RISK BASED STORAGE OF PCBS

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ABSTRACT

This assessment discusses the PCB hazards present at the Idaho National Engineering and Environmental Laboratory (INEEL) Radioactive Waste Management Complex (RWMC) Transuranic Storage Area Retrieval Enclosure (TSA-RE); the various controls: natural, engineered and administrative that are in place to manage these hazards and minimize any potential risks; and the monitoring and surveillance activities that assure the aforementioned actions are indeed protective of the environment and the public and the worker. This assessment covers only the interim storage of polychlorinated biphenyls (PCBs). It does not address the risks associated with the planned retrieval and treatment. This assessment also includes a quantitative evaluation of potential impacts using very conservative and bounding assumptions. The results confirm that there will be no adverse effects to human health or the environment. Collectively, this qualitative and quantitative evaluation should provide the necessary information to enable the Environmental Protection Agency (EPA) to decide that the present storage configuration with associated controls in place does not and will not pose an unreasonable risk of injury to health or the environment.

INTRODUCTION

The Environmental Protection Agency (EPA) promulgated federal regulations in 40 Code of Federal Regulations (CFR) 761.61(c) effective on August 28, 1998, that allowed for risk-based storage of PCB remediation waste. Those regulations state that any person wishing to store PCB remediation waste in a manner other than prescribed in 40 CFR 761.65, must apply in writing to the EPA Regional Administrator in the region where the site is located. The regulations further state that EPA will issue a written decision on each application for a risk-based storage method for PCB remediation wastes. EPA will approve such an application if it finds that the method will not pose an unreasonable risk of injury to health or the environment. The following information constitutes the risk-based application for the continued storage of PCB remediation waste at the Idaho National Engineering and Environmental Laboratory (INEEL) Radioactive Waste Management Complex (RWMC) Transuranic Storage Area – Retrieval Enclosure (TSA-RE).

SITE OVERVIEW

At the end of this paper, there are three figures and one photo that show the TSA-RE and its relationship to other facilities. Figure 1 is a map of the INEEL depicting the location of the RWMC. Figure 2 shows the location of cells. Figure 3 is an example of TSA container stacking configuration. Photo 1 is a close-up of the TSA-RE looking north to south.

HISTORY OF PERTINENT SITE ACTIVITIES

Since 1970, transuranic (TRU) waste, as defined in DOE Order 5820.2A, *Radioactive Waste Management*, has been placed in retrievable storage at the RWMC under the premise that the waste will be retrieved and transported to a permanent repository. The TSA is an area within the RWMC, an operating waste management facility. The RWMC covers approximately 0.6 km^2 located near the southwest corner of the INEEL. Since 1970, contact-handled transuranic (CH-TRU) waste has been stored in containers on ground level asphalt pads within the TSA. This waste was primarily generated by operations conducted for DOE and its predecessors in support of defense programs. CH TRU is defined as containing > 100nCi/g of alpha emitting TRU radionuclides with a half life of > 20 years and having a container surface radiation level of ≤ 200 mR/hr.

The waste is located on three adjacent storage pads. On two of the asphalt pads (TSA-1 and TSA-2), the waste was placed in an assortment of containers that were stacked neatly and covered with a plywood cover, fabric and 0.9 to 1.2 m of soil. On the third pad (TSA-R) the waste containers were neatly stacked and some were covered with fabric only. The pads are divided into 14 sections referred to as cells.

The TSA-1/TSA-R waste pad storage appears as a mound of soil approximately 6.1 m high, 235 m long, relatively flat across the top for 46 m, then sloping down to grade to the west at a 1 to 1 slope and to a shoring wall on the east at a height of 0.9 to 3.0 m. The adjacent TSA-2 pad storage is 6.1 m high, 74.4 m long by 45.7 m wide and merges at the top with the east side of the TSA-1 mound. The waste containers on TSA-1 and TSA-2 consist primarily of 208 liter drums and fiberglass reinforced plywood (FRP) boxes. These containers are stacked approximately 4.9 m high and covered with plywood sheeting, plastic tarp, and 0.9 to 1.2 m of soil. The waste containers on the TSA-R consist principally of 208 liter drums, metal and FRP boxes, and metal bins. TSA-R Cell #1 is a unique configuration in that it contains 208 cargo containers stacked two high and loaded with 208 liter drums. Metal bins stacked two high form the perimeter of this cell. Also, Cell #1 is the only cell on TSA-R covered with soil; Cells #2 and #3 are covered only with a vinyl –coated geo-fabric tarp. The entire waste storage is divided into 14 cells, which are 45.7 m wide by 12 to 46 m long. Firebreaks, walls consisting of a meter or two of soil, isolate each cell. TSA-1, TSA-2, and TSA-R contain waste placed on the storage pads from time frames 1970-1975, 1975-1980 and 1975 to approximately 1989 respectively.

