and Development Authority (NYSERDA) is conducting studies aimed at eliminating this problem and others encountered at the site. Trenches in the northern section of the site where the seepage occurred contain more than 3 curies of cesium-137, 15,000 curies of strontium-90, 46,000 curies of cobalt-60, 26,000 of combined carbon-14 and tritium, 15,000 curies of tritium, 19,000 curies of mixed fission products, and 50,000 curies of other radionuclides.

After the seepage incident, NYSDEC required the implementation of a temporary program to control trench water levels. In the northern section of the site, where trench water levels were already high, water was pumped out of the trenches, treated, diluted, and discharged into a nearby stream. An evaluation determining that this procedure would cause any significant health implications was performed prior to implementation. In the southern section, where improved capping procedures were initiated in 1968, trench water levels had not risen in a manner similar to those in the north.

Considerable erosion has also been noted during investigations of the burial site. Erosion was noted in the north end of the site where the older trenches are. In the future, erosion could cause serious problems here, including shortening distances between man, his environment, and the buried radioactivity and in the worst case, exposure of the buried radioactive material.

Future studies of the West Valley disposal site are needed to determine the cause and extent of the problems that have been identified and to develop workable solutions. At present, there are four major interrelated areas of

study;

-- Hydrogeologic data, needed to predict water migration rates, are being collected by the U.S. Geological Survey.
-- Information on the rates and pathways of any migrating radioactivity is being collected for the EPA by a number of New York State agencies under the lead of the New York Geological Survey.
-- A long-term solution to the problem of trench water level control and site erosion control are the objects of studies being conducted by NYSERDA.
-- Data on the type and concentration of radioactivity that leaves the site and enters the general environment are being collected through the monitoring system set up around the site by NYSDEC.

If the goals of low-level nuclear waste disposal are confinement and containment of the waste for the duration of its hazardous lifetime, then the low-level waste buried at West Valley may require containment on the order of several hundred to several thousand years. Based on available hydrogeological and radiological data, the following primary conclusions have been drawn:

-- In the fourteen years of operation, the north trenches at the West Valley site have not met these goals.
-- At present, radioactive material that has seeped or been pumped from the burial area does not appear to have significant health implications in terms of offsite dose levels.
-- The West Valley site does not meet 3 of 9 recommendations used for evaluating low-level radioactive waste disposal sites.
-- The West Valley does not meet 3 of 13 recommendations for evaluating a secure hazardous waste landfill.
-- More data may be needed to determine how the site can be made to meet its basic purpose which is retention of the waste for its hazardous lifetime.
-- Unless remedial measures are taken, erosion and trench water infiltration may increase the rate of movement of radioactive material.
-- THE STATE OF NEW YORK IS COGNIZANT OF THE PROBLEMS ASSOCIATED WITH THE SITE AS THEY ARE NOW KNOWN AND IS ATTEMPTING TO DETERMINE, INITIATE, AND IMPLEMENT EFFECTIVE REMEDIAL ACTIONS WITH FEDERAL ASSISTANCE.

Based on experience at the West Valley site and at other similar sites, the following general conclusions have been drawn:

-- If the goal of shallow land disposal is 100 percent retention of the waste for the duration of its hazardous lifetime, the goal cannot be met under present conditions at West Valley. Improvements are needed in the waste forms (solidification), containers, and methods of trench constructions; if West Valley and other nuclear waste burial sites in humid climates are to achieve this goal.
-- Additional Federal guidance in the form of criteria or standards, has been requested by the States and is needed to control the siting, licensing, operation, and maintenance of shallow land low-level nuclear waste disposal facilities.

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I. INTRODUCTION

A. Background

The State of New York authorized the establishment of a commercially operated, low-level radioactive waste disposal area on part of a larger site containing a facility for the reprocessing of nuclear fuel. A site in Cattaraugus County known as West Valley was evaluated and approved as suitable for a fuel reprocessing plant. Nuclear Fuel Services (NFS), the reprocessing plant operator, was licensed to operate the disposal site and in November 1963 the first radioactive material was buried. Figure 1 shows the location of the site. Shallow trenches were dug to hold the waste and an earthen cap (cover) was placed over each trench after it was filled with the waste.

In the mid 1960's all burial trenches in the northern portion of the site began to fill with water shortly after they had been covered. This posed a serious potential problem as the water could carry buried radionuclides out of the trenches and into the environment. To eliminate or reduce the water accumulation, burial procedures were changed for trenches in the southern portion of the site. The new procedures were required by the State in 1968 and stipulated new trench capping methods be used to prevent surface water from entering the trenches. To date, no significant water accumulation has occurred in the south trenches. Figure 2 is a map of the site showing the location of the various trenches.

In the early 1970's the New York State Department of Environmental Conservation (NYSDEC) detected small increases in the levels of radioactivity in streams adjacent to the burial site area. The NYSDEC hypothesized that these increased levels were caused by either burial site surface contamination or by migration of radioactivity from the trenches and asked EPA to assist in determining which pathway was the most prevalent.

Based on the NYSDEC request EPA agreed to provide funds and technical assistance to support a lithological boring study to examine (1) the amount, if any, of radioactive material moving or migrating from the site; (2) factors leading to any movement or migration; (3) generic problems of disposal sites in humid climates; (4) effects of burial operations; and (5) possible improvements in the areas of site selection, development, and operation to reduce environmental impacts of the site. The study was performed during the winter of 1973 and the spring of 1974.

By 1974 three of the trenches in the north area had developed high levels of water. Water levels in the south trenches, where modified capping procedures had been used, remained low. In March 1975 water in one trench (trench 4) in the north area seeped through the trench cap. The contaminated surface runoff from this seepage was detected by the NYSDEC surveillance program and confirmed during an onsite inspection. A similar seepage was noted shortly thereafter along the west side of the cap on trench 5 /1/. Based on this occurrence, NFS closed the burial site and it has not been reopened.

During the period from October 1963 through March 1975 more than

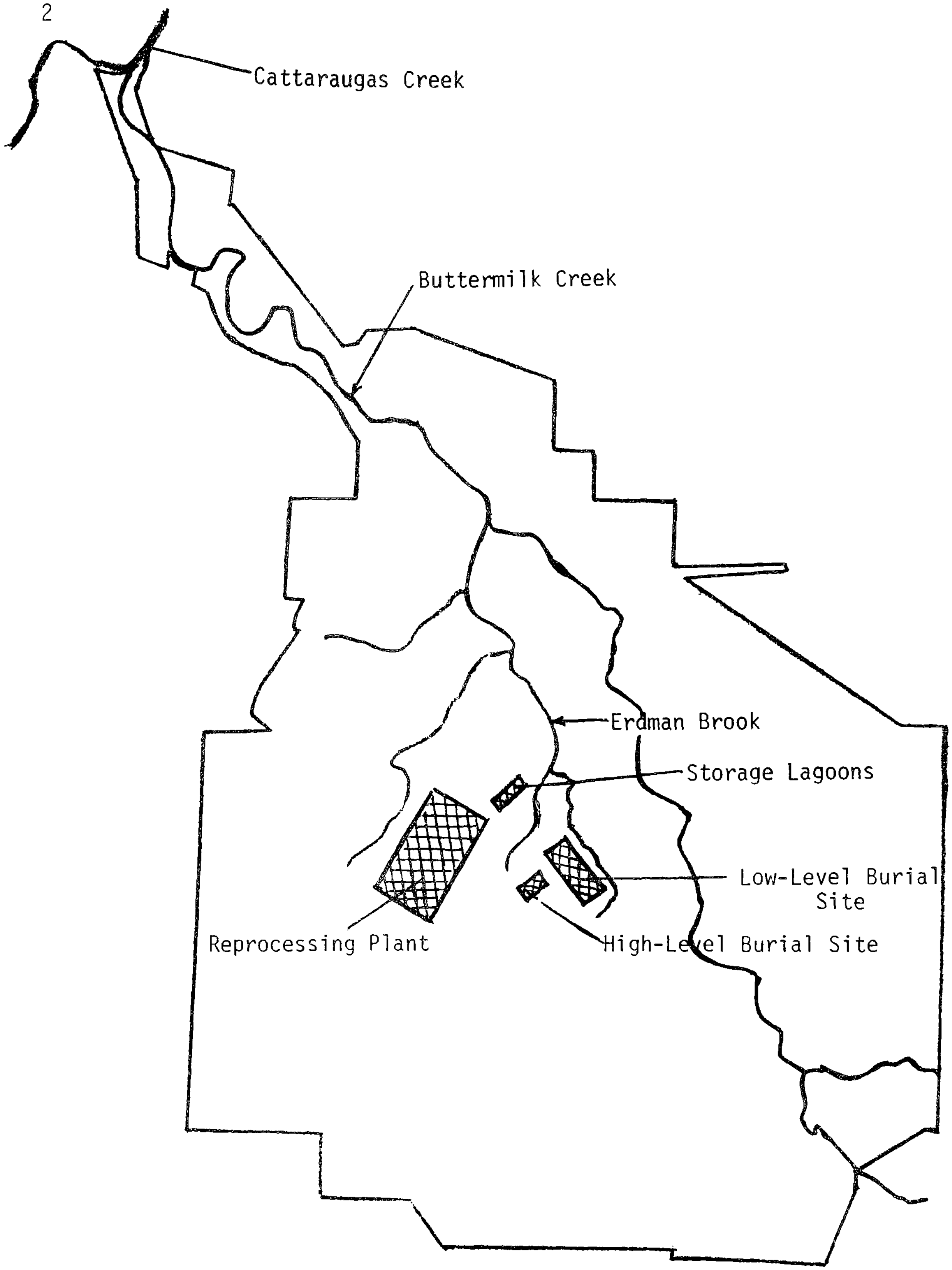
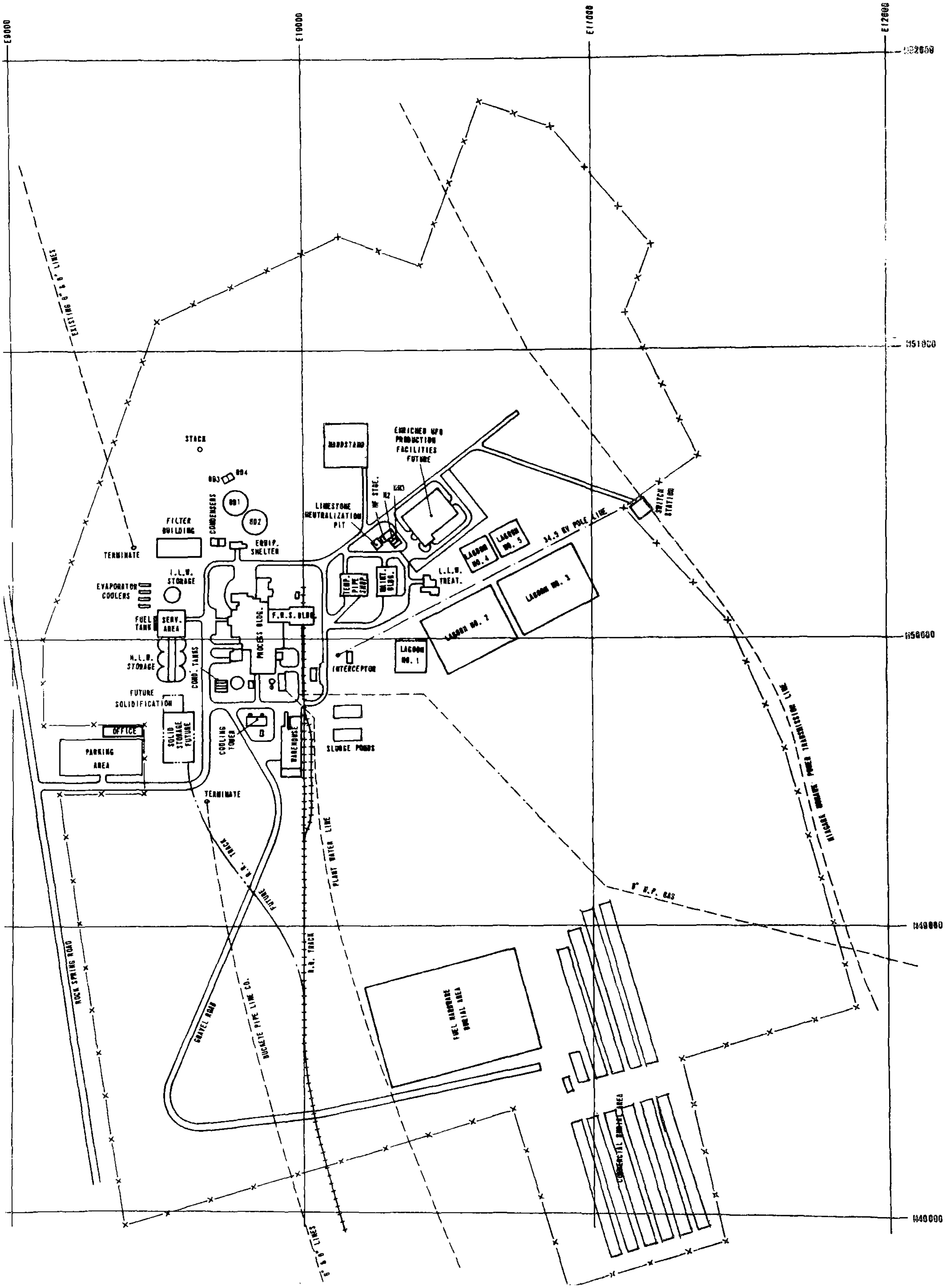


Figure 1: Geography of the WNYNSC Site

Figure 2 - Map of NFS Site



2,000,000 cubic feet of low-level radioactive waste were buried in the West Valley trenches. Kilocurie quantities of strontium-90, tritium, carbon-14, and cobalt-60 have been emplaced in the trenches along with such isotopes as radium-226, plutonium-239, uranium-233, uranium-235, and thorium-232.

The NYSDEC and NFS agreed that a program to control the water levels in the north trenches was needed to prevent further leakage. Shortly after the first seepage was detected, NYSDEC approved a NFS plan to pump water from the trenches with high water levels. The water was pumped to a low-level liquid radioactive waste treatment facility which was part of the fuel reprocessing facility for treatment. The water was then diluted and released into Erdman Brook (also known as Frank's Creek) under carefully controlled conditions.

The NYSDEC evaluated the potential health effects of the proposed pump down and treatment operation and determined that the pump down, treatment procedure, and the release of the treated trench water could be conducted in a manner which would minimize dose levels to man.* A pump down of 267,000 gallons from three north area trenches was initiated in March 1975.

Pumping water from the burial trenches to alleviate the potential impact of trench leakage is regarded by all cognizant state agencies and EPA as an unacceptable procedure for long-term maintenance of the burial site. The pump down and treatment operation may, however, be used as an interim measure to maintain positive control over radioactive releases to ensure that they are small and that they do not pose significant danger to man or the environment.

B. Purpose

The purpose of this report is to take the information gathered in the lithological boring study along with information from other pertinent studies performed on the site through March 1975 and examine the several pathways, actual and potential, for radioactivity to move from the site. Using the same information an examination of the status of this site will be compared with recommendations made for low-level nuclear waste disposal sites and hazardous material disposal sites. Possible improvements in the areas of the site selection, development, and operation to reduce environmental impacts of this and similar sites will be recommended. Finally, follow up studies that are either needed or being performed will be described.

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* Dose levels were estimated by NYSDEC to be below 0.001 mrem the maximally exposed person from all pathways resulting from the pump down. The dose was estimated by NYSDEC to be less than 1.0 man-rem.

II. METHODOLOGY AND PARTICIPANTS

This report represent two separate and individual tasks. The first task involved a literature survey of past studies conducted during the siting, development, operation, and maintenance of the low-level burial site until March 1975. The second major task involved the lithological boring study of the site performed during the winter of 1973 and the spring of 1974.

A. Literature Survey

Studies conducted on the West Valley site fall into five categories: (1) siting studies, (2) outside surveillance reports, (3) NFS surveillance and operational reports, (4) health effects studies, and (5) field observation studies. In general, most of the studies encountered do not concentrate on, or are specific to, the burial area but refer to the entire fuel reprocessing and low-level radioactive waste disposal facility site that is officially known as the Western New York Nuclear Service Center (WNYNSC).

Siting Studies

The New York Geological Survey (NYGS) and the United States Geological Survey (USGS) conducted geological, hydrological, and geophysical evaluations for siting of a facility for the reprocessing of spent nuclear fuel elements and the storage of high- and low-level radioactive wastes. These studies are best summarized in a paper entitled "Geology and Hydrology of the Western New York Nuclear Service Center" /2/. In general, the main objective of most siting studies was finding a suitable site for a reprocessing plant. There was less emphasis on the suitability of the site for low-level radioactive waste disposal.

Outside Surveillance Studies

Most of the outside surveillance reports for the site were performed by the NYSDEC*. The NYSDEC maintains an ambient radiation monitoring network throughout the state with several types of monitors being located around the NFS site. The NYSDEC publishes data from this network in quarterly and annual reports. The NYSDEC also performed a study under contract from EPA to survey the amount and type of radionuclides buried in the West Valley trenches from October 1963 to December 1972.

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*Prior to 1970, the date NYSDEC was created, the New York State Department of Health performed environmental surveillance of the site.

In July 1968, the New York State Department of Health's Bureau of Radiological Health (NYSBRH) issued a document entitled "Environmental Surveillance Report Around Nuclear Fuel Services, Inc., Ashford, Cattaraugus County, New York (1965-1967)" /3/. This report evaluated releases from the fuel reprocessing plant and stated that there were "levels of radioactivity which were found in fish and deer which the NYSBRH felt should be reduced to as low a level as practicable in order to keep the risk to public health as low as possible."

The Surveillance Report was important in pointing out the high background levels caused by the reprocessing facility. Since any burial ground activity affecting the site monitoring measurements was small in comparison to the reprocessing plant activity, it was difficult to determine if and how much radioactivity was moving from the burial site. This difficulty should lessen in the future as the reprocessing plant has not been in operation since 1972.

NFS Surveillance Studies

Since 1966 NFS has published semi-annual environmental reports describing the results of its ambient monitoring program. These reports contain an inventory of radionuclides emitted from the reprocessing activities as well as the results of ambient surveillance. The monitoring program has concentrated on the more critical fuel reprocessing plant and reveals little about burial activities. It is impossible to tell from the data how much, if any, radioactivity is moving from the burial area.

In September 1974 NFS issued a report entitled "Low-Level Radioactive Waste Management Research Project Final Report" /4/. This report was the product of a low-level waste research project that NFS had agreed with NYSERDA to undertake. The objectives of the research project were to characterize the waste being buried, to look at burial site characteristics, to evaluate alternate processes for solidification, and to develop disposal standards. The project included the NYSDEC recommended and EPA funded lithological boring study to evaluate radionuclide migration. As data were collected for this report, it became apparent that the topics associated with these objectives were more complex than originally believed. Waste characterization was limited to identifying the radionuclides in liquid effluents, evaporator systems, and ion-exchange resins found in pressurized water reactor (PWR) and boiling water reactor (BWR) plants. The study also sought to analyze data collected as part of the lithological boring study.

This Final Report discussed alternate solidification processes for liquid low-level wastes and contained an outline of desirable disposal standards. The relative advantages of using cement, vermiculite-cement, microcell, urea formaldehyde, chemical, and asphalt techniques to solidify or immoblize liquid wastes were also discussed. Although desirable standards for the disposal of radioactive wastes were discussed, no attempt was made to propose solutions to the specific problems found at West Valley. The appendix of the Final Report includes the siting study mentioned earlier /2/, a seismic study /5/, a physical description of the bore holes of the lithological boring program, and a comparison of cement and urea formaldehyde as solidification agents.

Dose Pathways Studies

A comprehensive evaluation of the dose pathways attributed to releases of radioactivity from the NFS reprocessing plant is provided by Magno et al. /6/. This study deals with only the liquid discharge from the reprocessing plant; however, it is of value in assessing the dose contribution of the trench pump down procedures. It is an important study because trench pump down discharges are treated and released through NFS's low-level waste treatment system, the same physical route as that for liquid releases from the fuel reprocessing operation. Magno et al. estimated the dose commitments to the population fishing the Cattaraugus Creek near the NFS plant during 1971 in this study. These dose estimates were based on empirical measurements of stream and discharge flow rates, quantities of radionuclides discharged, concentrations of radionuclides in fish, the number of people fishing the area, the quantity and type of fish caught and consumed, and a survey of the duration and number of times individuals fished the streams surveyed. Quantitative measurements of effective dilution factors, stream absorption factors, and water dilution factors were presented in an earlier report by Magno et al. /7/.

Field Observations

Field observation studies of the site have been conducted at various times. Three field reconnaissances of the burial site and the area around it were made by investigators from New York State and the Federal government /8/. Members of the NYSDEC staff also performed field reconnaissance /9/.

B. Lithological Boring Study

Methodology

During November and December of 1973 ten vertical borings approximately ten to fifteen feet from the trench perimeters were drilled to a depth of 50 feet. This work was funded by NYSERDA. Geologic logs were kept for these borings. The cores from the holes were analyzed for tritium (H-3) every 5 feet, and were used to determine H-3 concentrations. These holes were numbered holes 1,2,3,4,5,6,7B,8,9,10.

Eight additional holes were drilled in April 1974 after EPA funding became available. These holes were 25 feet deep and were sampled with Shelby tubes. The holes were located at the north end near trench 4 and at the south end near trenches 9 and 10. The Shelby tube samples were analyzed for tritium every 1.5 feet. Two of these holes (12 and 13) were drilled at a 25 degree angle and to a depth of 25 feet just west of trench 5 to determine if migration was occuring below the trenches. Slant hole 12 intersected trench 5, and the other was drilled under the trench. These eight additional borings were also analyzed for tritium content. Figure 3 gives the location of the borings made in November and December 1973 and April 1974.

Participants

In 1972, the NYSDEC monitoring program detected increased tritium levels downstream from the burial site. To ascertain the source of the tritium, NYSDEC recommended that a lithological study be performed to determine if subsurface migration of tritium from the low-level burial area was occurring. As a result of this recommendation, NYSERDA, and later EPA, committed funds for the program. During the study, NYSDEC acted as the Project Coordinator and provided technical assistance. The EPA's Office of Radiation Programs provided technical assistance in planning and executing the boring program.

For the lithological study, NYSERDA performed the Project Manager role by contracting and supervising the boring program and sample analyses. The sample analyses were performed by the New York State Department of Health Radiological Sciences Laboratory (RSL). Some samples were cross checked by the NFS Laboratory.

Although the lithological boring program has been completed, studies of the site still continue with some being based on the preliminary findings from this boring study. These ongoing studies are being performed by NYSDEC, NYSERDA, EPA, and other State and Federal agencies and are described in the final chapter of this report.

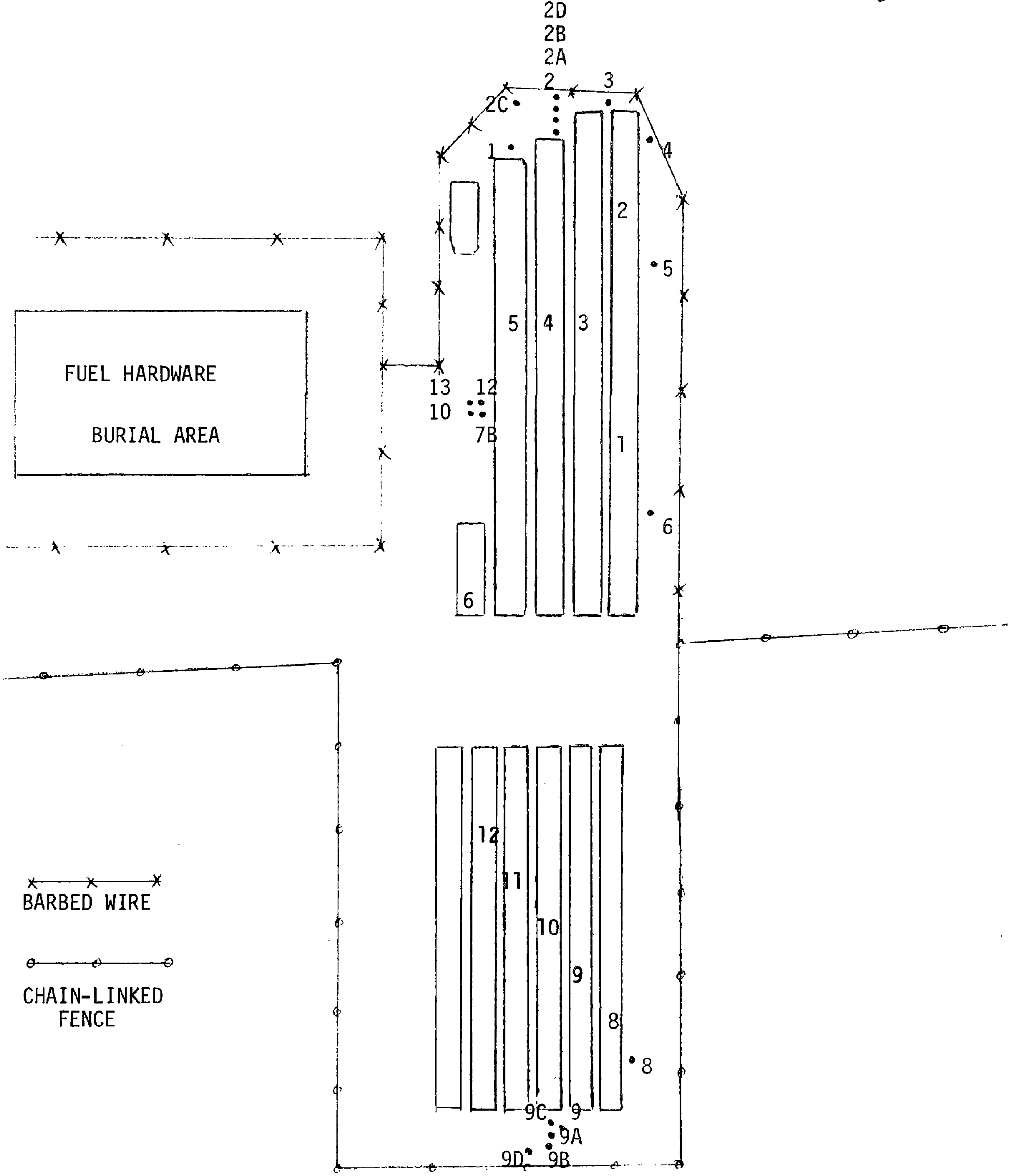

FIGURE 3: LOCATION OF BORINGS MADE IN WINTER 1973 AND SPRING 1974.

III. DATA PREVIOUS STUDIES

A. Site Description

The West Valley site is located on a small plateau that is cut by Buttermilk Creek and its tributaries. Buttermilk Creek empties into Cattaraugus Creek and finally into Lake Erie, 39 miles away. All surface and subsurface water from the site flows into Buttermilk Creek and its tributaries. The NYSERDA owns all of the Buttermilk Creek Valley from the mouth of the creek to approximately 5 miles upstream and leases the site to NFS. The cities and villages downstream from the site do not use Cattaraugus or Buttermilk Creek water for domestic purposes. A map of the site is shown in Figure 1. The precise burial site specified in the NFS application to New York State is 1,000 feet southeast of the chemical nuclear fuel reprocessing plant and 4,050 feet from the nearest tract perimeter. The burial site is bounded by Erdman Brook (Frank's Creek) to the east and by a tributary of the same creek to the northwest as shown in Figure 1. Figure 2 shows the location of the burial site with respect to the reprocessing plant complex.

The central section of the site is on a rolling plain approximately 1,380 feet above sea level. Buttermilk Creek and its tributaries cut through the plain about 100 feet below its surface. The valley walls of the Creek are steep and badly slumped in places. The surface drainage system is not well integrated and consequently provides good drainage of the site. However, a marshy area does exist to the south of the burial area.

Climatological data for the site were recorded at surrounding stations. The temperature data were taken at Franklinville, which is 12.3 miles south of the site. The average temperature was 45 F taken over a 13-year period. Rainfall and snowfall were averaged from data recorded at surrounding stations. The annual rainfall was 40 inches and the annual snowfall was 80 to 100 inches averaged over a 10 to 15 year period /10/.

In addition to surface geologic and hydrologic studies made by the NYGS and USGS in 1963, subsurface studies were also conducted. One-hundred and eight power auger holes and 14 deep wells were drilled, and a seismic survey was performed. Although these studies gave a good profile for siting the fuel reprocessing plant, only a few borings were applicable to determine the suitability of the area for the burial of low-level radioactive wastes.

The entire site is 3,345 acres; the designated burial site is approximately 25 acres, 6 of which are used for burial /11/. Approximately 3 to 5 of the 108 power auger holes were bored in the vicinity of the burial site. If the subsurface studies were intended to determine the suitability of the area for burial, more drillings may have been needed in that area. More detailed reports of the original studies can be found in the NFS's Preliminary Safety Analysis Report (PSAR), the Safety Analysis Report (SAR), and the Environmental Report. Appendix A contains a description of the methodology used in the subsurface siting investigation as well as a description of the geological findings from the investigations. Appendix B contains a description of the general hydrology of the site.

B. Burial Operations and Maintenance

Past Burial Operations

Since it opened in 1963, the West Valley site has handled more than 2,000,000 cubic feet of radioactive waste material. The operation of the site was regulated by a license granted to NFS in November 1963 by NYSBRH. The regulatory authority for the site was transferred from NYSBRH to NYSDEC in October 1974. During the time that the burial site was in operation, the original license was amended considerably. The amendments included major alternations and minor refinements and reflected the experience gained from operation of the West Valley burial site. While no amendments have been added since 1969, an updated permit was being considered by NYSDEC in 1975. At present, NFS is negotiating with NYSERDA to terminate their use of the site. The conditions and amendments written into the NFS burial license are enumerated in Appendix C.

The designated burial area was prepared for use by partially leveling the land. This procedure uncovered areas of weathered till in the southern part of the burial area, as shown in Figure 4b. The removal of the relatively permeable overburden on the silty till in the southern portion of the site may be an important factor that has minimized water infiltration into trenches 8 through 14.

Burial trenches were excavated to a depth of 20 feet and width of 30 feet. Excavation was achieved by use of a bulldozer which would back into the trench, down a ramp toward the face of the waste pile. The blade would make a cut on its upward pass, mixing the excavated material and piling it on top of a previously completed trench adjacent to the one being excavated. This procedure would help compact the newly completed trench. Usually a trench was opened a segment (150 to 200 feet) at a time, and less than fifty feet of open trench floor was maintained in front of the leading edge of the waste pile. The procedure minimized the inflow of rain and runoff to the trench. However, some water would still accumulate at the bottom of the open trench, become radioactively contaminated, and be brought to the surface area adjacent to the trench by way of the bulldozer's tread or blade. A completed trench was up to 800 feet long /8/.

Waste containers consisting of 55-gallon drums and rectangular containers made of cardboard, wood, and concrete were laid into the trench by hand and stacked on their sides. After placement, there was a large volume of void space remaining between the horizontally laid drums, casks, boxes, and bags of waste /8/. In one case, the wastes were stacked above the graded plane of the trench (Figure 5). Containers with high levels of external radiation were placed in the trench by means of a crane. Containers that were

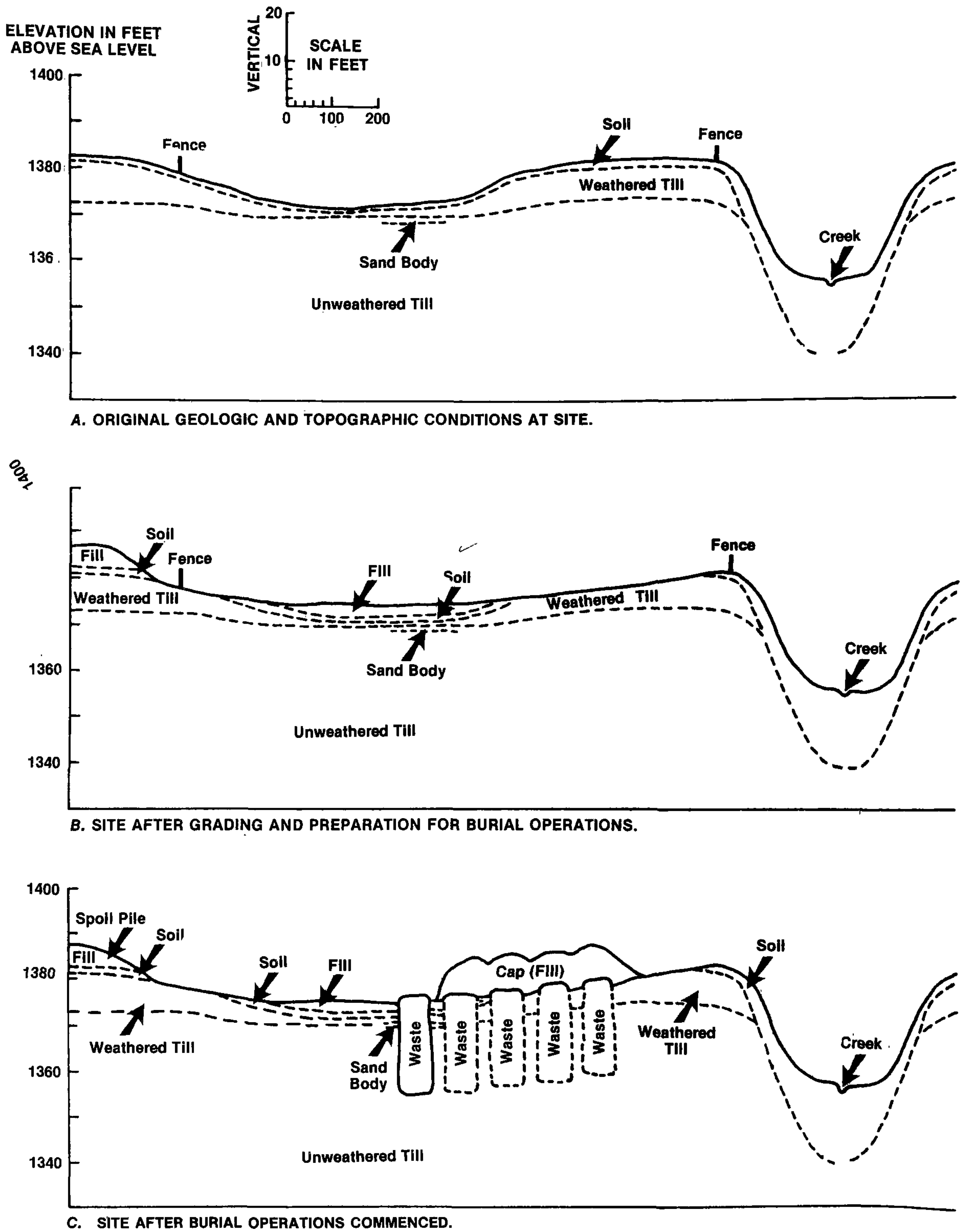

FIGURE 4: EAST-WEST CROSS SECTIONS OF SOUTH END OF COMMERCIAL BURIAL GROUNDS AT NFS. THE CROSS SECTIONS INTERPRET THE GEOLOGY OF THE SOUTH END OF THE BURIAL GROUNDS A) IN ITS ORIGINAL STATE, B) AFTER PREPARATION FOR BURIAL OPERATIONS, AND C) DURING BURIAL. THIS INTERPRETATION IS BASED ON DATA FROM CORE HOLES, TOPOGRAPHIC MAPS, AND FIELD INFORMATION.

