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VOLUME II

LOW-LEVEL WASTE STRATEGY AND PLANNING

DECONTAMINATION AND DECOMMISSIONING

COMPLIANCE MONITORING

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Texas Site Selection and Licensing Status

Robert V. Avant, Jr., P.E.
Deputy General Manager
Texas Low-Level Radioactive Waste Disposal Authority

ABSTRACT

Texas has identified a potential site in Hudspeth County in far West Texas near the town of Fort Hancock. The Authority over the past year has been conducting detailed geology, hydrology, meteorology, soils, and flora and fauna evaluations. An authorization by the Board of Directors of the Authority to proceed with a license application, assuming that the detailed evaluation indicates that the site is suitable, is expected by September. A prototype license has been prepared in anticipation of the order to proceed with licensing, and the formal license application is expected to be submitted to the Texas Department of Health - Bureau of Radiation Control in December, meeting the license application milestone.

Although site selection processes in all siting areas across the country have experienced organized opposition, El Paso County has funded a particularly well-organized, well-financed program to legally and technically stop consideration of the Fort Hancock site prior to the licensing process. Many procedural, regulatory, and technical issues have been raised which have required responses from the Authority in order to proceed with licensing. This has provided a unique perspective of what to expect from well-organized opposition at the licensing stage.

This paper presents an update on the Texas siting activity with detailed information on the site evaluation and license application. Experience of dealing with issues raised by opposition relating to NRC guidelines and rules is also discussed.

BACKGROUND

In 1981, the 67th Texas Legislature passed and the Governor signed into law the act creating the Texas Low-Level Radioactive Waste Disposal Authority. The act provided the following:

- created the Authority as an independent agency of the state.
- defined low-level waste as any radioactive material with a half-life of 35 years or less or having less than 10 nanocuries per gram of transuranics. Materials with half-lives of greater than 35 years may be classed as low-level waste if special criteria are established by the Texas Department of Health Bureau of Radiation Control.
- established a Board of Directors appointed by the Governor, composed of a certified health physicist, geologist, attorney, medical doctor, and two private citizens.
- specified general site selection criteria and procedures for site selection and licensing.
- defined administrative and contracting procedures.
- authorized fees and penalties.

Subsequent sessions of the legislature have amended the act to revise siting criteria, require consideration of state land, create a Citizen's Advisory Committee, incorporate alternative designs, and establish a special low-level radioactive waste account in the state treasury.

The Authority began its activities in 1982 when a staff was assembled. Figure 1 provides a chronology of Authority activities. The Authority is currently conducting detailed site evaluation on a site about forty miles east of El Paso near Fort Hancock, Texas. The geology, ground and surface water hydrology, meteorology, soils, flora and fauna, seismicity, and background radiation of the site are being evaluated by a team of investigators from various state university institutes.

Site investigations should be complete in the summer of 1989 and a final site determination by the Authority's Board of Directors is expected then. An affirmative decision will trigger the preparation of an environmental report and license application with submittal to the Texas Department of Health, Bureau of Radiation Control in December 1989.

The licensing process, including a contested hearing, is expected to take two years with issuance late in 1991. Construction will start upon license issuance and will take 6-9 months with completion by the Fall of 1992. Figure 2 is the anticipated schedule. It should be emphasized that a lawsuit anywhere in the process prior to construction could result in a two year delay.

SITE EVALUATION

Fort Hancock Site

The Fort Hancock site is located on a large block of state land in southwestern Hudspeth County. The site area is approximately 40 miles east of the El Paso city limits, 12 miles east of the El Paso/Hudspeth line, and 10 miles northeast of Fort Hancock, Texas.

Site specific investigations began in late 1984 on a several square mile area. The site area lies between the Rio Grande to the south and the Diablo Plateau to the north. The Finlay Mountains are about 4 miles to the east of the study area. It is an area of low relief with surface drainage to the south, southwest, and west into Alamo Arroyo which flows south into the Rio Grande. Camp Rice Arroyo lies to the south of the study area. The primary study area is near the northern boundary of the state land.