In 1996, the retrieval enclosure (RE), an engineered metal building, approximately 29,100 m^2 was constructed over the pads. The nominal size of the enclosure that extends over the TSA-R and TSA-1 pad areas is 61 m wide x 358 m long, with an average ceiling height of 9.1 to 10.7 m. An adjacent 56 x 130 m annex extends over the TSA-2 pad.

SITE SPECIFIC OBJECTIVES

The purpose of this application is to provide necessary information to the Environmental Protection Agency to gain Agency concurrence for the risk-based storage of PCB remediation wastes as allowed under 40 CFR 761.61c. An analysis is provided herein of the PCB hazards present at the RWMC TSA-RE; the various controls: natural, engineered and administrative that are in place to manage these hazards and minimize any potential risks; and the monitoring and surveillance activities that assure the aforementioned actions are indeed protective of the environment and the public and the worker. This application also provides a quantitative evaluation of the potential risks to demonstrate confidence in the safety of the storage configuration. It is the objective of this application to provide the necessary information to enable the EPA to decide that the present storage configuration with associated controls in place does not and will not pose an unreasonable risk of injury to human health or the environment.

NATURE OF CONTAMINATION AND HAZARDS

The nature of contamination and hazards associated with the TSA-RE facility are the radioactive materials and the chemical hazardous materials. The waste types stored within the TSA-RE facility can be grouped into seven general categories (1):

- Construction material
- Laboratory equipment and material
- Process materials
- Process equipment
- Protective clothing
- Maintenance equipment
- Decontamination materials

These waste types are radioactively contaminated with five major nuclides. The isotopes and their associated decayed activity and mass are shown in the table below:

Table I. Mass and specific activity for the RE dominant radionuclides (1).

Isotope	Decayed activity as of 2/93 (Curies)	Specific Activity (Curies per gram)	Mass (grams)
Am-241	71,824	3.43	20,940
Pu-238	48,640	17.11	2,843
Pu-239	32,120	0.062	518,064
Pu-240	7,860	0.227	34,626
Pu-241	128,880	102.96	1,252
	289,324		577,725

These same seven waste categories are also contaminated with non-radioactive hazardous constituents such as carbon tetrachloride, asbestos, lead, and PCBs. The contaminant of interest for this assessment is PCBs. Reference 2 "Hazardous Stored TRU Waste Source Term for the RWMC's TSA" provides additional details on the contaminants and their quantities. This reference also specifies a maximum expected quantity of PCBs to be slightly less than 180,000 kg.

SITE CONCEPTUAL MODEL

The Radioactive Waste Management Information System (RWMIS) identifies 51,840 m^3 of waste stored in the TSA-RE facility. This can be represented in the site conceptual model by a 230 m long, 5 m high, 45 m wide volume of waste. The waste volume has a 1 m soil cover on all sides, and sits atop an asphalt pad, a 180 m vadose zone and a 76 m thick aquifer. The quantity of PCBs is 180,000 kg and for the purposes of this evaluation is assumed to be uniformly distributed throughout the entire waste volume and soil cover. Based on this assumption, the average PCB concentration is 2.75 mg/cc.

The net water infiltration rate for the INEEL is about 10 cm/yr. The conceptual model will use this same rate for the 26 years (1970 -> 1996) prior to the construction of the TSA-RE facility and will use 0.0 cm/yr for the next 24 years (1996 -> 2020) after the TSA-RE was installed.

DATA QUALITY OBJECTIVES

Will the PCBs stored in the TSA-RE pose an unacceptable risk (40 CFR 761.61(c)) to human health and the environment during the next 20 years? More specifically, will the continued storage of the PCBs in the TSA-RE result in soil contamination levels inside the confines of the TSA-RE building > 1.96* mg/g for a worker or 98.2 mg/g for a visitor in the next 20 years or groundwater contamination levels > 5.0 e-4 mg/l at any time?