FIGURE 5: PHOTOGRAPH OF WASTES PILED ABOVE THE GRADED SURFACE

too heavy to be laid by hand were also placed in the trench by crane. A row of individual holes was provided within the confines of trench 7 to handle containers that had to be covered immediately for shielding purposes.

Starting with trench 8 in the south portion of the site, waste material in an operating trench was covered with 4 feet of soil. When a trench finally reached capacity, it received a mounded cover approximately 8 feet in depth. Figure 4 shows a cross section of the south burial area. As noted, the soil from each new trench excavation was piled on top of the previous trench. This resulted in some degree of soil compaction. After about four trenches had been completed, a grass-vegetative cover was started over a completed trench. Figure 6 shows a cross section of a burial trench with the cover requirements used since the 1968 permit amendment. Davis observed during a field trip to the site that "the result of this operation is a very pervious landfill with a moderately well but apparently not optimal well compacted shell or cover. Whereas an ideal landfill operation consists of many individual sealed cells, this one consists of one heaped and covered cell" /8/.

Several problems associated with burial operations and trench maintenance have been identified by NYSDEC and in many cases some corrective measures were implemented for subsequent operations /12/.

-- Soil Failures

Some of the trench walls have experienced soil shear failures particularly during wet conditions. During some early excavations, the adjacent completed trench material was reexposed due to these shear failures. This occurrence has been prevented by increasing trench separation from 6 to 10 feet and by more stringently controll of trench center lines as specified in the 1968 permit amendments.

-- Erosion

Two sides of the north burial area have steep slopes. During times of heavy rainfall, rapid surface water runoff has caused significant soil erosion to these slopes.

-- Shrinkage Cracks, Undermining Holes, and Settlement Cracks

During periods of dry weather, the clay fill over the trenches shrinks and cracks to considerable depths. Holes frequently appear in the cover during the first two or three years after a trench is completed. This is indicative of undermining; the clay particles are washed down into the void spaces, leaving a hole in the surface.

Natural compacting of the waste has also increased the rate of settlement of the trench cover. These settlement areas must be built up again, either by adding soil fill or by reworking the trench cover. These

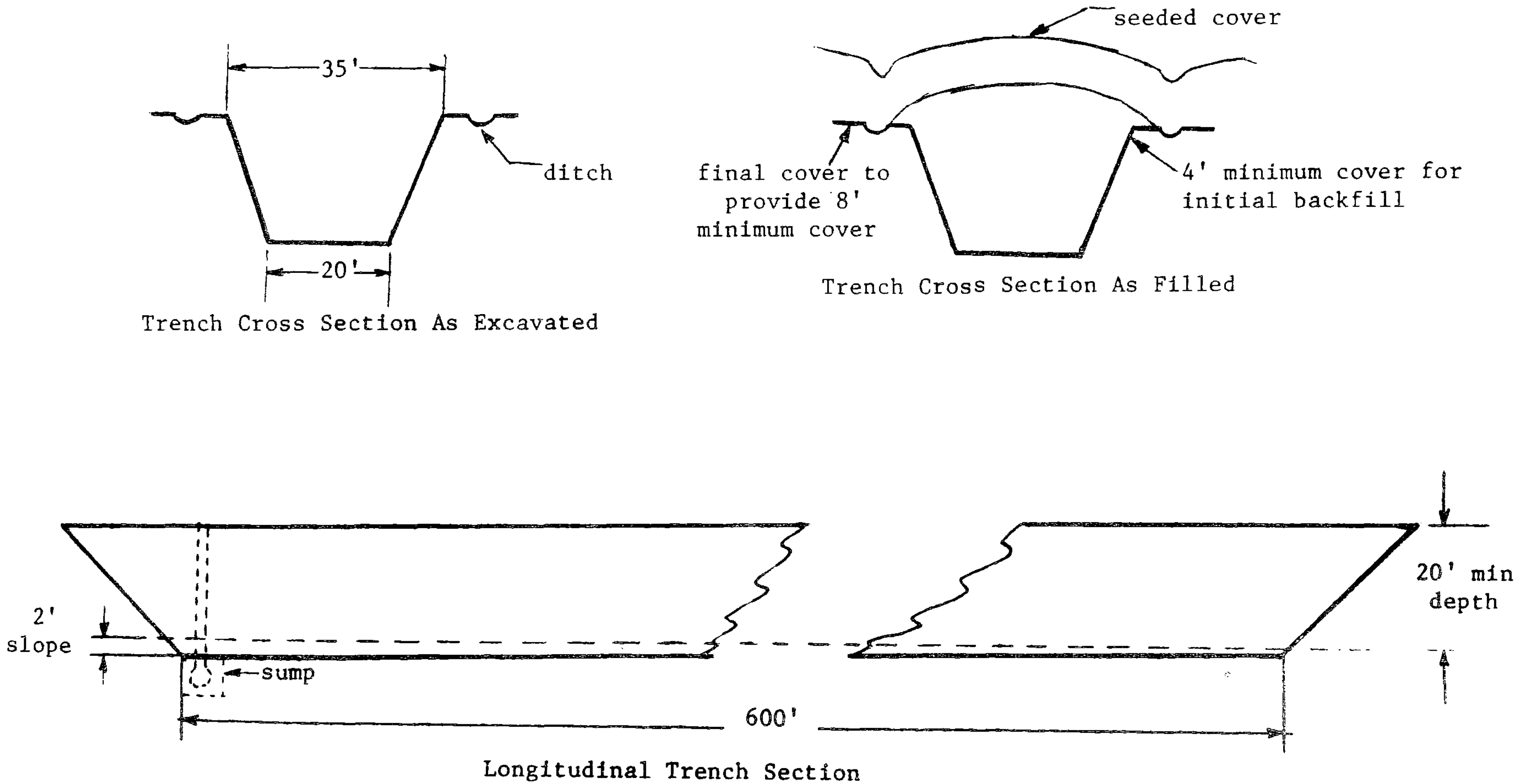

FIGURE 6. COMMERCIAL BURIAL TRENCH

remedial actions have not, however, been sufficient to prevent water accumulation to unacceptable levels in three of the north end trenches as discussed later. Further, these remedial actions, along with the movement of heavy machinery to effectuate them, result in some destruction of the vegetative cover of the trench area thereby extending the period over which cracking occurs.

-- Trench Water Level Rise (See Figure 25)

After trenches were completed, water began to accumulate in the trench bottom (the water level is monitored by sumps in each completed trench). Except for three north end trenches (3, 4, and 5), the water level rose only 5 to 10 feet during the first two to three years after trench completion and thereafter remained essentially at a consistent level. Trenches 3, 4, and 5, however, continued to accumulate water from the mid 1960's until in the spring of 1975 when the water in trenches 4 and 5 began to seep through the trench cover. As a result of this occurrence, site burial operations were stopped by NFS and no additional material has since been buried. After the previously mentioned health evaluations, NYSDEC approved the pump down of trenches 3, 4, and 5. The water was routed to the low-level waste treatment facility (part of the reprocessing plant complex) and after treatment and dilution, released to Buttermilk Creek.

The south end trenches were designed with thicker caps, as specified in the 1968 amendments to the NFS operating license, and have not experienced increased water levels. Evidence to date is that water levels in the south end trenches have not risen significantly because of better capping procedures. However, it may only be a matter of time before the trenches in the south burial area start to settle and it may not be possible to prevent water infiltration by routine maintenance.

C. Source Term

To better understand the NFS burial site NYSDEC, acting upon a request from the U.S. Environmental Protection Agency and with funding from EPA, conducted an inventory of the radioactive materials buried at the site. The inventory included the volume, type of waste, shipper, and quantity of radionuclides. The study ran from December 1972 through February 1973 and surveyed over 1,700,000 cubic feet of low-level radioactive waste which had been buried between October 1963 and December 1972. The following text and tables were extracted from a report issued in 1973 by Kelleher and Michael /13/. Information concerning studies characterizing low-level wastes on a generic basis is presented in Appendix D.

Table 1 shows the NFS estimates of the volume of soil excavated and the volume of waste buried for each individual trench. The percentage of waste to excavated volume ranges from approximately 38 to 70 percent. The higher percentage reflects the use of soil for shielding purposes and for backfilling of trenches that had experienced soil shear failures. Most shipping containers are not filled to capacity, and there is also considerable air space between the containers in the trench making the effective use of excavated volume about 20 to 30 percent.

Table 2 is a breakdown by trench of the quantities of various radionuclides buried. With the exception of trench 4, only trace quantities of Sr-90 were found in the trenches. For this reason, a separate column for Sr-90 was not included in Table 2. In trench 4 there are approximately 15,763 curies of Sr-90 which were the result of an industry shipment after the discontinuance of the space battery program in 1966-1967.

The by-product material (BPM) shown in the table includes radium and accelerator made radioactive material. Source material (SM) includes thorium-238 and natural uranium in pounds. The special nuclear material (SNM) expressed in grams, includes Pu-238, Pu-239, U-235, and U-233. There were 2.0 kilograms of Pu-238 and 1.5 kilograms of Pu-239 buried at the site until the practice of burying plutonium was stopped at the request of the State in 1973. Pu-238 is expressed in both curies and grams on Table 2. Shippers listed the Pu-238 by curies, and a direct conversion can be made to grams using a specific activity of 17.4 Ci/gm.

The isotope in greatest amount in terms of curies is tritium. Large shipments of over 500 Ci of H-3 were common and are probably tritium targets. The Co-60 buried in trench 5 is from large sealed sources from one shipper. The mixed fission products come mainly from nuclear power plants. The C-14 appears to come from sources such as medical and educational institutions, but is shipped by waste disposal firms. The mixture of H-3 and C-14 was listed separately because the mixture frequently appears in the shipping records. There was no way to determine the percentage of each isotope present because much of the tritium listed in the tritium column comes from targets, and it would be incorrect to use the ratio of C-14 to tritium obtained from the separate columns to estimate the individual amounts of C-14 and tritium in the mixture column.

Ra-226 is present in all of the trenches, with one shipment of approximately 2 Ci being a Ra-Be neutron source. Am-241 shipments increased in later years with the major source being an industry in New York State which manufactures sealed americium oxide sources. The Pu-238 comes from an out-of-state industry that produces plutonium power sources. The amount of Pu-239 in the Pu-238 was not provided on the shipping records but it may be as high as 20 percent by weight.

The mixture of isotopes contains many short and some long half-life materials. The shipping records indicate curies of radioactive material at the point of shipment with no correction for decay. While substantial number of curies may have been indicated at the time of shipment, the short-lived isotopes would have decayed away. In some cases the shipping records were incorrect. As an example, Tc-99 with a half-life of 212,000 years was listed in

Table 1 [13]

Volumes Buried by Type of Facility

Trench	Dates Start	Stop	Waste Vol. Ft^3	Excavated Vol. Ft^3	Precentage of Volume** 1	2	3	4	5	6
11	5/72	12/72	182,769		6.8	1.5	10.2	31.3	15.1	35.0
10	6/71	5/72	182,462	362,000	5.6	2.9	8.5	15.5	34.4	33.0
9	10/70	6/73	173,722	362,000	1.6	1.5	9.0	14.0	18.7	55.2
8	1/69	11/70	252,435	362,000	0.6	2.0	16.0	24.6	75.2	31.6
5	5/67	2/69	278,601	390,000	2.0	1.3	16.2	22.1	21.2	37.2
4	10/65	6/67	274,416	432,000	4.0	1.0	21.9	23.7	11.8	37.6
3	7/64	11/65	198,675	460,000	5.2	0.4	19.9	40.0	0	34.5
2*	5/64	10/64	114,246	450,000	3.0	0.2	24.0	53.6	-	19.2
1*	11/63	5/64	55,275		0.7	1.1	41.8	4.8	-	51.6
7	11/65	3/66	2,465		-	-	5.7	-	-	94.3
6	7/70	10/70	75		-	-	-	-	-	100.0

* 1 and 2 are the same trench

** 1 - Nuclear power plants
2 - Institutional, education, & hospitals
3 - Federal government
4 - Industrial, pharmaceutical manufacturers, & industrial research
5 - Nuclear Fuel Services at West Valley, N.Y. & at Erwin, Tennessee
6 - Waste disposal and decontamination companies

Table 2 [13]

Quantities of Nuclides Buried In State Licensed Site

Trench #	Total[1] Ci BPM + Pu-238	BPM[2] Ci	SNM[3] gr	SM[4] lbs.	SNM - Grams				SM - lbs.	
					Pu-238	Pu-239	U-235	U-233	Th-232	U-238 + U-Nat
1[9]	4,117	4,117	2,858	739	-	-	2,858	-	630	109
2[9]	2,215	2,215	659	553	-	9	650	-	-	553
3	17,061	17,061	1,894	44,583	0.1	100	1,794	-	108	44,403
4[10]	67,117	67,117	8,333	140,825	-	476	7,857	-	-	140,825
5	92,832	90,432	3,579	24,924	138	298	3,143	-	5,203	19,721
6[6]	10,245	10,245	-	-	-	-	-	-	-	-
7[5]	1,568	1,568	-	-	-	-	294	-	-	-
8	38,671	34,757	13,074	321,226	224	453	12,397	-	7,460	313,766
9	34,158	27,323	4,550	43,777	393	94	3,804	255	510	43,267
10	54,893	39,667	3,139	101,614	862	63	2,214	-	268	101,346
11	53,531	46,704	6,151	80,092	392	1	5,758	-	1,037	79,055

See footnotes on next page

Table 2 (Continued)

Quantities of Nuclides Buried In State Licensed Site

BPM - Curies											
Trench #	H-3	C-14	H-3 & C-14	Co-60	Cs-137	I-125 I-131	Ra-226	Am-241	MFP[7]	Mix & Misc.	Pu-238 Curies
1[9]	17	1	0.3	34	-	-	-	-	556	566	3,499
2[9]	8	-	620	139	-	-	0.2	-	915	533	-
3	667	5	5,498	4,017	-	98	0.5	-	2,808	3,968	0.1
4[10]	3,768	8	11,758	171	3	180	1.67	-	15,088	37,139	-
5	10,772	3	10,325	46,469	0.1	46	0.6	-	67	22,749	2,400
6[6]	-	-	-	10,208	-	-	-	-	-	37	-
7[5]	-	-	-	254	-	-	-	-	-	1,314	-
8	15,771	35	3,221	13,188	1	31	1,625	1.5	191	2,316	3,914
9	7,843	15	12,767	139	9	12	014	5	330	6,203	6,835
10	31,711	33	2,954	1,827	3	71	.003	4	292	2,992	15,006
11	36,139	342	5,090	264	3	6	1.0	7	586	4,266	6,827

1. Total Ci includes Pu-238 plus BPM.
2. BPM - By-product Material includes radium and accelerator made radioisotopes.
3. SNM - Special Nuclear Material.
4. SM - Source Material.
5. Trench #7 - short trench concrete encapsulated.
6. Area for Trench #6 set aside for holes to contain high external radiation Shipment.
7. MFP - Mixed Fission Products.
8. U enriched in U-235
9. 1 and 2 are the same trench
10. Mix & Misc. - Mixture & Miscellaneous includes 15,763 Ci of Sr-90.

Table 3 [13]

Record of Pesticides Shipments

Date	Trench	Shipper	Volume (ft^3)	Quantities & Isotopes
5/67	4	4.16	22	<0.1 mCi of ^{14}C
12/66	4	4.16	10	<0.1 mCi of ^{14}C
2/69	5	4.16	15	<0.1 mCi of ^{14}C
12/68	5	4.16	10	1 mCi of ^{3}H and ^{14}C
9/68	5	4.16	8	<0.1 mCi of ^{14}C
7/68	5	4.16	30	<0.1 mCi of ^{14}C
5/68	5	4.16	9	<0.1 mCi of ^{14}C
3/68	5	4.16	9	<0.1 mCi of ^{14}C
1/68	5	4.16	18	<0.1 mCi of ^{14}C
12/67	5	4.16	18	<0.1 mCi of ^{14}C
10/70	8	4.16	24	2 mCi of ^{14}C
7/70	8	4.16	11	<0.1 mCi of ^{14}C
6/70	8	4.16	11	<0.1 mCi of ^{14}C
5/70	8	4.16	24	<0.1 mCi of ^{14}C
3/70	8	4.16	20	<0.1 mCi of ^{14}C
10/69	8	4.16	15	<0.1 mCi of ^{14}C
9/69	8	4.16	15	<0.1 mCi of ^{14}C
7/69	8	4.16	12	<0.1 mCi of ^{14}C
5/69	8	4.16	22	<0.1 mCi of ^{14}C
5/71	9	4.16	13	<0.1 mCi of ^{14}C
4/72	10	4.16	24	2 mCi of ^{14}C
1/72	10	4.16	30	<0.1 mCi of ^{14}C
8/71	10	4.16	25	2 mCi of ^{14}C
11/72	11	4.16	36	2 mCi of ^{14}C
8/72	11	4.16	38	2 mCi of ^{14}C
7/72	11	4.16	28	2 mCi of ^{14}C
TOTALS			497	12 mCi of ^{14}C 1 mCi of ^{3}H & ^{14}C

Total Shipments were 26

some shipments in curie quantities whereas a check with the shipper indicated the curies content was for Mo-99-Tc-99m, which has a half-life of 66 hours.

Since 1967, there have been a total of 26 shipments of pesticides comprising 12 mCi of C-14 and one mCi of H-3 and C-14 mixture. The total volume of 497 ft^3 came from a manufacturer of industrial pesticides in New York State. While the shipping records indicated that the shipments were pesticides, they did not specify the chemical or physical form. Further, information provided subsequent to the NYSDEC inventory showed that much of the pesticide waste was inert material and that the pesticides were biodegradable. Therefore, these pesticide wastes are no longer considered hazardous. Table 3 lists the date, trench, volume, and quantity of isotopes for each pesticide shipment. A review of the inventory indicates these pesticides are the only toxic materials listed in the shipping records to be buried at the commercial burial site.

Most of the wastes buried at West Valley were shipped to the burial site in 55-gallon (208 l) steel drums or in wooden or cardboard boxes and were buried in their shipping containers. These burial containers are designed primarily to contain the wastes during shipment and to protect workers. The containment capability of these containers in water and leachate-saturated conditions after burial is assumed to be negligible.

Although the burial site inventory describes the quantities and types of radionuclides buried in the trenches, very little information is available from the records on the chemical and physical characters of the wastes buried at West Valley. Since it is probable that various industrial organic solvents are present in these wastes, it is reasonable to assume that chemical and physical reactions between the buried wastes and the surrounding burial environment are significant.

If ground water or infiltrating surface water comes in contact with the solid waste, leachate can be produced as at any landfill. Leachate is a solution containing dissolved and finely suspended solid matter, and microbial waste products. Depending on individual site conditions, the leachate may leave the fill at the ground surface as a spring or it may migrate through the soil laterally or vertically. Since the waste density is low, there is much oxygen available for aerobic decomposition, which produces carbon dioxide, water, and nitrate. As the oxygen supply diminishes, anaerobic decomposition produces methane gas, carbon dioxide, water, organic acids, nitrogen, ammonia, and sulfides of iron, manganese, and hydrogen. The production of carbon dioxide could lead to the dissolving of strontium in the form of the bicarbonate. This was confirmed by the high level of Sr-90 in the water pumped from trench 4.

D. Dose Pathways Studies

No studies of health effects from the West Valley low-level burial site have been made because movement of radioactivity from the burial site had been low. However, dose pathways from the adjacent fuel reprocessing plant were well studied /6,7/.

Magno et al. /6/ estimated doses from the fuel reprocessing plant as follows:

Organ	Mode	Dose: Maximum Individual (mrem)	Dose: Population (man-rem)
Whole body	Ingestion[a]	0.4	0.02
Whole body	External	1	0.04
Bone	Ingestion[b]	7	0.3

(a) Includes contributions from cesium-137, cesium-134, and zinc-65.
(b) Dose from strontium-90.

The dose levels calculated by Magno et al. were based on measured isotope concentrations in fish caught, number of fish ingested, and time spent fishing Cattaraugus Creek.

The gross-beta and strontium-90 discharge inventories are listed below.

Year	Quantity Discharged (Curies): Gross Beta	Quantity Discharged (Curies): Strontium-90
1966	8	--
1967	31	4
1968	46	5
1969	140	10
1970	87	14
1971	77	7

As mentioned in Chapter II, these data are particularly useful in calculating the dose from pump down and treatment operations subsequent to the seepage incident, since the material pumped from the trenches and the material released from the reprocessing plant received similar treatment and dilution followed the same environmental pathway.

E. Field Observations

Field Reconnaisance

The reports on the West Valley area, such as the Safety Analysis Report and the various environmental reports /14/ for the reprocessing plant, focused on the plant. More detailed information relative to the burial site's physical features and hydrogeology were needed for the lithological boring study. Therefore, investigators from New York State and the Federal government conducted three field reconnaisances of the burial site and the surrounding area.

Davis explained some specific inadequacies associated with past reports.

> "To be sure, I am not convinced that we have a clearly defined two or three layer system. The only reliable data to which one can refer, in order to describe the low level rad-waste burial area, is this most recent drilling program. It was with this attidude that Lew Meyer and I walked over the site" /8/.

Davis and Meyer observed rapid erosion of the side areas of the burial site as did Kelleher /15/. Davis and Meyer further reported that the "area needs to be protected from further gullying, so that the meager mass of silty, clayey earth between the radwaste burial trenches and the ravines is not further notched and diminished" /8/.

Specific observations suggest that the burial media at the site is a clayey silt which probably was deposited during the most recent retreat of the continental glacier. It appears to consist of lacustrine deposits that have been reworked by ice and running water. Davis could not tell from the field reconnaissance whether the site consisted of till, lake beds, or both. He recommended a detailed mapping of the deposits to determine their origin.

Davis and Meyer prepared a map (Figure 7) on their observations showing areas where water seepage was detected. Three types of seepage were defined:

1) spring - a place of small dimension (a square meter of less) from which water was flowing and near which succulent or hydrophytic plants were observed.

2) marshy area - an area larger than one square meter in size, where no flow was seen, but hydrophytes were growing.

3) wet area - an area which had a concentration of succulent plants and moisture to tolerant plants with no hydrophytes where oozing water was observed.

The seepage zones on the flanks of the broad, relatively flat nose or platform areas upon which surface the shallow burial trenches were excavated, filled, and covered.

Davis also expressed concern about the composition of the unweathered till zone. During the excavation of one trench a sand lense was observed. This lense was observed in the south end of trench 12 and measured two feet in thickness and sixty-five feet in length. The NYSBRH ordered site operation stopped until NFS determined the areal extent of the sand lense. It was determined to be a shallow dish shaped lense was limited in areal extent. Burial operations were authorized to be resumed with the conditon that the wastes would only be placed up to the bottom of the sand lense.

Cap Leakage Observation

On March 8, 1975, NYSDEC performed a survey of the north burial area after the leakage through the trench cover had been identified. Surface contamination from 500 to greater than 80,000 cpm beta-gamma readings, measured along the north end of trench 4, were observed. The survey utilized a Thyac-Victoreen GM survey meter and exposure rates were measured in the range of 0.1 mr/hr to 0.2 mr/hr at the two-inch level /1/. This uncontrolled discharge was in violation of NYSDEC's water pollution regulations and an abatement action was initiated by NYSDEC.

IV. LITHOLOGY AND LITHOLOGICAL BORING PROGRAM DATA

A. Radiochemical Data

The location of the holes drilled as part of the lithological boring program is shown in Figure 3. The holes were drilled approximately ten to fifteen feet from the trench perimeters. A precise determination of the location of the holes with respect to the trenches is not possible because the trench perimeters are poorly defined and the trench side walls are not vertical. The cores taken from each boring were analyzed by NFS and the Radiological Science Laboratory of the New York State Department of Health (RSL). For the purposes of this report, the RSL data have been graphed since analysis error ranges were recorded. The core samples were analyzed by RSL for tritium, strontium-90, cesium-134, cesium-137, ruthenium-106, cobalt-60, and antimony-125. These data are contained in Table 4. NFS data, which are contained in Table 5, were analyzed onsite and the analyses may be subject to outside interference from the residue of the fuel reprocessing plant activities.

Figure 8 through Figure 17 show the relationship between the depth of the boring and the tritium concentration at that depth for each hole. Two feet cores were analyzed for a particular depth (i.e., a 4' - 6' core was analyzed) and the tritium concentration was recorded at the 5' depth. With two exceptions, the simple soil descriptions were provided by NFS for each boring. The NFS descriptive data are listed in Table 6 for information. The drillers logs appear to be crude from a geological viewpoint and do not provide much information. The soil descriptions used in this report have been divided during a field reconnaisance by Meyer into the following:

fill: clayey, silty, moist, grey and brown mottled, firm to soft.

jointed-fractured weathered till: tough, homogeneous brown with scattered gravel bits, with joints and fractures throughout.

unweathered till: grey, plastic clay, scattered gravel, occasional buff-colored spots, some pebbles.

Data on the presence of water in the holes during coring operations were extracted by Kelleher from the driller's logs. Kelleher reported, "... Unfortunately, the copies are not very legible and I may have misinterpreted what was reported. However, there is strong evidence from the drill logs that relatively permeable material can be encountered and the water in the material is under a hydraulic head" /15/. A copy of the groundwater summary by Kelleher is listed in Table 7.

3. Lithology

FIGURE 7: Meyer and Davis Field Map

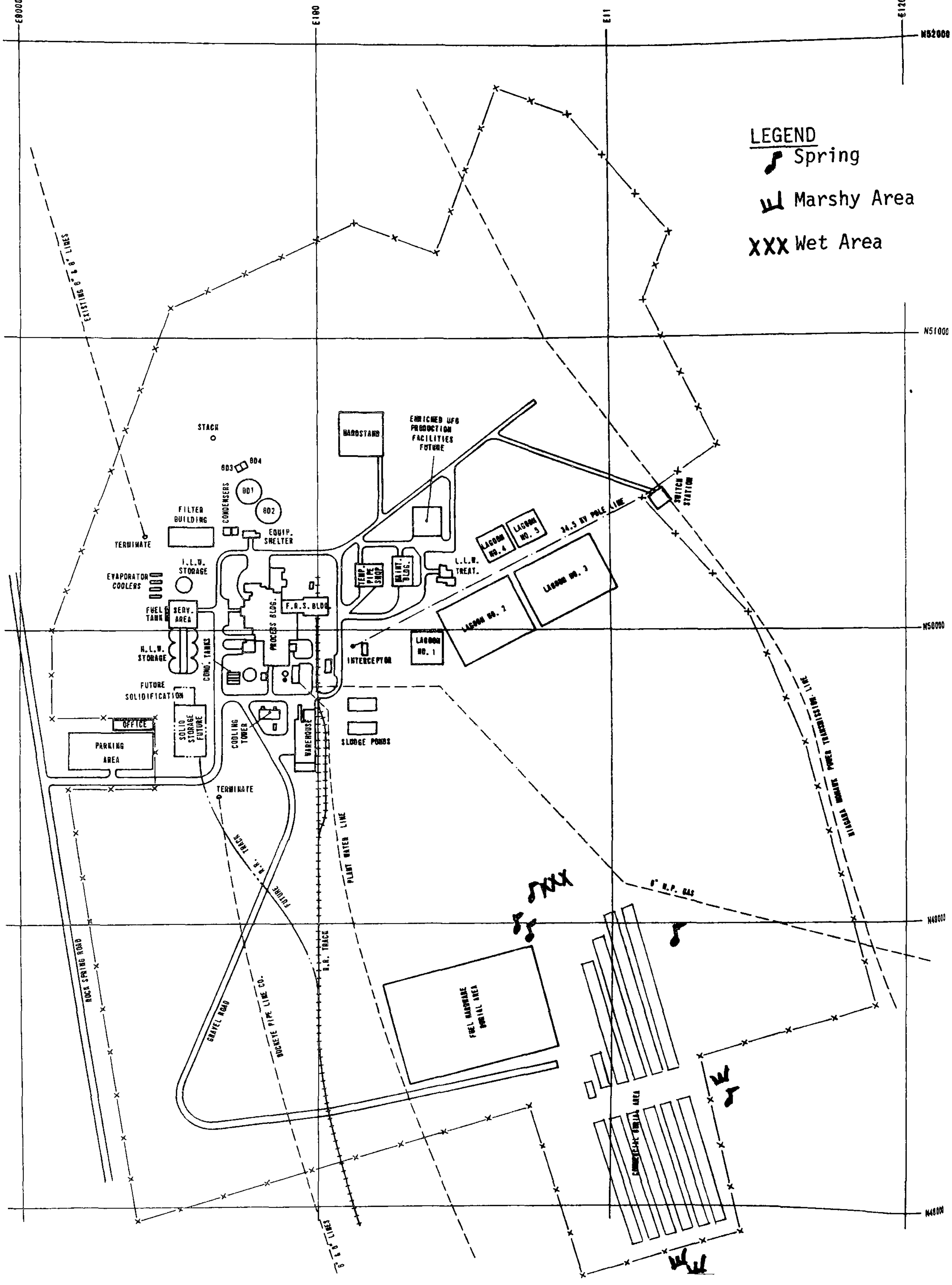

TABLE 4: WEST VALLEY DATA ANALYZED BY RSL

TRITIUM - (uCi/ml)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(1.08±0 05)E-05	(4 00±0.14)E-05	(1.44±0.06)E-05	(3.7±0.1) E-05	(6.4±0.4) E-06	(1.30±0.06)E-05	(1.55±0.05)E-04	(1.35±0.04)E-04	(3.21±0.10)E-03	(2.24±0.08)E-05
9-11	(3.2±0.3) E-06	(7.3±0.2) E-05	(1.96±0.06)E-04	(1.3±0.2) E-06	(5±2) E-07	(1.00±0.05)E-05	(1.22±0.04)E-04	(3.25±0.10)E-04	(1.26±0.04)E-03	(3.0±0.3) E-06
14-16	(0±2) E-07	(1.02±0.03)E-04	(2.1±0.3) E-06	(0±2) E-07	(0±2) E-07	(0±2) E-07	(0±3) E-07	(3.8±0.3) E-06	(1.05±0.03)E-04	(3±2) E-07
19-21	(0±2) E-07	(2.8±0.3) E-06	(0±3) E-07	(0±2) E-07			(1.9±0.3) E-06	(7±2) E-07	(6±2) E-07	(0±2) E-07
24-26		(2.4±2.0) E-07		(0±2) E-07						(5±2) E-07
29-31			(3±2) E-07	(0±2) E-07		(3.6±0.6) E-07	(1.1±0.3) E-06	(1.0±0.2) E-07	(1.0±0.2) E-07	
34-36				(0±2) E-07		(2.7±0.5) E-08	<3 E-07		(1.2±0.05)E-06	
39-41				(0±2) E-07		(8.1±0.4) E-08	(1.2±0.3) E-06		(1.7±0.5) E-07	
44-46				(0±2) E-07			(1.2±0.3) E-06			
49-51				(0±2) E-07			(7.0±2.9) E-07			

STRONTIUM - 90 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(4.2±0.4) E-07	(3.7±0.3) E-07	<9 E-09	<7 E-09		(2.4±0.8) E-08	(2.42±0.17)E-07	(4±3) E-08	(2.28±0.14)E-06	(6.4±0.3) E-06
9-11		<9 E-09	<4 E-09	<9 E-09			(1.27±0.17)E-07	(1.5±0.3) E-07	(1.8±0.6) E-08	<1 E-08
14-16		<4 E-09					<2 E-08		(1.3±1.0) E-08	
19-21							<5 E-09			
24-26, 29-31				<9 E-09						
34-36, 39-41				<9 E-09						
44-46										
49-51										