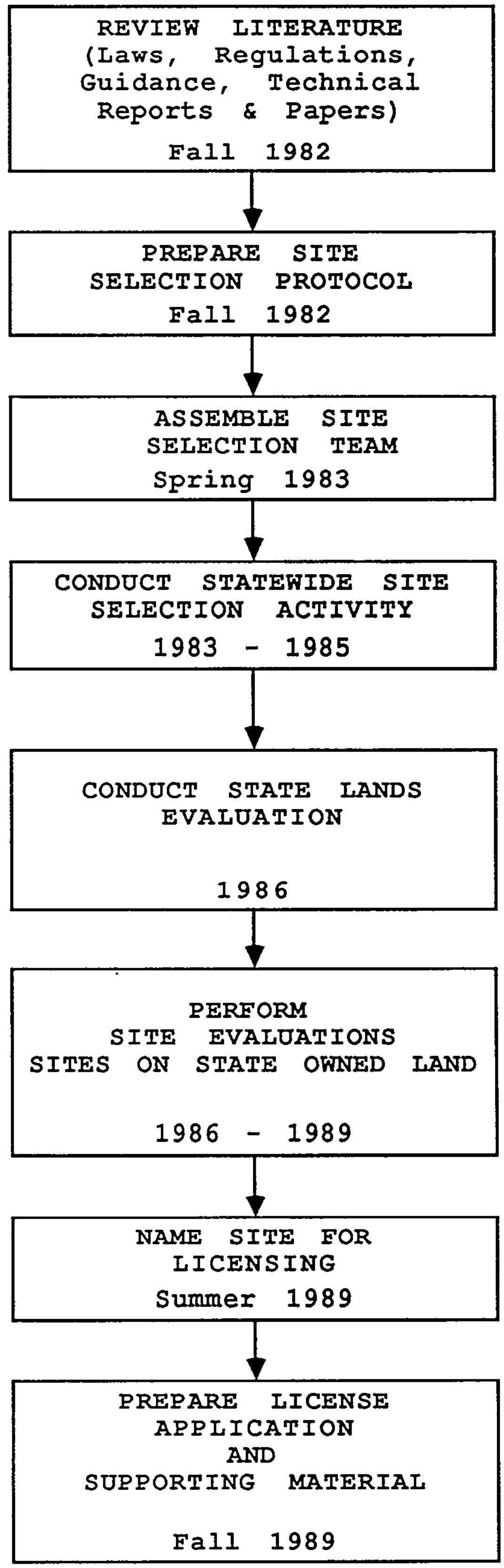


Figure 1 Texas Low Level Radioactive Waste Disposal Authority Chronology

Summer, 1989	Identify site
Fall, 1989	License application
1990	License review
1991	Hearing
1992	Construction
Fall, 1992	Operation

Figure 2 Authority Schedule

Transportion access to the site area is from Interstate 10 at Fort Hancock via a county road. Approximately 10 miles of road construction will be required to accommodate maximum weight trucks.

Both the site and surrounding areas are used as grazing land. The combination of soils, climate, and topography totally precludes any form of intensive agriculture.

The site lies at the eastern edge of the Hueco Bolson, a major basin and range graben. Rocks in the area range in age from Permian to Recent; the strata most important at this site are late Tertiary to Recent sediments that fill the Hueco Bolson. The Tertiary deposits that fill the Hueco Bolson would be the host sediments for the low-level radioactive waste disposal units.

A fault system cutting the Quaternary and Tertiary alluvial and basin-fill deposits in the vicinity of the study area has been mapped. The main fault is well exposed in several branches of Diablo Arroyo near Campo Grande Mountain and is informally referred to as the Campo Grande fault.

Cretaceous rocks form a plateau and underlie the area that is being considered for the potential site. Several wells in the area penetrate Cretaceous rocks of the Finlay, Cox, or Bluff Mesa Formations. No ground water was encountered in the bolson fill in the site area. The permeability and porosity of the bolson fill are expected to be heterogeneous because of the nature of the bolson. The annual recharge from precipitation into the gravel cover of the bolson is expected to be very small. The only aquifer observed at the site is the Cretaceous and is confined in the site area at about 500 ft below land surface. Data suggests that there is no significant hydrologic connection between the bolson deposits in the site area and the bolson deposits closer to the Rio Grande where it is used as a water supply.

The site area and surroundings are a part of the southern desert shrub vegetation region. Numerous native species inhabit the area, but population densities are low. A total of 26 vertebrate species are listed as threatened or endangered for Hudspeth County. Site investigations have revealed only one threatened species, the Texas horned lizard. No endangered species inhabit the site, and based on published habitat preferences, none are expected to occur. No threatened or endangered plant species are currently listed for the county.

Cultural features such as schools, churches, and cemeteries are located in the communities of Fort Hancock and Sierra Blanca, 10 miles southwest and 27 miles southeast respectively. Fort Hancock's slogan is "3 miles from Hell and 30 miles from Water!" Other areas of historic significance located along the Rio Grande and downstream include Fort Quitman and Indian Hot Springs.

The Guadalupe Mountain National Park extends into the northeast corner of Hudspeth County some 54 miles to the northeast of the site area and the Sierra Diablo Wildlife Management area is located approximately 47 miles to the east of site area.

The nearest archaeological features are prehistoric rock art sites of the Yamada Mogollon people in a header Canyon of Alamo Arroyo and at various spots along the Diablo Plateau escarpment to the north and east of the site, a distance of at least three miles from the site area. A detailed survey of the site area has revealed isolated hearth sites. Excavation of the most significant hearth sites revealed no significant cultural resources on the site area.

Detailed Site Evaluation Studies

The Authority began detailed site evaluation studies on the Fort Hancock site in the summer of 1988. More detailed data than had been developed during site screening activities was required to provide sufficient data to determine site suitability and to support licensing, if the site proved suitable.