(Eq.1) $$\text{Soil Concentration (mg/g)} = \frac{TR * BW(kg) * AT(years) * 365 \text{ days/year}}{SF(kg\text{-}day/mg) * IR(g/day) * EF(days/year) * ED(years)}$$

Where:

TR = Target Risk
BW = Body Weight
AT = Averaging Time
SF = Slope Factor
IR = Ingestion Rate
EF = Exposure Frequency
ED = Exposure Duration

In this case, a conservative yet reasonable exposure scenario is a worker who performs a weekly inspection of the TSA-RE waste pad storage. This inspection would take less than 4 hours. He would perform this inspection 50 weeks out of the year (the other two weeks would be inspected by someone else) and would do this for the next twenty years. Based on this scenario the parameter values are as follows:

BW = 71.8 kg
AT = 75 years
SF = 4.0 kg-day/mg
IR = .025 g/day
EF = 50 days/year
ED = 20 years

If the target risk is 1×10^{-4} then the associated soil contamination concentration would be 1.96 mg/g.

In the case of a visitor, a conservative yet reasonable exposure scenario is a person who tours the facility twice a year, two hours at a time for twenty years. An auditor would fill such a scenario. Based on this scenario the parameter values would be as follows:

BW = 71.8 kg
AT = 75 years
SF = 4.0 kg-day/mg
IR = .0125 g/day
EF = 2 days/year
ED = 20 years

If the target risk were 1 x 10^{-4} then the associated soil contamination concentration would be 98.2 mg/g.

Even though there is no reasonable scenario for drinking any contaminated water, in the interest of assuring protection of the groundwater resource, the same limit that is in the Versar document (3) will be used: 5.0 E-4 mg/L, the Safe Drinking Water Act Maximum Contaminant Level for PCBs.

MEDIA OF CONCERN

Based on the two exposure scenarios to the worker and the visitor, the only viable media of concern is the surrounding soil. Due to the importance of the aquifer, the groundwater, although not part of any exposure scenario, is evaluated as a media of concern.

POTENTIALLY EXPOSED POPULATIONS

Due to the access control and the period of interest (the next 20 years) the only two potentially exposed populations are workers and visitors.

EXPOSURE PATHWAYS/SCENARIOS

Based on the worker/visitor exposure scenario, the only exposure pathways would be incidental soil ingestion and inhalation. Although not part of any exposure scenario, the groundwater pathway will be evaluated against the data quality objectives.

EXPOSURE ALGORITHMS AND ASSUMPTIONS

Standard EPA CERCLA algorithms for the incidental soil ingestion and inhalation with modification of select assumptions will be used. For example, only an occupation scenario is considered (children and residents are not evaluated); the exposure duration would be 20 years instead of 30 years (this is the period of interest); and the exposure frequency would be 50 days a year instead of 250 (this is more appropriate for the planned activities over the next 20 years).

Note: The visitor scenario would be similar to the worker but with greatly reduced exposures. For example, one might envision a visitor at the site looking at the TSA-RE a couple of times a year for each of the 20 years. The visitor would spend no more than 2 hours each time.

For the groundwater pathway, both the standard EPA CERCLA algorithms and parameter default values are used.

TOXICITY VALUES

The slope factor for ingestion used is 4.0 $(\text{mg/kg-day})^{-1}$ (3).

There is no slope factor for inhalation.

PREVENTIVE AND MITIGATIVE FEATURES

There are numerous preventive and mitigative features that ensure that the PCB hazard is being properly controlled and managed. The first item is that the RWMC receives the vast majority of its waste in a solid waste matrix. For waste forms like sludges, additives were added to sorb any residual moisture.

There are a few isolated cases where small quantities of liquid were placed in the middle of much larger containers. The second item is that the waste containers generally had a plastic or poly liner. The third item is the waste container itself. While there were several types: cargo containers; 30-, 55-, 83-gal drums; plywood boxes; metal M-III bins; FRP boxes; these waste containers, while intact, all provide additional barriers to prevent contact with or migration of the wastes. The next layer of protection is the vinyl coated geo-fabric tarp placed over the waste containers. This helps to prevent moisture from contacting the waste containers. The next barrier is the 1 to 1.3 m of soil. The next item is the weather-tight engineered metal building. This prevents any moisture from coming into contact with the waste containers and eliminates any motive force for moving the contaminants. This building also provides protection from heavy snow loading and high winds. Yet another barrier is the underlying asphalt pad. This would help to retard any contaminants that did somehow escape the multiple barriers.

It is also appropriate to discuss the administrative controls that also perform preventive functions. For example access control, security, fire watch, monitoring and surveillance all contribute to the assurance that the wastes are being managed as expected. The administrative controls also minimize the potential for migration of contaminants and limit access (exposure) to the wastes.

All these collective features help to assure that the PCB waste will stay in place and any contaminant migration would be very limited for the foreseeable future.