TABLE 4: (cont.) 2 of 7

CESIUM - 137 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(2.1±0.6) E-07	(1.5±0.5) E-07	(8.5±1.2) E-07	<1.1 E-07		<6 E-08	<7 E-08	(0±7) E-08	(4.6±0.7) E-07	(9.0±0.9) E-06
9-11		<7 E-08	(1.3±0.6) E-07				(7±5.6) E-08	(1.1±0.5) E-07	(8.5±1.0) E-07	<6 E-08
14-16		<6 E-08							(0±5) E-08	
19-21							(4.2±2.9) E-08			
24-26				<7 E-08						
29-31				<7 E-07						
34-36				<9 E-08						
39-41										
44-46										
49-51										

COBALT - 60 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(1 0±0.6) E-07	(1.5±0.5) E-07	(1.9±0.6) E-07	(1.4±0.7) E-07		<6 E-08	(1.3±0.6) E-07	(0±7) E-08	(1.0±0.4) E-07	(1.42±0.09)E-06
9-11		<1 E-07	(1.4±0.6) E-07				<8 E-08	(6±4) E-08	(8±4) E-08	<6 E-08
14-16		<6 E-08							(7±4) E-08	
19-21							<2 E-08			
24-26				<8 E-08						
29-31				<9 E-07						
34-36				<1 E-07						
39-41										
44-46										
49-51										

RUTHENIUM - 106 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(1.0±0.6) E-06	<1 E-06	<1.4 E-06	<1.4 E-06		<8 E-07	<1 E-06	(0±6) E-07	(0±5) E-07	(2.4±0.7) E-06
9-11		<1 E-06	<8 E-07				<9 E-07	(0±6) E-07	<5 E-07	<9 E-07
14-16		<8 E-07							(0±5) E-07	
19-21							<6 E-07			
24-26				<8 E-07						
29-31				<9 E-06						
34-36				<1 E-06						
39-41										
44-46										
49-51										

ANTIMONY - 125 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	<2 E-07	<4 E-07	<3 E-07	<3 E-07		<3 E-07	(6±3) E-07			(1.9±0.2) E-06
9-11		<3 E-07	<3 E-07				<4 E-07			<4 E-07
14-16		<4 E-07								
19-21							<8 E-08			
24-26										
29-31										
34-36										
39-41										
44-46										
49-51										

TABLE 4: (cont.) 4 of 7

CESIUM - 134 (uCi/gm)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	(1.4±0.6) E-07	<1 E-07	(1.9±0.9) E-07			<8 E-08	<1 E-07		(1.7±0.5) E-07	(1.65±0.10)E-06
9-11		<1 E-07	(1.9±0.8) E-07				<9 E-08	(1±.5) E-07	(1.1±0.3) E-07	<9 E-08
14-16		<8 E-08							(5±4) E-08	
19-21							<3 E-08			
24-26										
29-31										
34-36										
39-41										
44-46										
49-51										

TRITIUM - (uCi/ml)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(1.15±0.46)E-05	(2.10±0.03)E-05	(3.78±0.11)E-05	(4.88±0.15)E-04	(2.41±0.05)E-04	(1.82±0.05)E-04
2-4	(3.91±0.12)E-05	(4.91±0.15)E-05	(9.0±0.3) E-05	(8.3±0.2) E-04	(8.2±0.2) E-04	(1.61±0.05)E-04
4-6				(1.35±0.03)E-03	(8.1±0.2) E-04	(8.0±0.4) E-06
6-8	(6.8±0.1) E-05	(2.79±0.08)E-05	(5.11±0.15)E-05	(1.87±0.06)E-03	(1.17±0.04)E-03	
8-10						
10-12	(5.3±0.2) E-05		(3±1) E-07	(2.7±0.08)E-05	(1.73±0.03)E-03	(3±2) E-07
12-14		<2 E-07				
14-16						
16-18	(4.9±0.3) E-06			(5.03±0.15)E-05		
18-20				(3.3±0.7) E-06	(1.12±0.03)E-04	

STRONTIUM - 90 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(8.7±0.7) E-07	(2.9±0.3) E-07	(2.1±0.3) E-07	(2.4±0.2) E-07	(2.3±0.2) E-07	<5.6 E-07
2-4	(1.65±0.15)E-07	(5.6±0.3) E-06	<8 E-09	(6.3±0.4) E-07	(1.26±0.09)E-06	(9.5±0.6) E-07
4-6				(8.9±0.5) E-07	(8.5±0.6) E-07	(1.2±1.1) E-08
6-8	(2.4±0.6) E-08	<8 E-09	(2.3±1.7) E-08	(1.31±0.08)E-06	(8.4±0.8) E-07	
8-10						
10-12	<1.3 E-08			<6 E-09	(2.8±0.3) E-07	
12-14						
14-16						
16-18	<1.0 E-08			<6 E-09		
18-20				<8 E-09	(1.3±0.7) E-08	

CESIUM - 137 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(5.6±0.6) E-06	(1.40±0.02)E-06	(7.9±1.2) E-07	(8.7±1.4) E-07	(1.9±0.2) E-06	(2.6±0.3) E-06
2-4	(5.3±1.3) E-07	(1.9±0.2) E-06	<8 E-08	(1.8±0.2) E-06	(5.1±0.5) E-06	(6.5±0.7) E-06
4-6				(1.33±0.14)E-06	(2.3±0.3) E-07	<6 E-08
6-8	<2 E-08	<4 E-08	(1.00±0.11)E-06	(3.8±0.4) E-06	(2.4±0.3) E-07	
8-10						
10-12	<2 E-08			<3 E-08	(3.6±0.5) E-07	
12-14						
14-16						
16-18	<7 E-08			<6 E-08		
18-20				<7 E-08	<8 E-08	

TABLE 4: (cont.) 6 of 7

ANTIMONY - 125 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(3.5±0.5) E-06	(4.9±0.5) E-06	<3 E-07	<2 E-07	<2 E-07	<2 E-07
2-4	<5 E-07	<5 E-07	<3 E-07	<3 E-07	(5±3) E-07	<3 E-07
4-6				<1 E-07	<1 E-07	<4 E-07
6-8	<7 E-08	<9 E-08	<1 E-07	<3 E-07	<3 E-07	
8-10						
10-12	<6 E-08			<8 E-08	<7 E-08	
12-14						
14-16						
16-18	<4 E-07			<5 E-07		
18-20				<2 E-07	<2 E-07	

CESIUM - 134 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(5.5±0.2) E-07	(1.9±1.2) E-07	<6 E-08	<1.0 E-07	<7 E-08	(3.2±1.0) E-07
2-4	<1.3 E-07	(2.1±1.2) E-07	<1.0 E-07	(4.4±1.3) E-07	(5.3±1.5) E-07	(4.5±1.5) E-07
4-6				(2.3±0.4) E-07	<3 E-08	(1.3±1.1) E-07
6-8	(9±4) E-08	<4 E-08	<5 E-07	(3.5±1.3) E-07	(4.1±1.4) E-08	
8-10						
10-12	<2 E-08			<3 E-08	(1.5±0.4) E-07	
12-14						
14-16						
16-18	(1.1±0.8) E-07			<8 E-08		
18-20				(1.1±1.0) E-07	<9 E-08	

TABLE 4: (cont.) 7 of 7

COBALT - 60 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	(2.4±1.0) E-07	(1.0±0.8) E-07	<5 E-08	<7 E-08	<6 E-08	<7 E-08
2-4	<9 E-08	<1.0 E-07	(4.5±1.2) E-07	<1.0 E-07	<9 E-08	(3.0±1.0) E-07
4-6				(4.7±1.2) E-08	<2 E-08	<7 E-08
6-8	(4±2) E-08	<3 E-08	<3 E-08	<9 E-08	(1.2±0.9) E-07	
8-10						
10-12	<2 E-08			<2 E-08	<2 E-08	
12-14						
14-16						
16-18	<8 E-08			<7 E-08		
18-20				<8 E-08	<8 E-08	

RUTHENIUM - 106 (uCi/gm)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
0-2	<2 E-06	<1.0 E-06	<7 E-07	<1.0 E-06	<9 E-07	<9 E-07
2-4	<1.5 E-06	<1.4 E-06	<1.5 E-06	<1.5 E-06	<1.5 E-06	<1.5 E-06
4-6				<3 E-07	<4 E-07	<1.2 E-06
6-8	<4 E-07	<3 E-08	<3 E-07	<1.5 E-06	<1.5 E-06	
8-10						
10-12	<4 E-07			<5 E-07	<5 E-07	
12-14						
14-16						
16-18	<1.0 E-06			<8 E-07		
18-20				<1.4 E-06	<1.1 E-06	

TABLE 5: WEST VALLEY DATA ANALYZED BY NFS

TRITIUM - (uCi/ml)

Sample Depth (feet)	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7B	Hole 8	Hole 9	Hole 10
4-6	<2.6 E-06	4.5 E-05	2.6 E-05	4.6 E-05	<2.6 E-06	<2.6 E-06	4.5 E-05	3.9 E-04	2.6 E-05	5.9 E-05
9-11	'	1.1 E-04	1.5 E-05	3.1 E-05	'	'	<2.6 E-06	2.6 E-05	2.8 E-03	4.4 E-05
14-16	'	2.6 E-06	<1.8 E-06	<1.8 E-06	"	'	3.8 E-05	<2.6 E-06	2.6 E-05	<2.6 E-06
19-21		<2.6 E-06	'	'	'		<2.6 E-06	'	<2.6 E-06	'
24-26	'	"	"	'	"	'	'	'	'	'
29-31		'	'	'	'	'	'		'	"
34-36	'	'	'	'	'	'	"		'	'
39-41	'	'	'	"	'	'	'	'	'	'
44-46	'	"	'	'	'	'	'	'	'	'
49-51	'		'		'	'	'	'	'	'

TRITIUM - (uCi/ml)

Sample Depth (feet)	Hole 2B	Hole 2C	Hole 2D	Hole 9B	Hole 9C	Hole 9D
4	1.0 E-03	8.9 E-05	2.1 E-04			
6	2.2 E-03	9.2 E-05	1.3 E-04			
8	5.7 E-05	1.5 E-05	1.4 E-05	1.2 E-03	2.3 E-03	<2.6 E-06
10	5.6 E-05	2.6 E-06	3.9 E-06	3.8 E-03	7.6 E-03	"
12	4.4 E-05		<3.0 E-06	4.8 E-05	4.6 E-03	"
14	3.0 E-05	<2.6 E-06	1.9 E-05	<2.6 E-06	<2.6 E-06	"
15.5				"	1.1 E-04	"
16	9.9 E-06	'	4.6 E-06		1.9 E-05	
18					4.0 E-06	

TRITIUM - (uCi/ml)

Sample Depth (feet)	Hole 12	Hole 13
10	8.3 E-04	
12	1.4 E-03	3.9 E-06
14	8.0 E-03	3.1 E-04
16	3.2 E-02	
18	1.7 E-01	6.1 E-04
18.8	2.5 E-01	
20		<2.6 E-06
		1.2 E-04
22	5.3 E-01	<3.0 E-06
23	5.6 E-01	
24	5.4 E-01	9.7 E-06
26	8.5 E-01	<2.6 E-06
26.25	8.5 E-01	
26.50	8.2 E-01	
26.75	7.9 E-01	
27	8.6 E-01	
30		3.4 E-05
32		1.2 E-05
		3.0 E-06
34		<2.6 E-06
46		<2.6 E-06

