SKI Report 2005:34

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ISSN 1104–1374
ISRN SKI-R-05/34-SE

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SKI perspective

Background

The nuclear power utilities in Sweden must under the so-called “Studsvik Act” [1] contribute with 0,15 öre (approximately 0,02 European cents) per kWh produced by nuclear power to the Swedish Nuclear Waste Fund. This part of the financing system was resolved by the Swedish parliament for the future expenses of decontamination and decommissioning of older Swedish research nuclear reactors and certain objects at the Studsvik site. The task to accrue appropriate capital is based on cost estimates for decontamination and decommissioning of individual facilities. It is therefore vital that these cost estimates are reliable, objective and long term sustainable; otherwise there will be a discrepancy between funded capital and future obligations. One central constraint is that a situation with a deficit in the fund must be avoided. Consequently, it is crucial that the cost estimates for the Storage Facility for Old Intermediate Level Waste[2] at the Studsvik Site is scrutinised and validated. This validation is done by a contemporary comparative cost. This mode of analysis may be regarded as a consistency test of the appropriateness of the cost estimates.

Purpose of the project

The aim of this applied study has been to describe and study the basis for the estimation of future costs for decontamination and decommissioning for the Storage Facility for Older Intermediate Level Waste at the Studsvik Site.

Results

This study demonstrates how a systematic comparative analysis of cost estimates can be done, in order to increase the traceability and reliability. A comparison of the estimated future costs for decontamination and decommission for the Storage Facility for Old Intermediate Level Waste at the Studsvik Site with benchmark references of the Map Tube Facility 317 Area at the Argonne National Laboratory, Chicago, USA, was partially conducted.

The main results from the evaluation of the estimated cost for the Storage Facility for Old Intermediate Level Waste compared with the Argonne Map Tube Facility decommissioning costs, and other selected derived decommissioning cost benchmarks, can be presented in the following three statements.

- The estimated costs for preparation of the project to decontaminate and dismantle the Storage Facility for Old Intermediate Level Waste appear to be adequate.
- There seems to be some risk of cost underestimation in the project support part, which also includes characterisation and decontamination due to e.g. uncertainty in facility radiological condition/degree of contamination, unsophisticated definition of contingency margins and possible implications of the preceding items for actual

[1] The complete name is the Act on the Financing of the Management of Certain Radioactive Waste etc. (1988:1597).
[2] In Swedish: Lagret för historiskt avfall, aktiva tråget (AT).

decommissioning methodology and related costs. It ought to be noted that it appears necessary to invest more in the characterisation program to determine if the final concrete demolition technique will be acceptable.

- The comparison suggests that the cost estimates for the actual dismantling of the Storage Facility for Old Intermediate Level Waste may be underestimated. The estimated costs of core drilling may for example be too low. In addition, depending on the radiological conditions discovered, the final method of demolishing the concrete vault structure may have to change, with potentially higher costs.

The report clearly demonstrates that it is possible to enhance and extend the present knowledge basis for cost estimates by using feedback of experience by trying to apply benchmarking data, but a successful outcome depend every so much on the quality of the original data.

This report shall be seen as a contribution to active learning; that may help to improve calculations of the decontamination and decommissioning cost so that a more reliable estimate can be presented on successive higher confidence levels.

Continued work

This study indicates that there exists a need to develop a more comprehensive platform for how to retrieve and gather decommission cost data in a clear, and traceable manner. Review of estimates and suggestions of how they can be more transparent gives contributions to our understanding of the prerequisites for good cost estimations, as well how more reliable cost estimates can be derived. But first and foremost these estimates must be based on a comprehensive and clear method.

Effects on SKI work

SKI will be able to draw inferences from this study in the yearly monitoring of cost estimates which are presented by the company AB SVAFO in late April every year. Thus, this study will give support to the current review process of the estimated decommissioning and dismantling costs of the Storage Facility for Old Intermediate Level Waste (AT).

Project information

At SKI Staffan Lindskog have been responsible to supervise and co-ordinate the project. Geoff Varley and Chris Rusch from NAC International, England, have accomplished the research task. Bryan McHugh was responsible for the translation of the original report into English.

SKI reference: 14.9-040333/200409076.

Prepared for
SKI

January 2005

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C-2005-01

ABOUT THE AUTHORS

GEOFF VARLEY

Dr. Varley has more than 28 years of experience in the nuclear industry, more than 16 years as a consultant and manager with NAC and, before that, more than 12 years with U.K. nuclear fuel services company British Nuclear Fuels plc (BNFL). Since joining NAC in April 1988, Dr. Varley has applied his experience and expertise to a wide range of consulting activities, serving clients worldwide. In June 1993 he became general manager of NAC's Zurich operations. In this capacity, he was responsible for all consulting, database and sales activities performed at NAC's European hub. In July 1996 he opened NAC's London office and in mid-2004 he was appointed as Director of Commercial Consulting for NAC, a function that he fulfils from a base close to London.

Dr. Varley's consulting expertise is applied to all nuclear fuel cycle sectors, with a special focus in the back end (reprocessing, plutonium and uranium recycle, waste management, spent fuel transport and decommissioning) fuel fabrication and enrichment market sectors. Since April 1988, Dr. Varley has visited numerous reactor and fuel cycle service facilities throughout the world.

CHRIS RUSCH

Mr. Rusch has more than 30 years of experience in the nuclear industry. In his position as a Senior Consultant, he utilises his great versatility to participate in a wide range of consulting activities, spanning all fuel cycle segments from the front end through waste management and decommissioning.

Before joining NAC, Mr. Rusch was the manager of nuclear fuel at Portland General Electric and was responsible for all phases of nuclear fuel procurement, including strategic and tactical planning, bid preparation, supplier and proposal evaluations, contract negotiation, contract administration, and economic analysis. Significant experience includes management of major projects, technical professionals (in-core fuel management and safety analysis personnel) and annual operating and capital budgets of $1 million and $25 million, respectively.

Mr. Rusch managed the procurement of nuclear fuel for a nuclear plant that consistently ranked among the top 10 plants in the United States with the lowest fuel costs. He organised and directed the evaluation and negotiation teams for the procurement of nuclear fuel fabrication services and directed a multi-department, four-year project to establish a new supplier of nuclear fuel fabrication services.

Mr. Rusch has broad utility experience as his assignments required interfacing with accounting, rates and revenues, finance, legal, power analysis and power operations departments and nuclear plant staff, including reactor engineering, licensing, quality assurance and nuclear engineering groups.

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Executive Summary

Overview

The Map Tube Facility (MTF) was a large concrete block structure constructed in 1952 at the Argonne National Laboratory site in the United States, for the purpose of storing radioactive waste. The block contained 129 storage tubes that were positioned vertically in the block during construction.

From 1952 though the early 1980s, the MTF was used to store containers of highly radioactive materials. The items stored included:

- Nuclear fuel elements
- Nuclear reactor components
- Materials samples
- Irradiated metal objects (bolts, wire, rods, etc)
- Concrete-encased objects

After MTF operations were discontinued in the early 1980s, most of the materials were removed from most of the tubes.

Decontamination and decommissioning of the MTF tool place in 1994. The objective was to eliminate the radiological and chemical materials within the MTF tubes to prevent ground water and soil contamination. Once these materials were removed, the block would no longer be a source of contamination (chemical or radioactive) and could then remain in place without risk to the environment.

The decontamination scope included the following actions.

1. Mechanically clean each tube (wire brush)
2. Dewater each tube
3. Remove the debris and sludge from the bottom of each tube
4. Fill each tube with concrete
5. Remove the tubes using a core drilling technique.

Project constraints precluded the use of excavation around the facility and sectioning of the MTF block or simple demolition, which led to the use of the core drilling technique.

The cost of decommissioning the MTF was approximately $2.6 million (1994 money values). Escalating this at 2.5 percent per year to January 2005 and converting to Swedish currency at the current exchange rate (January 2005 approximately 6.2 MSEK/$) gives an equivalent cost today of MSEK 20.6.

The AT facility in Studsvik is considerably larger than the MTF facility in Argonne – between six and seven times in terms of volume but with storage tube depth somewhat less. Unlike the MTF, AT has some storage vaults in addition to storage tubes. Based on available descriptions of the nature of the wastes stored in AT and the MTF, in general terms the range of wastes appears to be somewhat similar.

In the case of the MTF it was determined that radioactive sludge was present at the bottom of the tubes, resulting from water ingress and corrosion of both storage containers and their contents. In the case of AT it is not known exactly what the condition of the tubes is but it is recognised that leakage/contamination in the lower parts of the tubes is likely to have occurred. This is an important consideration in the planning of the AT decommissioning program and the related cost estimate, principally because of the potential consequence of different approaches and specific techniques chosen to implement decommissioning.

The AT decommissioning cost estimate report is not entirely clear in detail regarding the specific methodology to be adopted. In addition there are a number of important uncertainties concerning the extent of radioactive contamination. Depending on what the reality turns out to be, the decommissioning methodology could be affected and the quantities of wastes in various categories also could vary. In any event, the AT cost estimate report is unclear regarding waste volumes in a number of respects.

Main Conclusions

The AT cost estimate is presented in a similar fashion to several other recent decommissioning cost estimates prepared by Westinghouse for SVAFO, using an approach and presentation format that suffers somewhat from:

- Not always being clear
- Not always being unambiguous and easy to understand and,
- Lack of detail and clear substantiation of assumptions in some important areas.

Setting these concerns aside, the available information has been evaluated and compared with the Argonne MTF decommissioning costs and other selected NAC derived decommissioning cost benchmarks.

In summary the conclusions for the AT decommissioning cost estimate are as follows:

PREPARATION

The AT estimate appears to be adequate.

PROJECT SUPPORT (INCLUDING CHARACTERISATION AND DECONTAMINATION)

Some risk of cost underestimation related to:

- Uncertainty in facility radiological condition/degree of contamination
- Unsophisticated definition of contingency margins
- Possible implications of the preceding items for actual decommissioning methodology and related costs

It appears very necessary to invest more heavily in the characterisation program to determine if the proposed concrete demolition technique will in fact be acceptable.

ACTUAL DISMANTLING

The available data and relevant comparisons suggest that the AT cost estimate for this part of the project cost may be underestimated. The estimated cost of core drilling at AT may be low. In addition, depending on the radiological conditions discovered, the final method of demolishing the concrete vault structure may have to change, with potential higher cost implications. This reinforces the very important message that comprehensive characterisation of the AT facility is required and that the methodology for subsequent decommissioning work may need to change depending on the conditions revealed by this investigative phase.

1. Introduction

Statenskärnkraftinspektion (SKI) charged NAC International with the task of conducting a study of the decommissioning activities and costs for the Map Tube Facility (317 Area) at the Argonne National Laboratory, Chicago (hereafter referred to as the MTF) in comparison with the decommissioning plan and cost estimate for the AT Storage Facility for Old Intermediate Level waste at the Studsvik Site in Sweden. The AT cost estimate is contained in report SEP 01-317 prepared by Westinghouse Atom AB for AB SVAFO.

This report presents the conclusions of NAC's analyses and comparisons. It includes a full analysis of the MTF, the derivation of relevant benchmarking results from that decommissioning program and a prudence review of the AT cost estimate, looking at the reasonableness of the cost estimate as well as the completeness of the estimate and related logistics.

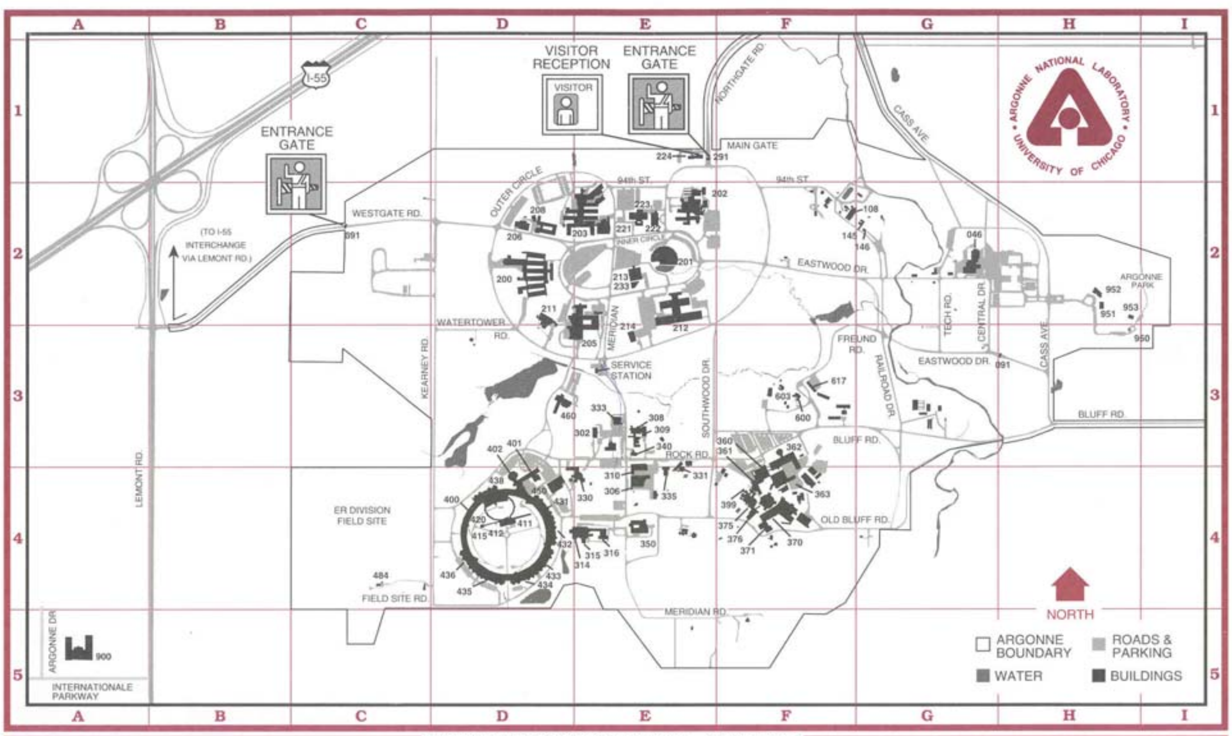
2. Argonne Map Tube Facility Description and Decommissioning Scope

2.1 Map Tube Facility Description

2.1.1 Site

The MTF is located in the 317 Area of the Argonne National Laboratory (ANL) located about 40 kilometres from Chicago, Illinois, USA. The 317 Area is situated in the south central portion of the ANL site, see sector E5 of Figure 2-1 (Site Map of Argonne National Laboratory).