Particular attention was paid early in the evaluation activities to items which could be fatal flaws from a licensing standpoint. Nuclear Regulatory Commission (NRC) Regulations - 10 CFR 61; Texas Department of Health, Bureau of Radiation Control (BRC) Regulations - Texas Regulations for Control of Radiation (TRCR), Part 45; and Authority requirements provided guidance on fatal flaw evaluations. Table 1 presents a comparison of absolute exclusion, performance based, and preferred site selection criteria from NRC, BRC, and Authority requirements. Generally, there are four absolute exclusion criteria relating to modeling/characterization, surface water hydrology, and groundwater hydrology which could result in a fatal flaw not related to site performance. In other words, some criteria could result in a fatal flaw regardless of the ability of a site to meet performance objectives - for instance a 100-year flood plain.

The detailed site evaluation program addresses the full range of regulatory criteria discussed above and is separated into three major study areas as shown in Figure 3. The program will produce detailed descriptions of the following:

Geology/Hydrology
Geology (University of Texas - Bureau of Economic Geology)
- Stratigraphy
- Geomorphology
- Structure
- Geochemistry

Geophysical (University of Texas at El Paso - Geology)
- Seismicity

Geotechnical (University of Texas - Civil Engineering)
- Strength of in situ materials

Hydrology (University of Texas - Bureau of Economic Geology-Civil Engineering)
- Surface Water
- Ground water

Environmental
Flora/Fauna/Soils (Texas Tech - Range and Wildlife Management)
- Endangered/Threatened Species
- Flora/Fauna/Soils Inventory
- Site Condition Analysis
- Soils Map

Socioeconomics/Demography (Texas A & M - Rural Sociology)
- Socioeconomic Condition
- Economic Impact
- Demographic/Public Service Impact
- Local Government Impact
- Historic, Demographic, Economic, & Rural Characteristics

Meteorology/Air Quality (Texas A & M - Meteorology)
- Regional/Local Climatology
- Airborne Pathway Analysis

Cultural Resources (University of Texas at El Paso - Sociology)
- Archaeological Survey

Performance Assessment
Environmental Monitoring (Authority)
- Background Radiation

Radiological Dose Assessment (University of Texas - Nuclear/Civil Engineering)
- Site/Facility Performance Assessment

Site Designation

Most of the detailed site evaluation studies will be complete in the summer of 1989. Then, the Authority's Board of Directors will consider formally designating the site. Designation will trigger the preparation

Table 1 - Comparison of Selected Regulations and Requirements

	10 CFR 61		TRCR Part 45.50		Authority	
	General	Prescriptive	General	Prescriptive	General	Prescriptive
1. Ensure Performance Objectives	X (PB)		---		- (1)	
2. Characterized, Modeled, Analyzed, Monitored	X (AE)		X (AE)		X (AE)	
3. Low Population Growth	X (PB)		X (PB)		X (PB)	
4. Natural Resources	X (PB)		X (PB)		X (PB)	X
5. 100 Yr Flood Plain	X (AE)		X (AE)		X (AE)	
6. Upstream Drainage	X (P)		X (P)		X (P)	X
7. Water Table	X (AE)		X (AE)		X (AE)	X
8. Ground Water Discharge	X (AE)		X (AE)		X (AE)	
9. Tectonics	X (PB)		X (PB)		X (PB)	
10. Surface Geology	X (PB)		X (PB)		X (PB)	
11. Nearby Facilities	X (PB)		X (PB)		X (PB)	
12. Aquifer Recharge Zone			X (PB)		X (AE)	
13. Soil Conditions			X (AE)		- (1)	
14. Meteorological Conditions					X (PB)	
15. Parks, Monuments, Wildlife Areas					X (P)	
16. Archaeology					X (P)	
17. Endangered Species					X (P)	
18. Conflicting Easements					X (P)	
19. Access					X (P)	
20. State Land					X (P)	
21. Transportation					X (P)	

PB - Performance Based AE - Absolute Exclusion P - Preferred
1 - This requirement is addressed in other Authority criteria

Geology/ Hydrology	Environmental	Performance Assessment
Geology	Flora Fauna	Environmental Monitoring
Hydrology (Surface) (Ground)	Socioeconomics Demography	Radiological Dose Assessment
Geophysical Geotechnical	Meteorology Air Quality	
	Cultural Resources	

Figure 3 Detailed Site Evaluation Program

and submittal of a license application by the end of 1989. Because of uncertainty over the Texas regulatory jurisdiction over mixed waste, the Authority anticipates submitting a Governor's certification on mixed waste along with a license application to ensure that the 1990 milestone is met.