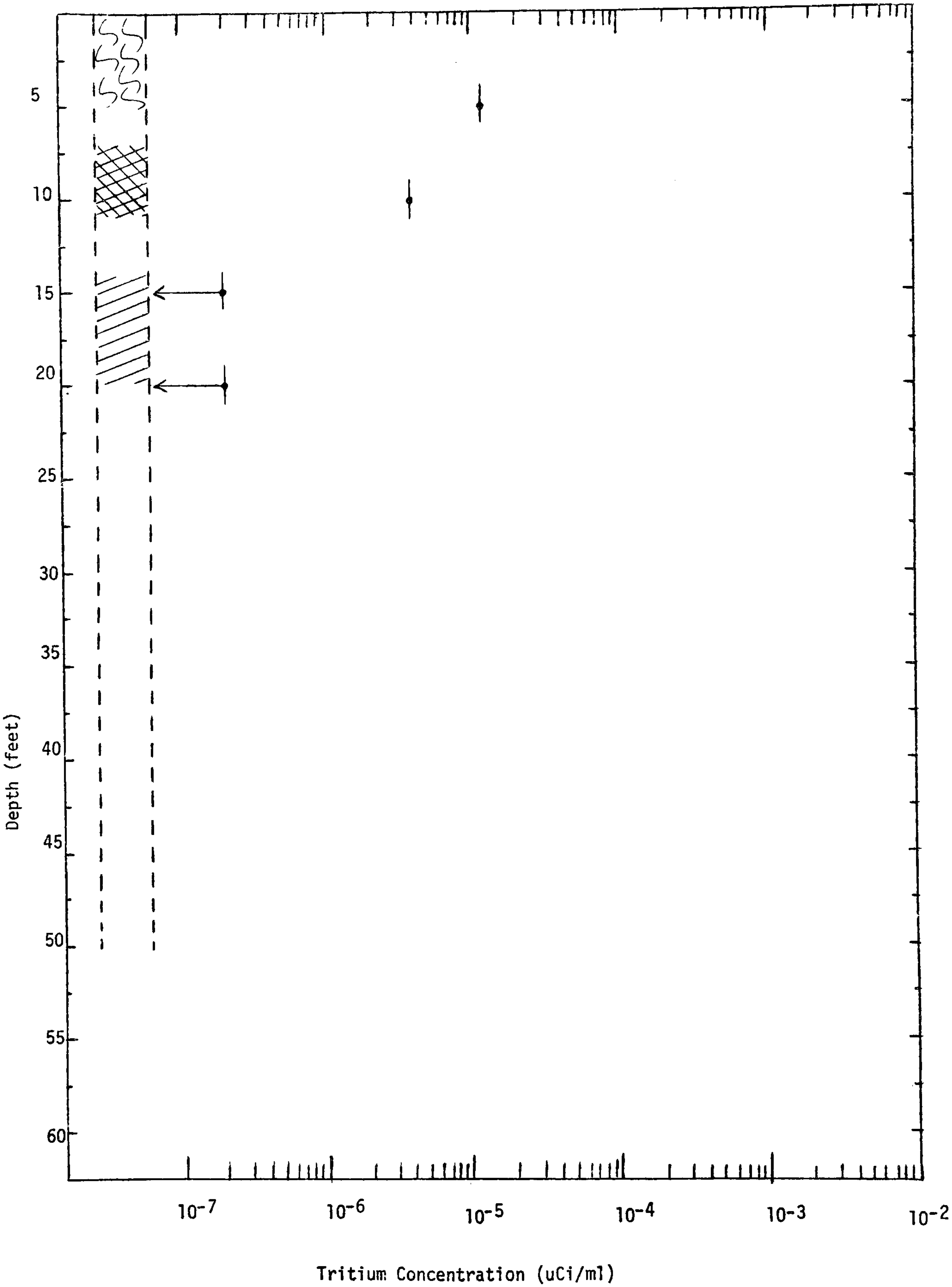

FIGURE 8. HOLE 1

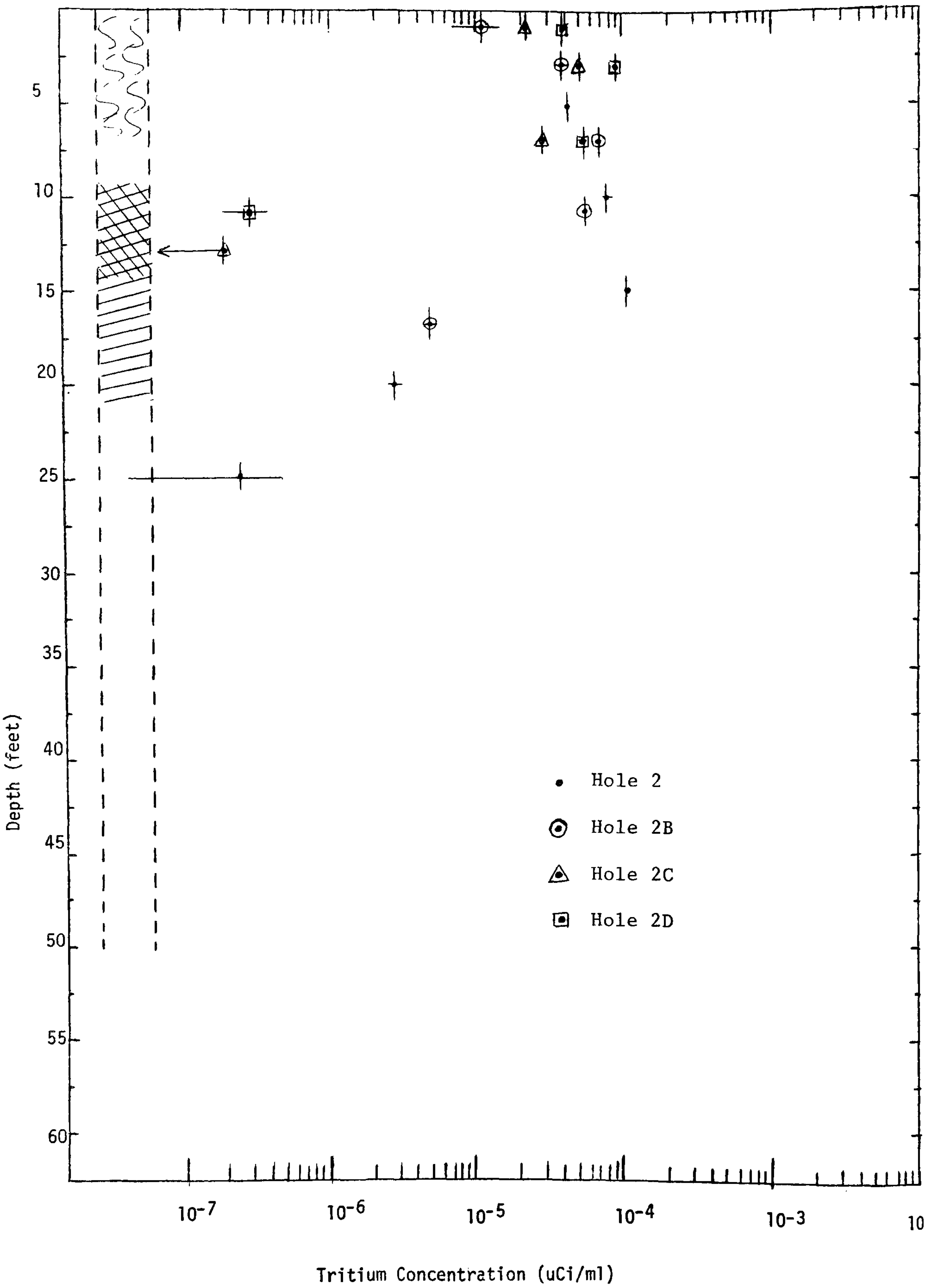

FIGURE 9. HOLES 2,2B,2C,2D

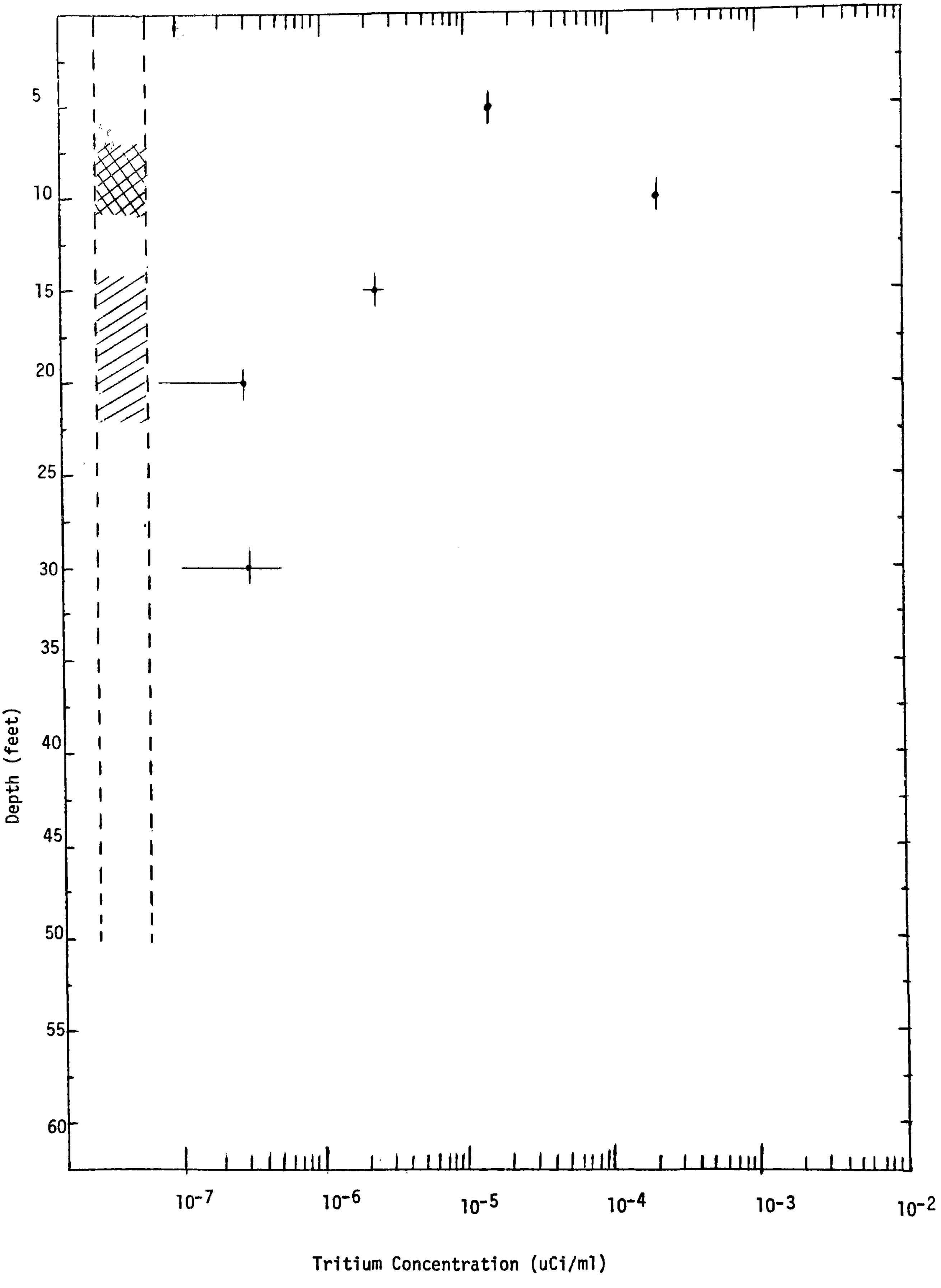

FIGURE 10.   HOLE 3

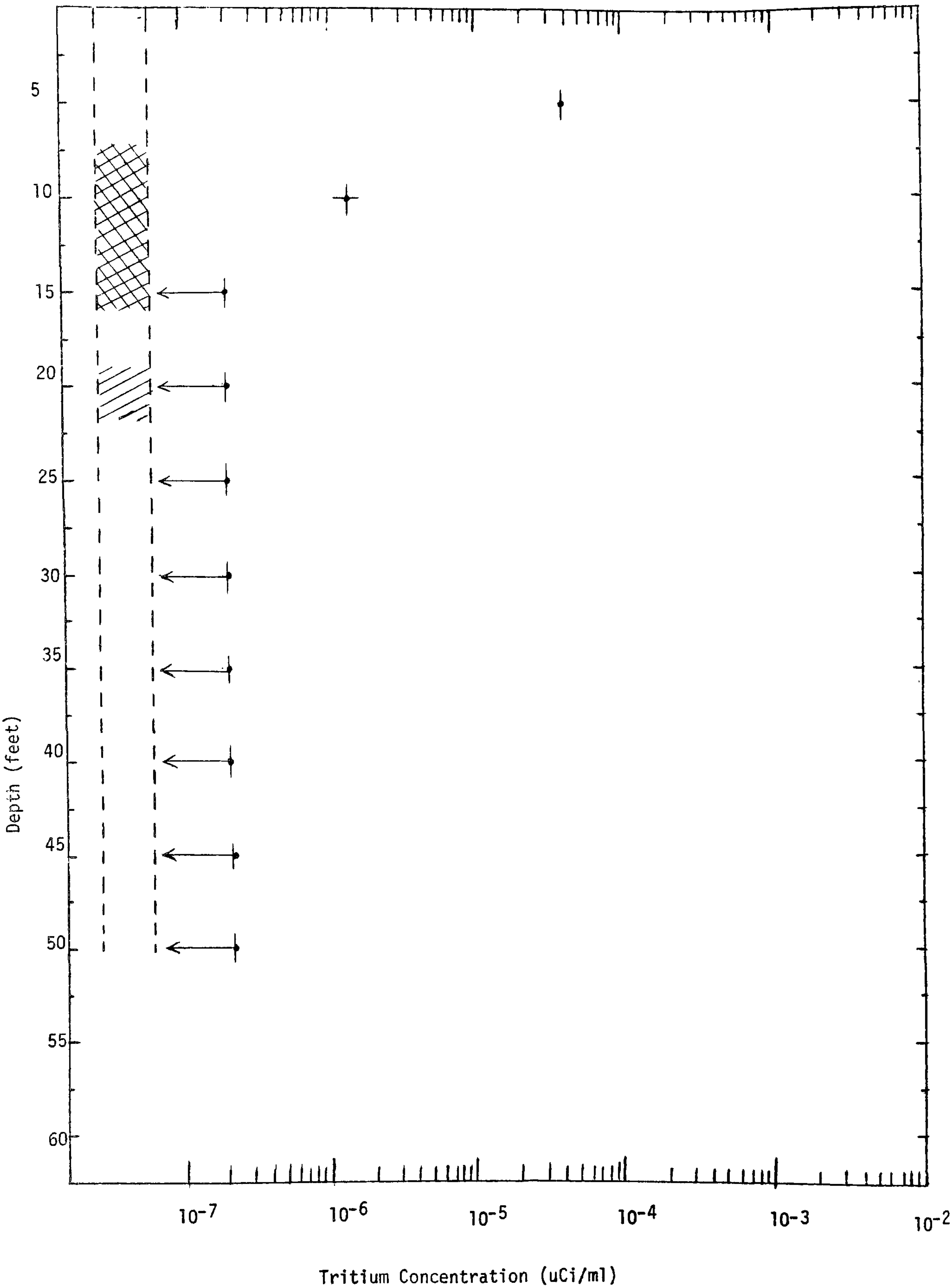

FIGURE 11. HOLE 4

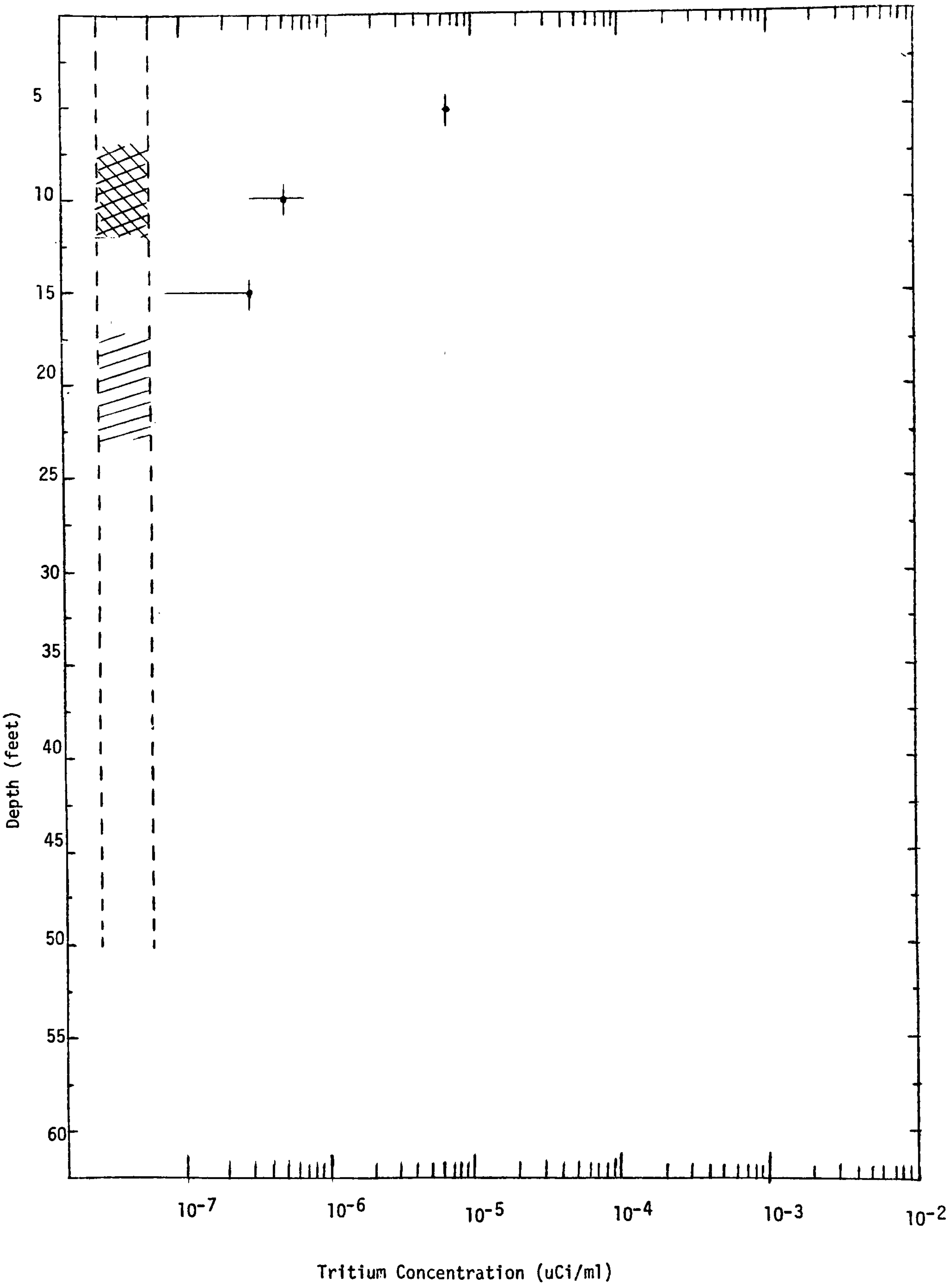

FIGURE 12. HOLE 5

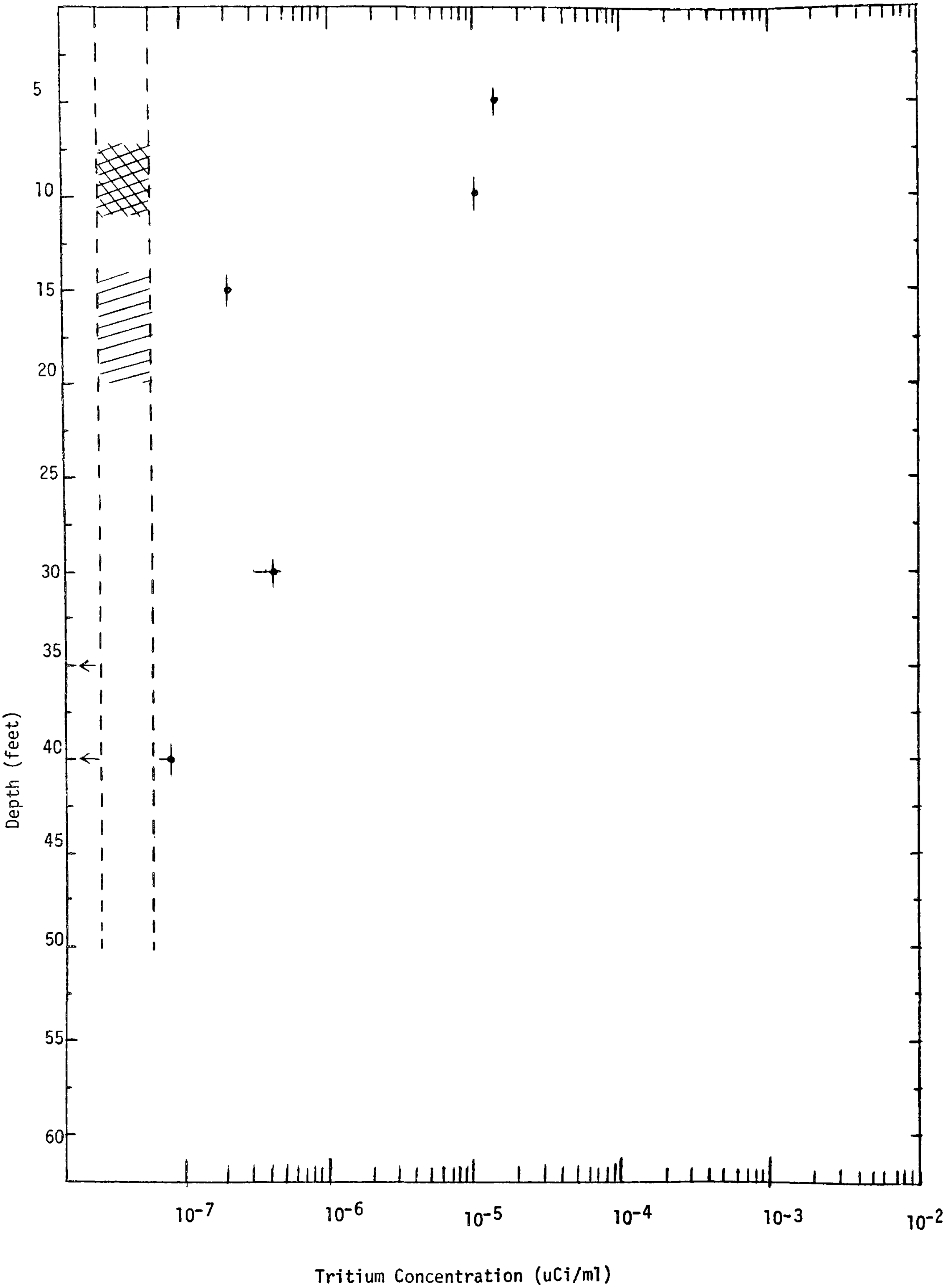

FIGURE 13. HOLE 6

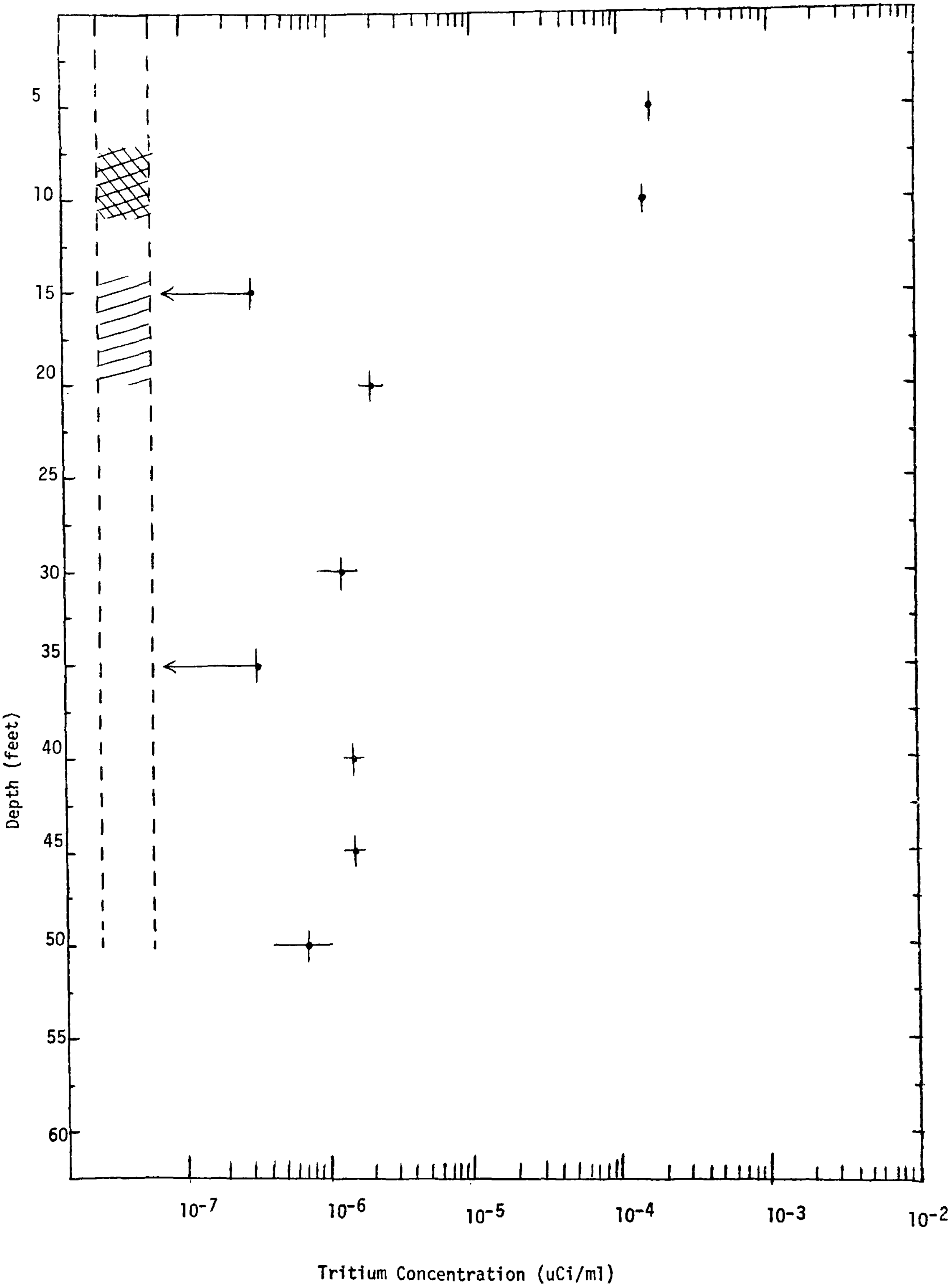

FIGURE 14. HOLE 7B

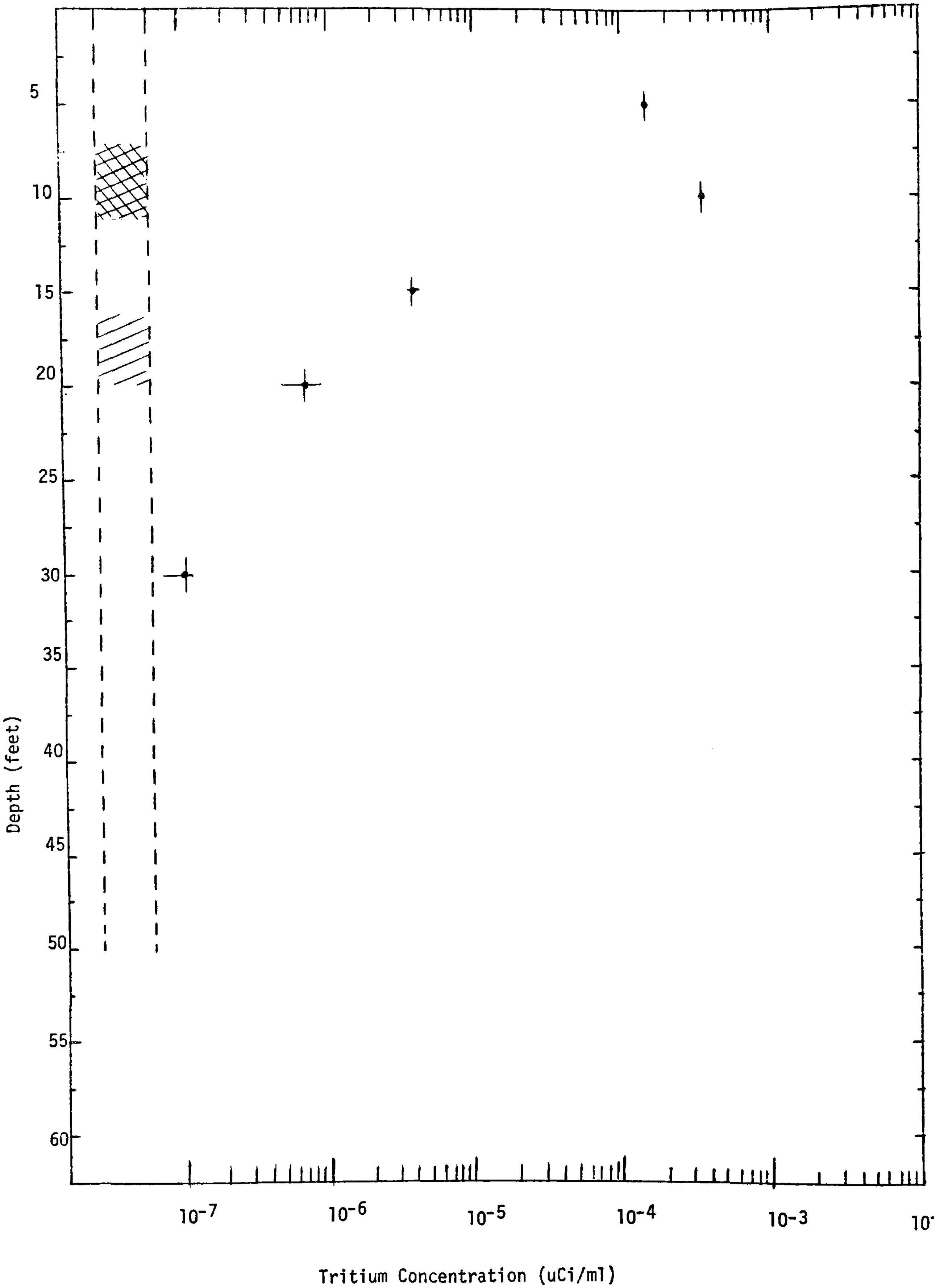

FIGURE 15. HOLE 8

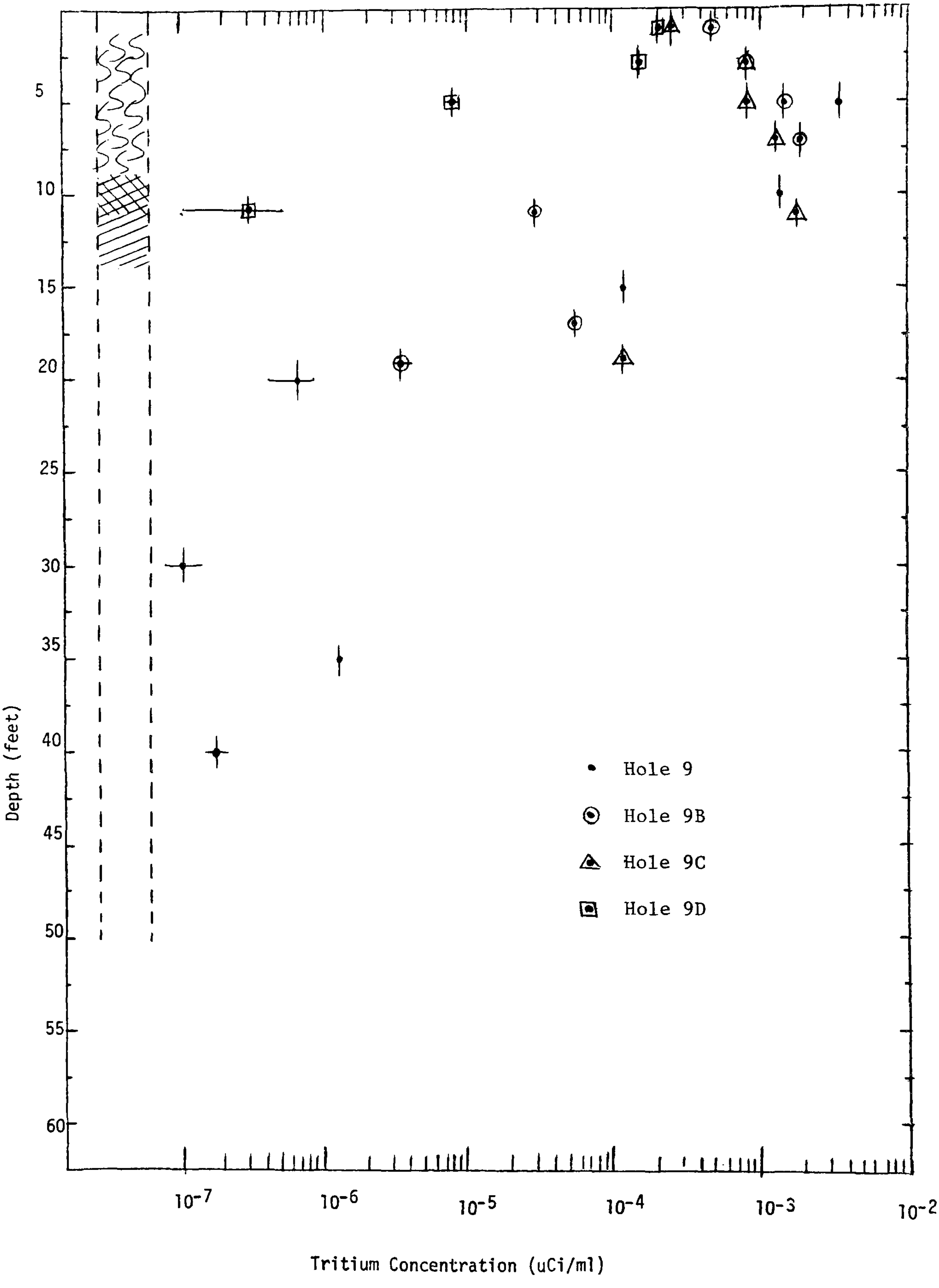

FIGURE 16. HOLES 9,9B,9C,9D

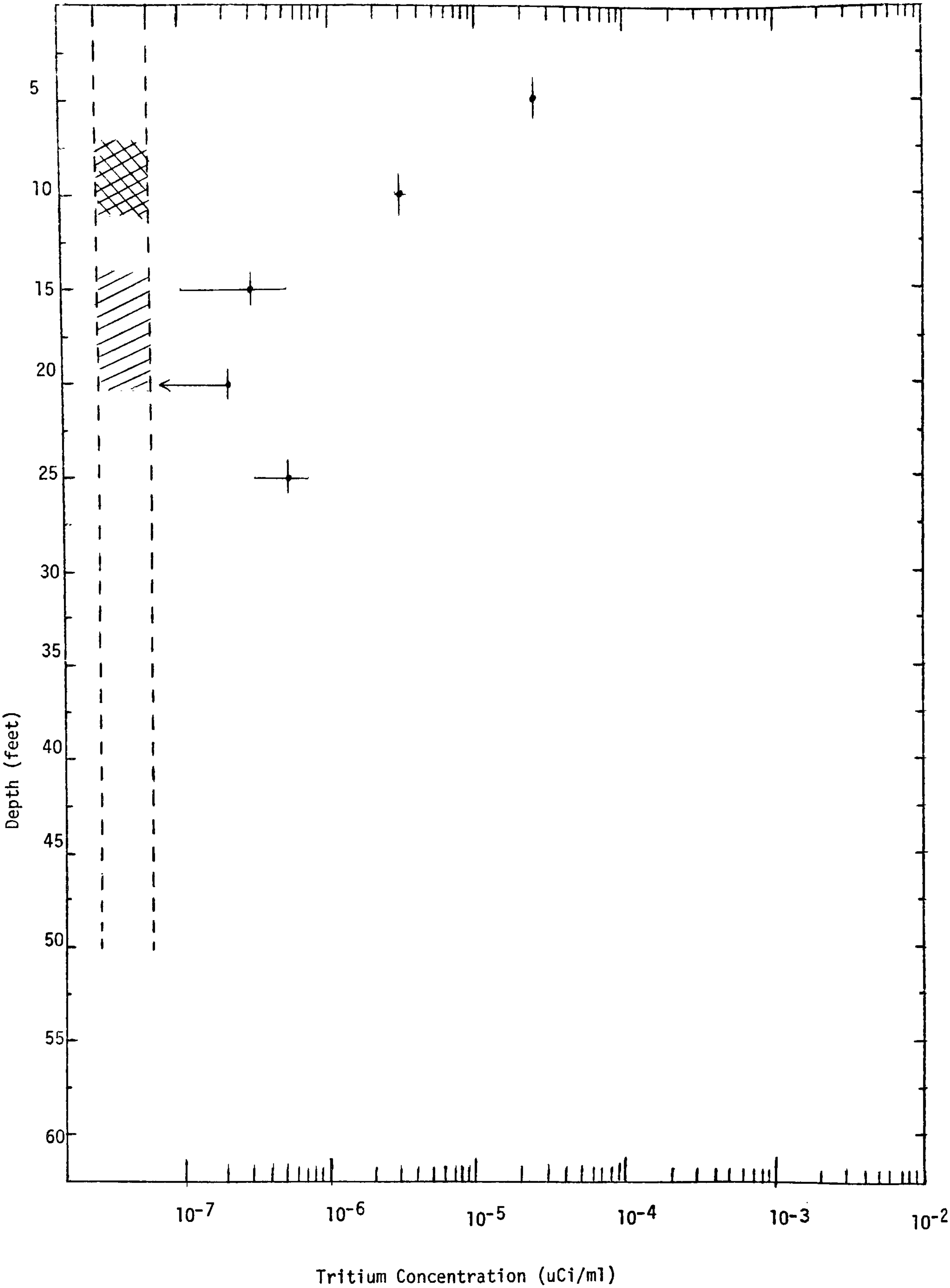

FIGURE 17. HOLE 10

TABLE 6 [14]

Hole #	Depth (Feet)	Soil Description
1	4-6	Brown silt clay few small stones
	9-11	Brownish grey silt clay few small stones
	14-16	Grey silt clay small amount fine stones
	19-21	Grey clay silt very few stones
	24-26	Grey clay silt few small stones
	29-31	Grey clay some silt very few small stones
	34-36	Grey clay silt few stones
	39-41	Grey clay silt few stones
	44-46	Grey clay silt few stones
	49-51	Grey clay silt few small stones
2	4-6	Brown silt clay few small stones
	9-11	Brown silt clay few small stones
	14-16	Grey brown silt clay few small to medium stones
	19-21	Dark grey clay with silt very few small stones
	24-26	Grey Clay silt few stones
	29-31	Grey clay silt few stones
	34-36	Grey clay silt few stones
	39-41	Grey clay silt few stones
	44-46	Moist grey clay silt few stones
	49-51	Grey clay silt very few stones
3	4-6	Brownish grey silt clay fine gravel
	9-11	Brownish grey silt clay fine gravel
	14-16	Moist grey clay fine embedded gravel
	19-21	Grey silt clay few small stones
	24-26	Grey silt clay few small stones (moist)
	29-31	Grey silt clay fine gravel very moist
	34-36	Grey silt clay few small stones
	39-41	Grey silt clay gravel with silt lenses
	44-46	Grey silt clay few small stones
	49-51	Grey silt clay few small stones
4	4-6	Brownish grey silty fine gravel clay
	9-11	Brown silt clay few small stones
	14-16	Brown silt some clay some small stones
	19-21	Grey silt clay few small stones

Continued TABLE 6 [14]

Hole #	Depth (feet)	Soil Description
4	24-26	Grey silt clay few small stones (moist)
	29-31	Grey moist silty clay gravel (some water)
	34-36	Grey silty clay few small stones
	39-41	Grey silty clay few small stones
	44-46	Grey silty clay sand layer 45.5 ft.
	49-51	Grey silty clay few small stones
6	4-6	Brown silt clay few small stones
	9-11	Brown silt clay few small stones
	14-16	Grey silt clay few small stones (moist)
	19-21	Grey clay silt few small stones
	24-26	Grey clay silt few small stones (moist)
	29-31	Grey silt clay fine gravel
	31-33	Grey silt clay fine gravel
	33-35	Grey silt clay fine gravel
	39-41	Grey clay silt few fine stones
	44-46	Grey silt clay few small stones
	49-51	Grey clay silt few small stones
7B	4-6	Brown silt clay few small stones
	9-11	Brown silt clay few small stones
	14-16	Grey silt clay few small stones
	19-21	Grey silt clay few small stones (moist)
	34-36	Grey clay silt few small stones (moist)
	39-41	Grey clay silt few small stones (moist)
	44-46	Moist grey clay silt few small stones
	49-51	Moist grey clay silt few small stones
8	4-6	Brown silt clay few small stones
	9-11	Brown silt clay few small stones
	14-16	Greyish brown silt clay few small stones
	19-21	Grey silt clay few small stones
	24-26	Grey silt clay few small stones
	29-31	Grey clay silt few small stones
	34-36	Grey clay silt few small stones
	39-41	Grey clay silt few small stones
	44-46	Grey clay silt few small stones
	49-51	Grey clay silt few small stones

Continued TABLE 6 [14]

Hole #	Depth (Feet)	Soil Description
9A	4-6	Brown silt clay fine stones
	9-11	Brown silt clay fine stones (moist)
	14-16	Grey silt clay fine stones (moist)'
	19-21	Grey clay silt few fine stones (moist)
	24-26	Grey clay silt fine stones (moist)
	29-31	Grey clay silt fine stones (moist)
	31-33	Grey clay silt few fine stones (moist)
	33-35	Grey clay silt few fine stones (moist)
	39-41	Grey silt clay few fine stones (moist)
	44-46	Moist grey clay silt fine gravel
	49-51	Moist grey clay silt fine gravel
10	4-6	Brown silt clay few fine stones
	9-11	Brown silt clay few fine stones
	14-16	Grey clay silt few fine stones (moist)
	19-21	Grey clay with silt gravel (moist)
	24-26	Grey silty gravel some clay (moist)
	29-31	Grey clay silt few fine stones (moist)
	34-36	Grey clay silt few fine stones (moist)
	39-41	Grey clay silt few fine stones (moist)
	44-46	Grey clay silt few fine stones (moist)
	49-51	Grey clay with silt fine gravel (moist)

Fill

The fill in the burial area at West Valley is a man-made mixture of soil, weathered till, and unweathered till resulting from excavation and general land surface preparation operations in the burial trench area. The fill observed was generally slate gray in color, and appeared to have a high clay and silt content with very little sand or gravel. Therefore, it is believed that the fill is composed primarily of unweathered till excavated from the trenches. Fill is used for leveling the working areas prior to trenching operations and as capping material for the trenches after they are filled with waste. The fill was also used to build up and partially level the north end of the site in preparation for installation of trenches 2, 3, 4, and 5 (Figure 24) in a major reshaping of the natural contours in this area.

No measurements of the porosity, permeability, or degree of compactness of the fill are available. A recent study /16/ measured the horizontal permeability of surficial gravelly deposits at the reprocessing plant site (but not at the burial area - See Appendix B) to be between 0.02 to 0.14 ft/day.

Soil

The original top soil in the vicinity of the burial trenches is largely missing as a result of trenching and burial operations. Where present, the soil is believed to be a product of weathering and therefore similar in composition to the underlying clay and silt till. Physical and hydraulic properties measurements of the soil were not made. As previously noted, the top soil was scraped off the south portion of the site. The history of the top soil disposition in the north portion of the site is not clear but appears to have been scraped off in some areas and covered with fill in other areas.

Weathered Till

The weathered till at the burial site is part of and has the same basic lithologic composition as the underlying unweathered till. However, it has been altered from a plastic grey till to a brown, tough or very firm, silty clay containing small bits of gravel or rock. Based on observations from open trenches and from core holes, the weathered till in undisturbed areas may extend from near land surface to a depth of 10 to 12 feet.

Intense irregular jointing can be seen both in the sidewalls of the open trenches (Figure 18) and in surface outcrops (Figure 19) at the south end of the burial site. The weathered till is noticeably less plastic than the unweathered till. Iron staining along the surfaces of the joints indicates that oxygen-bearing water (possibly precipitation) has circulated along these fractures. While the amount and length of time water has been circulating is unknown, the brownish color of the till itself suggests that extensive oxidation and alteration by weathering is the major source of the joints in the till.

TABLE 7 [15]

Data from original drill logs - all holes 51' deep

#1 - No water encountered.

#2 - No water in hole.

#3 - Groundwater at 13'
Groundwater at 25'
No groundwater as completion.

#4 - Groundwater at 29'
No water at completion.

#5 - No water at completion.

#6 - No water at completion.

#7B- No water in sample at 14'-16'
Groundwater at 14.3' after 19'-21 sample
Groundwater at 31.7' at completion.

#8 - No groundwater encountered.

#9 - No water encountered.

#10- No water encountered.

Physical properties measurements for the weathered till at West Valley have not yet been published. However, Williams and Farvolden /17/ noted that hydraulic tests of tills in northern Illinois indicated that permeability along joints in weathered tills was considerably greater than the permeability of intergranular pore spaces in these tills; water moving through the jointed tills move preferentially through the joints. Cherry and Grisak /18/ conducted field hydraulic tests on jointed tills and clays. These tests identified up to two orders of magnitude greater permeability in jointed tills under in situ conditions than laboratory measurement of core permeability of the same tills. In both studies, a major concern was vertical permeability.

Unweathered Till

The unweathered till is a slate to battleship grey, plastic, silty clay with scattered rock fragments and pebbles. Although the till is relatively uniform in overall composition, certain zones have higher silt, sand, and gravel contents. A thin, 2- to 3-inch thick gravel zone was noted in Core Hole 9A. A 1-foot thick body or lense of very coarse sand was noted in open trench No. 12 and is discussed briefly below.

The overall thickness of the unweathered till is not known. However, information from drilling and geophysical (seismic) surveys conducted during earlier investigations /19/ indicate that the till is 150 to 300 feet thick beneath the burial site. Occasional interbedded sand and sand-and-gravel lenses and beds have been observed in the silty clay till under much of the surrounding area. One fairly widespread deeper sand lense or member, which was identified as an "artesian aquifer,"* appeared to be missing beneath the burial site. With exception of random lenses of sand and gravel, the unweathered till has generally uniform composition of very low permeability. This would tend to prevent significant downward migration of contaminants and could effectively separate the trenches hydraulically from the underlying bedrock.

A limited number of physical properties measurements were reported for core samples from a drill hole and an exposed valley wall /19/. Vertical permeabilities for these samples ranged between 0..001 to 0..002 gal/day/ft^2 (3 samples). The applicability of these measurements to the present study is hard to confirm because no measurements of samples were reported specifically from the burial site area.

Sand Bodies or Lenses

A wedge-shaped body or lense of dark grey coarse to very coarse sand with some pebbles was observed in open trench 12 (Figure 20). Average grain size was estimated to be 1/2 to 2mm (millimeters) in diameter. To the north,

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*Although classed as an "aquifer," this lense appears to have very little storage capacity and limited areal extent, and may be completely enclosed by the till.

FIGURE 18: IRREGULAR JOINTING IN TRENCH SIDEWALL

FIGURE 19: PHOTOGRAPH OF SURFACE OUTCROP OF WEATHERED TILL AT SOUTH END OF SITE

the sand body thins to a feather edge and dies out. To the east, west, and south, it is approximately one foot thick with no sign of thinning as it disappears into the sidewalls and end of the trench, respectively. Burial operations were suspended pending investigation of the sand lense. Subsequent soil sampling by NFS indicated this lense was limited in areal extent and remained shallow.

Physical properties measurements were not available on this or similar sand lenses. In the absence of such information, estimates are still possible. Based on the ranges of permeabilities estimated by Todd /20/ for different types of sediments, coarse to very coarse sand* such as that observed in the open trench could have a permeability ranging from 10 to 10^4 gal/day/ft^2.

Bedrock

The Caneadea - Machias Formation, an Upper Devonian Shale of the Canadaway Group, is the bedrock immediately underlying the silty tills at the site. It is a thin-bedded, black and grey, moderately hard shale and siltstone which may attain a thickness of 400 feet or more beneath the burial area. It, in turn, is underlain by an additional 1,200 or more feet of interbedded shales of generally low permeability. The shale bedrock was identified as an artesian aquifer in the NFS Fuel Reprocessing Plant Safety Analysis Report /19/. The report states: "The direction and rate of movement in this aquifer are essentially unknown... the rock itself has a very low permeability, possibly in the same order of magnitude as that indicated for the till. However, the rock contains many factures that will transmit small but useable quantities of water to a well. The existence of fractures may effectively increase the permeability of the aquifer to several gal/day/ft^2. ...Water probably enters the bedrock on the tops and upper slopes of the higher hills. Thereafter, the water moves through the shale along fractures to point of discharge."

Additional information on the bedrock was made available by Chase /21/. In 1969, the USGS on behalf of the USAEC conducted an experiment to determine the feasibility of disposing the liquid radioactive wastes by injection of these wastes as a cement slurry through a deep well under high pressures into the bedrock beneath the West Valley site. A 1500-foot test well was drilled three to four thousand feet east-southeast of the disposal area as part of this experiment. Bedrock was encountered at a depth of approximately 170 feet. The hole was cored from 178.4 feet to total depth (1500 feet) with almost complete core recovery. The information from that core is as follows:

- Bedrock was encountered at a depth of approximately 170 feet.

- Twenty-four vertical or near vertical fractures were noted in the cores; of these only five exhibited appreciable permeability or effective porosity. The remainder was sealed by secondary mineralization or rock flowage.

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*0.5 to 2.0mm in diameter

- The shale and siltstone strata were nearly flat-lying and there was no evidence of local geologic structure.

Some of the shales tested had permeabilities of 10^{-6} to 10^{-7} millidarcies (at 1000 psi water containing 3,000 ppm NaCl). Total porosities were 29-35% but effective porosities were very small.

- Geomorphology and spatial relationships suggest that similar materials and conditions underlie the burial site.

- A zone of decomposed shale and rubble was noted at the contact between the overlying till and bedrock. Although there was no noticable loss of drilling fluids while drilling though the tills, circulation was lost and never recovered after penetrating the weathered contact zone. This further suggest that an "aquifer" or zone of permeability may exist inthe bedrocks or, at least, at the till bedrock contact.

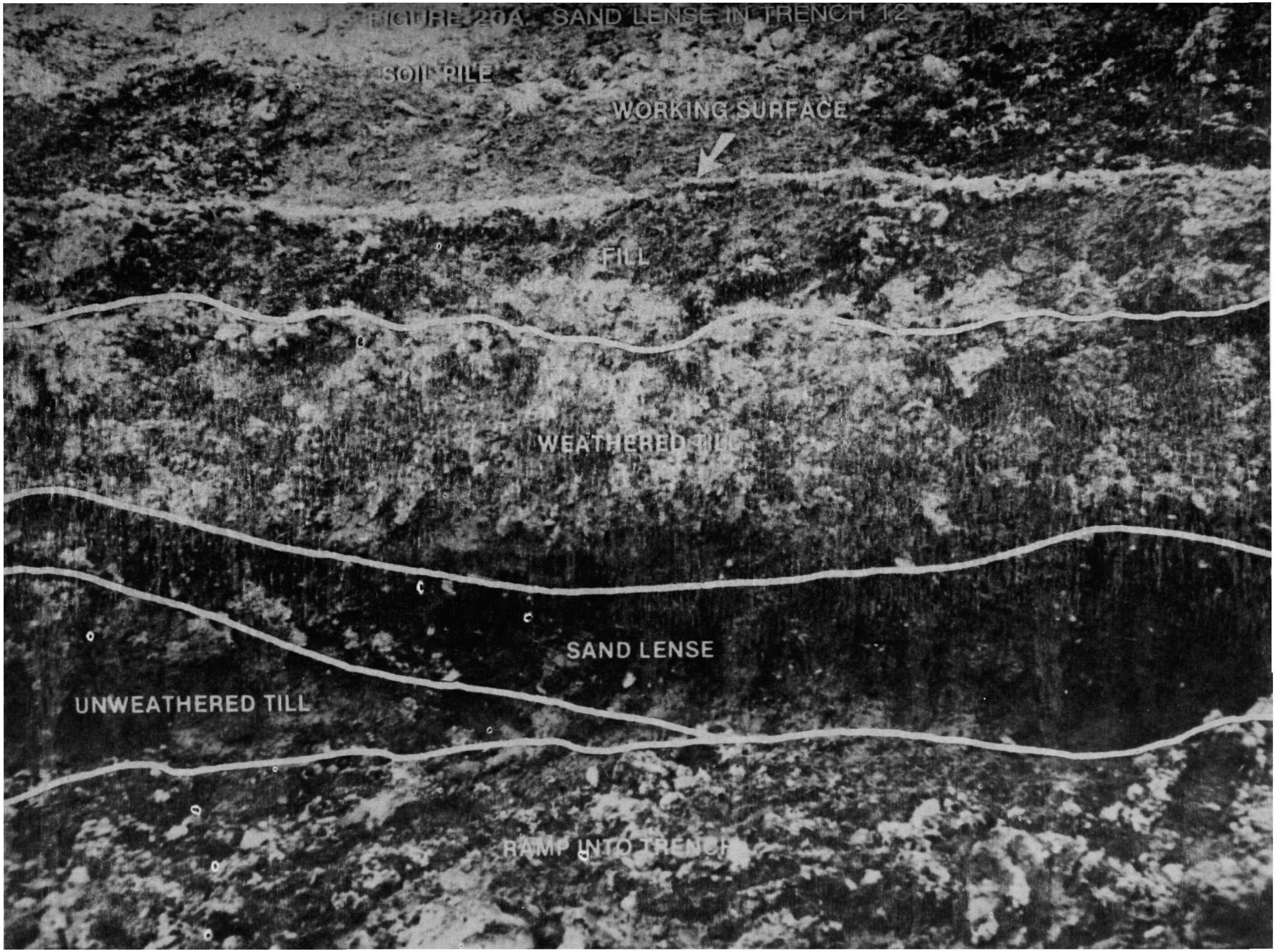

FIGURE 20A: PHOTOGRAPH OF SAND LENSE IN TRENCH 12

SCALE: 1" = 16'
NO VERTICLE EXAGERATION

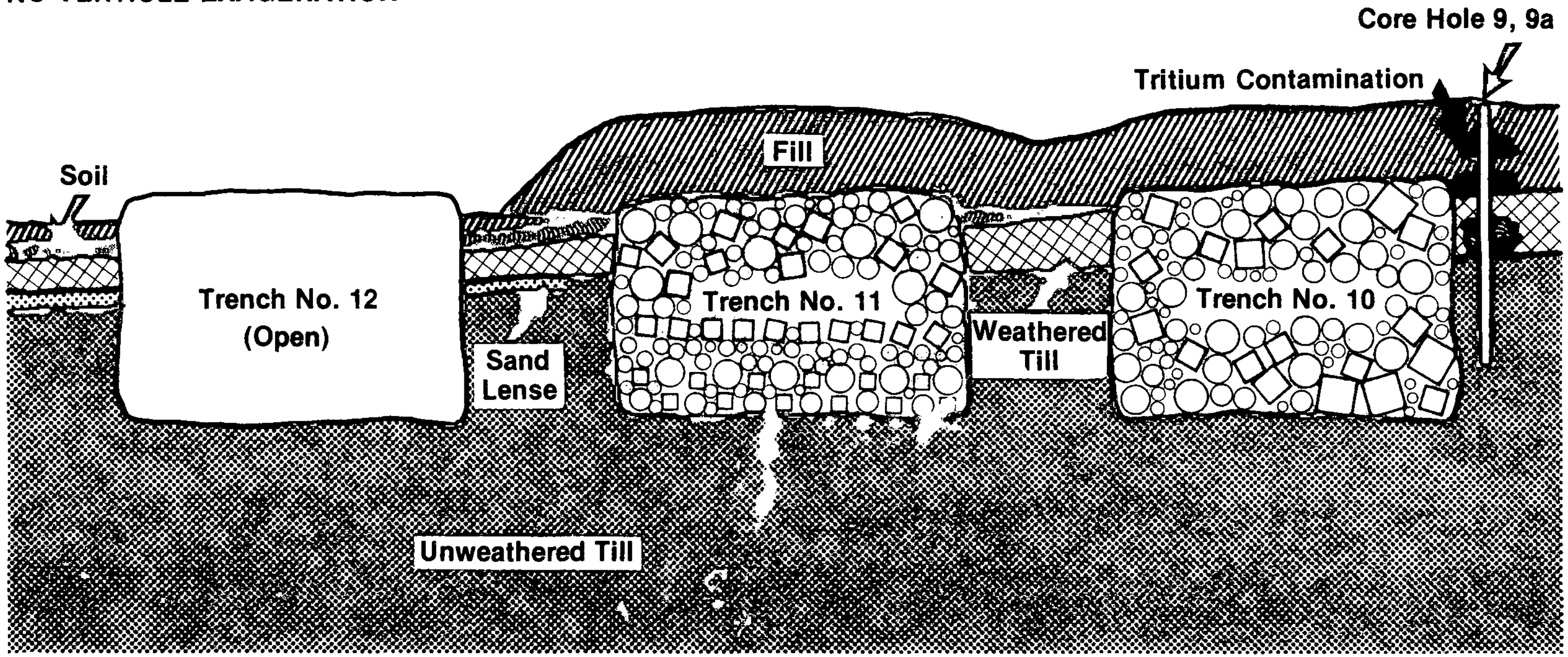

FIGURE 20B: **DETAILED EAST-WEST CROSS-SECTION THROUGH SEVERAL TRENCHES AT SOUTH END OF BURIAL SITE SHOWING WASTE — TRENCH — GEOLOGY — TRITIUM CONTAMINATION INTERRELATIONSHIPS (BASED ON FIELD OBSERVATIONS AND CORE HOLES 9 AND 9A.)**

V. ANALYSIS

A. Radiochemical Data

There appears to be two major potential sources of tritium detected in the core holes around the trenches; vertical migration of surface contamination or lateral migration of tritium contained in the burial trenches.