Figure 2-1 Site Map of Argonne National Laboratory



BUILDING LOCATOR (Building Number – Grid Location)

East Area	100 Area	200 Area		300 Area		360 Area	400 Area		600 Area	800 Area	Offsite	ANL Park
046 – G2	108 – F2	200 – D2	212 – E2	302 – E3	316 – E4	360 – F4	400 – D4	433 – D4	600 – F3	891 – C2	900 – A5	950 – H3
091 – H3	145 – G2	201 – E2	213 – E2	306 – E4	330 – E4	361 – F4	401 – D4	434 – D4	603 – F3			951 – H2
	146 – G2	202 – E2	214 – E3	308 – E3	331 – E4	362 – F3	402 – D4	435 – D4	617 – F3			952 – H2
		203 – E2	221 – E2	309 – E3	333 – E3	363 – F4	411 – D4	436 – D4				953 – H2
		205 – E2, E3	222 – E2	310 – E4	335 – E4	370 – F4	412 – D4	438 – D4				
		206 – D2	223 – E2	314 – E4	340 – E3	371 – F4	415 – D4	450 – D4				
		208 – D2	224 – E1	315 – E4	350 – E4	375 – F4	420 – D4	460 – D3				
		211 – D2	233 – E2			376 – F4	431 – D4	484 – C4				
			291 – E1			399 – F4	432 – D4					

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2.1.2 Area 317

This area contained a number of facilities, including six in-ground vaults, for handling and storing radioactive waste as shown in the Area 317 site plan (Figure 2-2 and Figure 2-3) and the overhead picture of Area 317 (Figure 2-4). The MTF is located in Area 317 and is the middle facility in the north row of vaults.

Figure 2-2 ANL Area 317 Site Plan

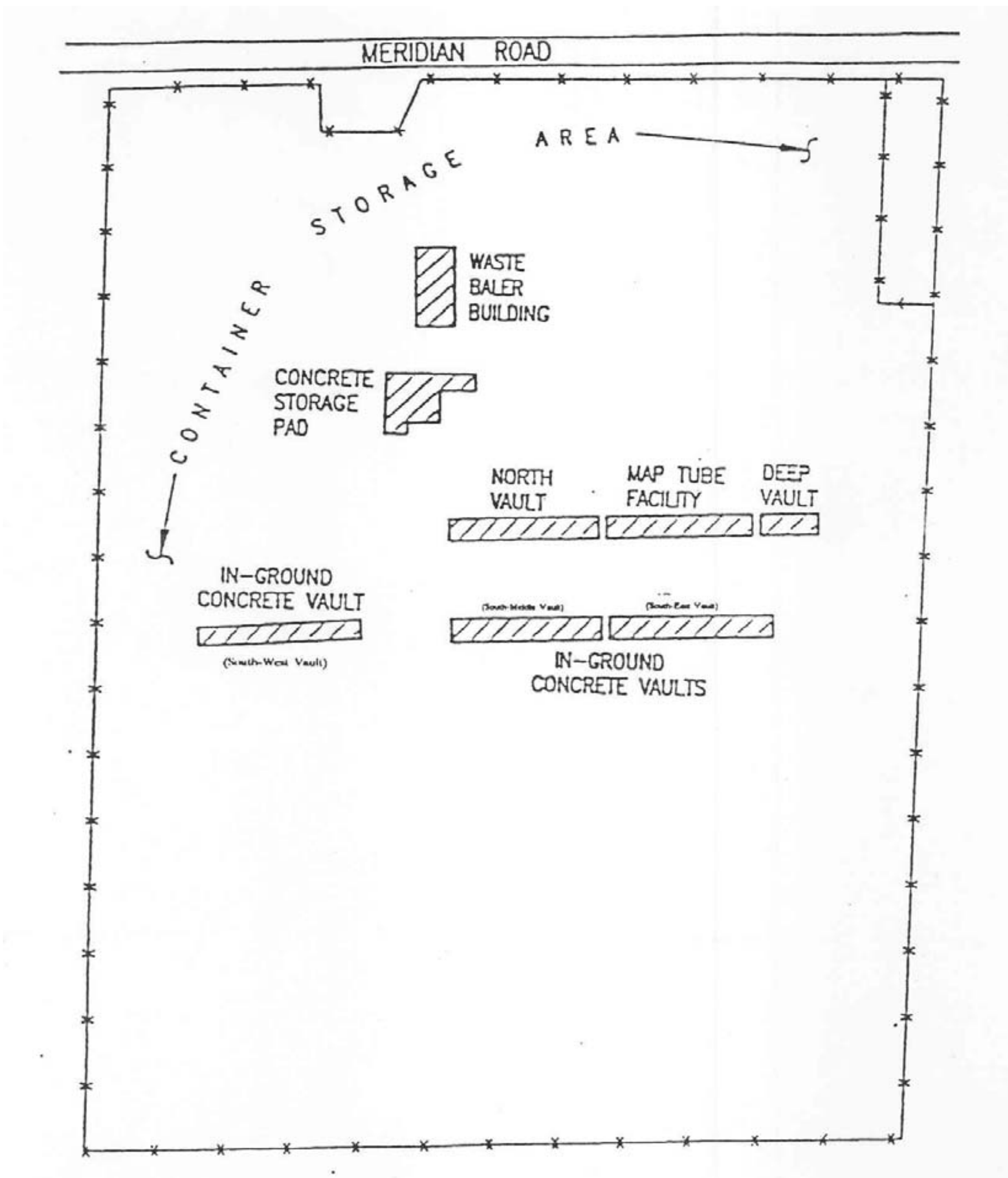


Figure 2-3 ANL Area 317 and Surrounding Area

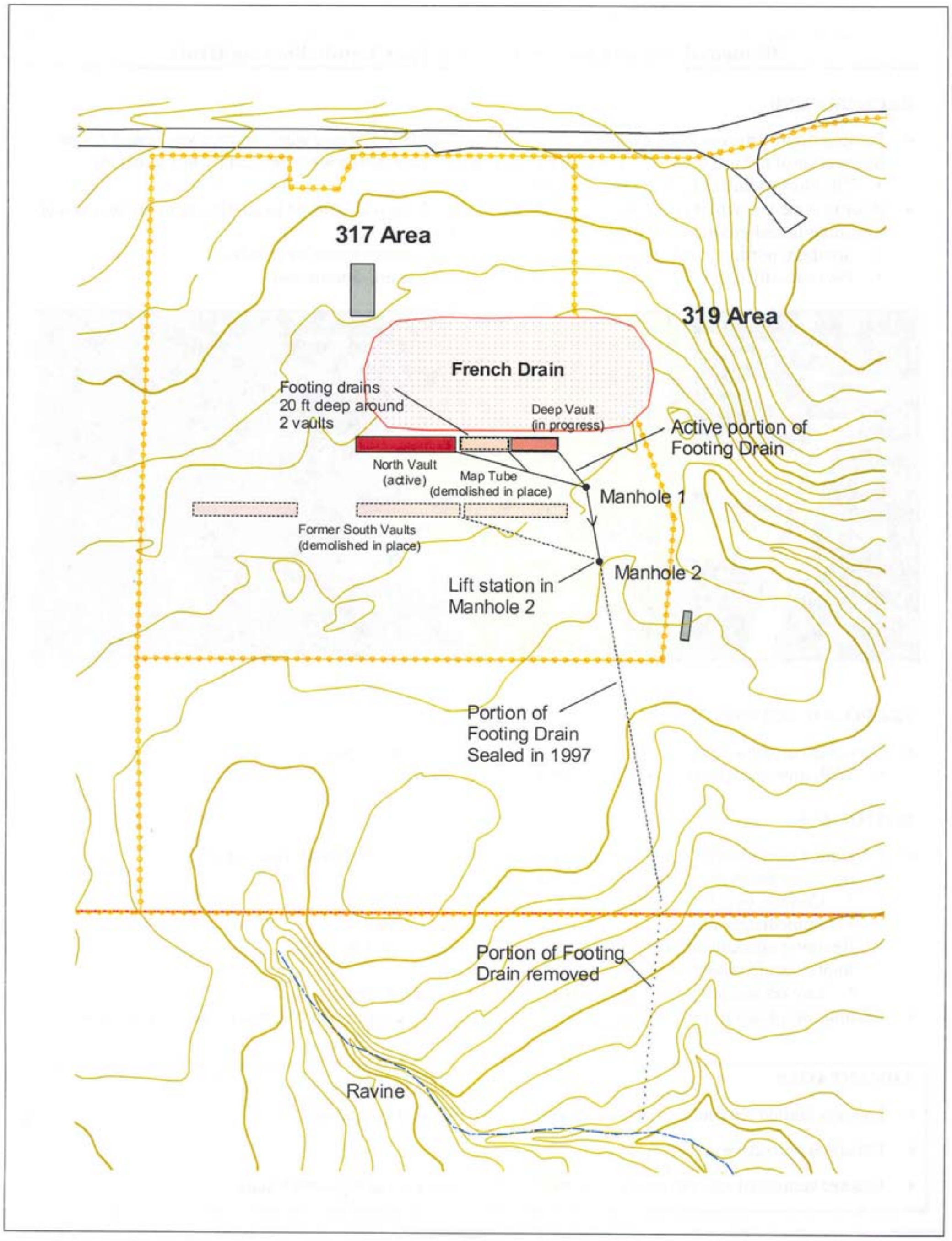


Figure 2-4 Overhead View of Area 317

ANL stored low and intermediate-level (transuranic) waste in four of the vaults, the three vaults in the lower row on Figure 2-4 and the left-hand facility in the upper row on Figure 2-4. The deep vault (right-hand facility on the upper row with overhead crane above the facility [Figure 2-4]) was used exclusively to store intermediate-level radioactive waste. Small containers of highly radioactive waste (HLW) were stored in the MTF, middle facility in the upper row on Figure 2-4.

Steel bins containing low-level radioactive waste (LLW) which were awaiting off-site disposal were stored in a gravel-covered area north of the vaults.

The Bailer Building was located in the 317 Area. Originally, the building was used to compact radioactive waste. This included waste compaction equipment (Figure 2-5) used in that era. Figure 2-6 shows compacted LLW being loaded into storage and transport bins. The tubes of the MTF were not designed to receive or store compacted waste.

Later, the building was used to decontaminate surface radioactivity from equipment, lead bricks and tools, using a carbon dioxide pellet blaster.

Figure 2-5 Waste Compacting Equipment

Figure 2-6 LLW Loading

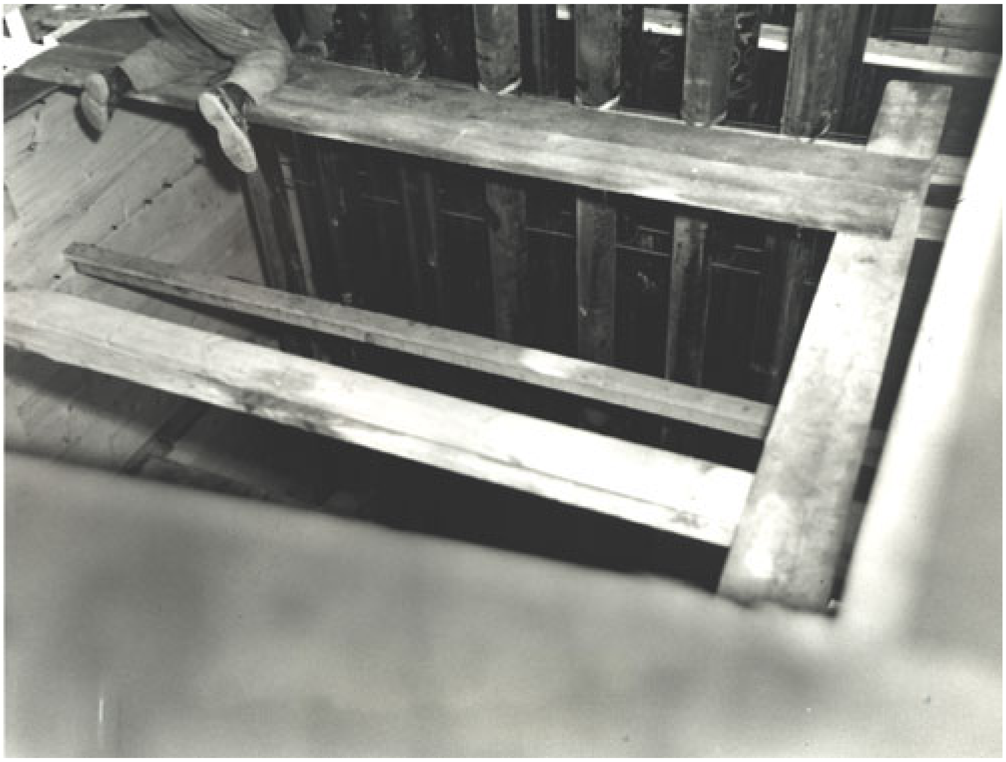
2.1.3 Map Tube Facility Description

The MTF was a large concrete block structure (Figure 2-7) that was constructed in 1952 for the purpose of storing radioactive waste. The block is 4 meters wide, 8.5 meters long and 6.4 meters deep (5.8 meters of which is below grade level). The block contained 129 cast-iron, bell and spigot[1] sewer pipes that were positioned vertically in the block during construction, see Figure 2-7 and Figure 2-8. Five pipes (hereafter referred to as “tubes”) were 25.4 cm in diameter, 84 tubes were 15.2 cm in diameter and 40 tubes were 10.2 cm in diameter. All tubes were the same length, approximately 6.2 meters.