QUALITATIVE RISK EVALUATION

There are three main components of any traditional determination of risk. The first is that there needs to be a hazard. As was identified, above the TSA-RE has both radiological and chemical hazards. The focus of this application is the PCB contaminated waste although this discussion will apply to the other hazardous constituents as well. The second required component is there needs to be a receptor. Someone exposed or potentially exposed. In this case, due to natural barriers (remote site, arid environment, and large distance to the water table), the engineered barriers (the waste containers, the waste liners, the soil cover, the metal building, and the asphalt pad), and the administrative barriers (access control and security), the potential for someone to be exposed by any means to any PCB hazard at the TSA-RE is very small. The last component necessary for a risk to occur is there has to be a pathway/mechanism for the hazard to get to the receptor or for the receptor to get to the hazard. There are only three very unlikely mechanisms available. The first could be inadvertent intrusion. This is not considered plausible due to the access restrictions, security and other institutional controls. The second mechanism is a fire. Here again there are preventive measures depending upon the initiator. For instance, if the initiator is lightning, there is a lightning protection system for the building. In the case of a range fire, there is a defoliated buffer area, a metal building with a fire protection system as well as the waste being under 3 to 4 feet of soil. The last mechanism is a flood. Much work has been done in the last 15 years to improve the flood control measures at the RWMC. Further the worst case scenario of a Mackay Dam failure coupled with a worst case historical Big Lost River flood showed the maximum water level to be below the RE (4). Also the RWMC flood diversion system has been analyzed for rain-on-snow floods with an estimated return of up to 10,000 years. The elevation of the RE is above these flood levels as well (5).

From this qualitative discussion of the key components of any risk assessment, any potential risk is negligible for the near term (twenty years).

QUANTITATIVE RISK EVALUATION

In order to provide some additional confidence in the results of the qualitative risk evaluation a conservative simplified quantitative risk evaluation is provided. This exercise is not intended to estimate the actual risk but to provide additional assurance that the data quality objectives (DQO) determined in the previous section will be met and therefore there will be no unacceptable risk posed by this interim storage.

SOIL INGESTION PATHWAY ANALYSIS

This evaluation is based on the site conceptual model described in the previous section. Two soil ingestion exposure scenarios are considered. The first is that of a worker: an occupational scenario. Standard CERCLA EPA algorithms and values are used with the following modifications. The exposure duration is 20 years, the period of interest, rather than the default value of 30 years. The frequency of exposure is one day a week, for four hours. This is to address the potential exposure during the four-hour weekly inspections. Body weight, soil ingestion rate, and averaging time are set at the EPA standard default values. The soil inhalation pathway, while a possibility, is not evaluated further due to the lack of an inhalation toxicity value.

The second scenario is that of a visitor, where someone might visit the TSA-RE a couple of times a year for each of the twenty years. Each visit would last two hours. All other parameters are set at the standard EPA default values.

For each of these two scenarios, there are defined acceptable soil concentration limits of < 1.96 mg/g for the worker and < 98.2 mg/g for the visitor. See the DQO section for derivation of these limits.

The first step involves making some very conservative and simplifying assumptions to determine the need to evaluate the situation more robustly. The assumption is that 100 % of the drums have failed completely and that the PCBs have homogeneously mixed throughout the waste volume and surrounding cover.

This is not a realistic possibility but bounds the actual situation.

For this example, we can then calculate an average soil concentration and compare it to the DQOs. If the number is less than the DQO for the worker, then a more rigorous evaluation is not needed. Also it is intuitively obvious that if the waste poses no unacceptable risk to the worker, the visitor will not be subjected to an unacceptable risk either since the soil concentration limit is 50 times higher.

$$\text{(Eq. 2)}\quad \text{Soil Concentration mg/g} = \frac{\text{kg of PCBs} \times 10^6 \text{ mg/kg}}{\text{m}^3 \text{ of waste + cover} \times 10^6 \text{ cm}^3/\text{m}^3 \times \text{soil density g/cm}^3}$$

where:

kg of PCBs	= 180,000 kg
m^3 of waste + cover	= 232 m long x 6 m high x 48 m wide = 66816 m^3
soil density g/cm^3	= 1.5 g/cm^3

therefore:

Soil Concentration mg/g = 1.8 mg/g

Even with the very conservative container failure numbers and subsequent mixing, this soil concentration number is still lower than the DQO for the worker. As such, no additional evaluation of the soil pathway is needed.