Surface contamination is possible since drums of low-level radioactive wastes were often laid on their side in the areas adjacent to the trenches. Fallout from the stack of the fuel reprocessing plant may have also caused deposition of tritium on the surface areas adjacent to the trenches.* Studies that investigate the downward movement of surficially deposited tritium are discussed in Appendix E as they might apply to West Valley. In this report, we have viewed surface contamination to decrease as depth increases based on the discussion contained in Appendix E and as shown in Figure 21a.

Contamination which might migrate laterally through the soil and tills at West Valley has been simplified to two categories. First, presuming that the soil is uniformly pervious, the tritium will migrate as a constant front through the trench. If jointing and fracturing pervade the weathered till to a sufficient degree, it can be considered an uniformly pervious soil. If one analyzed a boring of uniformly pervious soil for tritium, one would expect to find tritium concentration to be a constant over a range of depths as shown in Figure 21b.

Second, if a small zone such as a fracture or a sand lense is present, the tritium would migrate preferentially and the boring would have a higher concentration of tritium at a particular depth, lower concentrations above and below this depth, as indicated in Figure 21c.

Actual soil analyses do not yield graphs which are so easily interpreted. When plotted, the analyses for a particular boring may indicate that contaminants are moving along all three of these pathways. There may be surface contamination, migration through pervious soil, and migration through fractures and/or sand lenses. In addition, there is a significant change in lithology in the 12 to 16 feet depth in all the core holes. At this depth, the transition from the more permeable jointed weathered till to the less permeable unweathered till would limit downward migration of the radionuclides. Movement may predominate along one pathway or may occur along all three. But one can generalize and note that an increase in concentration with depth indicates that lateral migration through the soil or till is at least a feasible pathway unless the maximum water level in the

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*It should be noted that the March 1975 seepage incident which caused high levels of surface contamination in the burial area occurred subsequent to the drilling study and would not be a source of contamination at that time.

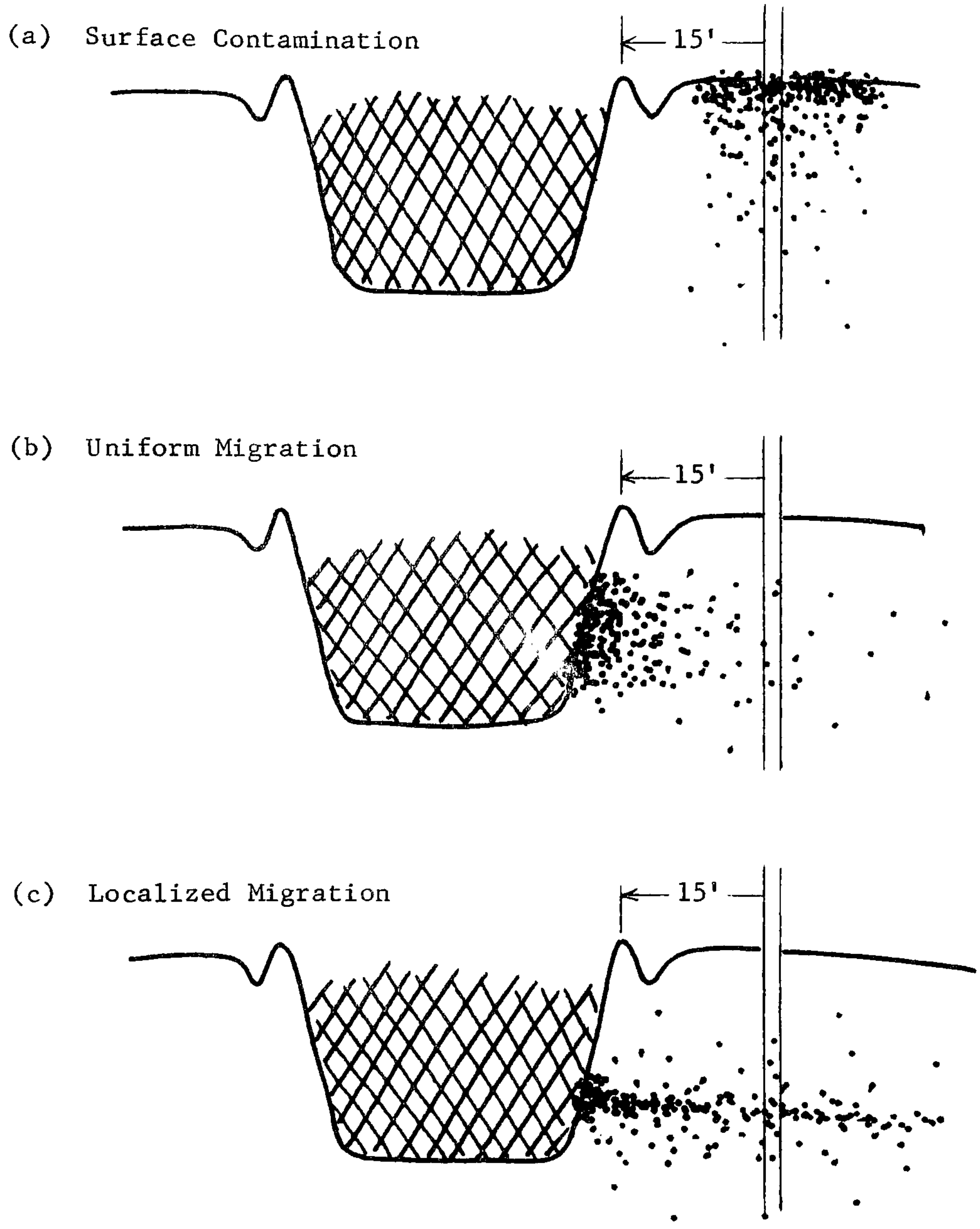

FIGURE 21: PICTORIAL SUMMARY OF PROPOSED CONTAMINATION PATHWAYS. VERTICAL LINES INDICATE BORING SAMPLES OF NUCLEI CONCENTRATION VS DEPTH.

trench was always below the level of the maximum tritium concentration for borings adjacent to the trench.

The analysis of the boring data was performed using the hypothetical data patterns shown in Figure 21a, b, and c as a template for the analysis. In some cases, both surface and subsurface migration pathways may be present in some combination. This analysis attempts to determine which pathways may be operative and, where possible, which pathway appears to be the predominant one.

There are some potential sources of variability in the tritium concentration data which may have resulted from surface contamination being carried to lower depths due to the metal bore used during the drilling. This possibility has not been resolved satisfactorily for the first ten bore holes analyzed. Another unresolved question regarding the variability in tritium concentration versus depth concerns radioactive background from non-West Valley related activities (namely weapons testing fallout). Considering the variability of data, it was considered prudent not to hypothesize pathways of tritium migration for any concentrations less than 1×10^{-5} uCi/ml unless supported by hydrogeologic data.

In general, Figure 8 through 17 show that concentrations of tritium in the first five feet of each boring may increase, decrease, or remain roughly constant. Concentrations in the first five feet of each boring are most probably attributable to surface contamination that has been mixed into the first five feet of material surrounding the trench as a result of burial operations such as site leveling or trench capping. The sources of surface contamination are believed to be; (1) fallout from the reprocessing plant stack, (2) radioactivity leached from contrainers placed adjacent to the trenches awaiting burial, or (3) radioactivity deposited from the tread or blade of a bulldozer exiting a partially finished trench.

For each boring the lowest concentration levels of tritium were found in the unweathered till zone. From this observation it can be said that subsurface migration occurring laterally through the unweathered till zone was not observed (it should be noted that no permeable layers such as sand lenses were encountered either).

In general, levels of tritium decrease rapidly in the weathered till zone indicating that the downward migration of surface contamination has occurred. The exceptions to this general tendency occur in holes 2, 2B, 2C, 2D, 3, 7B, 8, 9, 9C. In these holes, the tritium concentration does not decrease through the weathered till zone and in the case of the 2-series holes, holes 8, 9, and 9C, the concentration of tritium reaches a maximum at some point 5 to 15 feet below the ground surface. While the first impression might be to explain the phenomena for all of these holes by concluding subsurface migration has occurred, this would probably be incorrect for holes 8, 9, and 9C. In the case of holes 8, 9, 9C, the water levels in the adjacent trenches

(trenches 8, 9, 10, and 11) never came up to the level where contamination was found, hence this would not be the medium to carry the buried radionuclides through the weathered till zone by lateral migration. Considering that these holes are located adjacent to trenches in the south area of the site where substantial amounts of trench cover work were done subsequent to completion of these trenches, it is entirely possible that these levels at the 10 and 15 foot depth were caused during burial operations. The addition of subsequent cover over the area may have simply buried what was once surficial contamination. Additional support for this hypothesis comes from the fact that the direction in which these trenches were excavated was such that it faces the location of the bore holes. This would mean that a bulldozer tread or blade could have pushed radioactivity at the bottom of a partially excavated trench out of the trench and onto the adjacent surface area where it was subsequently covered by between 5 and 15 feet of till. This hypothesis seems more plausible for holes 8, 9, and 9C than the hypothesis of subsurface migration through the weathered till zone.

In the case of hole 7B, the water level was high enough in an adjacent trench (trench 5) to act as a conduit for subsurface transport through the weathered till. However, the depths of maximum tritium concentration are above the observed water level and the concentrations are not high when compared to the actual concentration of the trench water (1-2 x 10^{-4} uCi/ml). If direct subsurface migration were occurring then a much higher tritium concentration would be expected.

Increases noted in the 2-series holes are the most difficult to explain. Holes 2, 2B, 2C, and 2D show maximum concentrations below the ground surface; however, the depth of the maximum decreases with distance from the trench (i.e.; 2A - maximum at 20 feet, 2B - 15 feet, 2C - 10 feet, 2D - 5 feet). This would indicate one of two things: (1) there exists a permeable layer in the weathered till zone with an upward slope running away from the trench, or (2) the points of maximum may be coincident with a ramp used by a bulldozer to excavate the adjacent trench (trench 4). The latter hypothesis seems more plausible for two reasons. First, the concentration found at hole 2D, the furthest from the trench, was higher than those closer in at holes 2B and 2C. This would not occur if the concentrations occurred because of a permeable layer. Second, the concentrations are again far lower than those observed in the actual trench water samples as mentioned earlier for hole 7B. From this it would seem reasonable to conclude that elevated levels of tritium below the ground surface are most probably caused by some mechanical process involving the burial operation and not by direct migration through the weathered till zone.

From this analysis the following observations can be made about tritium movement:

1. Tritium was found to a depth of 15 feet in most of the core holes adjacent to the trenches.

2. Core data, field observations, and the tritium analyses indicate that a zone of relatively higher permeability underlies the site from the land surface to the 10 to 15 foot depth.

3. Several sources of the observed tritium are hypothesized including:

a. downward migration from fallout from the reprocessing plant;
b. downward migration from spillage occurring during burial operations;
c. lateral migration in certain areas;
d. other, as of yet, unidentified sources.

4. The data are not sufficient to indicate which way the tritium migrated to the core holes at the various depths. It can be surmised, however, that no significant lateral migration from trenches has occurred to date.

5. Additional studies (which are underway) are needed to accurately identify the source of the observed tritium.

The two radioisotopes of most interest would be Sr-90 and Cs-137 due to their importance in man's food chain. Holes 2 and 7B were analyzed more extensively and show that the concentrations of Sr-90 and Cs-137 were low, and it can be stated that there appears to be little if any evidence of subsurface migration of Sr-90 and Cs-137 at these two locations since these concentrations are so low. The Sr-90 and Cs-137 concentrations were on the order of 100 smaller than the tritium concentrations.

Normally, cesium and strontium are attenuated by the soil. Laboratory tests for ion exchange rates are usually conducted with simple salt solutions. Due to the variety of chemicals available for leachate formation in the trenches, it is doubtful that cesium and strontium exist in these simple ionic forms. If these elements form complexes, it is possible that the effectiveness of ion exchange will be diminished or by-passed. Also there is competition by other elements for ion exchange sites. If cesium and strontium are not preferred elements, then ion exchange is not a reliable inhibitor to migration. Due to the size of the trenches, the amounts of cesium and strontium available as leachate are very high. If the concentrations are too high the ion exchange sites nearest the trenches may be occupied and most of the radionuclides will migrate away from the trenches. The fact that these radionuclides were not detected in core samples taken fifteen feet from the walls of the trenches filled with leachate indicates that there has been little if any subsurface migration of these isotopes.

B. Hydrogeology

General

Identification of existing aquifers and their ability to transmit contaminated water from the burial trenches to land surfaces or to use points is of utmost importance. However, existing aquifers are only part of the hydrogeologic system of the burial site, and it would be inappropriate to consider their presence to be the only important part of the system. Of equal importance is the identification of unsaturated formations, horizons, and waste and construction materials within the immediate burial area which have the potential to transmit water when saturated.

Because of their low permeability, the tills and fill at West Valley do not transmit water in quantities which are useful to man. These materials also do not transmit water at rates which are readily observable except over a period of several weeks to several months. Further, the tills and fill may not become saturated before the beginning of burial operations. Therefore, the tills and fill often are not considered as significant parts of a hydrogeologic system of a disposal site. However, a new "micro-hydrogeologic" system is formed within the local and regional system once burial operations commence and trenches are excavated, filled with waste, covered, and begin to fill with water. The "disposal area" hydrogeologic system then becomes of primary importance when evaluating a disposal site.

Figure 22 schematically illustrates the "micro-hydrogeologic" system of the burial site area. Neither the original nor the present degree of saturation of individual units within the burial area are known. It is known, however, that the trenches in the north (old) area have filled with water and, unless these are kept dewatered, will impose a hydraulic stress on the system. The total effects of this stress are uncertain because little is known about the hydraulic properties of the geologic units within the system and the degree to which they are saturated.

Table 8 presents a comparison of preliminary estimates of the relative properties of hydrogeological units within the system. The estimates were made from information available at the time of this study. For example, the larger coefficient of permeability of the weathered till is based on field hydraulic tests made by others /17, 18/ on jointed weathered tills. This is corroborated by the fact that tritium has been able to migrate downward and possible laterally through the weathered till a few feet.

Figure 23 schematically illustrates the relationship of the units within the burial site "micro-hydrogeologic" system. Little more is known about the local/regional formations than is known about the burial area formations. Therefore, only generalized suppositions can be made about flow relationships within the burial and local/regional areas. The amount of vertical flow which may be occurring at the site, whether upward or downward, has not been determined. As stated above, for the unweathered till zone, it is not believed to be great in a downward direction relative to the horizontal flow which may occur at the elevation of the trenches within the hydrogeologic system. Specific hydraulic tests are needed to determine the rate of downward movement toward bedrock.

A key point to remember when evaluating the hydrology of the site is the charge to the hydrologic regime of the burial site brought by the burial processes and emplacement of wastes in the trenches. First, low permeability till is excavated from the trenches. Then, the trenches are filled with waste which has significantly greater permeability and porosity than the surrounding burial media. After filling, the trenches are then capped with a fill (formerly soil and till) which has relatively greater permeability and porosity then the surrounding undisturbed areas. Cap permeability is further increased by trench cap subsidence when the waste compacts during its decay.

The above factors allow the trenches to act as gathering areas for infiltrating precipitation. This then recharges the surrounding undisturbed burial media. Experience at other landfill operations in glacial tills tends to confirm this hypothesis. Hugh et al. /22/ found that as much as fifty percent of all precipitation falling on the trenches may infiltrate through the cap.

Based on field evidence that much of the surface of the burial site is a regolith resulting from the onsite weathering of the glacial till, certain more permeable component layers of the groundwater flow system are believed to be widely and uniformly distributed. Highly permeable sand lense(s) have been positively identified in the trench area. Although these are potential paths for significant recharge and discharge within the trench area, their areal distribution is not believed to be extensive. Figures 4 and 24 present an interpretation of the geologic frameworks at the north and south areas of the burial site. They depict (1) the original geologic and topographic conditions, (2) conditions after grading preparation for burial operations, and (3) the site today after burial operations. This interpretation is based on data from the core holes, topographic maps, and field observations.

The geologic framework and the mechanism for infiltration and recharge of the potential groundwater system (sand lense) appear to exist. Some discharge has also occurred. Some trenches have filled partially or completely with water, and overflow and seepage have occurred.

The groundwater flow system at West Valley appears to include a multimedia multiple layer geologic framework. Table 8 presents estimated coefficients of permeability for each component of the system. A range of potential travel distances for contaminants from the trenches to discharge points are also given. Travel time of contamination along each component of the system from the trenches to the nearest discharge point can be calculated by a number of simple formulae. However, almost all of the data used in these calculations are estimates and the resulting answers might not be meaningful. It is known, however, that discharge through the cap occurs almost instantaneously when the trenches fill with water. If there are sand lenses connecting the trenches with the land surface, then discharge of contamination could occur within several years. Likewise, movement of contaminants through the weathered till could occur at a rate faster than anticipated. Detailed field hydrogeologic investigations are needed to establish what is the real potential for movement of water through the burial area.

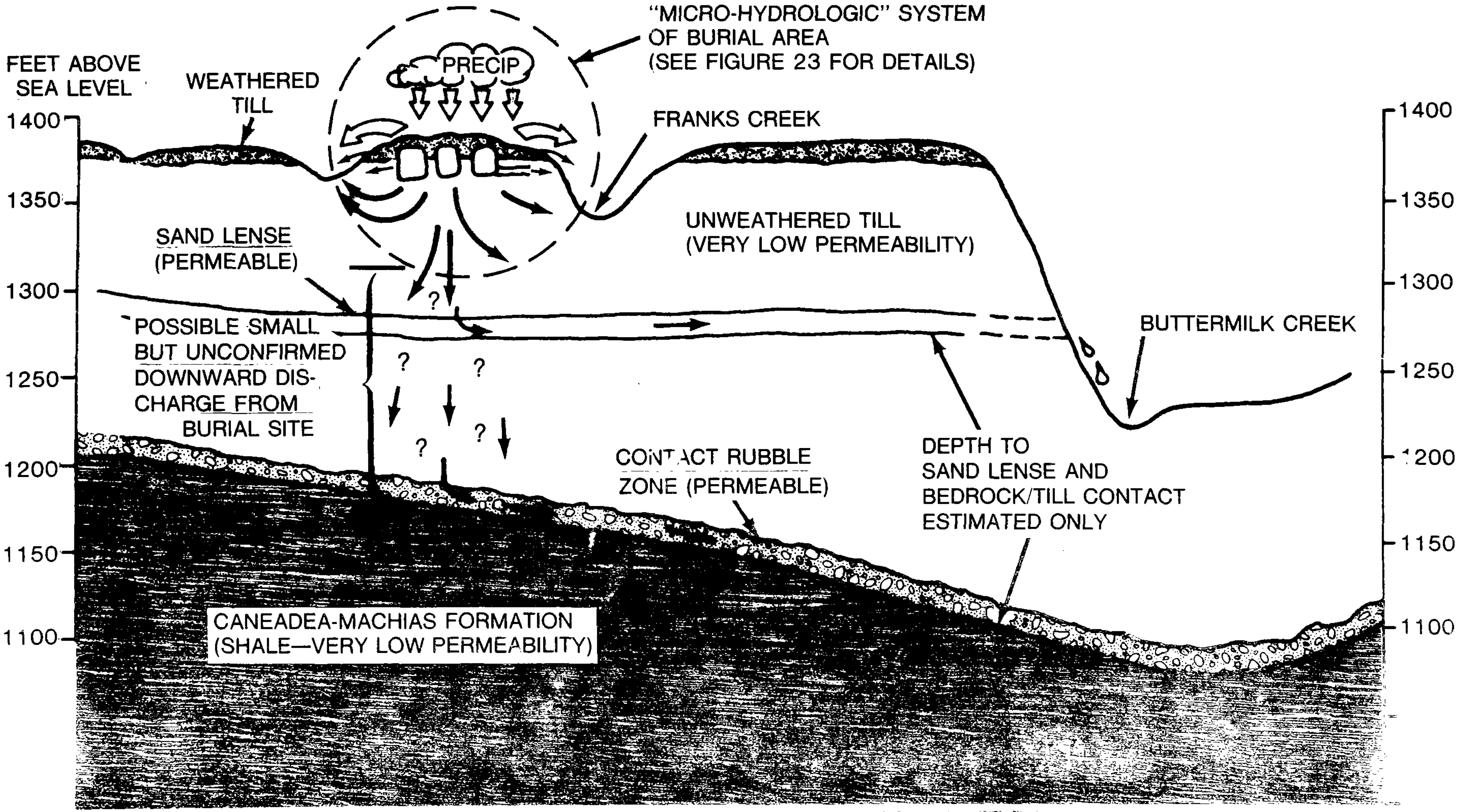

FIGURE 22: "MICRO-HYDROGEOLOGIC" SYSTEM

TABLE 8

Component	Estimated Coefficient of Permeability (gpd/ft^2) (Average)	Estimated Travel distance from trench to discharge point (ft)
Cap	.002 - .01 (1) (very large when ruptured)	3 - 8
Fill	.002 - .01 (1)	50
Soil	.002 - .01 (1)	50
Weathered Till	.01 - .05 (2)	50 - 125
UnWeathered Till	.001 - .005 (3)	50 - 125
Sand Lense	10 - 10^4 (4)	50 - 125 (possible but not established)
Waste	10 - 10^6	-0-

(1) Estimations by Meyer based on observations and assuming that cap, fill and soil are twice as permeable as the unweathered till.

(2) Based on information from reference 18 which states that the permeability of the weathered till maybe one order of magnitude greater than the unweathered till.

(3) [19]

(4) [20]

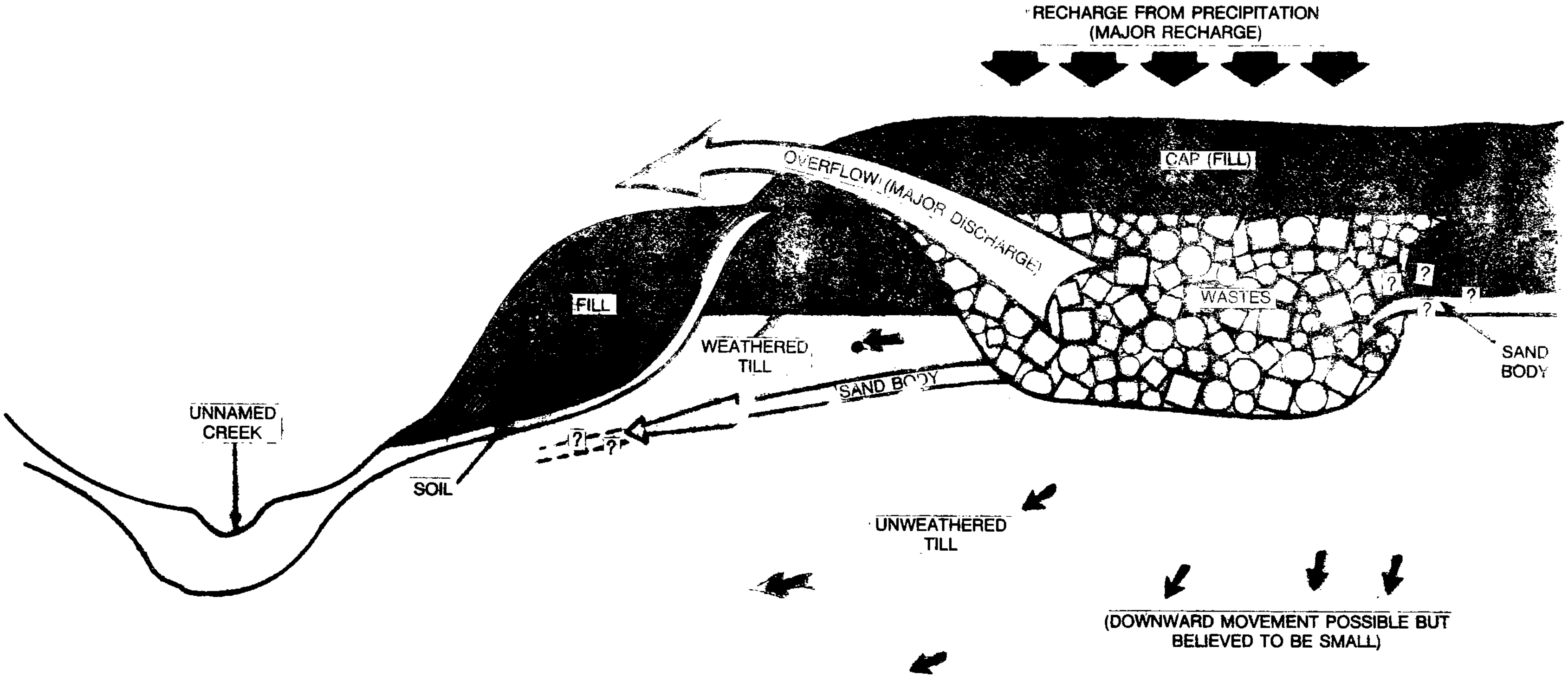

FIGURE 23: RELATIONSHIP OF BURIAL SITE "MICRO-HYDROGEOLOGIC" SYSTEM

The following points seem clear based on the limited information available.

> Overflow of trench water through the cap is the most direct flow path for contamination to leave the trenches under present conditions. The travel distance may be as little as three feet and the travel time is almost instantaneous after the trench fills with water. Most of the water collecting in the trenches appears to result from infiltrating precipitation. Therefore, keeping water out of the trenches is of utmost importance.
>
> The natural processes of freezing and thawing, wetting and drying, and erosion attack the integrity of the trench cap from without. Compaction of the wastes undermines the cap from within.
>
> The weathered till, fill, and soil, because of their relatively greater permeability, offer potential paths for the lateral migration of contaminants through the shallow subsurface. Travel distances via these paths may be as little as 50 feet and the travel time may be shorter than the anticipated hazardous life of the wastes. The relative importance of these paths are not known but appear to be less important than direct overflow and more important than downward migration to the deeper sand lense aquifer or the contact rubble zone. The extent and location of sand lenses should be fully investigated.

Water-level Measurements

Measurements of water levels in the trench sumps suggest that, for the present, the north and south areas of the burial site are behaving differently hydrologically. Water has collected in the north trenches to the point of overflow. Little water has collected in the south trenches. A comparison of trench water level rises (Figure 25) illustrates the difference in behavior of the northern and southern trenches. The thicker capping techniques used in the south may be preventing precipitation from infiltrating into the trenches. The observation that little water has accumulated in the new trenches with improved thicker caps is encouraging. As a result, there may not be a long-term problem with water accumulating in the trenches with accompanying overflow of contaminated water.

The lack of water accumulating in the south trenches may also be attributed to several other realistic hydrogeologic situations. Two examples follow.

> A sand lense or lenses such as observed in trench 12 (Figure 20a) may act as a drain system for the new trenches. Water may be infiltrating into the trenches but is being drained from the trenches at almost the rate it is infiltrating. This is not probable, however.

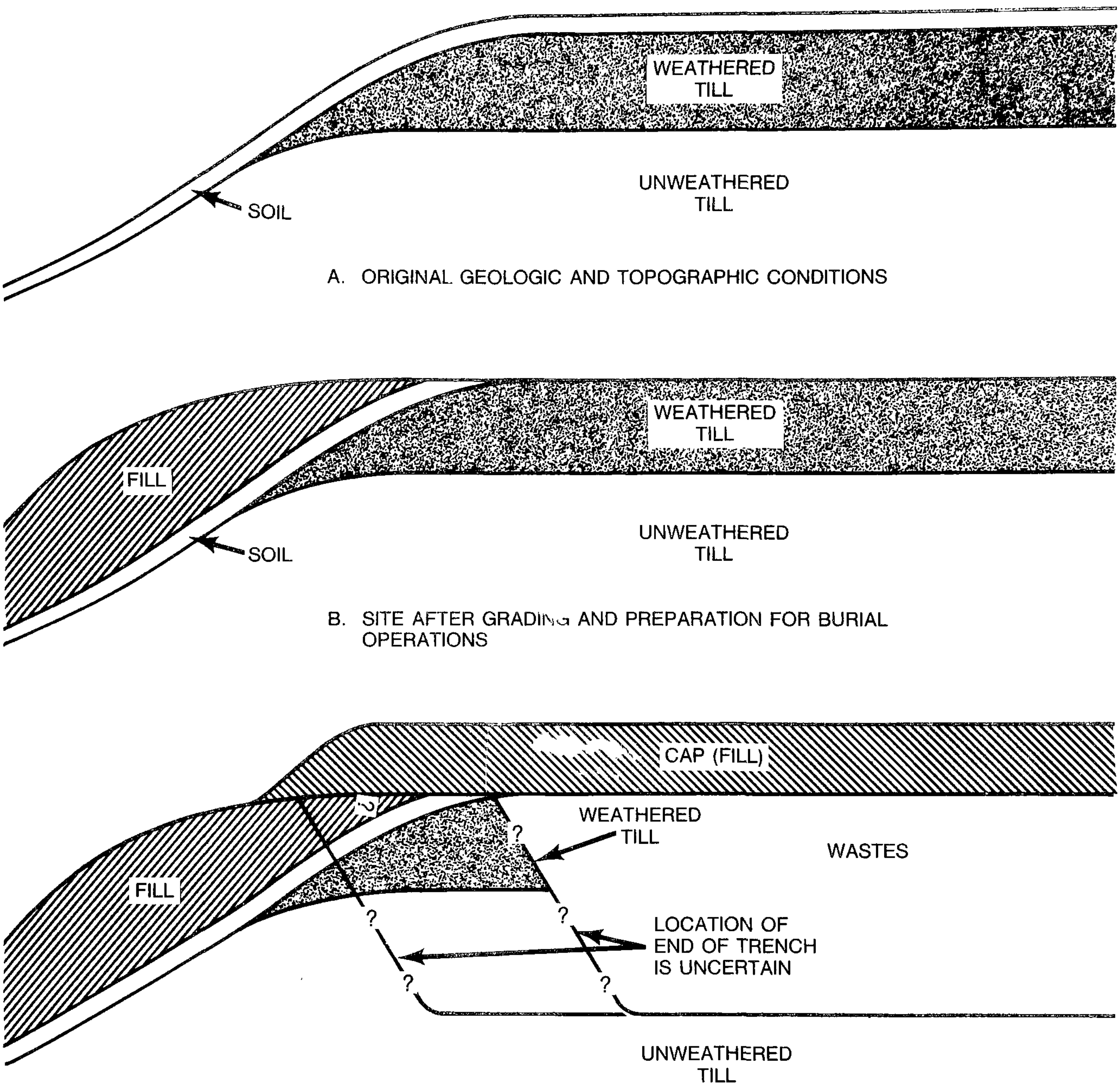

FIGURE 24: NORTH-SOUTH CROSS-SECTION OF NORTH END OF COMMERCIAL "LOW-LEVEL" RADIOACTIVE WASTE BURIAL GROUNDS AT NFS (WEST VALLEY, N.Y.). THE CROSS-SECTIONS INTERPRET THE GEOLOGY OF THE NORTH END OF THE BURIAL GROUNDS A) IN ITS ORIGINAL STATE, B) AFTER PREPARATION FOR BURIAL OPERATIONS AND C) AFTER BURIAL OPERATIONS COMPLETED. THIS INTERPRETATION IS BASED ON DATA FROM CORE HOLES, TOPOGRAPHIC MAPS AND FIELD OBSERVATIONS. (NOT DRAWN TO SCALE.)