Figure 2-7 MTF During Construction

1. “Bell and spigot” refers to the shape of the ends of cast-iron sewer pipes such that one pipe can fit to another pipe in a fairly tight joint.

Figure 2-8 Tube Placement



A cast-iron cap (end cap) was fitted to the bottom of each tube (the end caps are shown encased in concrete during construction, Figure 2-9). A lead oakum[2] seal was applied to the cap-tube joint, similar to the cast-iron sewer construction techniques of that era. Each tube also had a joint located about 0.6 meters from the top of the block (see the front row of tubes in Figure 2-7). This joint also contained a lead oakum seal. The lead oakum material represented a significant waste issue during the planning and decontamination of the MTF. Figure 2-10 depicts typical lead oakum joints.

2. "Oakum" refers to the material used to caulk seams in wooden ships. Its use here presumably is to indicate that a similar material was used to seal the lead joints of the cast-iron sewer pipes.

Figure 2-9 Tube End Cap Placement During Construction

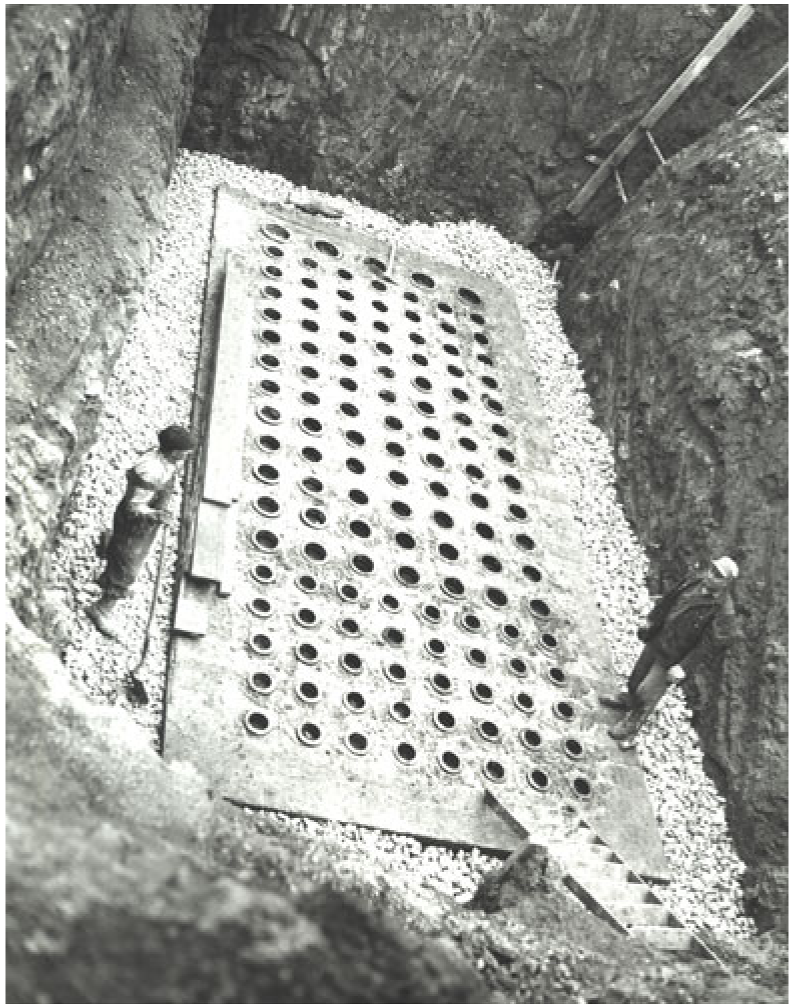
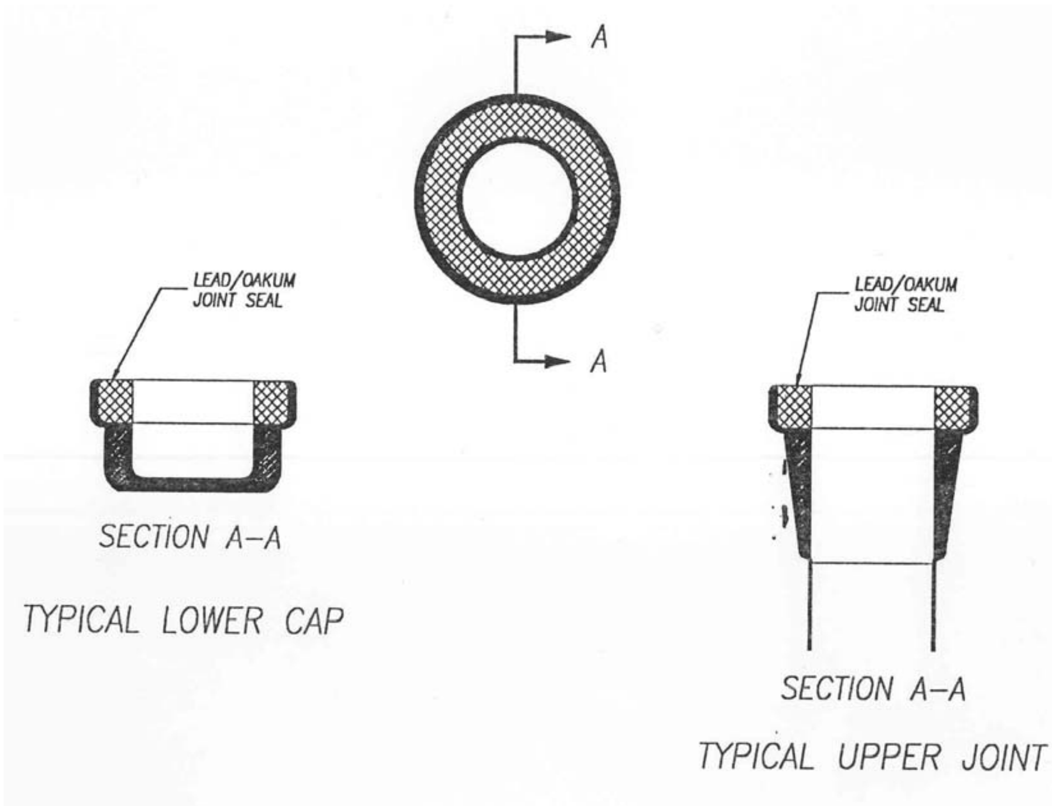


Figure 2-10 Typical Lead Joints



The mouth of each tube was covered with a loose-fitting lead cap approximately 15.2 cm thick. The caps are pictured in Figure 2-11. The cap weights are listed in Table 2-1.

Figure 2-11 Tubes with Caps in Place

Table 2-1 Tube Cap Weights

Tube Diameter (cm)	Cap Weight (kg)
10.2	13.6
15.2	27.2
25.4	45.4

Originally, the MTF was covered with a tent-shaped, removable roof.

2.1.4 Physical Condition

The removable MTF roof deteriorated in the late 1970s and was removed. Figure 2-12 provides a good representation of such roof deterioration over one of the LLW vaults pictured in the figure. This allowed the tubes to be exposed to the weather and became one of the principal paths for tube flooding.

Figure 2-12 Vault Roof Deterioration

In June 1989, five core holes were drilled through the base of the MTF to determine the presence of radioactivity underneath the facility. Soil and groundwater samples were collected and analysed for tritium and gamma spectrometry. Measurable levels of tritium were detected in the soil samples (0.01 to 0.31 Bq per gram) and water samples (10.85 to 4,074.1 Bq per liter).

The groundwater near the MTF was contaminated with low levels of tritium, cesium-137 and strontium-90. The MTF was the suspected source of this contamination because of deterioration of the lead joints in each tube and cracks in the concrete block. In addition, the “French Drain” (see Figure 2-3) located near the MTF was contaminated with chlorinated solvents and the chemicals listed in Table 2-1.

Table 2-2 French Drain Contamination

Chemical	Maximum Concentration (μg/kg)
Chloroform	21,000
Carbon Tetrachloride	54,000
Tetrachloroethane	190,000
1,1,1-trichloroethane	140,000
Trichloroethylene	47,000
4-methyl-2-pentanone	78,000
Isobutyl Alcohol	39,000

The highest levels of contaminated soil were located immediately north of the north row of waste storage vaults, see the "French Drain" designated area on Figure 2-3. That is, the contaminated soil was very close to the MTF. The presence of these chemicals had a significant impact on the technology selected for the MTF decontamination project, see section 3.4.1.

2.1.5 Wastes Stored

During 1952 though the early 1980s, the MTF was used to store highly radioactive materials placed in metal containers that were similar to the containers used to store maps and drawings, hence the name of the facility. Some of the materials were re-inserted into ANL research reactors for additional irradiation at different times and so the materials had to be easily retrievable. The items stored included:

- Nuclear fuel elements
- Nuclear reactor components
- Materials samples
- Irradiated metal objects (bolts, wire, rods, etc)
- Concrete-encased object

Figure 2-13 provides an example of the contents of a tube. At least nine tubes contained debris which ranged in weight from the weight of a paperclip up to 23 kgs. Table 2-3 lists the contents and radiation level in the tubes that contained debris.

Figure 2-13 Tube Contents Located in Map Tube

Table 2-3 Tube Contents and Associated Radiation Levels

Tube ID	Diam (cm)	Maximum Dose[a] (mSv per hour)	Description
A3	25.4	< 0.002	Metallic object buried in sediment
A5	25.4	< 0.002	76 cm long metal rod
D11	15.2	200	2 tubes and several wire-like objects
D12	15.2	< 0.002	Small rod (0.32 cm diam x 30.5 cm)
J10	15.2	0.06	12.7 cm diam metal tube cap
J12	15.2	500	15 tubes (61 cm long x 1.3 cm diam)
M12	15.2	400	Hexagonal tube with rods (91 cm long)
Q18	10.2	0.002	Metallic wire or clip (5 cm long)
R20	10.2	4	Concrete plug at bottom of tube

a. Near or on contact with an object

After MTF operations were discontinued in the early 1980s, most of the materials were removed from most of the tubes.

At the time of the characterization of the MTF in 1993, there was still some wire, bolts and an object that looked like an experimental breeder reactor (EBR) fuel assembly located in the tubes. The object (Figure 2-14) that looked like an EBR blanket assembly turned out to be a container with activated steel rods.

Figure 2-14 Container with Activated Steel

The most significant radioactive source in the tubes at the time of the 1993 characterization was the sludge at the bottom of the tubes consisting of corrosion products from metallic corrosion of the containers and contents and the radioactive contamination left after storing materials in the tubes.

2.2 Outline of Decontamination Plan Scope

2.2.1 Objectives

The objective of the MTF decontamination was to eliminate the radiological and chemical materials within the MTF tubes to prevent ground water and soil contamination. Once these materials were removed, the block would no longer be a source of contamination, chemical or radioactive, and could then remain in place without risk to the environment.

2.2.2 Original Scope

The original decontamination scope included the following actions.

1. Mechanically clean each tube (wire brush)
2. Dewater each tube
3. Remove the debris and sludge from the bottom of each tube

4. Fill each tube with concrete
5. Remove only the tubes (less than ten tubes) with the highest radiation levels

2.2.3 Final Scope

The funding for the decontamination of the facility was awarded incrementally. The original funding level permitted the scope of work outlined in section 2.2.2. Thereafter, on three or four occasions, new funding was assigned to the project after ANL management evaluated the project. With each new funding increment, it was decided to increase the number of tubes to be removed. Eventually, this lead to funding for the removal of all 129 tubes.

2.2.4 Principal Assumptions

Evidence of flooding in the tubes indicated the possibility of ground water intrusion. Given this possibility and the known contents of the tubes, the assumption was made that if ground water was entering the tubes, contaminants could be exiting the tubes and mixing with the outside ground water.

2.3 Outline of Planning and Institutional Requirements

2.3.1 General Process

ANL is a multiprogram research and development laboratory mostly funded by the U.S. Department of Energy (DOE). The resultant waste streams of some of the programs conducted at ANL include highly radioactive waste and chemically hazardous waste. No waste is currently disposed of on-site but, in the past, Area 317 was used as an interim storage site.

In the late 1980s, ANL began a program to locate, characterize and clean up waste sites. In 1987, ANL produced a Preliminary Assessment Report that identified 13 sites at ANL with known or suspected hazardous substances.

In December 1990, ANL applied for a Part B Permit under the Resource Conservation and Recovery Act [3](RCRA). This application triggered the Corrective Action provision of RCRA (Section 3004[u]). Based on the corrective action requirements, the Illinois Environmental Protection Agency (IEPA) conducted a RCRA Facility Assessment which identified 735 solid waste management units (SWMU) and five areas of concern. The list of SWMUs includes wastewater holding tanks, sumps, sewer lines, sludge beds, loading docks used to store waste, recycled materials staging areas, satellite accumulation areas and land disposal units. MTF was designated SWMU No. 12.

The first step after the assessment was to evaluate the 735 SWMUs against five areas of concern to determine those that require further action. It was determined that approximately 600 SWMUs should qualify for "no further action" status. The MTF was one of 71 SWMUs that definitely required further action.

Once a SMWU is designated for further actions the process is as follows:

1. Complete a characterization phase RCRA Facility Investigation (RFI).
2. Compile the Corrective Measures Study (CMS) that involves developing and evaluating several technologies for facility remediation. The regulatory agency selects the technology to be used.
3. The selected technology is then implemented during the Corrective Measures Implementation stage.

2.3.2 Specific Process for Area 317 and the Map Tube Facility

The clean up efforts are and were funded by the DOE Environmental Management Program. The three-step process above was identified as potentially very expensive and inefficient requiring many years for all 71 SWMUs that required action. As a result DOE encouraged interim actions and expedited remedial actions at DOE facilities.