SITE LICENSING

License Application Process and Format

Texas has Agreement State status to administer certain NRC regulations. The BRC will license the Authority's facility applying TRCR Part 45 which is based on 10 CFR 61. The license application format follows the structure of TRCR Part 45 and contains six sections as follows:

General Information
- General descriptions of applicant, personnel, facility, waste stream, and schedule

Specific Technical Information
- Design Criteria
- Natural Events and Phenomenon
- Codes and Standards
- Design Features
- Construction and Operation
- Source Term
- Quality Control
- Radiation Safety Program
- Operation and Procedures Manual
- Administrative Procedures

Environmental Information
- Statement of Need
- Schedule
- Area and Site Characteristics
- Natural Resources
- Flow Diagram
- Site Selection
- Project Alternatives
- Radiological and Non-radiological Impacts
- Environmental Effects
- Environmental Monitoring Programs
- Decommissioning and Site Closure
- List of Permits

Technical and Environmental Pathways
- Migratory Pathways
- Inadvertent Intruder
- Worker Protection
- Site Stability
- Nonradiological Impact

Institutional Information
- Certification of Post Closure Acceptance

Ownership of Site
Site Legal Description
Management Plan

Financial Information
Financial Stability
Funding of Closure, Stabilization, and Institutional Controls

Licensing Issues

Since the summer of 1988, El Paso County has hired several technical consulting firms and attorneys to scrutinize the Authority's site selection process, the Fort Hancock site, and the facility design.

The Authority has been following a generally accepted site selection procedure which was formulated in 1983. Although the Texas Legislature has intervened on several occasions to modify the site selection requirements, the process shown in Figure 1 has been followed.

Regulations do not address the site selection process except that BRC requires consideration of alternatives including an alternative siting analysis. Attorneys for El Paso County have not questioned the Authority's site selection process from a regulatory perspective. However, they have questioned the process on a procedural basis and have sought remedies twice in District Court claiming that the Authority violated due process. The first case was determined not to have merit, and the second case is pending. Because siting requirements are specified so generally, most lawsuits attacking the process will fail unless arbitrary and capricious actions can be proven. As long as it can be demonstrated that a sequential screening process has been followed evaluating alternatives no matter how limited they may be, it will be very difficult for adversaries to prevail.

The adversaries have resorted to attacking the technical adequacy of the site selection process including the integrity, qualifications, and professionalism of the Authority's staff and consultants. It is substantially easier to second-guess a process than to conduct a positive program based on professional judgement, experience, and knowledge of low-level radioactive waste disposal technology. The following is a list of general complaints submitted by the adversary's technical consultants: The Authority

- has not followed generally accepted practices exercising a standard for care,
- misinterpreted statutory siting requirements,
- characterized the site before it was formally designated,

- should have followed a traditional site selection process for "critical facilities,"
- should have conducted a fatal flaw analysis earlier,
- should have conducted a lineament analysis,
- should have reviewed site characteristics with appropriate regulatory agencies,
- conducted site evaluations on a scientific research basis rather than on an engineering basis,
- should have conducted a flood plain analysis earlier,
- should have conducted a regional fault analysis earlier,
- should have estimated maximum credible earthquakes earlier
- should have evaluated geomorphology, etc.

The preceding statements totally misrepresent the Authority's program and attempt to cast doubts on the program from procedural, technical, and regulatory perspectives. One of the principals of a consultant firm representing the adversaries admitted that they were raising as many questions as possible directly related to licensing issues so that a substantial amount of investigation, time, and money to address the questions would be required. Of course, the intention was to attempt to intimidate the Authority into abandoning the site. This ploy has been used successfully by adversaries of nuclear power plants, but El Paso County has ignored the fact that low-level radioactive waste disposal facilities are less sophisticated and the facility should not be considered "a critical facility." In numerous instances, consultants for the adversaries use phrases like "in our judgement," "reasonable assurance," "difficult to provide a high level of assurance," "it is our opinion," "we believe," "making detailed site characterization extremely difficult," "level of assurance," etc.

Site suitability and facility design are other major areas where adversaries will attack a project. El Paso's consultants basically followed 10 CFR 61, NUREG 0902, TRCR Part 45, and various other guidance documents as a checklist and have used substantial latitude in interpreting the letter and intent of these regulations and guidance documents.

Adversaries have placed their emphasis on a very strict interpretation of the regulations, basically claiming that the site must meet pass/fail judgement on each 10 CFR 61 or TRCR Part 45 site selection criteria. No credit is allowed for proving the acceptability of a site by demonstrating compliance with performance objectives because in the adversary's words, "it cannot be done with a reasonable level of assurance." For example, adversaries claim that because a significant capable fault is about three miles from the site, this is a potential fatal flaw and performance modeling should not be considered to determine whether the site will meet performance objectives. Adversaries have complained that there are no prescriptive site selection criteria either in NRC, BRC, or Authority requirements, implying that this does not comply with generally accepted practices. For instance, the adversaries would prefer prescriptive criteria which delineate distances to capable faults, maximum areas of upstream drainage, distances to populated areas, depth to groundwater, etc. Of course, as discussed earlier, 10 CFR 61 does not require prescriptive requirements except for modeling/characterization, the 100-year flood plain, water table, and ground water discharge. All other criteria rely on demonstrating that the site can meet performance objectives. If NRC had promulgated a rule that was highly prescriptive, many good sites could have been disqualified regardless of how well they might have met performance objectives.