The trenches are not "ripe"*. There can be little doubt that the increased thickness (greater than eight feet) and the practice of surcharging the caps of the adjacent completed trenches with soil from the working trench has reduced the amount of infiltration. Nevertheless, some infiltration can be expected to occur. With continued time (and infiltration) the wastes will become saturated, will compact, and the integrity of the trench cap may be disrupted at a later date resulting in the trenches filling with water.

Present information is limited to observations of water levels in trench sumps, knowledge of the approximate thickness of the trench caps, and experience at other landfills. This information is not adequate to evaluate how the hydrogeologic system in the south trench area is really operating. Specific research to determine the actual flux of water through the caps into the trenches seems essential before the long-term effectiveness of the improved capping techniques, and, therefore, the long-term integrity of the south area can be assured.

Future Developments

Until the actual cause(s) can be determined for the north area of the site behaving differently than the south, it is prudent to present a conservative (pessimistic) estimate of the potential long-term hydrogeology of the site under current knowledge of the hydrogeology and operational procedures at the site. Three possibilities are examined. IT SHOULD BE CLEARLY NOTED THAT NEW YORK STATE IS COGNIZANT OF THE CONDITIONS AT THE SITE AND IS COMMITTED TO A PROGRAM TO MAINTAIN THE INTEGRITY OF THAT SITE FROM ANY AVOIDABLE HEALTH RISK. (See Chapter VII). THE THREE POSSIBLE CONDITIONS THAT FOLLOW ARE PRESENTED TO SHOW WHAT COULD OCCUR IF NECESSARY REMEDIAL ACTIONS WERE NOT IMPLEMENTED.

Condition I (No trench pumping; no cap maintenance)

a. The trenches in the north will continue to fill with water, to overflow, and to discharge contamination at land surface.

b. Precipitation will slowly infiltrate into the trenches in the south, the wastes will compact, the caps will be damaged, infiltration will increase, the trenches will " ripen" and fill with water, and overflow will begin.

c. There will be an increased general discharge of contamination from the entire burial site which will be proportional to the total number of trenches and the amount and availability of radionuclides therein.

d. In addition to overflow, there will be the slower subsurface movement of contaminants through till, fill, and possible sand lenses. In the near-term, this release of contamination is believed to be significantly less important than overflow. The long-term consequences are not known.

e. Erosion will damage the trench caps allowing infiltration and possibly exposing the waste if allowed to continue unchecked. Contaminants brought to the land surface by the various hydrogeologic paths will be tied up

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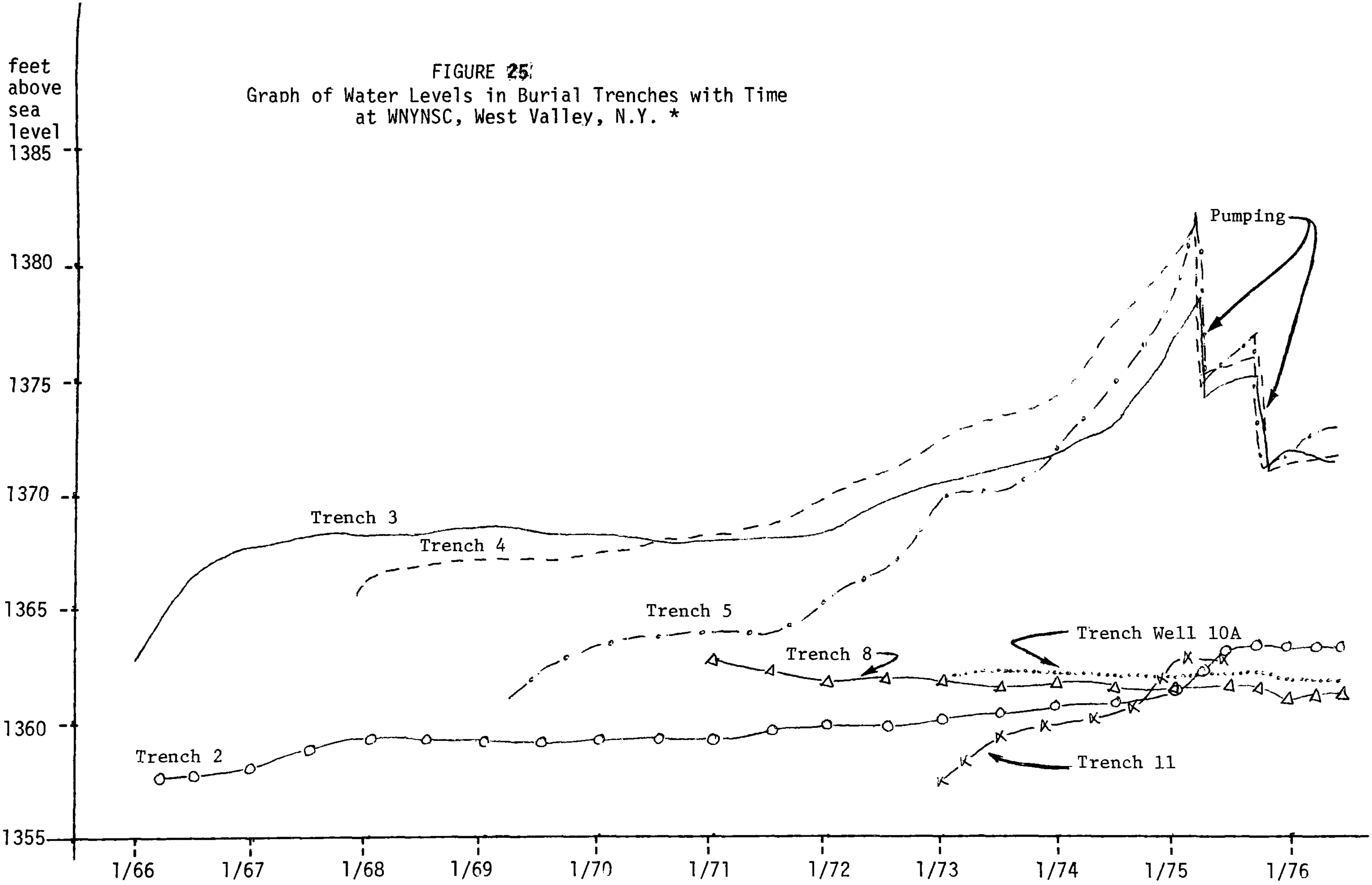
*A "ripe" trench is defined as one in which the wastes have become completely saturated and are compacting.

FIGURE 25
Graph of Water Levels in Burial Trenches with Time
at WNYNSC, West Valley, N.Y. *



*Based on a graph by E.J. Michael, 10/10/74, NYSDEC and on data from Ref. 6 [Extracted from NYSERDA/Dames& Moore Study, 1976] in the soils locally and will runoff in surface waters in solution or as suspended particles.

f. Contaminants in the soils and surface waters will then be transported along the hydrogeological and ecological pathways to man.

Condition II (Trench pumping; no cap maintenance)

a. The trenches in the north area will continue to fill with water but overflow will be prevented by pumping (dewatering) operations.

b. The radioactivity will be removed from the trenches by pumping, transferred to the liquid waste treatment facility, and the treated liquid with residual activity (primarily tritium) will be discharged to local streams.

c. The trenches in the south area will "ripen" and slowly fill with water. The pumping and decontamination of water from these trenches will also become increasingly necessary proportional to the number of trenches involved.

d. The subsurface movement of contamination from the trenches will continue at a slow and as yet undertermined rate, unless the trenches are completely dewatered rather than water levels being pumped down on a maintenance basis. The subsurface movement of contaminants will become of greater but as yet undetermined importance. Conditions similar to I-e and f will also pertain here.

Condition III (trench pumping; cap maintenance)

a. If the trenches are dewatered and waterproof caps are emplaced, water will not enter the trenches and the transport of contamination will be eliminated with two exceptions.

(1) If there is local ground water in the trench area, such as from a sand lense, water may continue to enter the trenches and continued pumping will be required. Whether local ground water exists is presently unknown.

(2) Erosion has been active at the site (see Figure 26) and could threaten the integrity of the trench caps and/or denude the wastes. Once the cap is breached, water can enter and fill the trenches, and pumping will again become necessary.

b. The surface movement of contamination from the trenches will continue at a slow and as yet undetermined rate. Conditions similar to I-e and f will also pertain here.

C. Dose Assessment

Several methods of calculating the health effects associated with the pump down of the north end trenches are possible. One method involving the use of empirical data would be to scale the population dose estimates due to fishing Cattaraugus Creek made by Magno et al. /6/. These dose estimates were made for the reprocessing plant's low-level liquid discharge but can be applied to the pump down operation since the treatment-and-discharge process for the pump down operation is effectuated through the same facilities and pathway as liquid discharges from the reprocessing plant. This method of estimation seems adequate for obtaining an approximate estimate of the dose due to trench pump down because the treatment routes are the same and the fishing-fish ingestion pathway is the critical pathway. The drinking water pathway is less critical since there are no drinking water

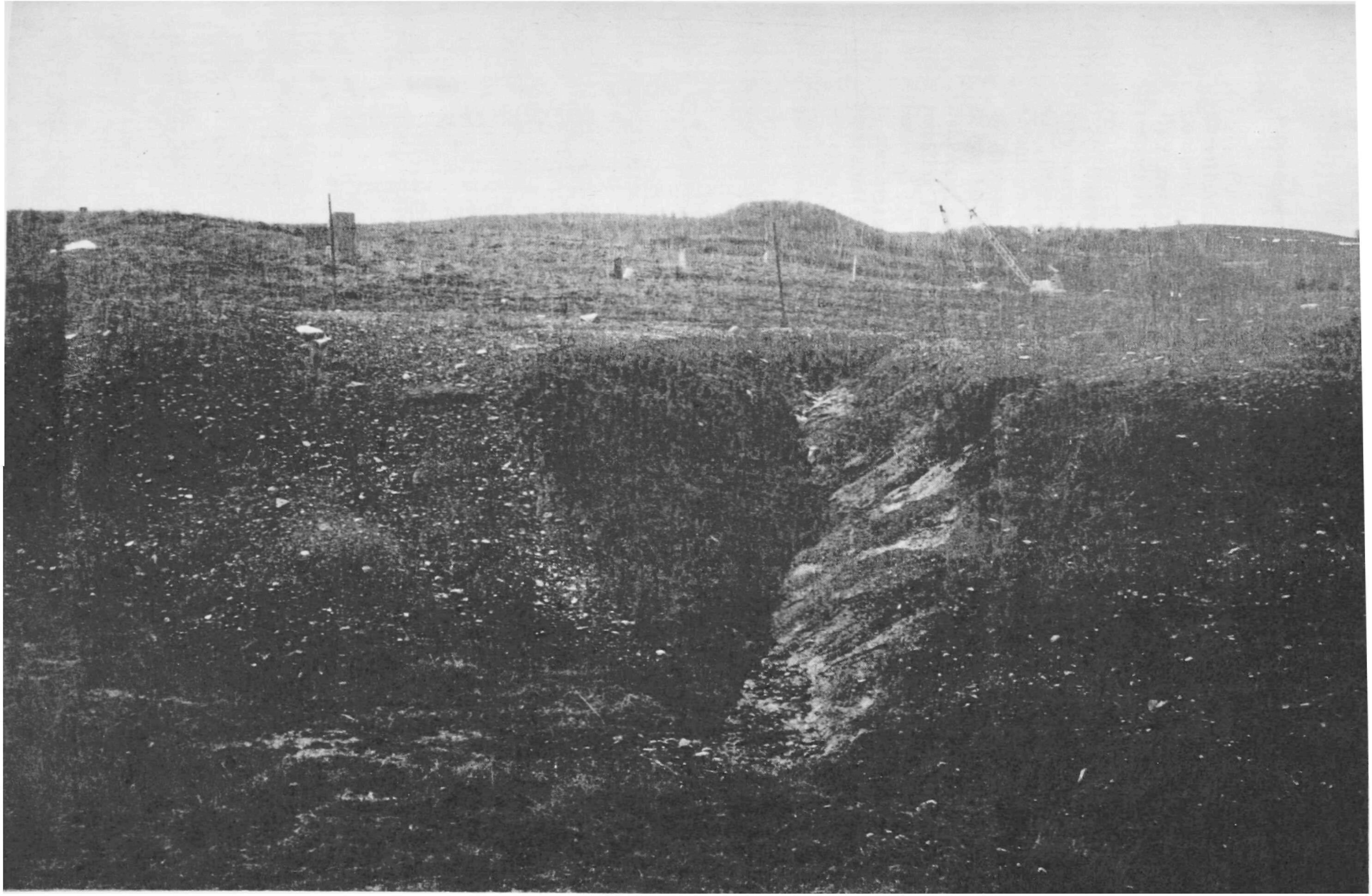


FIGURE 26: PHOTOGRAPH OF SITE EROSION

supplies on Cattaraugus Creek below the NFS discharge point.

For conservatism assume that the 1971 ingestion dose to bone from strontium-90 was due totally to the discharge of strontium-90 in 1971. This is conservative since strontium-90 is radiologically long-lived and discharges in 1969 and 1970 which were higher than that in 1971 (10, 14, and 7 curies respectively) undoubtedly had an effect on 1971 ingestion doses.

Based on grab samples taken of water pumped from trench 5, a concentration of $1.49 \pm 0.09 \times 10^{-4}$ uCi/ml was measured. A total of $8.3 \times 10^{+5}$ liters was pumped from the trenches. This indicates that 0.12 curie of strontium-90 was pumped from the trenches. Using extremely conservative assumptions such as no treatment but direct discharge into Buttermilk Creek, it can be seen that by using Magno's estimates, the dose to the maximum individual would be 0.12 mrem. In fact, treatment and dilution are performed, reducing the level of strontium-90 discharge by approximately a factor of between 100 and 300, hence the resulting dose would be less than 0.001 mrem to the maximally exposed individual by way of the fish pathway. Using an equivalent methodology, doses to other organs from other radionuclides would be below 0.001 mrem.

VI. FINDINGS AND CONCLUSIONS

A. Comparison with Recommendations for Siting of Low-Level Burial Sites

EPA and USGS have studied potential release mechanisms through which critical radionuclides buried in low-level burial sites could be introduced into the hydrosphere, atmosphere, or biosphere /23/. The potential release mechanisms are: a) transport of dissolved nuclides by water to wells, gaining streams, or springs; b) transport upward to the soil zone by capillary flow followed by the concentration of radionuclides in plants; and c) exposure and overland transport by normal erosion processes (water and wind), erosion due to floods, or erosion following disruption of landscapes by earthquakes. A suitable low-level shallow land radioactive waste burial site should therefore minimize the occurrence of these release mechanisms for the duration of the hazardous lifetime of the buried material.

Recommendations for the evaluation of the suitability of a site for burial of low-level nuclear waste have been presented by several investigators /18, 23, 24, 25, 26, 27/. One more recent report /18/ categories burial sites as: a) intermediate-term sites, suitable for wastes that decay to safe levels within several decades, for which protection is mainly provided by engineered structures in which the wastes are buried; and b) long-term sites, suitable for wastes with longer life, which depend mainly on hydrogeologic conditions for protection. This report presents hydrogeologic recommendations for both types of sites. These recommendations were later modified slightly by investigators working for EPA /23/. Table 9 is a comparison of the intermediate-term and the long-term recommendations with observations made at West Valley.

B. Comparison with Hazardous Waste Secure Landfill Recommendations

EPA's Office of Solid Waste Management Programs (OSWMP) has published a series of general recommendations for selecting and evaluating a chemical waste landfill site /28/. The development of these recommendations is discussed in Appendix F. Table 10 represents a comparison of these chemical landfill criteria to observations made based on data collected at the West Valley Site. The Federal government is presently formulating additional recommendations and guidance for low-level nuclear burial sites and these will be available in the future. From Tables 9 and 10, it can be seen that most of the recommendations are in good part met at West Valley. Further, the recommendations contained in Tables 9 and 10 do not constitute complete recommendations for a low-level burial site. As these recommendations indicate, for a complete evaluation of the suitability of the site, it is necessary to have a sufficient amount of hydrogeological data for the site so that the flow patterns and the rate of transport of radionuclides in the regional hydrogeologic system can be predicted. From Table 9 and 10 and based on the data presented in this report, the radiological data available for such predictions are insufficent.

TABLE 9. A COMPARISON OF HOW THE WEST VALLEY DISPOSAL SITE MEETS HYDROGEOLOGIC SITING RECOMMENDATIONS FOR SHALLOW LAND RADIOACTIVE WASTE DISPOSAL SITES. [23]

Recommendation Intermediate-Term Site	Conditions at West Valley	Comments/Evaluation
(1) The land surface should be devoid of surface water, except during snowmelt runoff and exceptional periods of rainfall. In other words the site should not be located in (flood plain,)* swamps, bogs, or other types of very wet (or potentially very wet) terrain.	(1) Surface streams and swampy areas are not found directly within the disposal trench area. However, these do occur within several tens of meters of the disposal trenches.	(1) Basically meets this recommendation. Water from the streams and marshy areas adjacent to the trench area does not threaten to enter the trenches and mobilize the wastes. However, the streams may act as transporting agents once contaminants are released from the trenches.
(2) The burial zone should be separated from fractured bedrock by an interval of geologic deposits sufficient to prevent migration of radionuclides into the fractured zone. Except in unusual circumstances the direction and rate of ground water flow as well as the retardation effects are very difficult or impossible to predict in ground water regimens in fractured rocks. This lack of predictability necessitates that fractured rock be regarded as a major hazard in terms of subsurface radioactive waste management. In fact, it is doubtful if contaminated ground water could be effectively detected and monitored in some types of fractured rock.	(2) The burial medium is separated from the underlying fractured bedrock by tens of meters of unweathered till with very low permeability.	(2) Meets this recommendation. The downward migration of contaminants from the trenches to low-permeability shales and the more permeable contact rubble zone between the till and the shales is not believed to be a significant hazard.
(3) The predicted rate of radionuclide transport in the shallow....deposits at the site should be slow enough to provide many years or decades of delay time before radionuclides would be able to reach public waterways or any other area which might be considered hazardous in the biosphere. In other words considerable time would be available for detection of contamination and for application of remedial measures if necessary.	(3) Radionuclide transport from the trenches was observed overflowing through the caps, a distance of 2 or 3 meters, within approximately 10 years in the northern area. Other less direct but possible near surface pathways exist. These include migration through the weathered till which may be measured in several tens of meters to hundred meters. Migration along sand lenses may also be possible.	(3) Fails to meet this recommendation in the north disposal area because movement through the shallow deposits has been by-passed by direct overflow through the trench. Insufficient information is available to determine whether site meets this recommendation as written. On a practical basis, radionuclides have moved rapidly from the trenches to the biosphere via the direct overflow through the trench cap whereas radionuclides appear to be moving relatively slowly

*Additions to the quote indicated by ( ), omissions by .....

		through the ground although the actual amount of movement is not known. The important point is that direct overflow have by-passed the retention capabilities of the hydrogeologic system.
(4) The site should have sufficient depth to water table to permit all burial operations to occur above the water table, or as an alternative the site should be suitable for producing an adequate water table depth by flow system manipulation.	(4) The depth to water is not known. It is believed to be below the bottons of the trenches in the south. There was no observed entry of water into the trenches during burial operations in the north. However, there are indications that the water table may intersect the trenches because of ground water mounding around the trenches or a saturated sand lense intersecting the trenches in the north end.	(4) Meets this recommendation under present conditions if flow system manipulation (pumping) is used. The south burial presently meets this recommendation without flow system manipulation. The north area may have originally met this recommendation without pumping before burial operations began but the infiltration of precipitation into the burial trenches appears to have altered the water table locally in the north. The main source of water problems appears to be the infiltration of precipitation. Stopping this infiltration appears to be the water control measure needed most.
(5) The site should be well suited for effective monitoring and for containment by flow-system manipulation schemes.	(5) The site appears to be well suited for monitoring of surficial and near surface migration. Although estimated to be small, the potential for subsurface migration is not known.	(5) Appears to meet the recommendation concerning effective subsurface monitoring. Surface and near surface monitoring are complicated by extraneous radioactivity from the adjacent fuel reprocessing plant and from operational spills.
Long-Term Site		
(1) a)The land should be generally devoid of surface water and b)be relatively stable geomorphically. In other words erosion and weathering should not be proceeding at a rate which could significantly affect the position and character of the land surface during the next few hundred years.	(1) a)Refer to (1) above. b)Erosion of the slopes at the north end of the site is actively occurring.	(1) a)See (1) above. b)The till is not geomorphically stable and erosion is damaging the integrity of the slopes and with time could possibly expose the wastes in the north trenches. It may well be the most serious long-term problem at the north end of the site. Erosion does not appear to be a problem at the south end of the site.

(2) The subsurface flow pattern in the area must be such that the flow lines from the burial zone do not lead to areas considered to be particularly undesirable, such as fractured bedrock, public waterways used by man, aquifers used for water supply, etc.	(2) See (2) and (5) above in regards to subsurface flow patterns. Of more direct interest and consequence is the overflow of water from the trenches. Contamination is discharged at land surface within a few meters of streams.	(2) Meets recommendations concerning deeper subsurface flow lines. Does not meet recommendations concerning surface and near surface flow lines. This recommendation does not clearly apply to the movement of radionuclides through the cap and the shallow subsurface under present conditions. The effect of the waste laden trenches has (1) altered the natural hydrogeologic system of the site and (2) this system has been bypassed by overflow and mounding of waters.
(3) The predicted residence time of radionuclides within an acceptable part of the subsurface flow system must be of the order of several hundred years. The hydrogeologic conditions must be simple enough for reliable residence-time predictions to be made. (underlining not in original quote)	(3) Some radionuclides have moved from the trenches in less than ten years. Their predominant movement to date has been overflow through the trench cap. Radionuclides have also been detected in the ground 15 to 30 feet from the trenches. It has not been determined whether this source results from lateral migration through the ground from the trenches or from fallout from the fuel reprocessing plant or spills during burial operations. No reliable residence-time predictions are available.	(3) Does not meet this recommendation. Although the predicted residence-time of radionuclides in the undisturbed subsurface flow system appears to be acceptable; the effects of emplacing the trenches and wastes in the system, recent overflow of the trenches, and the potential erosion have not yet been factored into the residence-time calculation.
(4) The natural water table should be below the burial zone by at least several meters and the hydrogeologic setting should be such that large water table fluctuations are very unlikely. This condition would provide additional assurance that leaching of radionuclides would not occur quickly in the event that low-level wastes are put directly in the ground.	(4) See (4) above. The wastes in some trenches are leaching because of precipitation infiltrating into the trenches.	(4) The site, in fact, appears to meet the recommendation concerning an adequate depth to the water table. However, the trench cover over the north trenches fails to prevent water from infiltrating, and leaching of the wastes is occurring.

TABLE 10. A COMPARISON OF RECOMMENDATIONS FOR SITING AND OPERATING A HAZARDOUS WASTE SECURE LANDFILL AND THE CONDITIONS AT THE WEST VALLEY SITE.

Recommendations	Conditions at West Valley	Evaluation/Comments
(1) Chemical waste landfills ideally should be located in areas of low population density, low alternative land use value, and low ground water contamination potential.	(1) The site is located in a low population density area. The State of New York conducted studies which determined that establishment of a nuclear park for fuel reprocessing, waste disposal, etc., was an appropriate use of the land. Contamination of a significant ground water supply appears remote.	(1) Meets this recommendation.
(2) All sites should be located away from flood plains, natural depressions, and excessive slopes.	(2) There are no flood plains near the disposal area. There is a low marshy area near the south end of the trench area; however, it is not believed that this marshy area threatens the site's containment. The hillside and berm at the north end of the site are sufficiently steep to be undergoing significant erosion.	(2) Fails to meet this recommendation with regards to excessive slopes. Significant erosion is occurring and could possibly unearth the wastes if allowed to continue unchecked.
(3) All sites should be fenced, or otherwise guarded to prevent public access.	(3) There is a fence around the disposal site and a fence around the entire nuclear park. Accidental entrance into the disposal area is not possible.	(3) Meets this recommendation.
(4) Wherever possible, sites should be located in areas of high clay content due to the low permeability and beneficial adsorptive properties of such soils.	(4) The burial medium is a clayey silty till which has very low permeability and potentially good adsorptive properties. However, the upper eight to fifteen feet of the till is weathered and highly jointed.	(4) Meets this recommendation. However, a serious question can be raised as to whether this recommendation is sound. The low permeability of the till causes water which has infiltrated into the northern trenches to collect as in a bathtub and to overflow. Further, the low permeability prevents the water which collects in the trenches from moving into the burial medium, therefore, prevents radionuclides in the trench water from being sorbed by the clayey burial medium. This recommendation is sound if the trench cover prevents water from infiltrating into the trenches.
(5) All sites should be within a relatively short distance of existing rail and highway transportation.	(5) A rail line runs within a hundred yards of the disposal site. All-weather, asphalt roads serve the West Valley facility.	(5) Meets this recommendation.

(6) Major waste generation should be nearby. Wastes transported to the site should not require transfer during shipment.	(6) The site is centrally located in the New England - Northeastern United States area and is, of course, adjacent to the reprocessing plant.	(6) Meets this recommendation if the concept of regional sites is accepted.
(7) All sites should be located an adequate distance from existing wells that serve as water supplies for human or animal consumption.	(7) There are no wells in the vicinity that serve as water supplies for human or animal consumption which might be affected by the site.	(7) Meets this recommendation.
(8) Wherever possible, sites should have low rainfall and high evaporation rates.	(8) The site receives more than forty inches of rain per year and the evaporation rate is not sufficiently high to prevent the infiltration of water into the trenches.	(8) Fails to meet this recommendation. Although the amount of precipitation falling at the site is normal for the region, it is sufficiently high as to cause water control problems at the site.
(9) Records should be kept of the location of various hazardous waste types within the landfill to permit future recovery if economics or necessity permit. This will help facilitate one analysis of causes if undesirable reactions or other problems develop within the site.	(9) Detailed records of the trench and approximate location within the trench are available for each shipment of waste.	(9) Meets the requirement that the location of the waste be known.
(10) Detailed site studies and waste characterization studies are necessary to estimate the long-term stability and leachability of the waste sludges in the specific site selected.	(10) Detailed site studies were not available for the disposal site. Little is known about the chemical or physical form of the wastes. The usual information furnished for a shipment typically consists of volume, the major isotope(s) and its activity, whether the waste is solid, liquid, or gas, and whether it is by-product material, special nuclear material, or source material.	(10) Fails to meet either of these two recommendations. Although adequate when done, initial site investigation studies conducted during 1961-1963 are not considered to provide the details now required for siting a low-level radwaste disposal site. Post 1963 experience and developments have pointed up the need for additional site data and characteristics; ongoing studies described in the text are developing this information. The need for more information about the types and quantities of wastes which can be disposed in a given site, criteria for the acceptability of the wastes which can be received and the limits for a given site has also been identified by the IAEA Advisory Group on Site Selection, Operation, Control, and Decommissioning.

(11)The site should be located or designed to prevent any significant, predictable leaching or run-off from accidental spills occurring during waste delivery.	(11)This recommendation is hard to evaluate. The distance from the trench area to the nearest streams is only several tens of meters at several points. Contamination of the nearby streams from overflow of the trenches, although not a health hazard at this time, has occurred. This may be analogous to operational spills.	(11)May fail to meet this recommendation.
(12)a)The base of the landfill site should be a sufficient distance above the high water table to prevent leachate movement to aquifers. b)Waste leachability and c)soil attenuation and d)transmissivity characteristics are important in determining what is an acceptable distance. e)Evapotranspiration and f)precipitation characteristics are also important. g)The use of liners, encapsulation, detoxification, and/or solidification/fixation can be used in high water or poor soil areas to decrease ground water deterioration potential.	(12)a)Insufficient information is available from the original siting investigations to accurately determine the water levels in the disposal area. The bottoms of the southern trenches are believed to be well above the high water table. However, some evidence suggests that the water table in the north end of the site may be shallower than anticipated. b)No information is available on the leachability of the wastes. c)No information is available on the soil attenuation capability of the burial media. However, routine laboratory-type K_d (exchange capacity) tests were made on samples of unweathered till similar to but outside of the disposal area. d)Although not known precisely, the permeability characteristics of the burial media in general are estimated to be very low. Thus, precipitation infiltrating through the cap collects in the trenches as in a bathtub, fills the trench, and then overflows out the top of the trench as the primary route of escape. e)There is little direct information on the evapotranspiration at the disposal site. f)There is information on precipitation. g)No protective action is taken to decrease the ground water deterioration potential of the wastes. The wastes in the trenches containing water are believed to have become saturated and it is known that radioactivity has leached from them.	(12)Meets this recommendation in fact. However, the real problem is the release of radioactivity to land surfaces by overflow; not the subsurface migration of radioactivity. b)Fails to meet this recommendation. Radioactivity is being leached from the wastes. c)Although laboratory K_d values are available for samples of till similar to the burial media, these tests and values in no way duplicate the combination and chemistry of the radionuclides in solution in the trench waters and therefore do not give a true indication of the attenuation by the soil which can occur. d)The very low transmissivity of the burial media appears to cause the major movement of water from the trenches through the cap by overflow. This causes the ion exchange capability of the burial media to be largely by-passed. e)Fails to meet this recommendation. f)Although precipitation values are generally known, insufficient additional information is available to calculate the water budget and the amount of recharge which is occurring at the site. g)Fails to meet this recommendation under present conditions. The trench caps do not prevent the water from infiltrating into the trench. Packaging and solidification of the wastes is primarily for the protection of the population and workers during transportation and burial operations. The wastes are subjected to direct soaking and leaching whenever water collects in the trenches.

(13) All sites should be located or designed so that no hydraulic surface or subsurface connection exists with standing or flowing surface water. The use of liners and/or encapsulation can prevent hydraulic connection.	(13) There is no surface or standing water connection with the trenches or the site. There may, however, be a subsurface water connection to the trenches through local sand lenses.	(13) May meet this recommendation. Insufficient information available to evaluate. However, direct infiltration of precipitation through the cap furnishes a known and critical hydraulic connection between water and the wastes.

C. Conclusions

If the major goals of low-level nuclear waste disposal are containment and confinement of the waste for the duration of its hazardous lifetime, then based on hydrogeological and radiochemical data the following conclusions have been drawn:

1. These goals have not been met based on observations of radioactivity seeping through trench caps and contamination of areas surroundings the burial trenches within fourteen years of initial operation.

2. The West Valley site does not totally meet all the recommendations established to evaluate suitable low-level shallow land radioactive waste burial sites or chemical waste landfill sites.*

3. Estimates of offsite dose levels appear to be insignificant at this time.

4. Remedial actions are necessary to control trench water levels and site erosion.

5. More data are needed to determine if the West Valley site can be considered a suitable disposal site based on the aforementioned recommendations.

6. At least three actual or potential major pathways for radionuclide movement at the site have been identified. These are in order of importance: surface water transport resulting from the runoff into nearby streams of contaiminated water seeping through burial trench caps (actual); surface water transport resulting from discharge of treated trench water into nearby streams (actual); and subsurface migration of contaminants through geological formations (potential).

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*It should again be emphasized that these recommendations were not available in the early 1960's when the site was established.

VII. RECOMMENDATIONS & FOLLOW UP ACTIVITIES

A. Future Studies at West Valley

This report has provided an overview of pertinent work and investigations conducted at the West Valley site from its inception until the seepage of radioactivity from trenches 4 and 5 and the subsequent pump down in March 1975. Particular emphasis was placed on the lithological boring study and the field observations.

An attempt has been made to point out areas where more data pertaining to the site are needed. In general, studies have already been initiated to obtain data needed to answer remaining questions about this site. Four major efforts which are in progress at the site are described below.

Hydrogeologic/Hydrochemical Studies

Empirical measurements of the physical and chemical properties (i.e. porosity, ion exchange, etc.) for the materials making up the burial media and the underlying geological formations have not been sufficient. Also, a detailed map of distribution and interrelation of the geology and hydrology has not been made. Other than the drilling program sponsored by EPA in 1974 and 1975, little had been done to measure the levels of radioactivity in and around the burial trench area and to correlate such information with hydrogeological information.

The USGS is currently conducting a detailed five-year field study which includes the collection of detailed information on the hydrogeological and hydrochemcial formation. Detailed geologic maps of the burial site and the area surrounding it will be made as well as measurements of the level of radioactivity in the trench leachate and in the vicinity of the burial trench area.

This study is one of five field studies at the commercial radioactive waste burial sites throughout the United States which the USGS is conducting to develop an understanding of the processes and principles of shallow land burial of radioactive wastes.