3. The Resource Conservation and Recovery Act (RCRA) was enacted in 1976 as an amendment to the Solid Waste Disposal Act of 1965. It was later amended in 1986. RCRA is a combination of the first solid waste statutes and all subsequent amendments. RCRA authorizes EPA [U.S. Environmental Protection Agency] to regulate solid waste management activities. RCRA authorizes states to develop and enforce their own waste management programs, in lieu of the federal program, if a state's waste management program is substantially equivalent to, consistent with, and no less stringent than the federal program.

ANL began an environmental restoration program (ERP) that maximizes the potential for interim actions by proceeding with some clean-up work before the CMS is completed. The result is that the costs for conducting the RFI, characterization, evaluating technologies and preparing the CMS report are significantly reduced. Costs are also reduced because escalating decommissioning and waste disposal costs are avoided. Initiating interim actions also minimizes the potential for a spread of contamination, which in turn reduces future costs.

ANL characterisation of the 71 SWMUs was used to identify the sites with the highest potential risk (human health or environmental risk as well as magnitude and nature of contaminated areas) and greatest economic liability. Two areas, area 317/319/ENE and area 800 met the risk and economic liability criteria for high priority action as determined by both DOE and ANL. The necessary funding was provided for interim remedial action.

The interim remedial action strategy uses available information including recent and historic aerial photographs (for MTF see Figure 2-4 and Figure 2-15), employee interviews, routine environmental monitoring information, compliance monitoring of surface and ground water, preliminary characterization radiological surveys, site closure sampling, and facility design information. The report "Design Memorandum for the Decontamination of the ANL 317 Area Map Tube Facility" (ANL-AT-0004) contains this information for the MTF.

Figure 2-15 Overhead View of Area 317/319

Specific site characterization was conducted. For Area 317, the characterization process was reported in, "ANL Area 317 Phase I & II Characterization Report" (ANL-TR-0001).

The process of evaluating SWMUs within the 317/319/ENE and 800 areas included evaluating interim actions for those SWMUs that have

1. significant contamination, and
2. interim clean up costs that meet budget constraints.

It was determined that the MTF met these criteria and an interim remedial action (decommissioning) was authorized.

In summary, the RCRA provides a complicated formal process for site remediation. In order to expedite site clean up while the RCRA process is pending, interim clean up measures were instituted by DOE. ***The MTF decommissioning project constituted one of many interim cleanup measures conducted at ANL.***

2.3.3 Costs

Because the MTF decommissioning program initially was part of a much bigger national effort to identify and characterise facilities and sites for decommissioning, it would not be straightforward to attribute planning and other institutional costs/resources needed specifically for the MTF. These unique circumstances in the U.S. indeed most likely would lead to a result that would not be meaningful in the context of the Studsvik AT storage facility. Accordingly a comparison of planning and institutional costs for the AT and MTF facilities is not attempted in this report.

3. Overall Work Program

3.1 Program Outline

The work scope included the following phases:

- Phase I - Characterization of the MTF tubes
  1. Measure surface radiation levels
  2. Underwater camera survey for tubes with high radiation levels
  3. Brush tubes
  4. High-pressure water spray the interior of tubes
  5. Dewater tubes
  6. Removal of sediment and debris
- Phase II - Seal the Tubes and Install Tube Lifting Devices
  1. Insert the lifting device in each tube
  2. Seal the tube by grouting the lifting device in place with concrete
- Phase III - Removal of Tubes By Concrete Coring
  1. Concrete coring of tubes with conventional vertical concrete coring rig
  2. Remove concrete core from the MTF block
  3. Remove tube end caps and upper joint sections of the cored tube
  4. Remove lead joints from the joint sections in No. 6 above
  5. Wrap the core sections with plastic sheeting in preparation for shipment
  6. Load the core sections onto a flat-bed truck for transport
  7. Transport cored sections to a LLW site for burial

3.2 Decontamination and Dismantling Implementation

3.2.1 Phase I - Map Tube Facility Characterization

3.2.1.1 Dewatering Process

During a six-week period from late 1993 to early 1994, the Energy Technology Engineering Center, Rocketdyne Division of Rockwell International[1] (ETEC) characterized the MTF. The first phase of the characterization was to assemble a temporary tent-type structure over the MTF, as shown in Figure 3-1. This provided two functions, airborne radiation containment and protection from the elements.

1. Boeing Corporation purchased Rockwell International subsequent to the completion of the MTF project.

Figure 3-1 MTF Containment Equipment

The surface radiation levels of all 129 tubes were measured. Virtually all tubes exhibited smearable contamination. Twenty-seven of the tubes were contaminated enough to generate elevated radiation levels within the tubes. General exposure rates in the tubes ranged from zero to 6 mSv per hour. Nine tubes contained debris and the highest exposure rate in one tube reached 500 mSv per hour near the debris, see Table 2-3. The tubes with the highest radiation levels were inspected with an underwater camera (Figure 3-2) to determine the contents of the tubes. Highly radioactive materials were discovered in six tubes; however, several tubes with high radiation readings did not contain objects. These tubes had contained radioactive objects that were withdrawn earlier but not before the objects had spread contamination in the tubes.

Figure 3-2 Underwater Camera Equipment

For the tubes with high radiation levels, underwater dose rates were measured and surface (smear) and water samples were collected. Tritium levels in the water samples ranged from 0.59 to 638.74 Bq per millilitre. The smear samples were analysed for cesium-137 and cobalt-60 and had concentrations from 0.0048 to 23.96 Bq per smear. The sediment also contained lead in excess of the RCRA toxicity limit of 5 mg per liter, meaning that it would have to be handled as a mixed waste.

ANL did not have a permit to treat mixed waste so a two-stage water removal process was performed. The water in each tube was pumped down to a depth of about 46 cm (Figure 3-3) into a 3,400-liter tank. The water in this tank was evaporated with on-site ANL liquid evaporation equipment.

Figure 3-3 Pumping Equipment

Each tube that did not contain debris was rinsed with a high-pressure water jet, scrubbed with a stiff bristle wire brush (Figure 2-11) and rinsed again with the high-pressure water jet. The residual water and sediment was pumped into three, 208 liter galvanized steel drums (Figure 2-12). An approved absorbent material was added to the drums which were then moved to an on-site mixed waste facility.

The rinse and scrub process was repeated until contamination had been reduced to an acceptable level. In addition, following debris removal, the process described above was conducted on the respective tubes.

The dewatering procedure worked well and equipment problems were minor which allowed this phase to be completed ahead of schedule. The dose rates at the filters did not exceed 0.40 mSv per hour which was attributed to the two-stage dewatering process. That is, removal of the water down to 46 cm above the bottom of each tube and then pumping the sediment and remaining water into steel drums. The sock filters located in “quick change” housings permitted a change of filter without interrupting pumping operations.

The equipment and materials required for dewatering the tubes are listed in Appendix A.

3.2.1.2 *Debris Removal*

The task of debris removal posed many unique challenges. Each tube with debris had the potential for problems with spreading contamination with activity and doses as summarized in Table 2-3.

The debris was handled with long-reach grappling tools (Figure 2-14, Figure 3-4 and Figure 3-5) that could grip, snare, or scoop a variety of objects. In order to minimize exposure, significant dry run and mock-up training was conducted. Three different handling procedures were defined for debris

1. < 1.0 mSv per hour,
2. equal to or > 1.0 mSv per hour and a dose assessment determined that the debris could be handled without using a transfer cask
3. equal to or > 1.0 mSv per hour and a dose assessment determined that the debris had to be handled with a transfer cask

Figure 3-4 Grappling Equipment

Figure 3-5 Grappling Equipment with Object from Tube

For category (1), the debris was removed from the tubes and handled by personnel on the ground using a 1.8-meter grapple (Figure 3-5) and inserted in a shielded transfer/storage canister (a typical canister is shown in Figure 3-6). For categories (2) and (3), the debris was withdrawn using long-reach grapple equipment that was handled by personnel from the top of a man-lift. The equipment and materials required for dewatering the tubes are listed in Appendix B.

3.2.2 Phase II – Insert Lifting Devices and Seal Tubes

The lifting device consisted of a 6.1 meter long piece of #4 rebar with a 4.6 meter long 1.3 cm wire rope attached to the rebar. The wire rope had a lifting eye at one end. This assembly was inserted into each tube with the lifting eye positioned at the top of each tube (Figure 3-7) and sealed in place with concrete. This process

1. Provided a lifting mechanism for removing the concrete core,
2. Sealed the tube so that water could not enter or exit the tube
3. Added strength to the fragile cast-iron tube

Figure 3-6 Core Drilling Rig on Flatbed Truck

Figure 3-7 Lifting Eye Inserted in Tube

The sealing function was particularly important because there could be a number of weeks or months between the time that the concrete was poured to secure the lifting device and the actual removal of the tube. In addition, as mentioned in section 2.2.3, the funding for the project was incremental and, at different times during the project, there was the potential that only a fraction of the tubes would be removed. Therefore, the sealing function also was required to prevent the spread of contamination for a considerable period of time.

3.2.3 Phase III - Removal of Tubes By Concrete Coring

Core drilling proved to be the most challenging and difficult phase of the project. The tube core drilling sequence is provided in Appendix C and Appendix D contains a list of the equipment and materials required for the drilling operation.

Problems associated with drill equipment were, in general, quickly solved. Problems unique to the MTF required more time.

Technical delays were caused by:

1. Vertical misalignment of the tubes
2. Separation of end caps due to drilling-induced vibration
3. Loss of cooling water
4. Jamming of the drill bit due to inconsistencies in the concrete
5. Foreign objects in the block

Other delays were caused by weather and weather warnings and the need to allow ANL personnel access to the vaults adjacent to the MTF.

The core-drilling rig was mounted on a flatbed truck (Figure 3-8) so that the equipment could be moved when access to the deep or north vaults was required. The flat bed truck dimensions from the end of the truck to the rear axle (Figure 3-8) were adequate to allow the drill rig to be positioned over every tube in the block.

Figure 3-8 Core Drilling Rig on Flatbed Truck

The most highly contaminated tubes were removed first. The coring operation was performed with one continuous cutting operation through 6.4 meters of concrete. Coring operations for nine tubes had to be abandoned and restarted either due to (1) loss of cooling water, (2) difficulty with foreign objects in the concrete, or (3) concrete integrity. In these cases, fresh concrete was injected into in the cuts and the coring was restarted after the concrete had cured.

Upon completion of the coring operation, where possible the core was removed immediately (Figure 3-9, Figure 3-10 and Figure 3-11). In some instances, cores were left in place for a period subject to crane availability for removing the cores and the shipment schedule for transferring the cores to the Hanford LLW site.

Figure 3-9 Tube Removal

Figure 3-10 Tube Removal

Figure 3-11 Tube Removal

3.2.3.1 *Coring Experiences*

With the exception of hitting the end caps, the positioning of the drill rig in general was very successful. Only three tubes were penetrated during the coring operations.

While the offsetting technique (see section 3.4.5) was used to account for the vertical misalignment of the tubes, still 34 end caps were hit by the drill during the coring process. In four cases, both the lead joint and radioactive contamination were exposed. In one case, only the lead was exposed.

Due to vibration of the tubes induced from the drilling process, the end caps of five tubes remained in the block when the tube was pulled. Three concrete cores below the end caps also remained in the hole after the tube was removed. The caps and related concrete cores were removed using grappling devices similar to those used to remove large pieces of debris from the tubes. Two of the five end caps that remained in the block required considerable time for removal, one required three hours and one four hours to remove the cap and associated concrete.

Tube R20 contained a radioactive object that was encased in concrete. The radiation levels on the exterior of the cored tube was 2.8 mSv per hour. The tube was cut approximately 1.4 meters from the bottom and covered with lead blankets. It was then moved to a hot cell for examination.

3.3 Management of Decommissioning Wastes

There were several types of waste generated from the project. Table 3-1 summarizes the wastes and associated quantities. A detailed description of the waste management situation applicable to each waste source is presented following Table 3-1.

Table 3-1 Waste Form and Disposition

Source	Waste Type	Form	Quantity	Disposition
Dewatering	Mixed	Sludge	420 liters	Shipped to Hanford
Dewatering	LLW	Water	11,360 liters	Evaporated @ ANL
Debris Removal	LLW	Metal	79 kgs	Shipped to Hanford
Drilling	LLW	Concrete & steel	129 cores (85 cu. metres)	Shipped to Hanford in 10 campaigns between 11 August and 27 October, 1994
Drilling	LLW	Concrete fines	38 cu. metres	Shipped to Hanford
Drilling	No activity	Concrete fines	23 cu. metres	Disposed @ ANL on-site
Drilling	Mixed	Lead shield caps	~3,060 kgs	Shipped to Hanford
Lead Seal Removal	Mixed	Lead from joints	~820 kgs & 0.6 cu. metres	Shipped to Hanford

3.3.1 Dewatering

The effort to minimize radioactive waste during the dewatering activity was very successful because of a two-step procedure, see section 3.2.1.1. As indicated, over 11,000 litres of water were pumped to a holding tank and eventually evaporated with no cost for radioactive disposal. A filtration system prevented particles greater than one micron from being pumped into the holding tank.

The sludge was pumped into three 208-litre drums and allowed to settle, after which the water was decanted (poured-off without disturbing the sediment). This water was also transferred to the holding tank and evaporated with the inventory above.

Sludge from the dewatering process was treated with moisture absorbent material to dry the material prior to packaging in steel drums along with other mixed waste, including small tools and materials.

All of the mixed waste was shipped to the DOE Hanford facility for storage or disposal.

3.3.2 Debris Removal

The metal objects retrieved from the tubes were packaged and shipped to a LLW facility. One object (the concrete-encased object in tube R20) had to be inspected in the ANL hot cells before sentencing.

3.3.3 Core Drilling Operations

A schedule was established to remove the most highly contaminated tubes in descending order. Due to the questionable structural integrity of the tube joints, the decision was made to remove the entire tube plus several centimetres of the surrounding concrete.