In NUREG 1199, reference is made to 10 CFR 100, which relates to nuclear power plants and to the Standard Review Plan for UMTRCA Title 1 Mill Tailings Remedial Action Plans. Adversaries have attempted to apply this guidance as absolute site selection and design criteria for a low-level radioactive waste disposal facility. Even though a low-level radioactive waste disposal facility may incorporate some similar site and design features, to apply the same design standards for a low-level radioactive waste disposal facility as for nuclear power plant containment domes or mill tailings facilities is inappropriate. Regulatory agencies and facility development groups need to adhere to a clear and strong policy that low-level radioactive waste disposal facilities will not be sited or designed to nuclear power plant or UMTRCA standards. Low-level radioactive waste facilities will be designed to meet performance objectives spelled out in 10 CFR 61.

Table 2 provides a detailed comparison of TRCR Part 45, El Paso's position, and the Authority's position regarding the Fort Hancock site.

CONCLUSION

The Authority expects to formally designate the Fort Hancock site in the late summer of 1989 assuming that the detailed site evaluation supports such an action. Licensing and final characterization activities will be conducted during the fall of 1989, and the Authority expects to submit a license application and/or a governor's certification by the end of December complying with the 1990 milestone.

While in site selection, the Authority has been sued twice on procedural issues. The Authority won the first case and the second case is pending; the Authority is confident that the second case will also be found to have no merit. El Paso County has spent approximately $1.1 million for attorney fees and consultants opposing the Fort Hancock site. Expenditure of such a large amount of money for a project outside the jurisdiction or boundary of a county is unprecedented. Usually, well funded, technical opposition to a major project occurs during the permitting stage, not during site selection. To be presented with volumes of perceptual, political, and technical objections to a site prior to license preparation is also unprecedented and will be very instructive to the Authority in preparing an defending its license application.

Table 2 - TRCR Part 45.50 Disposal Site Suitability Comparison
Fort Hancock Site

Requirement	El Paso County Position	Authority Position
a. The disposal site shall be capable of being characterized, modeled, analyzed, and monitored. (TRCR 45.50(a))	a. Serious scientific uncertainty about the number, orientation, and extent of present and future fissures, the nature of faulting in the bedrock and horizontal and vertical variability of the geologic deposits above the bedrock make it virtually impossible to characterize, model, analyze, and monitor the site with the level of assurance needed for safe disposal of low-level radioactive waste.	a. The objectives of the current site evaluation activities are being conducted so that the site can be conservatively characterized, modeled, analyzed, and monitored. UT-BEG is far along in analyzing the stratigraphy, neotectonics, surface features, and groundwater hydrology in detail which will allow scientifically defensible characterization and modeling of the site. The site has a definable range of characterization and performance modeling parameters. The only problem with modeling and monitoring the site is there is a net upward movement of water (not downward) because of the low rainfall rate and high evaporation rate. Consequently, modeling scenarios must assume unrealistic downward and lateral water movement. Modeling will assume a failure scenario where there is a direct unimpeded path to the groundwater. Based on current knowledge of the siting area, TRCR Part 45 performance objectives will still be met.
b. Within the region where the facility is to be located, a disposal site should be selected so that projected population growth and future development are not likely to affect the ability of the disposal facility to meet the performance objectives of this part. (TRCR 45.50(b))	b. An urban planner with the City of El Paso (Nestor Valencia) projects that El Paso will grow to the El Paso/Hudspeth County line in 30 - 40 years.	b. Growth projections for El Paso and Hudspeth Counties show that growth will be primarily to the northeast and along the I-10 corridor to a lesser extent. Using the highest possible growth rates, there is no reason to believe projected growth or future development will affect the site.
c. Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of this part. (TRCR 45.50(c))	c. Not known.	c. There are no known exploitable natural resources at the site according to available geologic data.

Table 2 (Continued)