GROUNDWATER PATHWAY ANALYSIS

As stated before, there really isn't a likely groundwater exposure route, but to provide additional assurance, a conservative analysis of the potential impacts to the groundwater is provided. The computational tool chosen for the groundwater pathway is GWSCREEN (6). GWSCREEN was developed for assessment of the groundwater pathway from leaching of radioactive and non-radioactive substances from surface or buried sources. The code was designed for implementation in the INEEL Federal Facility Agreement and Consent Order (FFA/CO) Track 1 and Track 2 assessment of Comprehensive Environmental Response, Compensation, and Liability Act sites identified as low probability hazard at the Idaho National Engineering and Environmental Laboratory (7). This is a groundwater risk-screening tool that has been used extensively during the past 8 years at the site.

The conceptual model used is as described in a previous section with the following modification. Since the code is unable to handle two different water infiltration rates, 5.2 cm/yr will be used. This rate is the average of 10 cm/yr for 26 years (the time prior to the TSA-RE, 1970 to 1996) and 0 cm/yr for 24 years (the time after the TSA-RE was constructed, 1996 to 2020). This rate is used for the entire simulation period that will run until the peak dose occurs. This is a conservative assumption since while the building is intact, the infiltration rate is zero.

Conservative and simplifying assumptions are made to determine if there is a need to evaluate this pathway more robustly. In this case, it is assumed that 100% of the drums have failed completely and that the PCBs have homogeneously mixed throughout the waste volume. Another assumption is that the unsaturated zone is 10% of the unsaturated basalt thickness. This is the INEEL FFA/CO Track 2 default value and accounts for the thickness of the interbeds (7). This also assumes that the travel time in the fractured basalt is instantaneous. The receptor is assumed to be at the downgradient edge of the waste volume. The standard EPA residential default values are used for frequency, duration and quantity of groundwater ingestion: 350 days, 30 years and 2 liters per day. Again, this is not a realistic possibility but will bound the actual situation.

Other key parameters in the model and for the simulation are the sorption coefficients in the source, the unsaturated zone and the aquifer; and the solubility limit. The Track 2 K_d default value for PCBs is 1,500 mL/g and for Aroclor –1254 it is 100 mL/g (7). At the INEEL, the aquifer K_d is assumed to be 1/25 of the source K_d . For this reason two cases are run: the first with a source and unsaturated K_d of 1,500 mL/g and an aquifer K_d of 60 mL/g. The second case is a source and unsaturated zone K_d of 100 mL/g and an aquifer K_d of 4 mL/g. The solubility limit for PCBs is 3.0E-02 mg/L as provided by "Basics of Pump-and-Treat Groundwater Remediation Technology" (8).

Based on these inputs the results are as follows:

Table II. TSA-RE PCB Groundwater Results.

Case TSA-RE-1	Case TSA-RE-2
Body Weight = 72 kg.	Body Weight = 72 kg.
Water Ingestion = 2 L/d	Water Ingestion = 2 L/d
Exposure Duration = 30 years	Exposure Duration = 30 years
Kd = 1500 ml/g	Kd = 100 ml/g
Kd aquifer = 60 ml/g	Kd aquifer = 4 ml/g
Solubility Limit = 3.1E-02 mg/L	Solubility Limit = 3.1E-02 mg/L
Exposure Frequency = 350 days/year	Exposure Frequency = 350 days/year
Initial Mass = 1.8E11 mg	Initial Mass = 1.8E11 mg
Slope Factor = 4.0 (mg/kg-day)-1	Slope Factor = 4.0 (mg/kg-day)-1
Peak Concentration = 2.487E-7 mg/L	Peak Concentration = 2.487E-7 mg/L
Time of Peak = 1.1E7 years	Time of Peak = 7.1E6 years

Note the peak concentration, 2.5 E-4 mg/L does not change. This is because the solubility limit has been reached.

Also, note that the peak concentration is ½ of the 5.0 E-4 mg/L data quality objective for groundwater. This result is acceptable even assuming very conservative and unrealistic modeling parameters. For this reason, no further evaluation is needed and the interim storage will not pose any groundwater risk.

CONCLUSIONS

While it is clear that there is a large quantity of hazardous materials being temporarily stored, it is also clear that there are adequate features both natural and manmade that assure that the storage poses no unreasonable risk of injury to health or the environment. Further, the quantitative evaluation of risk during the next 20 years confirms the adequacy of the storage configuration to protect the environment. Additionally there is also a surveillance and monitoring program that ensures that the system is being managed as planned during this interim period.