In a conventional concrete core drilling operation, water is used to both cool the drill bit and flush the concrete fines from the cut. The water is then uncontained as it runs from the cut. With the MTF drilling operation, the water had to be contained after cooling and flushing to ensure that the water was not contaminated; therefore, the quantity of water had to be minimized.

A special water recirculation container that mounted over the tube being drilled (Figure 3-12 and Figure 3-13) had to be designed to direct the water to a 570 litre tank for buffer storage and then recirculation. The fines would settle in this tank but as the concentration of fines increased, cooling efficiency decreased. As a result, the water in the storage container had to be changed (the water with fines was pumped to a separate holding tank and fresh water injected into the recirculation tank). The water had to be changed two to three times during the coring operation for one tube.

Figure 3-12 Core Drill with Recirculation Container in Place

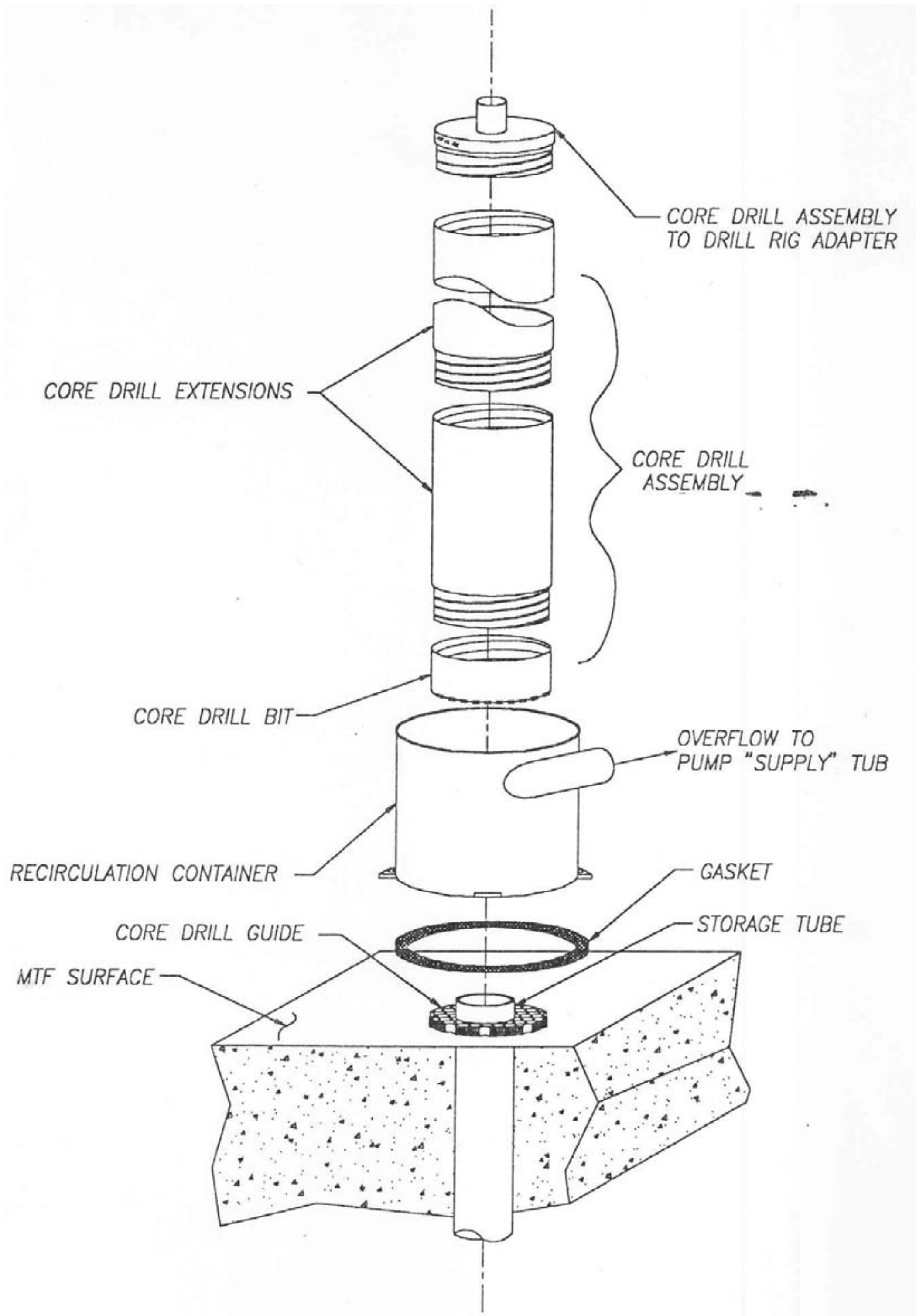


Figure 3-13 Core Drilling Cooling System

After the coring operation for a tube was complete, radiological analysis of the cooling water indicated if the tube had been breached during the drilling process. If the tube was not breached, the water would be pumped into a large storage container where the fines would settle and the water could then be recirculated. If a tube was breached, the water with fines was pumped into drums for disposal as contaminated LLW.

3.3.3.1 Non-contaminated Concrete Fines

The concrete fines were dense and difficult to handle and could not be handled with conventional equipment. In addition, the quantity was underestimated. The concrete fines sludge was scooped from the large container into a dump truck and transported to the on-site disposal area (Figure 3-14).

Figure 3-14 Dumping Concrete Fines

Originally, the plan was to use the non-contaminated fines to fill the voids in the block following removal of a tube. However, this was not possible because the fines formed a thick paste that could not be pumped.

3.3.3.2 *Contaminated Concrete Fines*

The concrete fines that were contaminated barely reached the radioactive content threshold for classification as LLW; however, the fines were packed into steel drums and shipped to the Hanford LLW disposal facility. The source of the contamination was believed to be in the top 0.5 metres of the block and resulted from waste handling operations in Area 317.

3.3.3.3 *Lead Caps*

The lead caps were painted in 1988 to fix radiological contamination on each cap. Initial surveys indicated levels of surface contamination below DOE criteria. However, it was uncertain if the paint contained alpha contamination and so the caps could not be released unless the paint was removed. The options for removing the paint (chemical and mechanical) proved to be more expensive than just disposing of the caps as mixed waste, which is the option that was selected.

3.3.4 Removal of Lead from the Tubes

A significant effort was expended to reduce the volume of this waste because of the difficulty of disposing of radioactive mixed waste. The effort resulted in a 99 percent reduction in the volume of mixed radioactive waste with total waste disposal costs reduced by about two-thirds.

After the tubes were removed, it was necessary to remove the lead oakum seals so that the entire volume of the cored tubes would not be classified as radioactive mixed waste. The tube end was positioned in a small containment with a HEPA filter and the end cap and associated concrete were separated from the tube with chipping hammers, jack hammers or concrete saws. In addition, approximately the top 0.6 meters of the tube (see Figure 3-15) was separated from the tube. With the lead joints exposed, the lead was easily removed with a handheld electric hammer. The lead was placed in steel drums for shipment to the Hanford facility.

Figure 3-15 Separated Tube Section

After the end caps and top portion of the tubes were removed, the tubes were wrapped with three layers of 0.03 cm thick, nylon-reinforced plastic sheeting.

3.4 Key Cost Drivers and Sensitivities

3.4.1 *Debris Removal*

The success of the debris removal was directly attributed to the experience of the personnel who were familiar with the design and use of remote tooling.

3.4.2 *Selection of Dismantlement Technology*

Three constraints were key in determining the dismantlement technology used at the MTF.

First, at the time of the dismantlement of the MTF, there were radioactive waste storage facilities that were still operating in Area 317. Specifically, two of these facilities were the deep vault and the north vault, which were located in-line with the MTF (see Figure 2-2 and Figure 2-3 and Figure 3-16). Tracks that allowed access via an overhead crane ran along either side of these three facilities. The overhead crane in Figure 3-16 is positioned over the MTF. It was necessary for the overhead crane to have access to the vaults on either side of the MTF; therefore, the technology used to dismantle the MTF had to allow this operational flexibility.

Second, regarding the chemical contamination of the soil immediately to the north of the MTF (as discussed in section 2.1.4), excavation around the MTF (Figure 2-7 provides a good indication of the excavation during construction) followed by sectioning the MTF with a diamond wire saw[2] would have been easier than tube removal. However, such excavation around the MTF would have exposed personnel to significant chemical contamination and would have created a mixed waste disposal problem.

2. Diamond wire cutting is a well-tested technology for segmenting concrete blocks in decommissioning projects. A diamond wire saw consists of a diamond-impregnated wire that rotates around circular wheels (guides) similar to a band saw. As with core drilling, significant quantities of water are used to provide cooling and to flush concrete fines from the cut. In decommissioning projects, such water must be managed because of potential contamination.

Figure 3-16 Overhead Crane Over MTF

In addition, excavation near the deep and north vaults would have changed the loads on their respective walls and affected the structural strength of those facilities. The north vault was only 3 meters deep and excavation would have undermined its foundation.

Third, the incremental funding of the entire project (see section 2.2.3) required a technology that could incrementally dismantle the MTF tubes.

Any of these three project constraints precluded the use of excavation and sectioning of the MTF block or demolition. By using a mobile drill rig mounted on a flatbed truck (Figure 3-8), the drilling operation could be interrupted with minimal impact on the MTF dismantlement.

3.4.3 Core Drilling Guide

First, starting a cut in the exact location desired is difficult without a guide. One solution is to use the diameter of a tube as a guide but this was not possible because both lead joints on each tube extended beyond the nominal pipe diameter (Figure 2-10) hence an over-sized drill bit and an associated guide were required.

3.4.4 *Water Management during Core Drilling*

Section 3.3.2 discussed the requirement for a cooling water containment and recirculation system for the concrete core drilling operation. This system was only required because of the possibility of breaching a tube and introducing LLW into the cooling water. In most concrete drilling projects is used on a once-through basis, so the water recirculating system may be considered as a special provision with associated additional costs.

3.4.5 *Drill Rig Size*

The initial core-drilling rig selected was too light to withstand the stress of coring through 6.4 meters of concrete. Considerable wobble was experienced and it became apparent very early in the drilling phase that a more substantial drill rig would be required.

3.4.6 *Guide for the Drill Bit*

A special nylon guide (see “Core Drill Guide” on figure 5) was designed to keep the drill bit in the exact position required because the drill rig would be positioned off-centre with respect to the tube opening, see section 3.4.5. Along with the water recirculating system, this was also a unique design for this project. Typically, in core drilling, the core size itself will provide the template or guide for drilling. Due to the need to compensate for the off-centre position of the tubes, a unique guide had to be devised to keep the drill located in the proper position with respect to the angle of each tube.

3.4.7 *Vertical Angle of Tubes*

The tubes were essentially vertical when the MTF was constructed, see Figure 2-7. However, forces from concrete pouring, shifting and settling, etc caused the tubes to become off-vertical by as much as 10 cm. When drilling operations first began, there was some trial and error associated with compensating for the fact that the tubes were at a slight angle. It was very important to compensate for this situation because the drill could contact the cast-iron tube (see Figure 3-17, Figure 3-18 & Figure 3-19) and thereby release contaminated material.

Figure 3-17 Core Drill Contact with Tube

Figure 3-18 Core Drill Contact with End Cap

Figure 3-19 Core Drill Contact with Tube

At first, the drill rig was tilted slightly to compensate but maintaining the rig at an off-vertical angle while drilling proved impossible. Drilling at an angle accentuated the normal drift of the rig. Finally, the solution was to determine the location of the bottom of the tube with respect to the tube opening, i.e. determine the angle and direction of the tube as it descended into the MTF block. With this information, the drill rig was positioned off-centre with respect to the tube opening. This compensation technique proved to be successful.

3.4.8 Concrete Fines

The concrete fines (sludge) were dense and difficult to handle and conventional waste haulers would not handle this material. In addition, the quantity was underestimated.

3.4.9 Concealed Drilling Hazards

Concealed hazards caused some drilling delays. In some locations bad concrete (loose concrete) occurred around the storage tubes. Upon reaching a zone with loose concrete the drill bit would stick. Several tubes required concrete to be injected or poured into the area to bind loose concrete before drilling could continue.

Voids (Figure 3-20), cracks and other defects including objects (pipes, wood, cabs, etc) that were buried in the concrete caused a loss of cooling water. Again, concrete would be injected or poured into the offending location and allowed to solidify before coring could continue.

3.4.10 Worn Drill Bits

Two sizes of drill bits were used during the coring operations. A 45.7 cm (diameter) drill bit was used for the 25.4 cm diameter tubes and a 35.6 cm (diameter) drill bit was used for the 10.2 and 15.2 cm (diameter) tubes. Nominally, four to five tubes could be drilled before replacing a drill bit. However, a drill bit could be rendered useless after only a few meters of cutting if foreign objects in the concrete were contacted. The turn around time for refurbishing a drill bit was three days and so three of the 35.6 cm (diameter) drill bits were utilized, which allowed two spares to be on-site at all times. Since there were only five 25.4 cm (diameter) tubes, only two of the 45.7 cm (diameter) drill bits were used.

Figure 3-20 Voids in Concrete

3.4.11 Working Relationship

Reference 1 specifically mentions that the good working relationship between the main subcontractor and the ANL project and technical personnel proved extremely helpful in providing rapid turn around of radiological and chemical data, which in turn allowed rapid implementation of action plans.

4. Map Tube Facility Decommissioning Cost Analysis

4.1 *Program Cost Breakdowns*

4.1.1 General

The cost of decommissioning the MTF was approximately $2.6 million. This cost as well as the other costs in this section 4.0 are stated in terms of 1994 U.S. dollars. The discussion below provides estimates of the breakdown of this cost. The major cost breakdown is presented in Table 4-1.

As explained in section 2.3, the MTF was one of 735 SMWUs to undergo preliminary evaluation by ANL and one of 71 SWMUs that was evaluated in more detail by ANL, making the cost of planning and institutional effort not relevant to the AT facility. Accordingly the cost of the planning process conducted by ANL is excluded from the data in Table 4-1.