Environmental Pathways Study

New York State agencies, under the lead of the New York State Geological Survey, are conducting a detailed four year EPA funded field study to determine the impact of the burial site on the environment and on man. The goal of this study is to define the movement of water and contaminants in sufficient detail in order to develop a working mathematical mass transport model for the site. From this model, the amount of leakage, if any, and the potential for future leakage, if any, can be estimated.

This study is the first of a series of EPA funded detailed field studies aimed at developing a generic empirically based pathways model for predicting the impact of present and future burial sites on the environment.

Reactor Waste Study

There is a lack of information concerning the amount and types of low-level wastes produced by nuclear power plants as is evidenced by the data cited in Appendix D. While wastes from nuclear power plants do not presently constitute a great percentage of the low-level nuclear waste buried at West Valley and the other commercial burial sites, they are expected to make up the majority of all wastes buried in the future, both in volume and in radioactivity.

More specifically, it is expected that solidified concentrated liquids (evaporator bottoms) and ion exchange resins will make up the bulk of the wastes received from reactors. Therefore, EPA has funded a study by NYSERDA to determine the amount and types of radionuclides present in ion exchange resins and evaporator "bottoms" (concentrates) from boiling water reactors and pressurized water reactors. Sample resins and bottoms collected from four reactors in New York State are being analyzed in this study.

Site Engineering/Water Control Study

NYSERDA is conducting comprehensive site engineering and water control studies at the burial site. The scope of this study includes: determining the cause and recommending solutions to the problem of water accumulation in burial trenches, defining an erosion control program for the surface area and the edges of the burial area, and designing an improved onsite subsurface monitoring network for detecting radionuclide movement.

B. Monitoring Programs

NYSDEC is responsible for all ambient environmental radiation monitoring in New York State. Part of NYSDEC's monitoring program includes the monitoring regime around the West Valley site. Elevated levels of radioactivity at the site were originally discovered by this network. NYSDEC will modify and improve their monitoring program of the burial site as appropriate on the basis of new information made available from the studies described in the previous sections. In particular, it is expected that the hydrogeological/hydrochemical and environmental pathways studies will identify the best locations for future long-term monitoring stations at West Valley.

C. General Recommendations for Future Shallow Land Low-Level Burial

The data available from our studies at the West Valley site make it clear that there are a number of specific areas pertaining to the shallow land disposal of low-level nuclear wastes that require additional guidance and criteria development to assure the safety of shallow land disposal technique. These seven areas include: (1) criteria for locating sites; (2) methods for evaluating and predicting the impact of sites; (3) burial procedures; (4)

trench capping procedures; (5) types of wastes which may be buried; (6) long term monitoring; and (7) perpetual care and maintenance. Studies are currently being conducted by the NYSGS, NYSERDA, USGS, and EPA which will aid in developing criteria and guides on these points. However, some preliminary recommendations can be made from the data accumulated by this study.

- In locating and evaluating a potential burial site, a procedure for data collection similar to that required for nuclear power plant environmental reports is generally needed.

- The environmental assessment program for the site should include the development of hydrogeologic mass transport and environmental pathways models which are suggested by previous studies /22, 28/ and are consistent with empirical measurements.

- A set of criteria, guidelines, and/or standards are needed to judge if the data collected in the environmental report show the site to be acceptable.

- After a site has been found acceptable based on a detailed environmental assessment, a site operation plan should be developed which includes the exact location of the burial area and a preliminary analysis and description of the procedures to be used in the actual burial operation.

From this information and the environmental assessment data, a monitoring program for the proposed site should be established. The program should provide for sufficient surveillance of all the potential pathways described in the environmental assessment. Predetermined levels of radioactivity should be established after reviewing background data that would serve as indicators of leakage or migration from the site. Protective and remedial actions should also be predetermined based on these monitoring levels.

During the operation of a shallow land low-level nuclear waste burial site, many precautions should be taken to ensure that the operation does not result in the contamination of the surrounding environment. To accomplish this, a strict set of burial procedure guides should be established and adhered to.

Burial procedures should be carefully designed so as to eliminate contamination of the surface area adjacent to the trenches during burial. Burial procedures should contain provisions for handling shipments that arrive damaged or leaking so that the burial of such shipments do not cause site contamination. This is important because while only a small percentage of shipments may arrive in damaged condition the concentration these shipments in one area may lead to a fairly high level of surface contamination. One method of handling this problem might be to provide supplementary waste packaging on site. All burial trenches should be clearly marked by monuments of some form.

The amount and type of radionuclides accepted for burial should be predetermined. Shipments to the burial site should clearly state the content and activity of the shipments. Provisions for an onsite check of shipments so as to determine the accuracy of the shipper's information should be available and performed on at least a "spot check" basis. A log of the shipment and its exact burial placement should be kept. Procedures for handling wastes which are particularly active or hazardous should be predetermined. A survey of trench walls for existence of anomalies such as sand lenses should be made following excavation. Photographic documentation of waste stacking in the trenches should be considered.

In general, a quality assurance program for the burial operation is a desirable way to assure that the operation utilizes the best possible techniques and that contamination due to the operation is avoided.

D. Recommendations for the West Valley Site

1. A trench water control program should be established which eliminates the pump down procedure presently under use.

2. An erosion control program for the burial site should be initiated.

3. The onsite monitoring program should be improved to detect both the surface and subsurface movement of radioactivity. The monitoring program should provide for the early detection of such movement so that remedial actions can be implemented to prevent the moving activity from reaching man's environment.

4. The studies in progress should be completed culminating in the development of hydrogeological and environmental pathway models which describe the movement of radioactivity from the burial site and predict the long term impact of the buried waste on the environment.

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APPENDIX A

GEOLOGIC DESCRIPTION OF THE WESTERN NEW YORK NUCLEAR SERVICE CENTER (WNYNSC) SITE

Appendix A summarizes information obtained from the "Environmental Report NFS' Reprocessing Plant, West Valley, New York" and the report "Geology and Hydrology of the WesternNew York Nuclear Service Center." The geologic description is based on a survey done on the over 3,000 acres site.

During the site selection process, the area was explored by 108 power auger holes, 14 deep wells, and a seismic survey. A power auger, equipped with continuous flights, 6 inches in diameter was used to drill approximately 38 of the test holes in the reprocessing facility construction area. Screened observation wells, 1.25 inches in diameter, were installed in or adjacent to most of these auger holes. These auger holes, which ranged from 6 to 40 feet in depth, were sampled at 5-foot intervals by driven split-tube samplers or, in a few instances, by the auger. Seven deeper holes, called "drill holes," were drilled by other methods, but were also sampled by either the split sampler or the auger. The location of the power auger holes, the drill holes, and the burial site are shown in Figure A-1 /11/.

Broughton /2/ described the geology of the area in the following narrative:

> Western New York from a little south of the latitude of Buffalo, lies in the Allegheny Plateau physiographic province. Along the meridian of the Western New York Nuclear Service Center site, the land surface rises from an elevation of approximately 250 feet at the Pennsylvania line. The preglacial erosion surface in this area was naturally dissected upland with deeply incised valleys. Many of these valleys have been deeply buried by glacial deposits with the result that much of the present drainage is post-glacial and bedrock valleys, which have depth and direction varying from the present ones, which may be delimited by well data. The regional topographic slope is underlain by a thick series of flatlying sedimentary rocks (shales, sandstones, and limestones) up to as much as 9000 feet in thickness. The rocks actually dip gently to the south at 20 to 40 feet per mile. The result is that as one goes from north to south, the sedimentary rock section progressively increases in thickness and younger formations appear to the surface. The depth to crystalline "basement" rocks at the site is estimated at about 7000 feet. In the upper 2000 feet of rock section a lateral change of rock type also takes place in which the relative percentage of shale increases westward away from the Genesee River Valley.
>
> Much of central and western New York is underlain by a salt basin which is thickest beneath the central Finger Lake and trends both east and west. Approximately 10,000 square miles of New York State is underlain by this salt. The salt bed beneath the Nuclear Service Center site, based on gas well records, should range from 11 feet to 30 feet in thickness.
>
> All of western New York, with the exception of the area generally encompassed by Allegheny State Park, is overlain by a veneer of glacial deposits left by the last glacier. Most of this consist of till (ground up clay-rock fragments containing cobbles and pebbles) and thick deposits of sand, gravel, and clay.

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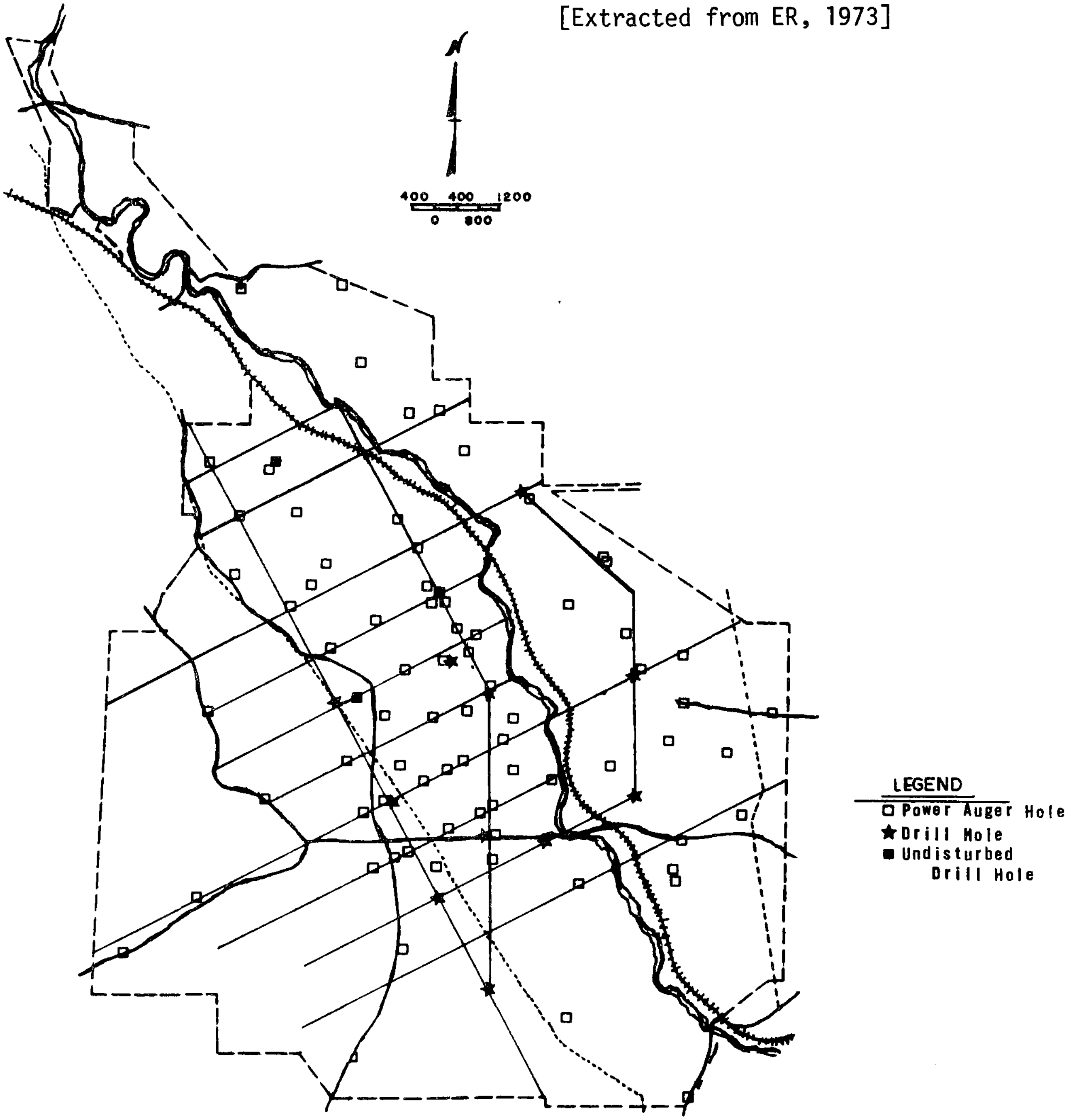
Figure A-1 [11]

BORING LOCATION PLAN
WESTERN NEW YORK NUCLEAR SERVICE CENTER
[Extracted from ER, 1973]



The results of the geologic field mapping conducted for siting purposes show that shale and siltstone bedrock is exposed in the upper valley walls of Buttermilk Creek Valley /2/. Both types of bedrock belong to the Machias formation of the Upper Devonian Canadaway Group. They are exposed in rock cuts of the lower portion of Buttermilk Creek not far from its confluence with Cattaraugus Creek. These are the only outcrops of bedrock in the area.

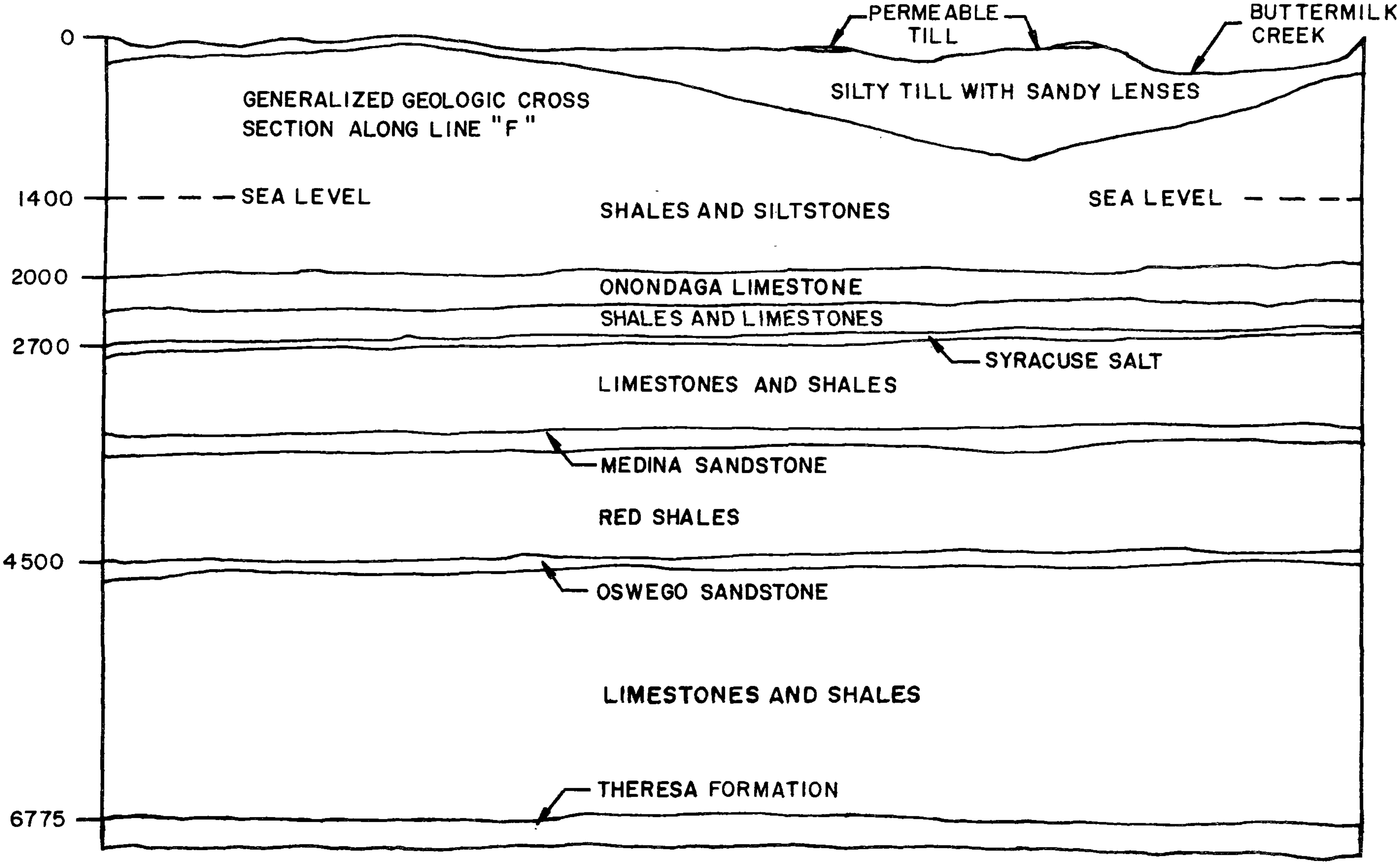
Information on the bedrock depth can be found in reports of subsurface geological investigations in neighboring areas, in incomplete logs of old wells drilled for gas, and in USGS studies related to the subsurface disposal of radioactive wastes by hydraulic factoring. These studies indicate that the site is underlain by a thick series of flatlying gray and black shales down to the top of the Onondaga limestone at an estimated depth of 2,000 feet. Included in this section are 6 black shale layers with estimated thicknesses of 120, 20, 185, 20, 20, and 30 feet, respectively. In addition, there are two dark gray shales with thicknesses of 80 and 95 feet, respectively. The black and dark gray shales are uniformly impervious but fissile /11/.

Limey shales and limestones underlie the Onondaga limestone, with the Syracuse salt member of the Salina formation at a depth of approximately 2,700 feet. The stratigraphic section from approximately 2,700 to 7,000 feet deep also includes shales, sandstones, and limestones. There are two deep saline aquifers which have been identified in gas wells 20 miles west and 13 miles northeast. These are the Oswego sandstone, 90 feet thick at an estimated depth of 4,500 feet, and the Theresa formation, 300 to 650 feet thick at an estimated depth of 6,775 feet.

Data obtained so far indicate that the present course of Buttermilk Creek Valley and its streams are cut mainly into glacial deposits and recent alluvium which fill a deep pre-glacial bedrock gorge. This gorge trends approximately N 25 W; indications are that the gorge initially drained northward past Springville and Boston across the present course ofCattaraugus Creek. The gorge has an average depth of 550 feet and slopes northward, its configuartion is more rugged than that of the present land surface /11/.

The present Buttermilk Creek Valley was formed by the erosion of unconsolidated glacial materials during the 10,000 to 15,000 years since the disappearance of the last glacier. The original and much larger bedrock valley beneath the glacial deposits was eroded by stream action over a period of at least 60 million years and was probably deepened further by glacial scour as the ice moved down the valley. The difference in the power of the erosive agents and the length of time over which the erosion was accomplished adequately accounts for the difference in size of the valleys.

STRATIGRAPHIC CROSS-SECTION
WESTERN NEW YORK NUCLEAR SERVICE CENTER SITE



SCALE: 20mm=1000FT.

FIGURE A-2 [11]
[Extracted from ER, 1973]

Glacial deposits in the Buttermilk Creek Valley range from 5 to 560 feet or more in thickness. They are neither uniform in thickness nor consistent in lithology, the result of a single deposition. Glacial ice advanced over and melted back from this area several times. After several such oscillations, a series of deposits are thinnest on the higher hills along the perimeter of the site where they form only a veneer over the bedrock surface. The deposits thicken toward the central part of the site where they partially fill the pre-glacial bedrock valley. Two principal types of material at the surface in the central part of the site are /11/:

1. Till - a very fine grained compact, dark blue-gray, heterogeneous mixture of clay and silt, containing minor amounts of sand and stones. The upper few feet are yellowish-brown due to weathering.

2. Coarse granular deposits - a mixture of sand and pebbles up to several inches in diameter, which also contains minor amounts of silt and clay. The deposits are yellowish-brown to a depth of about 15 feet and dark greenish-gray below. The deposits are stratified or well sorted according to grain size in some places, but not in others.

Drilling and field mapping have disclosed the existence of two types of subsurface deposits /11/:

3. Outwash - coarse granular deposits of stratified, well sorted sands (S) and gravels (G). Some deposits appear to be thinbedded units of both sand and gravel (SG, GS). Such deposits are dark greenish-gray in the drill holes, but are oxidized to a yellow-brown color where exposed in valley walls. These deposits were laid down by melt-water streams from the ice sheets.

4. Lake deposits - fine-grained, thin-bedded sands, silts, and clays (V) with minor amounts of fine pebble. Individual beds are usually well sorted. These deposits are dark blue-grey, compact, dense, and moist. Such materials were deposited in melt-water lakes impounded between the ice front and higher ground in the valley south of the site. In their gross aspects, they strongly resemble the till previously described, differing chiefly in their laminated lithology and lower pebble content /11/.

The surface distribution of the principal deposits described in the previous paragraphs is shown in Figure A-3. The coarse granular deposits overlie till in a broad belt along the lower slopes of the high hills to the west and in a section extending out onto the northern part of the area east of Erdman Brook. These deposits range from 0 to 25 feet thick. The tops and upper slopes of the hills west of the construction area are covered with 3 to 10 feet of till overlying bedrock. The till in these areas is oxidized and leached of calcium carbonate to nearly its full thickness. Locally, the surface is littered with stones ranging from pebbles to boulders; the finer materials have been eroded from the till.

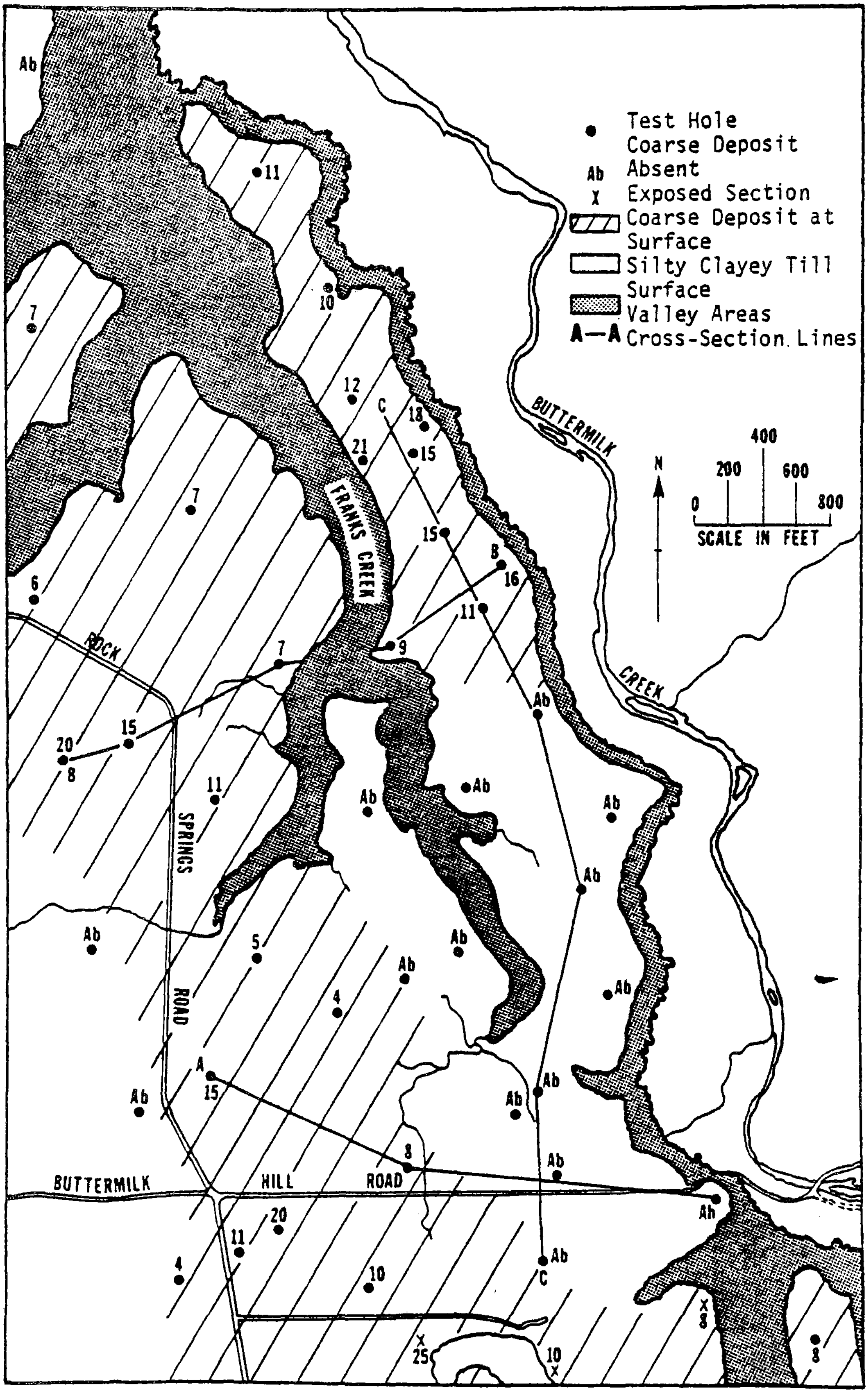


FIGURE A-3 [11] PLANT AREA MAP - DISTRIBUTION AND LITHOLOGY OF SURFICIAL DEPOSITS

[Extracted from ER, 1973]

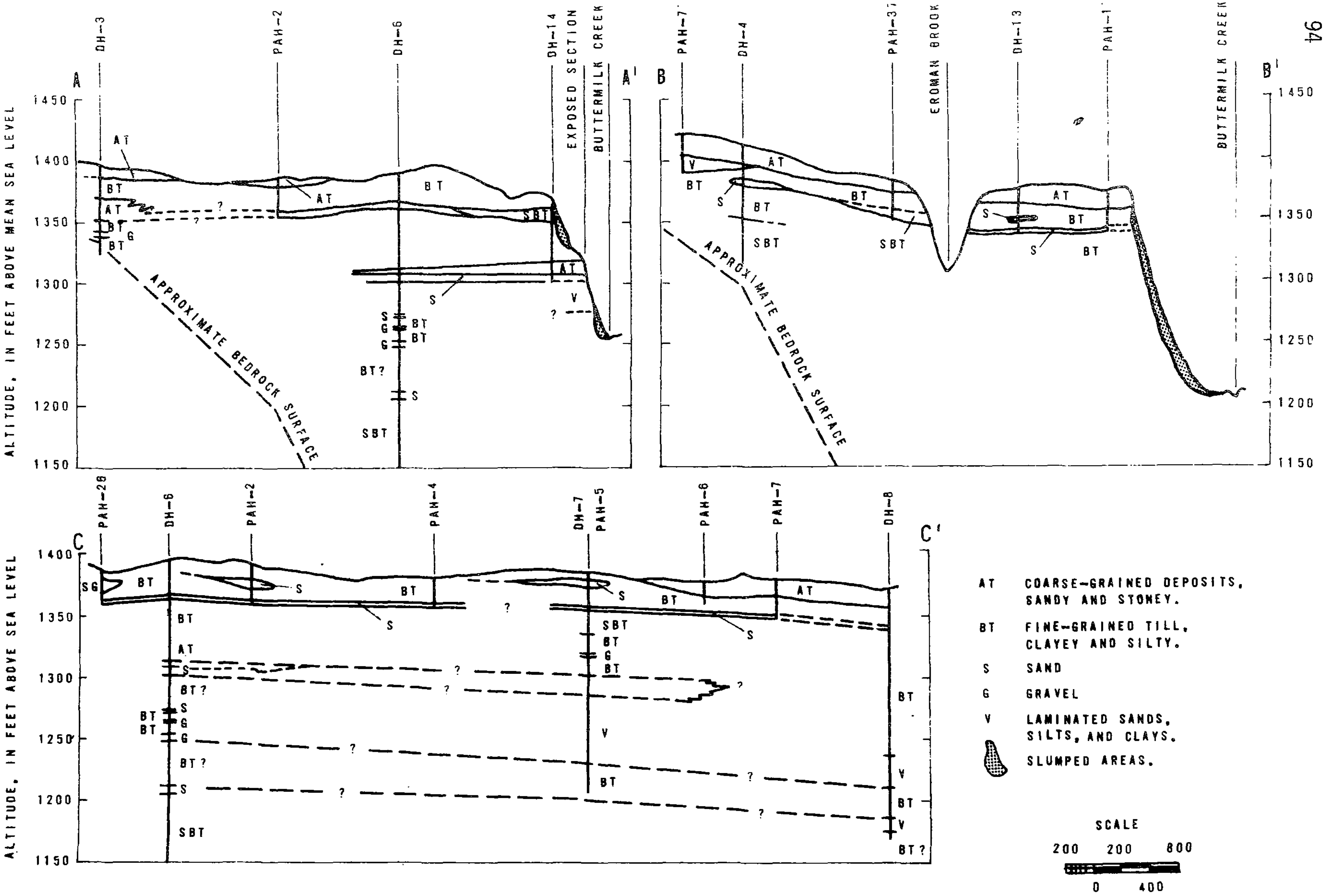


FIGURE A-4 [11]

[Extracted from ER, 1973]

GEOLOGIC CROSS SECTION IN THE PLANT AREA

The till that is beneath the coarse granular deposits on the lower slopes and that is at the surface in the central part of the construction area forms a fairly uniform sheet from 20 to 30 feet thick. In much of the area between Buttermilk Creek and Erdman Brook, the till sheet is almost entirely clayey and silty. However, Broughton and Stewart /2/ report that in much of the area from Erdman Brook west to the lower hill slopes, the lower parts of the till sheet contain a considerable amount of very fine sand, perhaps as much as 20 percent. The sandy zones appear to be related to the underlying materials.

Figure A-4 gives three geological cross sections drawn along the section lines indicated in Figure A-3. All three cross sections show the relationships of the surficial deposits just discussed. Section A-A' and B-B' also show the lower sandy zones in the uppermost till sheet as "SBT." All three sections show a thin layer of sand (S) at an altitude of about 1350 feet. The sand unit has been destroyed in some areas by incorporating into the overlying till sheet, as the till sheet was being deposited. Geologically, this is to be expected in till sheets and is not significant in itself. However, in this instance it may affect groundwater conditions near the burial site and is discussed later in this report. The coarse granular surficial deposits are apparently not found in the several borings made in the burial site area nor were they seen during the surface mapping /11/.

The sequence of deposits encountered in Section A-A' and C-C' may be considered as generally representative of those in the valley area. The generalized section /11/ is as follows:

Symbol	Unit	Depth Below Land Surface (Feet)
BT	Till, dark blue-gray silt and clay small pebbles; dense, compact, moist	0 to 21
S	Sand, coarse, some fine sand and silt water-bearing	21 to 25½
BT	Till, as before	25½ to 76
AT	Gravel, coarse, and sand; silty compact permeable but apparently not water-bearing	76 to 80
S	Sand, coarse, some silt and fine pebbles	80 to 88
BT	Till, as before, abundant fine pebbles	88 to 115
S	Sand, some silt and fine gravel compact	115 to 117
BT	Till, as before	117 to 125½

G	Gravel, coarse, sparse fine material	125½ to 126½
BT	Till, as before	126½ to 135
G	Gravel, coarse to fine, sparse fine material	135 to 141
BT	Till, as before	141 to 178
S	Sand, some fine gravel and silt	178 to 185
SBT	Till as before, plus 20%± very fine sand	185 to 240

In Section B-B' which is in the specific plant site location, the following sequence of deposits /11/ were encountered.

Symbol	Unit	Depth Below Land Surface (Feet)
AT	Gravel, coarse, and sand; scattered cobbles very silty; brown, friable, unstratified damp	0 to 15
V	Silt and fine sand; brown, stratified, sand laminae up to ¼ inch thick	15 to 16½
BT	Till, brown silt, coarse stoney and sandy unstratified, moist	16½ to 25½
BT	Till, silt, clayey, gray-brown; occasional pebble, less than ¼ inch diameter; unstratified, damp	25½ to 29½
S	Gravel and sand, approximately 20% silt and clay; gray, tough, unstratified, damp	29½ to 31½
BT	Till, dark blue-gray silt and clay, contains abundant pebbles up to 1½ inches in diameter; tough, dense, damp	31½ to 40
BT	Silt, clayey, gray, very sparse coarse material; laminated, tough, dense, moist (possibly till)	40 to 41½
BT	Till, as at 31½ to 40 feet	41½ to 61
SBT	Till, very stoney with flat cobbles; hard; compact; poor recovery, losing drilling water	61 to 62

SBT	Till, greenish-gray, silt, clayey, abundant small pebbles; very tough, damp	62 to 62½
SBT	Till as at 61 to 62 feet; sandy	62½ to 64½
SBT	Till, gray-green, sandy; abundant pebbles up to 1 inch diameter; very little material smaller than fine sand; pebbles are approximately 50% of sample (hard boulder at 70 to 70½ feet). Unstratified, very compact damp. Unit drains drilling mud and water from hole overnight and during drilling	64½ to 81½
SBT	Till, as at 64½ to 81½ but less moisture and smaller pebbles	81½ to 90
SBT	Till as at 81½ to 90, but very sandy and with profuse fine to medium pebbles; silty, tough, damp	90 to 103
SBT	Till, dark gray silt and clay, abundant fine pebbles, sparsely fine sandy; dense tough, damp. Becomes more sandy below 110 feet	103 to 115½
--	Shale, gray-green, thin bedded, moderately hard	115½ to 120 5/6

Studies of drill samples and exposed sections indicate that several till sheets shown in the cross sections are nearly identical in texture, color, and composition. Correlation of these deposits between outcrops and drill holes in the cross sections indicate that some of the outwash units (S, G) and lake deposits (V) are discontinuous. This may be due to local non-deposition or to local destruction during the deposition of the subsequent till sheets. Local discontinuity is typical of glacial deposits /11/.

APPENDIX B

HYDROLOGIC DESCRIPTION OF THE WESTERN NEW YORK NUCLEAR SERVICE CENTER (WNYNSC) SITE

Appendix B is a summary of information obtained from the "Safety Analysis Report, NFS' Reprocessing Plant, West Valley, New York." The hydrologic description is based on a survey done on the over 3,000 acres site.