These collective actions and features assure that the wastes are being managed safely, that appropriate safeguards and monitoring are in place and that any impact to the worker, public, and the environment is unlikely. This satisfies the requirements presented in 40 CFR 761.61c for risk-based storage of PCB remediation waste.

FOOTNOTES

∗ Note the soil contamination limit was calculated using the same algorithm as the limit for remediation waste in the ASSESSMENT OF RISKS ASSOCIATED WITH THE PCB DISPOSAL AMENDMENTS prepared for the U.S. EPA by Versar, Inc. dated May 11, 1998 (3). The difference is in the values selected for the various parameters.

REFERENCES

1. INEL-95/0267 published October 1996 "Transuranic Storage Area Retrieval Enclosure Safety Analysis Report"

2. EDF ENV-003 dated 2/5/90 "Hazardous Stored TRU Waste Source Term for the RWMC's TSA"

3. ASSESSMENT OF RISKS ASSOCIATED WITH THE PCB DISPOSAL AMENDMENTS prepared for the U.S. EPA by Versar, Inc. dated May 11, 1998."

4. EGG-WM-9502 dated December 1990 "Hydrologic Modeling Study of Potential Flooding at the Subsurface Disposal Area from a Hypothetical Breach of Dike 2 at the Idaho National Engineering Laboratory", R. C. Martineau et al

5. Dames and Moore, March 29, 1993, "Flood Evaluation Study, Radioactive Waste Management Complex, Idaho National Engineering Laboratory

6. INEEL/EXT-98-00750, Revision 1, February 1999 "GWSCREEN: A Semi-Analytical Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination Theory and User's Manual Version 2.5" by A. S. Rood

7. DOE/ID-10389, Revision 6, January 1994 "Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL.

8. EPA, 1990, "Basics of Pump-and Treat Groundwater Remediation Technology", EPA/600/8-90/003, U. S. Environmental Protection Agency