Table 4-1 MTF Decommissioning Cost Breakdown (US$k 1994)

Category	U.S. $k
Primary Contractor – ETEC (including concrete drilling subcontractor)	1,800.0
MTF Characterization - ETEC	200.0
Radioactive Waste Disposal @ Hanford LLW disposal facility	200.0
Lead Cap Disposal	16.0
Waste Transportation	84.0
ANL Supervision	100.0
Other	200.0
Total	**2,600.00**

4.1.2 Characterization and Lifting Device Insertion

Sections 3.2.1 and 3.2.2 outline the scope of work. ETEC, performed the work. The total cost was about $200,000. The majority of the characterization costs, $146,900, are attributed to the equipment and materials listed in Appendices A and B.

The site characterization required six weeks to complete or 1,440 hours of direct labour estimated to cost about $53,100. Management, supervision and technical support from ETEC both off and on-site cost about $26,700 and ANL supervision cost about $12,500.

4.1.3 Core Drilling

Section 3.2.2 outlines the core drilling scope of work. The primary contractor was ETEC. The total ETEC contract was for $2 million; therefore, after subtracting the cost of characterization, the cost of drilling operations was about $1.8 million.

The lifting device and core drilling phases required about 6.5 months to complete. The labour breakdown is presented in Table 4-2.

Table 4-2 Labour Breakdown for Core Drilling (US$k 1994)

Category	Man-Hours	U.S. $k
ETEC Program Manager (2/3 of the time for 6.5 months)	747	43.33
ETEC Technical Manager (1/3 of the time for 6.5 months)	373	18.06
ETEC On-site Supervisor (full time for 6.5 months)	1,120	54.17
ETEC On-site Lead Technician (full time for 6.5 months)	1,120	54.17
Direct Labour – 113, 10-hour day shifts (3 ETEC technicians @ $30 /hour, 2 drilling operators @ $30/hour and 2 health physicists @ $20/hour)	7,910	214.70
Direct Labour – 61, 10-hour night shifts (2 ETEC technicians @ $30/hour, 2 drilling operators @ $30/hour and 1 health physicist @ $20/hour)	3,050	85.40
Direct Labour for holidays (3) and lost time (22 days) both @ 8 hours per day	1,856	50.96
Total Contractor and Subcontractor Labour		**520.79**
ANL supervision (3 staff 1/3 of the time)	1,120	54.17

The equipment and materials for the core-drilling phase (Appendix D) represent the remaining cost of $1.27921 million.

4.1.4 Waste Handling and Disposal

Section 3.3 and Table 3-1 provide detailed information regarding the disposition of the waste forms generated from the MTF decommissioning project. Table 4-3 provides the cost breakdown for waste disposal, storage and transportation.

Table 4-3 Cost of Waste Disposal, Storage and Transportation (US$k 1994)

Waste Form	Waste Type	Quantity	Action	U.S. $k
Sludge	Mixed	420 litres	Storage at Hanford	16.0
Metal	LLW	79 kgs	Disposal at Hanford	
Concrete fines	LLW	38 m^3		
Lead from joints	Mixed	~820 kgs & 0.6 m^3	Storage at Hanford	4.0
Lead shield caps	Mixed	~3,060 kgs	Disposal	16.0
Concrete & steel	LLW	129 cores & 85 m^3	Disposal at Hanford	180.0
			Transport LLW and mixed waste to Hanford	84.0
	Total			**300.0**
Concrete fines	No activity	23 m^3	Disposed at ANL on-site	No additional charge
Water	LLW	11,360 litres	Evaporated at ANL	No additional charge

Regarding labour, a system was established in which the full crew (ETEC and drilling subcontractor technicians) was involved in pulling a cored tube and then setting up the drill rig for the next coring operation. Once the drill rig began the coring operation, the drilling subcontractor technicians operated the drilling equipment. This allowed the ETEC technicians to work on removing the lead seals from cores already removed, disposing of uncontaminated concrete fines on-site at ANL, packaging the various waste for shipment, and loading the waste onto vehicles. Therefore, the labour cost associated with waste packaging and handling did not represent additional cost for the project. Such costs are included in the ETEC costs outlined in sections 4.1.1 through 4.1.3.

4.1.5 Productivity

The main aspect of the MTF decommissioning was the removal of 129 tubes from the concrete block that formed the structure for the facility. Table 4-4 provides an indication of the productivity as a function of tube removal.

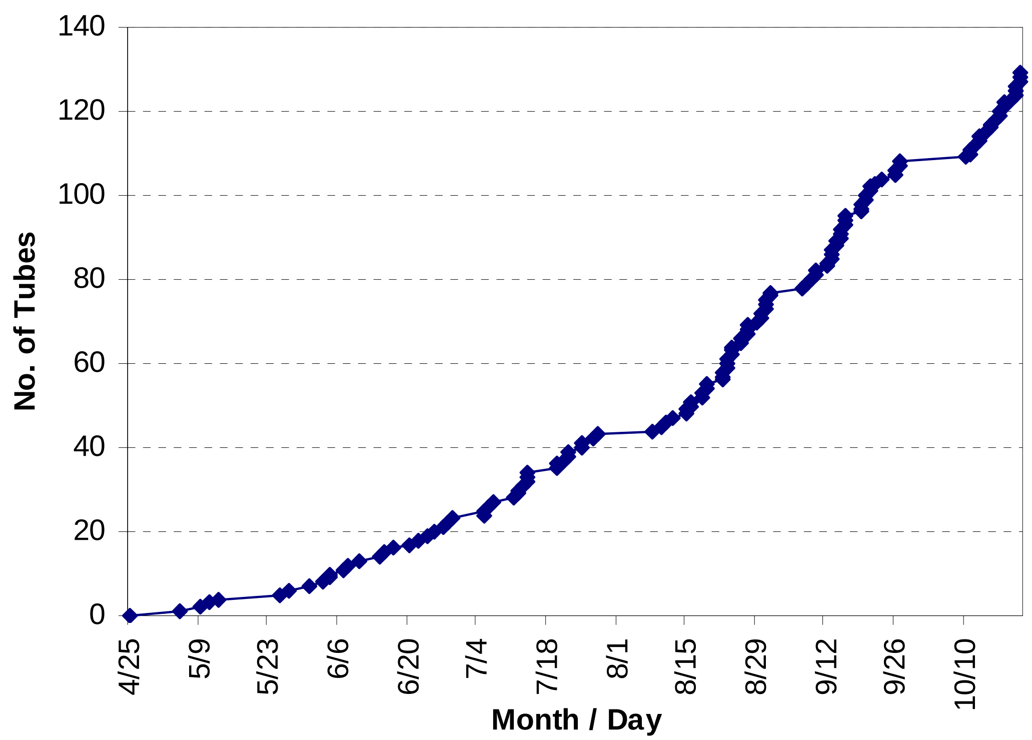
Table 4-4 Productivity (US$1994)

Activity	No. of Staff	Unit Cost
Characterization (240 hours working time duration and 129 tubes)	See table note a	$1,550 / tube and 11.2 manhours / tube
ETEC Core Drilling	See Table 4-2	$13,950 / tube and 11.95 hours / tube
Core Drilling Direct Labour	See Table 4-2	$2,330 / tube
Core Drilling Direct Labour and ETEC On-site and Off-site Management	See Table 4-2	$3,640 / tube
Core Drilling Direct Labour, ETEC On-site and Off-site Management and ANL Management	See Table 4-2	$4,060 / tube
Core Waste Disposal		$1,400 / tube
Tube sludge, debris and lead seals		$155 / tube
Lead Cap Disposal		$120 / tube
Waste Shipping		$650 / tube

a. 3 technicians, 1 HP, program manager 2/3rds time, technical manager 1/3rd time and 1 supervisor

Figure 4-1 shows the rate of tube removal. The rate increased after a fairly long learning curve from the beginning of the core drilling through the end of May. After the shutdown at the end of July, the rate achieved increased substantially and this was then sustained for the remainder of the project.

Figure 4-1 Rate of Tube Removal



4.2 Derived Benchmarking Results

The two main tasks, characterization and core drilling , are summarized in this section.

4.2.1 Characterization

The characterization effort was conducted over a six-week period during normal business hours; i.e. 240 hours. With a mixed team of technicians and managers, a total of 1,440 manhours at an average labour rate of about $36.9 per manhour were expended on this effort. The total cost was $200,000, with $53,100 for staff (direct labour and management) and $146,900 for equipment and materials.

The unit cost of characterization therefore was $1,550 per tube and 11.2 mixed team manhours per tube. However, the cost of equipment to some extent probably was a fixed cost, so the application of a cost per tube benchmark figure to a project with a different number of tubes would be incorrect. A fixed amount would be more appropriate, with some variable allowance to account for drill bit replacement and other operational materials.

4.2.2 Core Drilling

The core drilling effort was conducted over a 6.5-month period with a combined team effort of 16,176 manhours at an average labour rate of about $32.2 per hour. The total cost (excluding ANL supervision) was $1.8 million - $520,790 for staff (direct labour and management) and $1.28 million for equipment and materials.

On an individual tube basis, the unit cost of core drilling was $13,950 per tube and 125.4 manhours per tube. The total waste disposal cost averaged $2,325 per tube.

The volume of the concrete cores removed was 85 m^3. Assuming a typical concrete density of 2.4 MT/m^3, this equates to 204 MT, or 1.58 MT/core. On this basis the following benchmark results are obtained:

- 79.3 manhours/MT
- $6,275/MT equipment and materials

The gross volume of concrete involved at the MTF was higher however at an estimated 218 m^3 (see Table 5-1). Using this as a reference the benchmark results transform to the following lower values:

- 31.4 manhours/MT
- $2,480/MT equipment and materials

The cost of equipment to some extent probably was a fixed cost, so the application of a cost per tube benchmark figure to a project with a different number of core drillings would be incorrect. It would be more appropriate to apply a fixed amount plus some variable allowance to account for a possible equipment hire cost component, drill bit replacement and other operational materials.

4.2.3 Comparison with Other Benchmarking Results

The characterisation work performed at the MTF was very specific to that particular facility. Earlier decommissioning cost analyses performed and reported on to SKI by NAC do not provide any examples of characterisation work that could be compared in any meaningful way with the MTF characterisation program.

A somewhat meaningful comparison can however be made between the core drilling work at the MTF and the bio-shield cutting work carried out at the Westinghouse Test Reactor (see SKI report 02:2 entitled *R2/R0-WTR Decommissioning Cost Comparison and Benchmarking Analysis*).

WTR BENCHMARKING DATA

At WTR the quantity of bio-shield concrete dismantled was 1,018 MT. The technique used for dismantling was diamond wire cutting. The estimated resources needed to complete the task were as follows:

- 35.8 manhours/MT
- $146/MT for health Physics consumables
- $542/MT for equipment hire

WTR/MTF BENCHMARKING DATA COMPARISON

If the results related to the net volumes of the removed concrete cores are used, then the MTF benchmarks are higher than experienced at WTR. On a per MT of concrete basis, the manhours were higher by a factor of 2.2 and the combined cost of equipment and materials a factor of 9.1 times higher. However, taking the gross volume of concrete that was effectively decommissioned at the MTF (albeit with a different technical approach and end condition) these ratios are quite different. The manhour resources needed at the MTF were lower (but quite close) at about 87.5 percent of those needed at WTR Expenditure on equipment and materials remains higher but by the much reduced factor of 3.6.

There is no reason to believe that the two methods of dealing with a large concrete structure should result in similar costs. It turns out however, on the basis of the available information, that the labour resources needed for the coring approach compared with a diamond wire cutting approach are very similar. The coring approach has a much higher cost for equipment and materials. The coring approach also leaves an uncontaminated concrete structure *in situ*, as opposed to the diamond wire cutting approach that facilitates complete removal of the concrete structure.

5. Comparison of Map Tube Facility with the Studsvik AT Facility

5.1 Physical Comparison

The AT facility is located in the NE of the Studsvik site, as shown in Figure 5-1. A plan layout of the building internals is shown in Figure 5-2. The AT storage vaults and related equipment are housed within a relatively light building structure. An overhead travelling crane with a 12.5 MT weight limit services the inside of the building along its full length.