Usable quantities of ground water occur in three aquifers on the site. In this report, the term "usable" means a yield of 1 to 10 gallons per minute from a well or spring /19/.

The coarse granular deposits at the surface (see Figure A-3) constitute the uppermost aquifer on the site. This minor aquifer is referred to as the non-artesian aquifer. Figure B-1 is a map showing the shape and altitude of the water table by means of contour lines based on water levels in wells screened in this aquifer. A comparison of this map with the topographic base map of the site shows that the water table in this aquifer generally follows the configuration of the land surface /19/.

The non-artesian aquifer is recharged by the infiltration of precipitation. Of course, not all of the precipitation that falls on the surface reaches the water table. Much of it is returned to the atmosphere through evaporation and through transpiration by plants; some of it flows directly over the land surface into streams. Ground water is also discharged from the aquifer into the surface drainage system.

Over much of the site, the stream valleys cut through the non-artesian aquifer, which results in relatively short travel distances by the ground water from points of recharge to points of discharge into surface streams. The coefficient of permeability for this aquifer has been estimated to be 100 gallons per day per square foot /2/. The porosity of the coarse granular deposits is estimated to be about 25 percent. An approximate rate of ground water movement in this aquifer may be determined by using the estimated permeability and porosity, and the distances and hydraulic gradients shown on Figure B-1.

The non-artesian aquifer seems to be absent from the burial site area. This suggests that the aquifer has no significant connection with or impact on the hydrogeologic system of the burial site. However, the aquifer may discharge into Erdman Brook at several marshy areas adjacent to the brook (see Figure B-1). Since these marshy areas are topographically higher than, and up-gradient from the burial site area, they may represent discharge points from the non-artesian aquifer. If this is the case, water quality and radionuclide analyses of samples collected from seeps in these areas may be useful in estimating the original composition of Erdman Brook water and the present degree of contamination of the brook from the burial site, if any, and from the reprocessing facility.

The silty clayey till at the site is not an aquifer; it is, however, largely water saturated. Pore spaces in these deposits are very small and poorly interconnected. The movement of ground water through the till is very slow and almost entirely capillary in nature. Three undisturbed samples from drill hole 7 were submitted to the Hydrologic Laboratory of the USGS for analyses of porosity, permeability, and grain-size analysis.

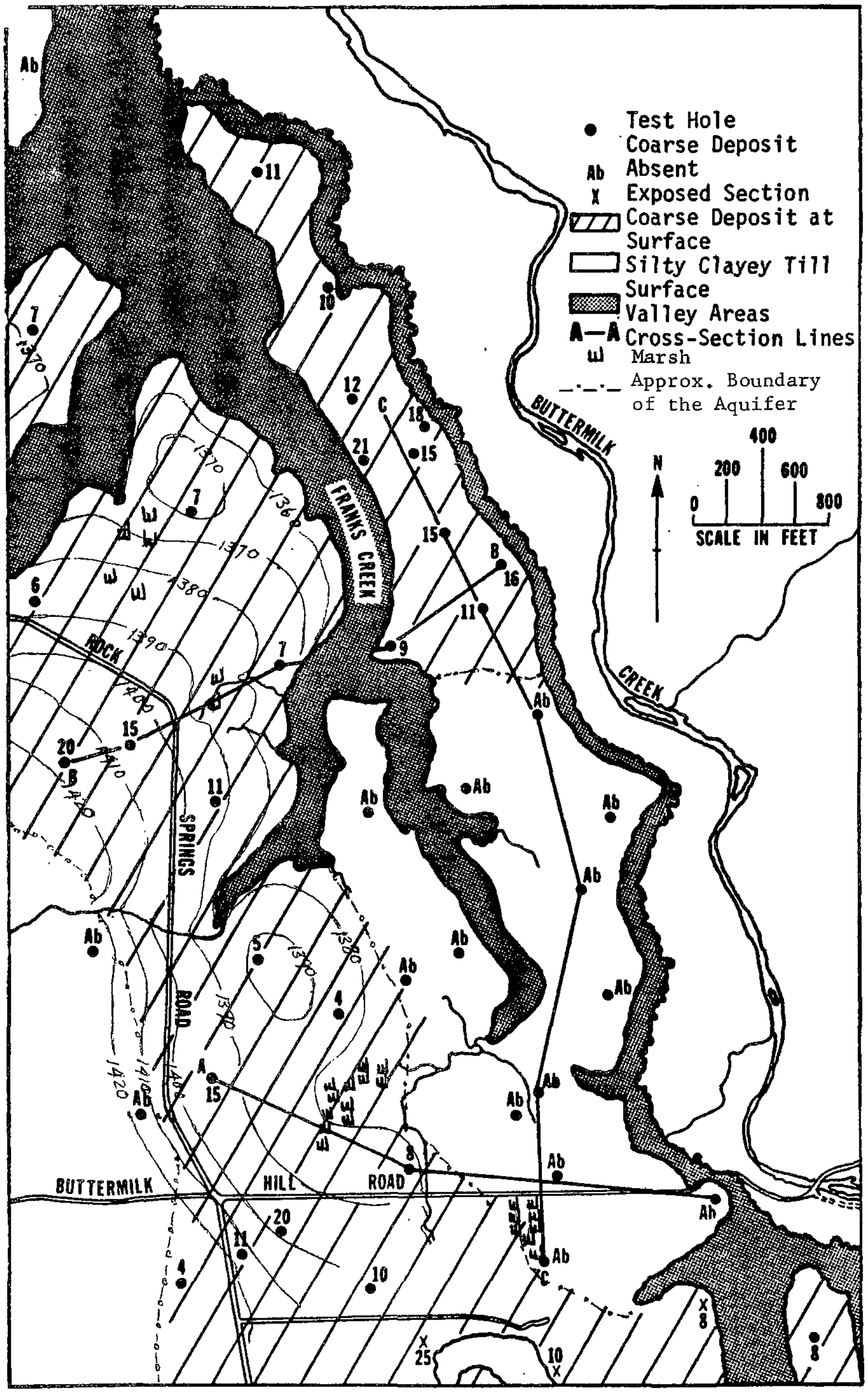


FIGURE B-1: MAP OF CONSTRUCTION AREA SHOWING CONTOURS ON THE WATER TABLE, JANUARY, 1961. [19]

The samples from hole 7 are located in Section C-C' as shown in Figure A-4. The permeabilities of these samples are reported in Table B-1. Undisturbed horizontal samples were collected from exposed valley walls near power auger holes 18, 19, and 34. The horizontal permeabilities were found to be 0.005, 0.004, and 0.004 gal per day per square foot, respectively.

The thin sand unit which underlies the uppermost till sheets at an approximate elevation of 1,350 feet above sea level (see Figure A-4) constitutes a second aquifer in the valley area. This aquifer is called the shallow artesian aquifer. It is found in most of the areas between Buttermilk Creek and Erdman Brook. The water levels in this aquifer and the extent of the aquifer known at this time are shown in Figure B-2. The overlying till sheets confine the aquifer, causing artesian conditions. Water levels in the aquifer stand 5 to 17 feet above the top of the aquifer and 8 to 22 feet below the land surface.

The shallow artesian aquifer seems to be absent from the area where the reprocessing plant and burial site facilities are located. This area is bordered on the east by Erdman Brook and on the west by an unnamed stream. The incision made in the valley floor by these two streams is deep enough and the water table contours are such (see Figure B-1) that any radioactivity carried by the ground water from the plant or burial site area will show up eventually in one of these two streams and nowhere else except, of course, for that radioactivity which is sorbed upon the soils and held therein.

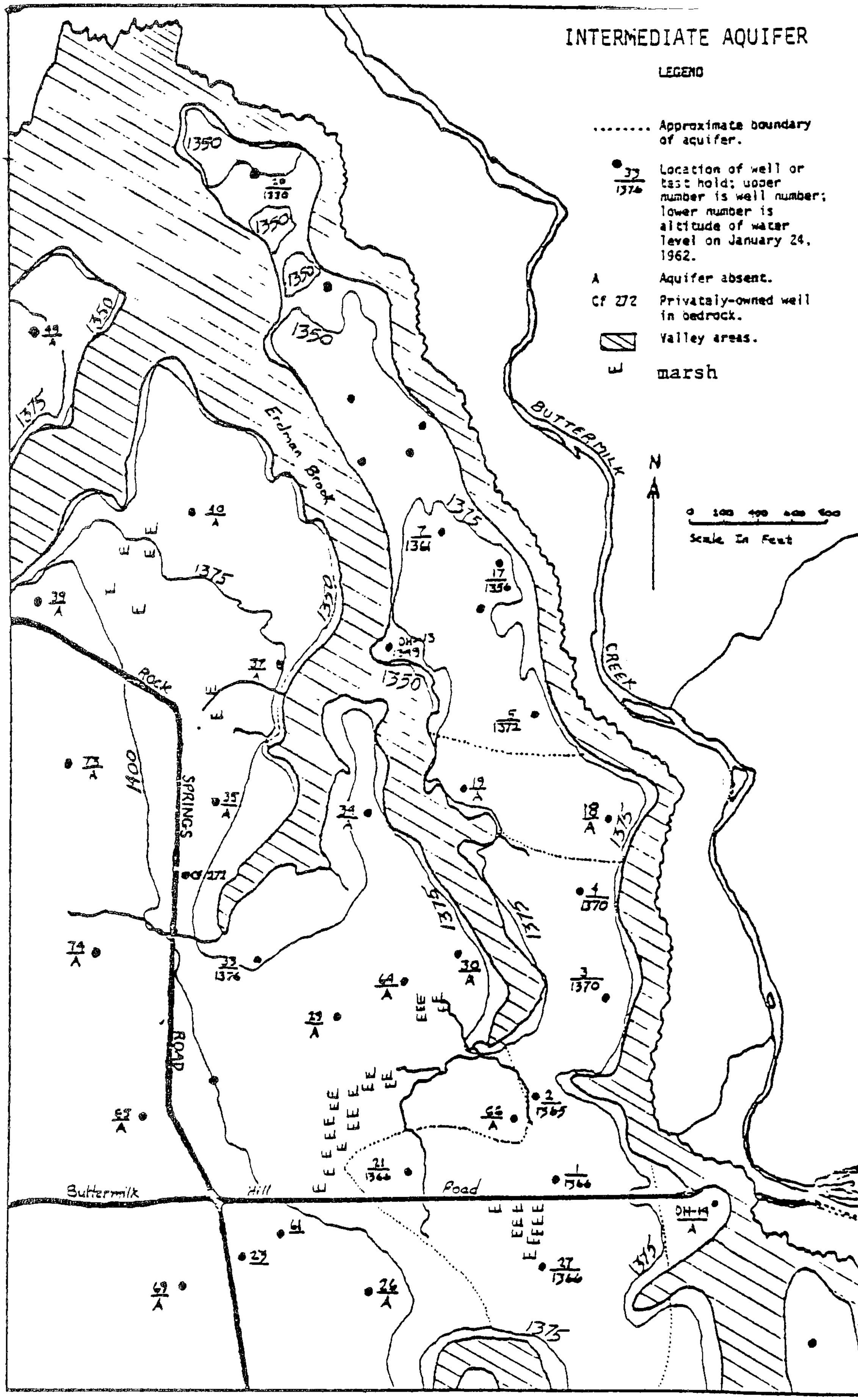
The shale bedrock constitutes the third aquifer in the area. The rate and direction of movement of water in this aquifer are essentially unknown because of the few wells available for observation. The shale itself has a very low permeability, possibly in the same order of magnitude as that indicated for the till. However, a zone of decomposed shale and rubble at the point of contact between the shale and the overlying till transmits small but usable quantities of water to a well. Recharge water probably enters the bedrock on the tops and upper slopes of the higher hills, where the till cover is thin; thereafter the water moves through the shale along the fractures to points of discharge.

Table B-1 /19/

Summary of Hydrologic and Physical Properties

of Tills from Drill Hole
Extracted from SAR, 1962

	Depth of Sample		
	3-5 Feet	13-14.8 Feet	45-47 Feet
Porosity	35.5%	35.4%	36.7%
Coefficient of permeability[a]	0.002	0.002	0.001
(gallons per (day) (square foot)	0.002	0.002	0.001
Grain-size distribution:			
Clay - less than 0.004 mm	50.4	50.2	55.4
Silt - 0.004-0.0625 mm	34.2	32.1	32.2
Very fine sand - 0.0625-0.125 mm	3.8	3.0	2.7
Fine sand - 0..125-0.25 mm	3.3	2.8	2.3
Medium sand - 0.25-0.5 mm	2.3	2.2	2.3
Coarse sand - 0.5-1.0 mm	1.1	1.1	1.0
Very coarse sand - 1.0-2.0 mm	1.0	1.1	0.2
Very fine gravel - 2.0-4.0 mm	2.0	1.8	1.6
Fine gravel - 4.0-8.0 mm	1.9	1.9	2.3
Medium gravel - 8.0-16.0 mm	---	3.8	---



Map of the construction area showing water levels and extent of the shallow artesian aquifer.

Figure B-2 [19]
[Extracted from SAR, 1962]

APPENDIX C

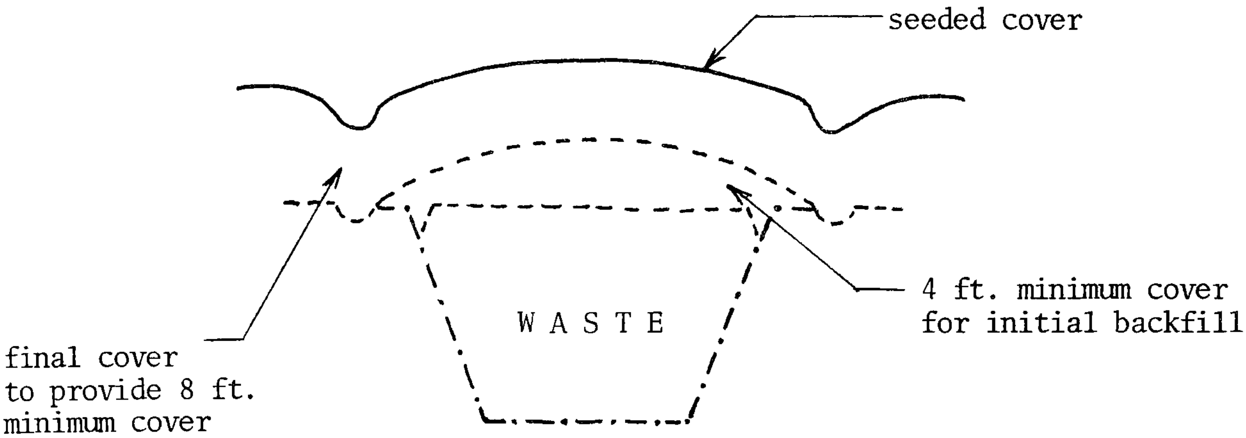
Conditions and Amendments to the NFS Burial License

The burial site must conform to the requirements of Section 16.8 of Part 16 of the New York State Sanitary Code except for conditions which were written into the NFS burial license. These conditions and the appropriate amendments are enumerated /29/.

Condition 1 The application specified the burial of solid radioactive waste (atomic numbers 1 through 91, and limited amounts of U-233 and plutonium) of any physical or chemical form. This was amended on August 13, 1965 (Amend. No. 4) to permit burial of solid radioactive waste with a surface dose rate not to exceed 10,000 R/hr for "neutron activated" waste and 200 R/hr for "soluble in water" waste. Also the dose rate at the surface of a covered trench shall not exceed 1 mR/hr. Amendment No. 5-1 (4/4/66) permitted the burial of one package of solid radioactive waste with a surface dose rate exceeding 200 R/hr. Amendment No. 5-3 (4/17/64) permitted the burial of unpackaged uranium-contaminated building material. The waste was limited to 4,000 tons and 0.002 uCi/gm. Amendment No. 5-4 (11/4/68) permitted the burial of unpackaged soil containing 50 mCi of corrosive products, mainly Co-60 in 4,000 cubic feet of soil. The activity was not to exceed 3.0×10^{-4} uCi/gm. Amendment No. 5-5 (6/27/69) permitted the burial of liquid wastes in capped vials of 200cc capacity. The cartons of vials were to be surrounded by vermiculite and enclosed in 55-gal. drums. The drums were to be placed near the surface of the trench in order to avoid crushing.

Condition 2 Each new trench had to be inspected by NFS or BRH before burial operations commence. The inspection was to check the soil strata, the existence of a continuous permeable till, or aquifer. If such were found, burial could not proceed unless authorized by BRH.

Condition 3 The original license stated that the radioactive material must be at least four feet below the surface grade. This was modified in Amendment No. 2 (1/11/65) to require covering the waste with four feet of fill, compaction, and repair of any cracks or openings in the trench. This amendment removed the restriction that the waste be at least four feet below the surface based on economic arguments by NFS as well as to minimize the areal extent of the buried wastes. It was argued that the Kentucky burial site utilized the full depth of the trenches. Agreement with DOH was reached such that the trenches may be filled to the surface grade provided the triangular edges of the trenches are not filled with waste, as illustrated below.



A ditch was dug circumscribing the trench to provide improved seal between the undisturbed soil and the fill material. The NFS operator was required to submit a report by January 1, 1966, which would record the liquid levels at the ends of the trenches, analyze the radioactivity in the liquid samples, and include the state of the surface drainage system.

Amendment No. 3 (5/17/65) required waste to be covered within one week after the trench is filled. Trench separation must be such that undisturbed soil remain in place between trenches. Weekly measurements of liquid levels and monthly analyses of the liquid were required. These two amendments were added due to the concern by BRH in the continued accumulation of water in the completed trenches.

Amendment No. 4 (8/13/65) required that the waste filled trench have a "mounded" cover to aid in surface drainage, as shown above.

Amendment No. 5-2 (4/23/66) amended the license by not requiring an observation well in Trench 7 nor the necessity of reporting liquid levels in the trench. Trench 7 contained wastes that were embedded in concrete.

Amendment No. 6 (5/20/68) completly revised the burial procedure for the new trench area (Trenches 8-11). No excavation or filling could take place until a plan was submitted to and approved by BRH. Amendment No. 6 stated: /30/

"A new burial area shall be designed as follows: a minimum of 8 feet of soil cover above the waste fill in the trench; individual mounds over each trench with a grade from centerline of the surface of the trench from one end to the other shall not exceed 7 feet; a minimum separation between trenches of 6 feet of undisturbed soil; the cover over trenches and the fill around the perimeter of the burial area shall be designed so as to drain water away from the trenches, yet to minimize erosion."

"Trenches shall be constructed such that the amount of open trench space at any time is minimized. There shall be sufficient separation of trenches to insure that undistrubed soil remains in place between trenches.

The bottom of the trench shall be sloped so that precipitation will not drain into previously deposited waste containers. During construction, a minimum soil cover of 4 feet shall be provided and cracks, fissures, or other openings in the earth cover shall be repaired promptly. The earth cover shall be maintained during construction, so as to provide adequate drainage away from trenches. All excavated soil shall be used at the burial area. Provisions shall be made to drain surface water away from open trenches; pumping of rain or snow water from the open area of a trench may be done to allow for proper working conditions in the trench."

"One or more wells shall be constructed in each new trench in such a manner that measurement of water elevation in each well is indicative of the water level in the trench. Each well shall be constructed to allow pumping from a completed trench for sampling or other purposes. There shall be no pumping from the wells without first making application to, and obtaining approval from, the New York State Health Department."

"A report shall be submitted to the State Health Department by March 1 of each year, describing the operating experience for the previous year. The report shall include the following; measurement of liquid levels at two-week intervals for those trenches for which a final cover has not been constructed; surface drainage conditions as they may relate to maintenance and to water levels noted in the trenches; the type and/or form of radioactive wastes buried in open trenches that may account for the presence of radioactivity in water pumped from the open trench; the elevation of the finished ground surface over each covered trench given at the center and ends of each trench on plot plan of the burial site."

"The final surface for a trench shall be applied in accordance with the approved plans, and a vegetative growth started on a trench when the fourth parallel trench removed is being excavated and filled. The completed cover shall be maintained by keeping a good vegetative growth and be promptly filling any holes or fissures that appear to be more than two feet in depth. The cover over trenches shall be reworked whenever the surface at the center to the trench is at a lower elevation than the surface at the edge of the trench and shall be reworked to fill depressions that cause ponding of water over the trench."

Condition 4 It was evident that water contact with solid waste in the uncovered trench should be kept to a minimum. If water did accumulate in the uncovered trench, it could be discharged into Erdman Brook provided the water has been analyzed for radioactivity and discharged in such a way as to not violate Part 16 of the State Sanitary Code. Amendment No.3 (5/17/65) forbade the pumping of water from the completed trenches into a lagoon or surface stream without authoriztion from BRH. Amendment No. 6 (5/20/68) affected new trenches by stipulating the water from the uncovered trenches may be discharged provided that the contribution of gross alpha, gross beta, and tritium to the Cattaraugus Creek were below limits set in the amendment. Analysis to determine the existence of I-129 had to be performed semi-annually. A stream northeast of the burial site was to be monitored as an indicator of underground flow of radioactive isotopes.

Condtion 5 Burial operations were to be conducted to minimize the dispersion of radioactive materials via weather or wildlife.

Condition 6 NFS was required to maintain records for each trench. Amendment No. 3 (5/17/65) required that the trench boundaries be delineated and that the concrete cairns be provided within six months after the trench is completed. Amendment No. 4 (8/13/65) required records be kept on the burial location of each waste shipment. The records were to indicate length from the cairns and depth to the waste.

Condition 7 Due to the extensiveness of soil relocation, procedures had to be developed to minimze soil erosion.

Condition 8 Restrictions were placed on vehicles which carried radioactive waste to the site if they exceeded limits set in the license.

Condition 9 A sampling station downstream from the burial site had to be maintained to analyze samples for radioactivity.

Condition 10 The burial site had to comply with the procedures in the Application for Radioactive Materials License of August 23, 1963 in the letters from NFS, and in the Waste Storage Agreement between NYS-ASDA and NFS.

Condition 11 The authorization for the operation of the burial site was to cease upon termination of the Waste Storage Agreement.

Condition 12 Permission to bury any designated wastes could be rescinded upon notification by BRH to NFS as stated in Amendment No. 4 (8/13/65).

Condition 13 Provisions were made in Amendment No. 7 (9/4/68) for the burial of special high-level wastes in an area designated as "Special Purpose Burial Area."

An amendment was proposed on November 27, 1972, but not adopted since the burial site was closed in March 1975. It prohibited the burial of transuranium nuclides with atomic number greater than 91, of nuclides with atomic numbers 82 through 91 with a half life greater than 1,000 days, of I-129, of fuel elements, of explosive or pyrophoric materials, of liquids, and of pesticides, chemicals, biologicals, or other toxic constituents.

APPENDIX D

GENERAL LOW-LEVEL WASTE CATEGORIZATION

The Atomic Energy Commission divided radioactive waste products into two categories, "high-level waste" and "other than high-level waste." The latter is commonly called "low-level waste." High-level waste is defined as "aqueous waste resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated waste of subsequent extraction cycles, or equivalent, in a facility from reprocessing irradiated reactor fuels" /31/.

The low-level wastes may include transuranium contaminated wastes; these wastes can be buried at commercial burial sites, regardless of the activity and hazard potential of the waste, unless there are specific site regulations against it. The NFS license permitted the burial of radionuclides of atomic numbers 1-91, U-233 and plutonium; the last two items were subject to license limitations. However, at the request of the State, NFS stopped the burial of plutonium at the site. The types and quantities of radionuclides buried are also important. Nuclear power plant wastes account for only 10 percent by volume of the total waste buried at NFS. Institutional or industrial wastes make up a large portion of the waste buried, but these are usually limited in the variety of radionuclides. For example, institutions produce mainly C-14 and H-3.

Estimates of the typical radioactivity content of PWR and BWR wastes are presented in Table D-1 and D-2 and are based on estimates by the U.S. Nuclear Regulatory Commission (NRC) /32/. Estimates made by NRC of the annual radwaste volumes and specific activities for a 1,100 MWe light water reactor are presented in Table D-3. The EPA, however, estimates that approximately 25,000 cu-ft. of low-level solid wastes are produced and shipped offsite per year from a 1,000 MWe PWR /33/. The reactor wastes include evaporator concentrates, filter sludges, resins, filters, dry trash, and miscellaneous used or failed equipment. The large differences in the various estimates of the total solid radwaste produced and the high degree of variability in the data concerning specific activity of such wastes show than an accurate characterization of reactor-generated solid wastes is difficult at this time.

Most of the wastes buried at West Valley are believed to be large volume, low hazard potential, solid wastes such as paper trash, cleanup materials and sorbed liquids, packing materials, broken glassware, plastic protective clothing, radioactive carcasses of experimental animals, and contaminated equipment. In describing the wastes actually being buried at commercial burial sites, Morton estimated that 70 percent volume would be paper materials and that the density of the total waste would be about 10 lbs/ft^3 /34/.

TABLE D-1 [32]

Typical Radioactivity Content in Solid Waste - PWR Plants

Nuclide	Half Life	Activity* (Ci/Yr Reactor)
Sr-89	52.7 d	2.0
Sr-90	27.7 y	2.7
Zr-95	65.0 d	0.64
Ru-103	39.5 d	0.10
Ru-106	368.0 d	1.7
Te-127m	109.0 d	11
Te-129m	34.1 d	1.3
Cs-134	2.0 y	2.8×10^3
Cs-137	30.0 y	2.7×10^3
Ce-144	284.0 d	4.2
Cr-51	27.8 d	0.35
Mn-54	303.0 d	22
Fe-55	2.6 y	200
Fe-59	45.6 d	1.8
Co-58	71.4 d	120
Co-60	5.3 y	280
Total		6.1×10^3

* After 180 day decay

TABLE D-2 [32]

Typical Radioactivity Content in Solid Wastes - BWR Plants

Nuclide	Half Life	Activity* (Ci/Yr Reactor)
Sr-89	52.7 d	49
Sr-90	27.7 y	90
Zr-95	65.0 d	1.1
Ru-106	368.0 d	2.1
Te-127m	109.0 d	1.6
Cs-134	2.0 y	130
Cs-137	30.0 y	120
Ce-141	32.5 d	0.25
Ce-144	284.0 d	5.1
Cr-51	27.8 d	0.60
Mn-54	303.0 d	13
Fe-55	2.6 y	800
Fe-59	45.6 d	6.6
Co-58	71.4 d	130
Co-60	5.3 y	200
Total		1.6×10^3

*After 180 day decay

Table D-3 [32]

Estimated Annual Radwaste Volumes and Activities From 1100 MWe Light Water Reactors

	PWR		BWR	
	Ci/Ft^3	Ft^3/Yr	Ci/Ft^3	Ft^3/Yr
Process Solids:				
Resins	10-00	1,300	0.1-1	2,000
Sludges or Concentrates	0.1-1	3,000	1-20	7,300
Trash	<0.01	3,000	<0.01	3,500
Failed Equipment	>100	200	>100	200
Total		7,500		13,000

APPENDIX E

TRITIUM DEPOSITION STUDIES

A study by Jordan et al. /35/ has determined that the rate of variation of a controlled deposit of tritium varies with depth up to a depth of 40 centimeters. To summarize the portion of this work pertinent to the boring data, the investigators observed an approximate one order of magnitude increase in tritium levels over a band of roughly 30 centimeters proceeding downward as a "slug" of radioactivity up to 145 days after deposition. The depth to which the slug of tritium traveled was about 40 cm at which time uptake by roots was given credit for the gradual decrease in concentration. The investigators did not conclude positively or negatively that the slug would travel further in depth than 40 centimeters if roots were not present. It was concluded by Zimmerman et al /36/ that the slug is a slowly broadening pulse. These observations were made over a period of months.

At West Valley, the time scale of vertical radionuclide movement is 5-10 years for the north end trenches (trenches 1-5). Based on Zimmerman et al., it is believed that the slug will be broadened and be diluted, hence there would be little evidence for the existence of a slug after a few years. Also, experiments were designed to observe the tritium distribution in the soil after one application of tritiated water. In the case of West Valley, the surface contamination due to the fuel reprocessing plant would have been an ever-present surface source of tritium over the five years it operated. Subsequent to its closing in 1972 contamination from the plant to the surrounding area should have ceased.

This would indicate for the purpose of this report that if tritium were deposited on the surface area adjacent to the trenches, it would probably not appear in the boring data as a downward travelling slug at depths of greater than a few feet because of diffusion, root uptake mechanisms, and the length of time since deposition. This is critical since to determine if surface contaimination migrating downward or subsurface leakage migrating laterally is present, one must be able to distinguish some pattern for each contamination mechanism.

APPENDIX F

SECURE HAZARDOUS WASTE
LANDFILL DISPOSAL CRITERIA BACKGROUND

One of the primary conclusions of EPA's Report to Congress on Hazardous Waste Disposal is that current hazardous waste management practices are generally unacceptable, and that public health welfare are unnecessarily threatened by the uncontrolled discharge of such waste materials into the environment, especially upon the land /37/. With the exception of radioactive and pesticide wastes, landbased hazardous waste treatment, storage, and disposal activities are essentially unregulated at the Federal level. Hazardous waste legislation has been enacted in a few states but efforts spawned by these State laws are still in early stages of development and program staffing levels are fairly low. Thus, the disposal of the majority of hazardous wastes generated in the U.S. is not regulated by either State or Federal government. In roughest terms the cost to treat and dispose of hazardous waste in an environmentally adequate manner exceeds the cost for simple dumping on land by an order of magnitude /39/. Given the regulatory climate and economics as described, it is easy to understand why current hazardous waste management practices are unacceptable.

A further consequence of the absence of substantial incentive to dispose of hazardous wastes adequately is the inevitable lag caused in the research, demonstration, and refinement of suitable disposal methods. Secure land burial, or the "chemical waste landfill," in particular is far from established as a well-developed science. In general terms, such operations provide complete long-term protection for the quality of surface and subsurface waters from hazardous waste deposited therein, and against hazards to public health and the environment. Such sites should be located or engineered to avoid direct hydraulic continuity with surface and subsurface waters. Generated leachates should be contained and subsurface flow into one disposal area eliminated. Monitoring wells should be established and a sampling and analysis program conducted. The location of the disposal site should be recorded in the appropriate local office of legal jurisdiction.

A special operating permit will not likely be required under the terms of future regulations. Of course, these requirements are also desirable in standard sanitary landfills. The primary difference involves the degree of concern and care which must be exercised where hazardous materials are involved. If there is potential for hazardous wastes to percolate or leach to ground water, then the use of barriers and collection will be necessary. Due to potentially hazardous reactions, wastes must be segregated and records kept of disposal areas. Neutralization, chemical fixation, encapsulation, and other pretreatment techniques are often necessary. Because of the high concentrations of hazardous wastes, attentuation capacity may be reached relatively quickly. Leachate treatment may be more complex due to the wide variety of waste types and constituents. Due to volatility or for other reasons, land disposal of hazardous wastes normally requires a greater degree of care and sophistication in design and operation at a given site than would normally be necessary with municipal refuse /38/. Some of the general criteria to be considered in selecting evaluating a chemical waste landfill site are as follows /28/:

(a) Chemical waste landfills ideally should be located in areas of low population density, low alternative land use value, and low ground water contamination potential.

(b) All sites should be located away from flood plains, natural depressions, and excessive slopes.

(c) All sites should be fenced or otherwise guarded to prevent public access.

(d) Wherever possible, sites should be located in areas of high clay content due to the low permeability and beneficial absorptive properties of such soils.

(e) All sites should be within a relatively short distance of existing rail and highway transportation.

(f) Major waste generation should be nearby. Wastes transported to the site should not require transfer during shipment.

(g) All sites should be located an adequate distance from existing wells that serve as water supplies for human or animal consumption.

(h) Wherever possible, sites should have low rainfall and high evaporation rates.

(i) Records should be kept of the location of various hazardous waste types within the landfill to permit future recovery if economics or necessity permit. This will help facilitate an analysis of causes if undesirable reactions or other problems develop within the site.

(j) Detailed site studies and waste characterization studies are necessary to estimate the long-term stability and leachability of the waste sludges in the specific site selected.

(k) The site should be located or designed to prevent any significant, predictable leaching or run-off from accidental spills occurring during waste delivery.

(l) The base of the landfill site should be a sufficient distance above the high water table to prevent leachate movement to aquifers. Waste leachability and soil attentuation and transmissivity characterisitcs are important in determining what is an acceptable distance. Evapotranspiration and precipitation characteristics are also important. The use of liners, encapsulation, detoxification, and/or solidification/fixation can be used in high water or poor soil areas to decrease ground water deterioration potential.

(m) All sites should be located or designed so that no hydraulic surface or subsurface connection exists with standing or flowing surface water. The use of liners and/or encapsulation can prevent hydraulic connection.

The use of liners is becoming somewhat more widespread. When impervious basins are desired at a landfill site and the existing soil is not suitable, artificial liners are a potential solution to the problem. All prospective liners should be pretested for strength and compatibility with the expected wastes. Due to relatively few applications and recent emergence of various liner materials, the long-term effects of different hazardous wastes in landfill upon the liner's life cannot be determined in a definitive manner.

The primary EPA program responsibility for land disposal of hazardous wastes resides in OSWMP. A concerted effort is being conducted by OSWMP and involves the development of a full-scale model hazardous waste land disposal demonstration project. Appropriate waste and site preparation procedures necessary to dispose of selected hazardous wastes will be included. Site selection, management, and operating procedures and problems will also be highlighted.