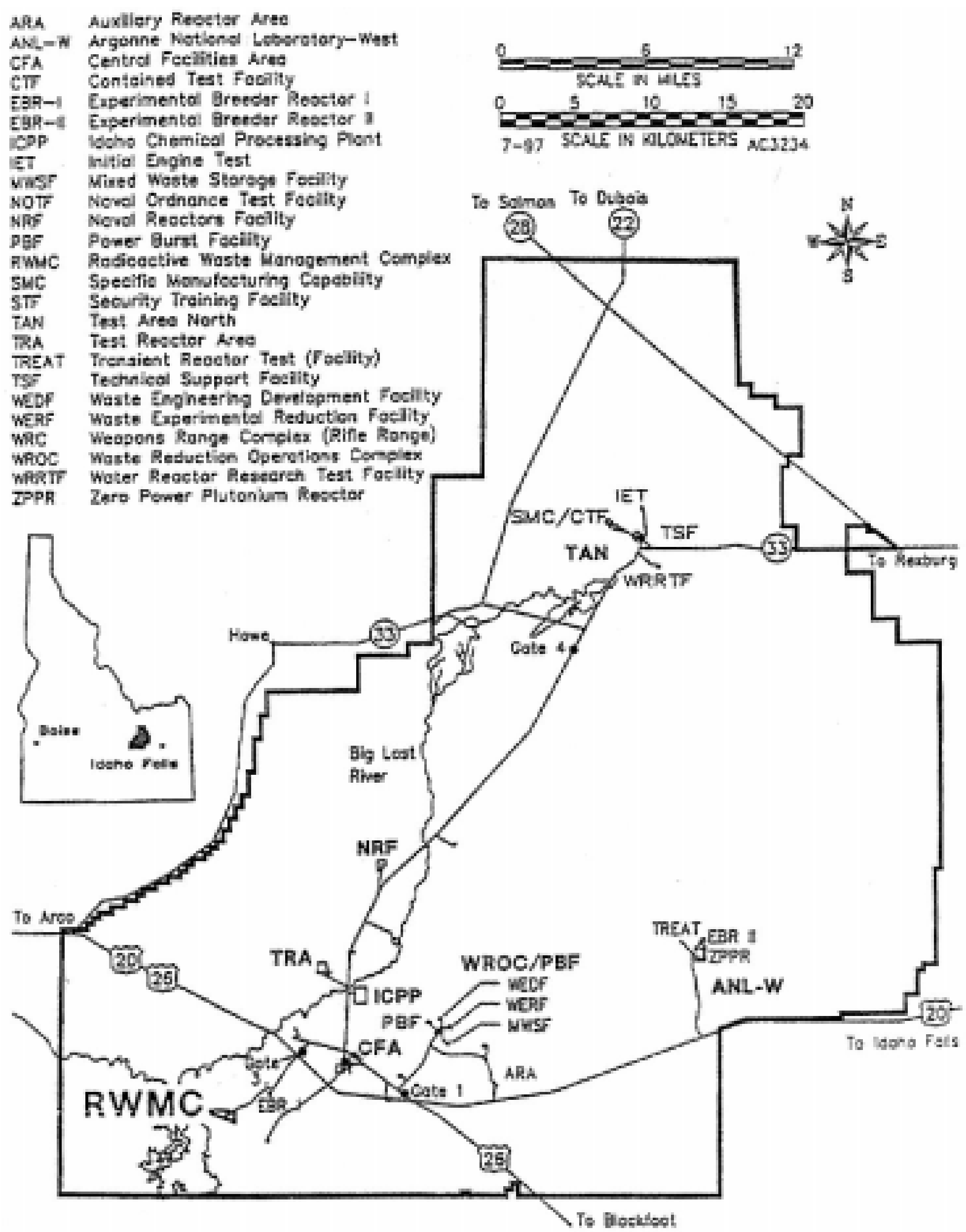

Figure 1. Map of the INEEL depicting the location of the RWMC.

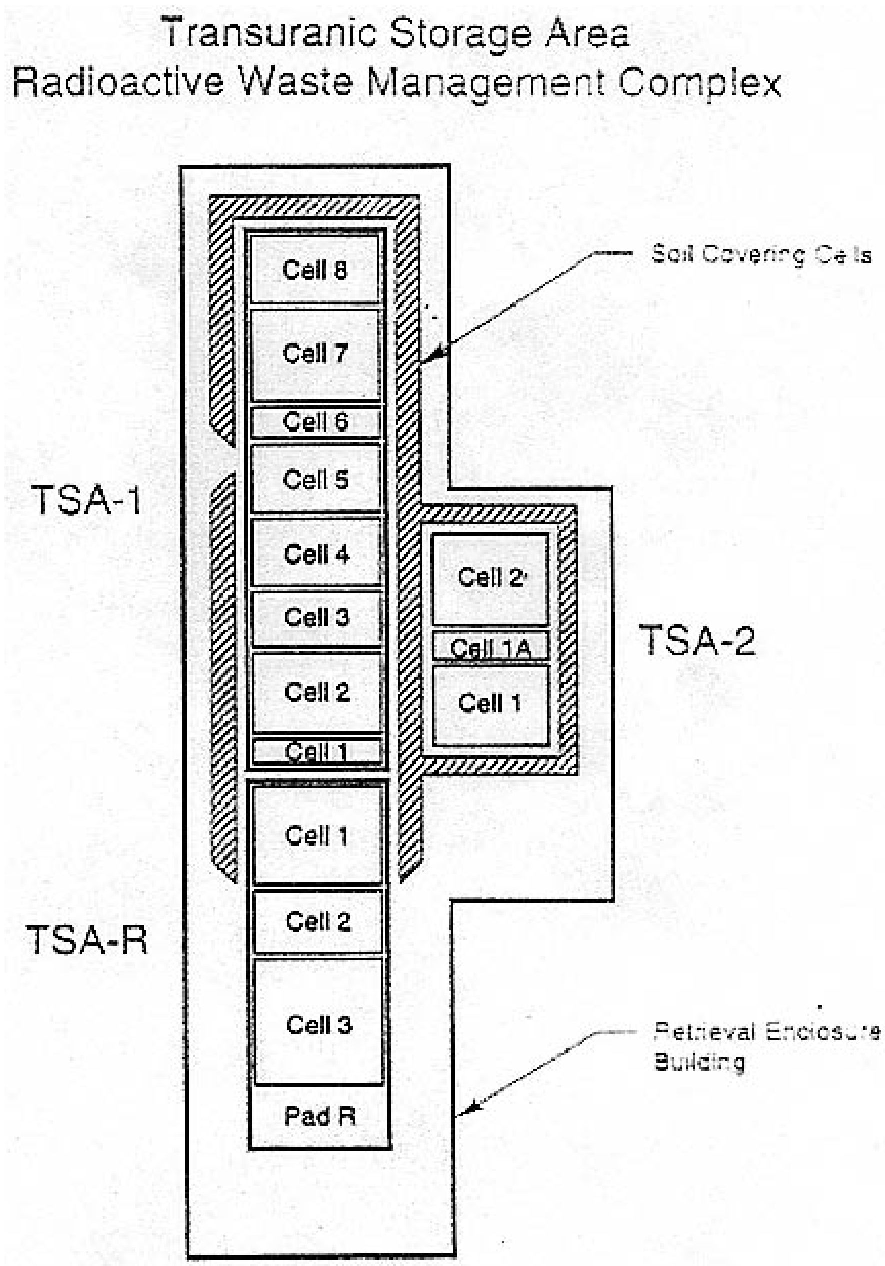

Figure 2. Location of cells at TSA-1, 2, and R.