Figure 5-1 Location of the AT Facility at Studsvik

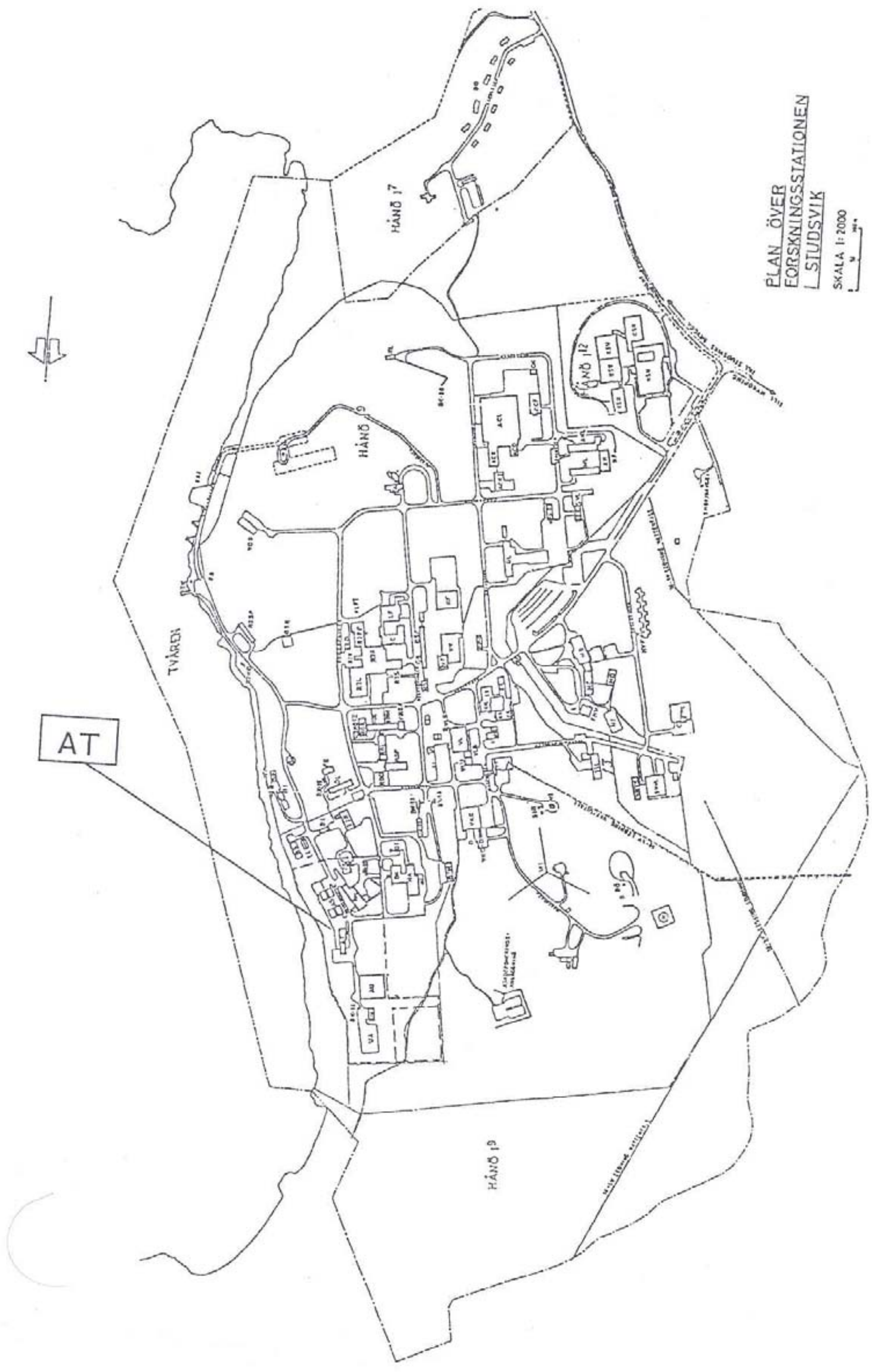
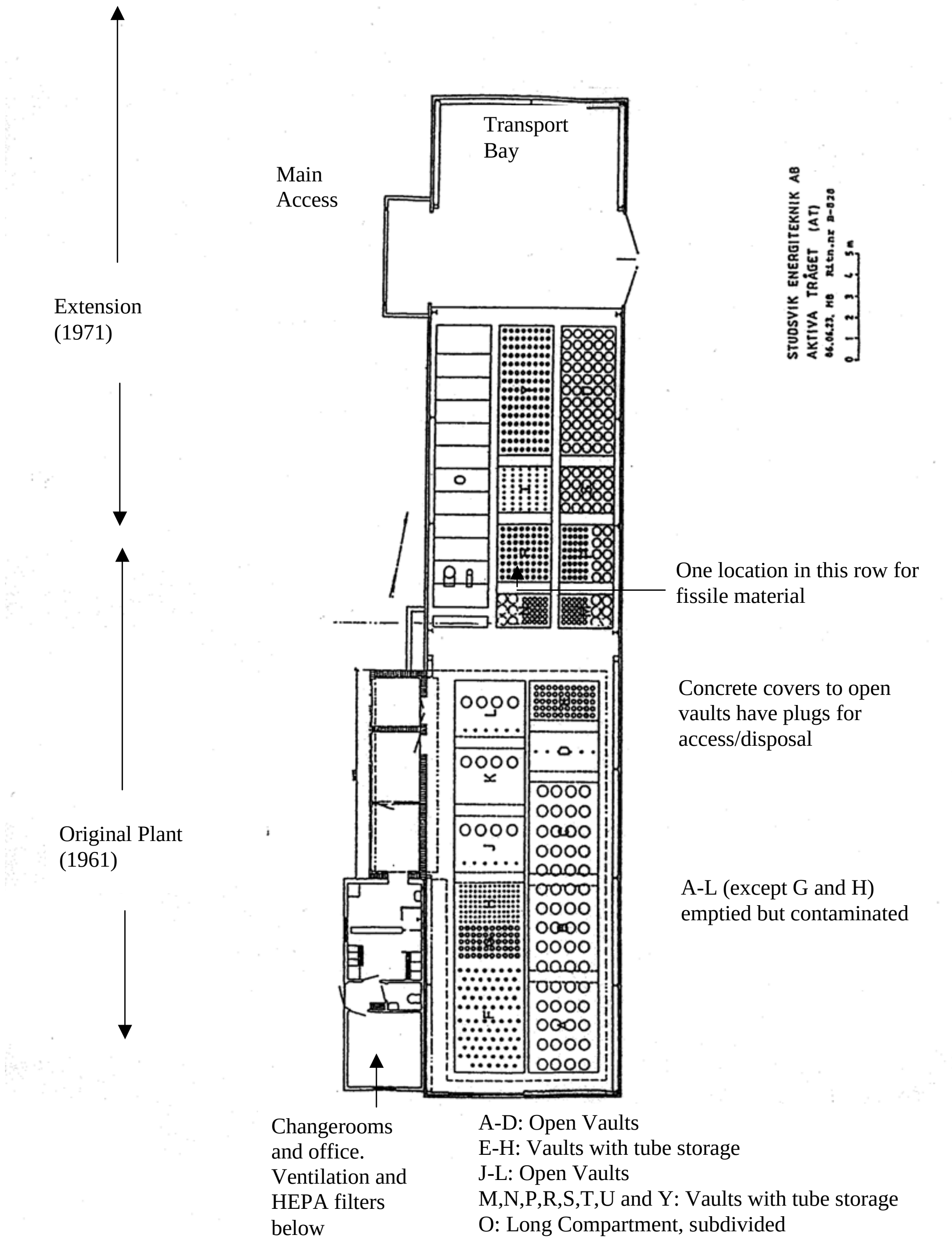


Figure 5-2 Internal Building Plan Layout for the AT Facility



An approximate physical comparison between the AT and MTF facilities is presented in Table 5-1. The AT facility in Studsvik is considerably larger than the MTF facility in Argonne – between six and seven times in terms of volume but with storage tube depth somewhat less. Not all of the storage tubes are surrounded by concrete over their full length. Unlike the MTF, AT has some storage vaults in addition to storage tubes. In Argonne there are storage vaults but they are located in facilities adjacent to the MTF in Area 317 and were not involved in the decommissioning program.

Table 5-1 Comparison of AT and MTF Storage Structure Physical Parameters (all dimensions approximate)

Feature	AT	MTF	Ratio AT/MTF
Length (m)	35	8.5	4.12
Width (m)	12.75	4	3.19
Depth (m) [a]	3.4/4.6	6.4	0.53/0.72
Volume (m^3)	1,466	218	6.72
# Vertical Tubes	705	129	5.47
# Vaults	8	0	-

a. Maximum length of concrete around storage tubes/estimated gross depth of overall concrete vault structure

Based on available descriptions of the nature of the wastes stored in AT and the MTF, in general terms the range of wastes appears to be somewhat similar (see section 2.1.5). This in itself is not relevant because in both cases removal of the stored wastes is a precursor to the commencement of decommissioning activities.

However, concerning the condition of the tube stores, in the case of the MTF it was determined that radioactive sludge was present at the bottom of the tubes, resulting from water ingress and corrosion of both storage containers and their contents. In the case of AT, it is not known exactly what the condition of the tubes is but it is recognised that some leakage/contamination in the lower parts of the tubes could have occurred. This needs to be an important consideration in the planning of the AT decommissioning program and the related cost estimate, principally because of the potential difference in the approach and specific techniques chosen to implement decommissioning. It is potentially important that at MTF all of the storage tubes were lined with steel whereas at AT some of the tubes are understood to have been unlined.

The depth of concrete contamination has been identified by Studsvik staff as a significant uncertainty. In addition to routine penetration mechanisms, cracks could be present in the concrete and, with the vaults being very dry, radioactive powder could have dispersed into the cracks.

Radioactive mapping at AT to date has been limited. However it is known that radioactivity in the open vaults that have been emptied is very high. Long-lived radioisotopes, including plutonium and other actinides are expected to be present in certain parts of the AT facility.

In other facilities at Studsvik, asbestos has been present. Studsvik staff have advised that it would be prudent to assume that AT also contains some asbestos but where and to what extent is not known at the present time. The AT decommissioning cost estimate report also acknowledges this expectation.

The condition of the concrete at AT is somewhat uncertain. There is the possibility of some concrete including iron ore in the original aggregate, to provide extra radiation shielding. This could impact concrete cutting/dismantling. Studsvik reports that the effects of age-hardening in concrete also have been observed in the work performed so far.

AT has only limited if any capability to handle contaminated liquids. There is a tank with a capacity of a few cubic metres in the basement area (below the change rooms) to collect water from the showers and suchlike. Given that the AT decommissioning plan includes concrete drilling and cutting activities, it appears unavoidable that significant volumes of cooling fluids will be needed as part of the decommissioning effort. Given that such cutting operations will be in proximity to radioactive, or suspect active, parts of the facility, supplementary equipment for containment/recycling of the fluids probably will be required, as was the case at MTF. This cost may not have been included in the AT estimate.

A very important issue in evaluating AT decommissioning versus the MTF is the overall physical situation of the facility. In the case of the MTF, the technical options for decommissioning activities were constrained by two main considerations:

- The requirement to preserve access to adjacent facilities using overhead traveling crane equipment
- The impracticality of excavating surrounding ground, due to structural issues and the need to avoid chemical contamination, thereby eliminating the technical option of diamond wire cutting of the concrete vault structure.

In addition the incremental funding of the MTF project to some extent dictated the adoption of decommissioning techniques that could be implemented on a modular/progressive basis, as opposed to an up-front commitment to a solution for the whole facility.

In the case of AT, the facility is in a relatively clear position, unencumbered by any surrounding facilities, giving good access on all sides. Based on a visit to the facility in early 2004, there was no evidence of difficulties similar to those prevailing at the MTF, leaving open options that were not available to the MTF program. For example if total funding had been available at MTF from the beginning and if full access to the concrete structure had been possible, diamond wire cutting of the concrete structure would have been adopted instead of the individual core drilling approach actually used.

5.1.1 Methodology and Scope of AT Decommissioning

The AT decommissioning cost estimate report is not entirely clear in detail regarding the specific methodology to be adopted. In addition there are a number of important uncertainties concerning the extent of radioactive contamination. Depending on what the reality turns out to be, the decommissioning methodology could be affected and the quantities of wastes in various categories also could vary. Regarding the quantities of waste summarised in the AT decommissioning cost estimate, in any event the descriptions in different parts of the report are not obviously consistent. This in itself creates uncertainty. In addition the report introduces contingent allowances without explaining any real rationale for their magnitude. Such allowances also may not be introduced in a coherent way.

5.1.2 Methodology

The only parts of the AT decommissioning that can be directly compared to the MTF scope are the decontamination and dismantling of the concrete storage structure.

5.1.2.1 Dismantling

The ultimate goal for AT is different to that for the MTF. AT will be returned to a Greenfield status (including backfilling of AT foundations with much of the dismantling waste) whereas at MTF the objective was to remove the contaminated storage tubes and, after sealing, leave the main concrete structure in place. The MTF program accordingly adopted the relatively sophisticated approach of core drilling to remove the radioactive storage tubes.

It appears that the current plan for AT is to also perform core drilling to remove the storage tubes, to use ablative techniques to remove surface contamination in the storage vaults and then to break up the entire upper part of the concrete storage vault.

Both approaches have to deal with the uncertainty of radioactive contamination. The MTF core drilling approach was a relatively engineered solution, involving precision and the ability to adjust to the circumstances discovered. For example, if cracking of the concrete was experienced, fresh concrete could be poured to fill and seal the cracks. The AT approach appears to be to remove as much radioactive contamination as possible, using various ablative techniques, to core drill the storage tubes and then to use a relatively unsophisticated approach for removal of the concrete structure. The AT technique on which the cost estimate was based involved drilling a series of holes in the residual concrete structure and then using a wedge to break the block along the lines of the holes. It is also mentioned that some of the existing storage tube holes could be used in this way.

This approach to the final break up of the residual concrete structure might be satisfactory – even if unexpected contamination is experienced – as long as the planned use of plastic sheeting to segregate the area being dismantled in this way is effective. However, it would appear to introduce some risk, given the declared uncertainty over the inventories of wastes that have been stored in AT and the uncertainty over the extent of corrosion, leakage and contamination that has taken place. Depending on the success of the core drilling operations, there could be significant residual radioactive contamination.

The better physical access prevailing at AT lends itself well to a method of breaking up the concrete into relatively large blocks. However, it might be worth considering an alternative method of achieving this. The most obvious method would be to use diamond wire cutting. This method would afford greater precision in dismantling and also potentially some additional control in the event of hitting an area of contamination. It would be more expensive, however.

It is not a firm recommendation of this report that the diamond wire dismantling technique should be used for AT. However, it might be worth considering if this alternative would bring some overall benefit, taking into account costs, quantities of radioactive wastes for disposal and ALARA/ALARP consideration for the decommissioning workforce (see also section 5.3).

Another issue that should be considered is the structural integrity of the AT concrete. At MTF. After drilling out a number of tubes/cores, the residual holes were backfilled with concrete I order to preserve the integrity of the whole facility. The concern was that if such backfilling was not done, the integrity of the structure might be compromised. This issue should be considered for AT also. If needed the implications would be twofold. First there would be the additional cost of filling the holes with concrete. Second, the chosen final solution for breaking up the concrete structure, if ultimately appropriate, would require more effort by way of having to drill more holes prior to cracking the block apart.