Requirement	El Paso County Position	Authority Position
d. The disposal site shall be generally well drained and free from areas of flooding or frequent ponding. Waste disposal shall not take place in the 100 year flood plain, coastal high hazard area, or wetland, as defined by Executive Order 11988, "Flood Plain Management Guidelines" (TRCR 45.50(d)) (codified now as 44 CFR Part 9).	d. About 80 percent of the 1280 acres (518 ha)[1], or all but 256 acres is indicated as being within the 100 year flood plain. The largest contiguous uninundated area is approximately 120 acres (49 ha); about 275 acres (110 ha) would be required for the facility.	d. Consultants for El Paso County first used HEC 1 & 2 models prepared by the U.S. Corps of Engineers. HEC 1 & 2 models are considered to be good engineering practice for surface hydrology (flood plain) evaluations if they are applied with acceptable engineering judgement within accepted parameters. HEC-1 basically determines the yield of rainfall, i.e. the flow rate of water at a given time. HEC-2 determines the route water will take after the flow rate has been determined. For the HEC-2 model to be correctly applied, channels (i.e. creeks, streams, gullies, etc.) must be defined. El Paso first used a classical HEC-2 analysis to arrive at their conclusion that 80% of the site floods. Since their first analysis, El Paso's consultants now have decided to use an entirely different model developed specifically for modeling alluvial fans and they have modified the HEC-2 model to consider overland flow. The alluvial fan model may not be appropriate because the Authority's siting area is more appropriately defined as an alluvial slope - not an alluvial fan. FEMA recommends a completely different analysis for an alluvial plain or slope. Contrary to El Paso's claim that 275 acres are required for a site, only about 80 acres is needed for waste processing and disposal activities. The remainder of the site involves non-radioactive waste items like berms, the buffer zone, the administration building, roads, etc., which are not by regulation dependent on the 100 year flood plain. In spite of El Paso's claims to the contrary, their own evaluation demonstrates there are sufficient areas of land out of the 100 year flood plain in the siting area; therefore, this is not a fatal flaw. Finally, by shifting the site southwest by about 1 mile, still within the siting area on state land, the flood plain issue becomes moot.

1 - The siting area is 1710 acres.

Table 2 (Continued)

Requirement	El Paso County Position	Authority Position
e. Upstream drainage areas shall be minimized to decrease the amount of runoff which could erode or inundate disposal units. (TRCR 45.50(e))	e. The large upstream drainage area and the need for extensive flood protection barriers do not meet the established site selection criteria, nor prudent engineering practice, or the normal and ordinary standard of care for siting critical facilities such as the Fort Hancock site.	e. The drainage area upstream of the site is about 11 square miles and does not present a major surface water management problem. If the entire Alamo Arroyo basin associated with the siting area is considered, about 100 square miles is in the basin and the site is located in the upper 11% of the basin. It should be noted that the California site has about 6 - 10 square miles of upstream drainage. The facility design addresses upstream flows which will be diverted by berms. On-site water management and off-site water diversion is accepted and prudent engineering practice, exercising normal and ordinary care.
f. The disposal site shall provide sufficient depth to the water table that groundwater intrusion perennial or otherwise into the waste will not occur. (TRCR 45.50f))	f. The earth covers protecting the waste could become damaged, water could flow by damaged waste vaults and canisters infiltrating to the groundwater. The groundwater supply for El Paso could then be contaminated because pumping could reverse the groundwater gradient causing flow toward El Paso rather than away from El Paso. Also, earthquakes could cause the geology of the aquifers to be changed causing continuity among them.	f. The nearest underground water table is approximately 500 feet below the site. Because excavation will be only about 30 feet deep, there cannot be direct contact of the waste with the water table. Concern has been expressed that tectonic activity and fissures could cause waste to be exposed to infiltrating groundwater which would flow through fissures to the water table. Although fissures are present in the siting area, the UT-BEG has estimated that the deepest fissures are between 100-200 feet deep and are filled with sediment. The depth of the fissures is not known, but they are not likely to be a direct, open conduit to the water table. In order for groundwater to be contaminated, the following events would have to take place: 1) An earthquake or other phenomena would have to crack canisters or vaults containing waste and a majority of the waste would have to be exposed. 2) An open fissure projecting to the water table or a gravel stratum would have to be present near a cracked disposal unit. 3) The trench cap would have to fail above the cracked disposal unit. 4) A large sustained rainfall event would have to saturate the upper 30 feet of soil and cause a massive amount of water to flow through the failed trench cap, into the cracked disposal units, past a majority of the waste, and then into the open fissure.

f. Continued on next page

Table 2 (Continued)

Requirement	El Paso County Position	Authority Position
Continued from page 17		There would have to be enough water flow to flush contaminated water to a water source either at the water table or at a gravel exposure in the arroyos. If the ground is not saturated, small amounts of water will not move downward because of high soil suction. Any water entering an open surface crack will be stopped by the suction effect of the soil. Even assuming a direct pathway, calculations show that migration of radioisotopes in the underground water table to a water supply would take 300,000+ years under the most liberal conditions.
g. Avoid recharge areas of sole source aquifers unless the site can be designed, constructed, operated, and closed without an unreasonable risk to the aquifer. (TRCR 45.50(g))	g. The site area is a recharge area for the Hueco Bolson, an aquifer serving as the sole source of water for nearby communities.	g. The Hueco Bolson is not a sole source aquifer as defined by the Texas Water Commission. In any event, the site is not over the recharge of the Hueco Bolson aquifer and it will not affect water quality of the drinking water supply. Furthermore, as shown in f., a reasonable scenario for ground or surface water contamination cannot be demonstrated because of the multiple redundancies protecting the site and the facility design.
h. The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site. (TRCR 45.50(h))	h. The perched shallow groundwater in the area is evidenced by the presence of phreatophytes.	h. There is no discharge of groundwater within the siting area, and no shallow groundwater has been discovered from drilling or site investigations. Phreatophytes grow where there is a higher soil moisture content as in depressions and creeks, but their mere presence does not indicate shallow groundwater.
i. Areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet performance objectives of this part or may preclude defensible modeling and prediction of long-term impacts. (TRCR 45.50(i))	i. The Campo Grande, Amargosa, and other faults in the area could damage disposal units from high ground accelerations from numerous reccurring seismic events.	i. The Authority recognizes that the Campo Grande fault is a capable fault. Seismic effects are a design issue which will be addressed during the design process. Preliminary calculations indicate that the current design can withstand major seismic events. The Authority disagrees with the assertion that ground motion from earthquakes will affect the disposal units to the degree that waste would be exposed to a pathway that would adversely affect performance ojbectives.