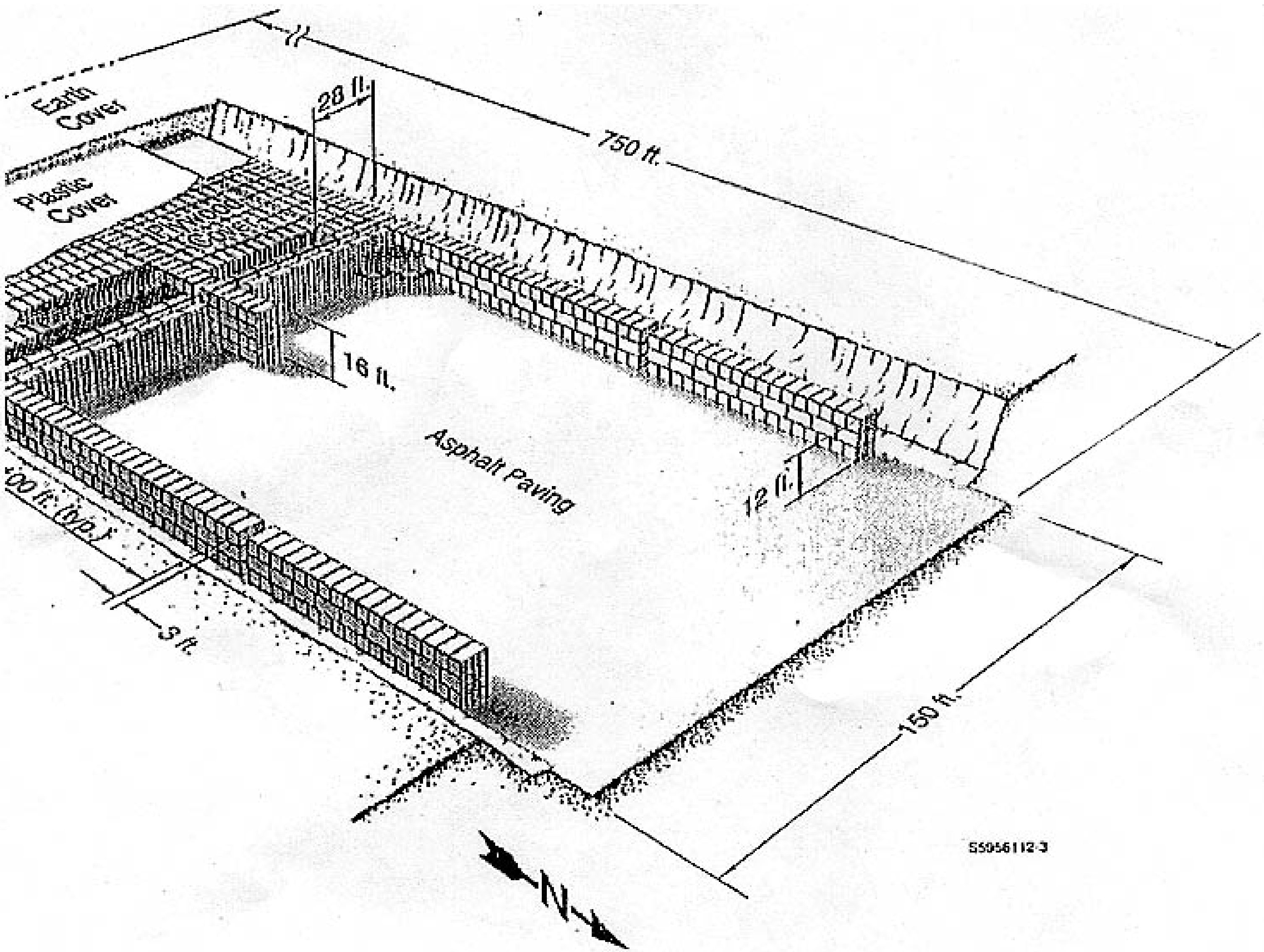

Figure 3. An example of TSA container stacking configuration

Photo 1. A close-up of the TSA-RE building looking north to south.