5.1.2.2 Decontamination

The decontamination technique used at the MTF was largely a combination of washing with a high pressure water jet plus surface abrasion with a wire brush. The AT estimate is based on surface removal using methods such as grinding or chipping for the open storage vaults and blasting with solid CO_2 for the storage tubes. The storage tubes would be removed to the northern area of the facility on an interim basis. The estimate is not clear on whether or not further decontamination would take place. It is implied that subsequent cleaning with high pressure water jets might not be sufficiently effective to reduce the residual contamination to a level that would change the ultimate disposal route. Earlier benchmarking estimates developed by NAC for SKI do not provide any meaningful references for comparison with the suggested CO_2 technique for AT.

5.1.3 Waste Volumes

The AT cost estimate report is unclear regarding waste volumes in a number of respects. In the abstract to the report the waste quantities are summarised as shown in Table 5-2.

Table 5-2 AT Waste Quantities from Cost Estimate Abstract

Description	MT	M^3
From Equipment Dismantling		
For dumping	19	20

For safe storage	200	200
Useful for backfilling	650	260
Equipment Sub Totals	869	480
From Building Dismantling		
For dumping	87	280
For safe storage	300	120
Useful for backfilling	420	170
Building Sub Totals	807	570
Total Quantities	**1,676**	**1,050**

In section 9 of the cost estimate report the waste quantities are declared to total 1,680 MT but then are summarised differently, as shown in Table 5-3. The total appears to not correspond to the figure of 1,680 MT, nor to the breakdown information presented in the abstract.

Table 5-3 AT Waste Quantities from Cost Estimate Section 9

Description	MT	M^3
From Equipment Dismantling		
For dumping	110	310
For safe storage	210	210
Useful for backfilling	1,200	480
Equipment Sub Totals	1,520	1,000

It is possible that the supporting calculations to the estimate are entirely consistent but the reporting of the waste quantities is confusing and undermines confidence in the accuracy of the estimate. Table 5-4 summarises the apparent differences in the two sets of data.

Table 5-4 Comparison of Table 5-2 and Table 5-3 Data

Source	Abstract		Section 9		Ratio Section 9/Abstract	
Description	**MT**	**M^3**	**MT**	**M^3**	**MT**	**M^3**
For dumping	106	300	110	310	1.04	1.03
For safe storage	500	320	210	210	0.42	0.66
Useful for backfilling	1070	430	1,200	480	1.12	1.12
Totals	**1,676**	**1,050**	**1,520**	**1,000**	**0.91**	**0.95**

The descriptions in the cost estimate also are not clear on whether or not there is expected to be a shortage or an excess of waste suitable for backfilling in the underground space at AT.

5.2 Comparison of Map Tube Costs with AT Cost Estimates

The AT estimate does not provide very much detail on a financial level related to the decontamination and dismantling work. Broad groupings of expenditure make it difficult to extract resources needed/costs for work scope that can be compared with confidence to the MTF data. The construction of AT costs using two benchmarking references from the MTF project has been attempted to provide a basis for comparison.

5.2.1 Core Drilling

Applying the MTF core drilling benchmark data to AT gives the constructed AT cost as shown in Table 5-5:

Table 5-5 Constructed Cost for Core Drilling at AT

Parameter	Value
MTF manhours/tube	125.4
Number of AT tubes	705
Derived base manhours for AT	705 x 125.4 = 88,407
AT manhours adjusted for shorter concrete core length (weighted average)	88,407 x (2.5m/6.2m) = 35,648
Add back allowance for fixed manhours for set up per tube	Revised total approx 40,000
AT worker cost	SEK 450/hour
Estimated minimum cost for equipment and materials (MTF cost of $1.28M escalated to 2005)	MSEK 10
Total derived AT core drilling labour cost	MSEK 28

The AT estimate refers in item R1.2 to demolition of storage positions at a total cost of MSEK14.04, to which is added a 20 percent contingency for an implied total of MSEK16.85. This is considerably less than the derived number above but the scopes are somewhat different. In the case of AT it is believed that the cost includes more than just core drilling. It also will include at least the final breaking up of the residual concrete structure. Surface removal at AT appears to be included separately as part of item R 1.3.

At MTF the core drilling exercise included some extra activity, including filling the tubes with concrete and segregation of selected components such as lead end caps. In addition, with the MTF cores being substantially longer than those in AT, the set up and alignment of the drilling equipment and the margin of extra core diameter to account for possible tube distortion from vertical will have introduced extra time needed and hence an expected higher unit cost. MTF also had to install a special recirculating water cooling system to support the core drilling operations. The cost of this is not known. With AT having selected CO_2 blasting this should not be an issue at AT.

As shown in Figure 4-1, the rate of tube removal started off slowly at MTF, doubling after a pause half way through the program. If this low initial productivity could have been overcome sooner, the constructed cost for AT would have reduced from MSEK28 to about MSEK23 for this activity. A further reduction to allow for the other factors just mentioned could see this figure reduce to perhaps as low as MSEK16.

This constructed estimate is not particularly robust, due to the limited information available. Also, it assumes that there would be no significant problems encountered at AT. Given the declared uncertainties in the condition of the AT facility, especially relating to the possibility of leakage and the spread of contamination that could have occurred during the storage phase. At MSEK16, the low-end constructed estimate would not leave much margin to cover demolition of the residual concrete vault structure at AT.

5.2.2 *Characterisation and Decontamination*

In the MTF project the characterisation program, including dewatering and decontamination of the tubes, was performed at a total cost as summarised in section 4.2.1. Assuming that the equipment and materials cost was part fixed (1/3 to 2/3) and part variable (the balance to be adjusted for AT in proportion to the higher number of storage tubes at AT) and assuming the same labour requirement in a mixed team (4 workers and 2 supervisors equivalent) of 11.2 manhours, a constructed cost for the AT facility has been developed as shown in Table 5-6:

Table 5-6 Constructed Cost for AT Characterisation and Decontamination

Parameter	Value
MTF manhours/tube	11.2
Number of AT tubes	705
Derived base manhours for AT	705 x 11.2 = 7,896
AT mixed labour rate	SEK 560/hour
Constructed AT labour cost	MSEK 4.4
MTF equipment and materials cost (escalated from1994 US$ value and converted at Jan2005 exchange rate of 6.2 SEK/$)	MSEK2.8 to 4.6
Estimated total AT characterisation and decontamination cost	MSEK7.2 to 9

For completeness, if the MTF unit benchmarking 1994 figure of $1,550/tube were assumed to be a totally variable cost, this would give an upper (probably unrealistic), escalated, constructed cost today of about MSEK13 for the AT facility.

It is not straightforward to pick out all of the elements in the AT cost estimate that should be included in the list to be compared with the MTF cost. From the AT estimate it appears that the items for inclusion could include as a maximum the items listed in Table 5-7.

Table 5-7 Characterisation and Decontamination Activities in the AT Cost Estimate

Item	Cost (MSEK)
P1. Radiological survey and survey of inactive hazardous materials	0.18
P6. Planning for decontamination (equipment and labour) plus subsequent radiological survey	0.36
A4. Decontamination of storage positions prior to demolition	0.33
A5. Cleaning of localities	0.42
A13. Decontamination of building surfaces and measurement of activities	6.9
20% Contingency	9.95

The approach to characterisation and decontamination is clearly different for AT compared with MTF but, in global terms, the AT estimate is at approximately the same level as the best estimate range of constructed costs using MTF information. The AT decommissioning cost estimate report notes that in respect of item A13 there is a significant uncertainty related to the radiological condition of the storage tubes. A contingency of 20 percent is included in the estimate but there is no particular justification given for this figure. Whether or not the estimated costs for these activities would be sufficient remains as a significant uncertainty, with potential knock-on effects in the actual dismantling implementation (see also section 5.3).

5.3 Reasonableness of the AT Cost Estimate

5.3.1 Global Cost Breakdown

The AT cost estimate report summarises decommissioning costs, including contingency allowances, as shown in Table 5-8:

Table 5-8 Summary of AT Cost Estimate

Activity	AT Cost Estimate	Including
Preparation	MSEK 7.4	Project group support in all phases
Project group work prior to actual dismantling	MSEK 36.8	MSEK 26 for waste disposal charges
		MSEK 10.8 for decontamination and auxiliary services support
Actual Dismantling	MSEK 30.8	MSEK 3.36 on building demolition

	MSEK 16.85 on demolition of the storage positions
	MSEK 10.61 on other activities and related equipment

5.3.2 Preparation Cost

As stated in section 2.3.3 there is no meaningful basis on which to compare MTF and AT preparatory costs, essentially due to the MTF context being part of a much bigger US DOE program. However, it is instructive to crosscheck the AT estimate against other AB SVAFO decommissioning cost estimate data.

As reported in SKI Report 2004:13 prepared by NAC, entitled *A review of the Decommissioning Plan and Cost Estimate for the Studsvik Rock Facility (AM) for the Storage of Low and Intermediate Level Wastes*, benchmarking for preparatory work derived from AB SVAFO decommissioning cost estimates for R2(R0), Ågesta and AM indicated a fixed resource requirement in the region of 20 to 25 man months plus a variable requirement of 0.25 man months per MSEK of estimated total project cost.

Using these benchmarking figures with a labour cost of SEK 120,000 per man month (as assumed in the AT cost estimate report), the preparatory cost for AT would be forecast at MSEK4.65 to MSEK5.25. The AT estimated cost of MSEK7.4 is above these values by a margin of 40 to 60 percent. On this basis the AT estimate for this component of the work program appears to be comfortably adequate.

5.3.3 Characterisation and Decontamination

Based on the comparison presented in section 5.2.2, the AT cost estimate for decontamination work appears to be in the right order of magnitude. It is a little difficult to compare precisely the MTF and AT costs because the activities undertaken are somewhat different. Based on the available information, two significant uncertainties exist. One relates to the extent of contamination in the storage tubes and the other relates to the depth to which contamination has penetrated other building surfaces in the open storage vaults and other areas of the concrete vault structure.

It is appropriate to include an adequate contingency margin to protect against additional costs for these aspects of the project. The AT estimate includes a 20 percent contingency but the basis for this is not explained, so it is not possible to determine from the available information if this is adequate or not. It could be that there is a shortfall in the cost allocation of several MSEK and it is recommended that the implications of these uncertainties is revisited. As recommended in SKI report 2004:13, page 6-3:

7. Any estimate of course is just that i.e. an estimate with associated uncertainty. It is therefore important to understand how robust the estimate is. A summary of the main factors that might affect the total estimated cost, with an indication of by how much, would be helpful.

9.c It tends to be common practice to add a percentage of the assessed base cost as a contingency. In order to increase confidence in the estimate, contingency amounts included should be linked to and explained in relation to the assessment of uncertainties and sensitivities as described under item 7.

With regard to decontamination activities, not only could the effort on decontamination be higher but, if so, the related quantities of contaminated waste in various categories could be different, requiring potentially more expensive overall disposal costs. If the radiological conditions were not adequately characterised during this phase of work, it could be that the end solution for breaking up the concrete structure might have to be different, with attendant significant extra cost (see section 5.3.4).

5.3.4 Actual Dismantling

The low-end constructed cost of about MSEK16 for core drilling in the AT dismantling phase is close to the entire allowance for AT dismantling in the AB SAVFO cost estimate report, which includes final breaking up of the concrete vault structure. Based on the comparison with MTF costs, it appears likely that the AT dismantling estimate is low by at least an amount equal to something like the cost of final concrete structure demolition. The cost for the latter activity is not visible in the AT report however.

Depending on the discovered radiological condition of the storage tubes, it is possible that the selected demolition technique may not be acceptable. If a more sophisticated and precise technique were needed, for some or even all of the structure, the associated cost could be higher. As an example, if a diamond wire cutting technique were adopted and applied to the entire structure, the extra cost could be in the order of MSEK75 based on benchmarking data on diamond wire cutting of the WTR bio-shield concrete. This is equivalent to the entire budget in the current AT cost estimate. Of course if diamond wire cutting were adopted in the beginning, there could be savings on core drilling and possibly also on characterisation and decontamination, while waste disposal costs might be higher.

5.3.5 Use of Earlier Reference Information

There are a number of instances in the AT cost estimate report where data references from earlier studies are used as a basis for deriving projected decommissioning costs. The scope of this study has not extended to a thorough investigation of all of these earlier references, so it is not possible to make a reliable judgement on the appropriateness of the references so used. NAC would however recommend that these cases be reviewed with an impartial and critical eye to determine the validity of their adoption and application.

5.3.6 Conclusions

The AT cost estimate is presented in a similar fashion to several other decommissioning cost estimates prepared by Westinghouse for SVAFO, using an approach and presentation format that suffers somewhat from not always being clear, unambiguous and easy to understand, and which also lacks detail and clear substantiation of assumptions in some important areas.

Setting these concerns aside, the available information has been evaluated and compared with the Argonne MTF decommissioning costs and other selected NAC derived decommissioning cost benchmarks.

In summary the conclusions for the AT decommissioning cost estimate are as follows:

PREPARATION

The AT estimate appears to be adequate.

PROJECT SUPPORT (INCLUDING CHARACTERISATION AND DECONTAMINATION)

Some risk of cost underestimation related to:

- Uncertainty in facility radiological condition/degree of contamination
- Unsophisticated definition of contingency margins
- Possible implications of the preceding items for actual decommissioning methodology and related costs

It appears very necessary to invest more heavily in the characterisation program to determine if the final concrete demolition technique will in fact be acceptable.

ACTUAL DISMANTLING

The available data and relevant comparisons suggest that the AT cost estimate for this part of the project cost may be underestimated. The estimated cost of core drilling at AT may be low. In addition, depending on the radiological conditions discovered, the final method of demolishing the concrete vault structure may have to change, with potential higher cost implications. This reinforces the very important message that comprehensive characterisation of the AT facility is required and that the methodology for subsequent decommissioning work may need to change depending on the conditions revealed by this investigative phase.

References

1. Area 317 Map Tube Facility Decontamination Report (ANL-AR-0005) dated November 11, 1994 prepared by the Energy Technology Engineering Center, Rocketdyne Division, Rockwell International.

2. SVAFO – Rivningsstudier för Studsviksanläggningar – Lagret för Historiskt Avfall (English translation)

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