Table 2 (Continued)

Requirement	El Paso County Position	Authority Position
j. Area shall be avoided where surface geologic processes such as mass wasting, erosion, slumping, land sliding, or weathering occurs with such frequency and extent to significantly affect the ability of the disposal site to meet performance objectives or may preclude defensible modeling and prediction of long-term impacts. (45.50(j))	j. The site is in a very active area where erosion has caused the weathering of buried caliche horizons. Fissures are also fatal surface processes.	j. Mass wasting, slumping, landsliding, and/or weathering are not phenomena which will affect the performance objectives of this site. In fact, data indicates that the area is aggrading rather than eroding. There are no observed phenomena which would adversely affect performance objectives or modeling over geologic time. Frosion and deposition have occurred on the site, but this is not considered to be a concern during the time span of the site. Waste will be buried at the depth which will not be affected by active surficial process. Detailed evaluations of the site area have identified an older, possibly more stable surface approximately 1 mile southwest within the siting area on state land. Fissuring is a surface geologic process that needs to be further defined. These fissures do not prohibit modeling of the site, do not affect the structural stability of the disposal units, and have not been proven to occur in the proposed disposal area. This item, although not a fatal flaw, is anticipated to be a major issue at the licensing stage. There is no evidence proving one way or the other that the fissures are a direct pathway to groundwater. UT-BEG estimates that the fissures may be 100-200 feet deep. Because of the depth to groundwater, the low rainfall rate, and the high suction of the soil, downward motion of water is not anticipated under any reasonable set of circumstances.
k. The disposal site shall not be located where nearby facilities or activities could adversely impact the ability of the site to meet performance objectives of this part, or may significantly mask the environmental monitoring program. (TRCR 45.50(k))	k. Not known	k. There are no nearby facilities which will affect performance objectives or mask environmental monitoring.
l. The site shall not be located where soil conditions would make clean up impracticable. (TRCR 45.50(l))	l. Not known	l. Clean up at the site would be practical.

SITE SELECTION AND LICENSING ISSUES
SOUTHWEST COMPACT LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE

JAMES L. GRANT
JAMES L. GRANT AND ASSOCIATES, INC.

1. INTRODUCTION

The low-level radioactive waste disposal site in California is being selected through a three-phase program. Phase 1 is a systematic statewide, regional, and local screening study. This program was conducted during 1986 and 1987, and culminated in the selection of three candidate sites for further study. The locations of the candidate sites are shown in Figure 1. The candidate sites are identified as the Panamint, Silurian, and Ward Valley sites. Phase 2 comprises site characterization and environmental and socio-economic impact study activities at the three candidate sites. Based upon the site characterization studies, the candidate sites are ranked according the desirability and conformance with regulatory requirements. Phase 3 comprises preparation of a license application for the selected candidate site. The license application will include a detailed characterization of the site, detailed design and operations plans for the proposed facility, and assessments of potential impacts of the site upon the environment and the local communities.

The site selection process followed in California has been developed to meet the requirements of California law and guidelines established by the California Department of Health Services. These requirements assure that the chosen site will be protective of public health and the environment, be acceptable to the public, and be operable at a reasonable cost to the users of the site.

Five types of siting criteria were developed to govern the site selection process. These types are:

technical suitability exclusionary criteria,

high-avoidance criteria beyond technical suitability requirements,

discretionary criteria

public acceptance, and

schedule requirements of the LLWR Policy Act Amendments.

Technical suitability criteria were established to assure that the selected site will meet all applicable regulatory requirements. These criteria establish locational restrictions, performance standards and acceptance thresholds which must be met by the site and the facility to assure compliance with the regulatory requirements. Ten technical criteria govern the site selection process in California. Eight of the criteria address hydrological and geotechnical issues. The other two address demographic and natural resource concerns.

This paper discusses the application of the hydrological and geotechnical criteria during the siting and licensing studies in California. These criteria address site location and performance, and the degree to which present and future site behavior can be predicted. Primary regulatory requirements governing the suitability of a site are that the site must be hydrologically and geologically *simple* enough for the confident prediction of future behavior, and that the site must be stable enough that frequent or intensive maintenance of the closed site will not be required.

This paper addresses the methods to measure site suitability at each stage of the process, methods to gather data to address the criteria, and tradeoffs necessary to locate sites which conform to sometimes inconsistent requirements.

The technical criteria considered in this paper are as follows:*

Hydrologic Suitability Criteria: Four criteria describe hydrologic suitability.

Criterion No. 1. To facilitate full characterization, modeling, monitoring, and analysis, seek sites in topographically closed basins.

Topographically closed basins generally are smaller, more homogeneous and less complex than larger, open basins. The final destinations of surface and ground waters generally are evident in closed basins, and potential points of water use are limited.

Criterion No. 2. Seek sites in arid areas receiving less than ten inches average annual precipitation.

Arid areas are preferable from the standpoints of site operations and site performance. Less rainfall means fewer problems associated with water management during operations, and less likelihood that water will move through closed trenches, providing a mechanism for mobilizing and transporting radionuclides from the trench confines.

Criterion No. 3. Avoid water bodies, wetlands, and potential flooding areas. Aside from the regulatory requirement to avoid such locations, site design and operation is much simpler if the site is not subject to flooding or seepage.

Criterion No. 4. Seek sites with ground-water conditions that minimize the potential for contact with the wastes. There should be sufficient distance between the waste and the underlying ground water to allow for early detection of any leakage well before it would contact the ground water.

Water provides a mechanism for leaching and transport of radionuclides, and so should be excluded from the waste disposal trenches to the extent possible. Locating the site in an arid area where there is a thick unsaturated zone below the trenches eliminates the possibility for direct contact between the wastes and ground water.

A minimum depth of 100 feet between ground surface and the most-shallow permanent saturated zone was chosen as a convenient yardstick during the Phase 1 and 2 siting studies. This allowed for a separation of at least 50 feet between the ground water and the bottom of a 50-foot deep trench. The depth to ground water at the candidate sites was much greater than 100 feet.

Geotechnical Suitability Criteria: Four criteria describe geotechnical suitability.

Criterion No. 5. Seek sites underlain by porous, non-indurated geologic materials that have primary porosity rather than difficult to characterize secondary (fracture or solution opening) porosity that occurs in bedrock.

One of the primary objectives in choosing a site is to choose a site at which the geologic features which will contribute to the isolation of the wastes are homogeneous, pervasive, and easily measured and characterized. Determining the location of fractures in indurated materials, and predicting the movement of water in fractures is difficult. Locations where indurated materials could represent a primary pathway of migration were avoided.

* US Ecology, *Proponent's Environmental Assessment, California Low-Level Radioactive Waste Disposal Project.* Newport Beach, California, May 1, 1989.

Criterion No. 6. Avoid areas displaying the possibility of significant future tectonic activity.

Criterion No. 7. Avoid areas of potential future volcanic activity.

Criterion No. 8. Avoid geomorphically unstable areas of sand dunes, active dune sand, subsidence and landslides.

Criteria 6, 7, and 8 reflect steps to meet regulatory requirements to assure site predictability and stability.

2. SITE CHARACTERIZATION

This section discusses site characterization issues and describes techniques used by the study team to characterize aspects of site areas and sites at the different phases of the selection process.

2.1. Surface Water Considerations

2.1.1. Phases 1 and 2

Surface water characterization during Phases 1 and 2 addressed the drainage and erosional stability of potential sites. Key evaluation criteria used are:

The site must be well-drained and free from areas of flooding or frequent ponding.

Waste disposal shall not take place within the 100-year floodplain (as defined in Executive Order 11988).

Candidate sites with small upstream drainage basins are sought.

Areas where erosion rates are high, or where potential erosion could significantly affect the site's ability to meet the performance objectives should be avoided. (This is the surface water expression of the site stability requirement).

The following surface water conditions at the candidate sites were compared:

1. Proximity to the 100-year floodplain and the Regional Maximum Flood limits for flows in well-defined washes,

2. Flood zone classification with respect to upstream drainage,

3. Long-term flood protection requirements against the Probable Maximum Flood, and

4. Short-term flood protection and debris considerations.

Candidate sites were evaluated using the above parameters. The comparisons favored sites that were well-drained, stable, and would allow simple and effective storm-water management during site operations and after closure.

A standard FEMA procedure was used to evaluate the floodplain status of candidate sites on alluvial fans. This method determines the return period of a storm sufficient to create a one-foot depth of flow over the alluvial bajada. If the return period of this storm is 100 years or less, then the fan is considered within a 100-year floodplain.

Long-term flood protection requirements were compared by evaluating the erosional potential of the Probable Maximum Flood (PMF). A part of the evaluation consisted of calculating the maximum depth of scour which would occur during the PMF if flow became channelized above the site. The other component of this evaluation comprised determining the size and thickness of riprap necessary to protect facility features from erosion during the PMF.

Short-term flood protection requirements were compared by evaluating smaller flood flows and the potential for debris accumulation at the sites.

2.1.2. Phase 3

Surface water characterization during Phase 3 comprised calculations and analyses necessary to support the design of storm-water management features for the facility. These analyses comprised calculation of flood flows from off-site and on-site drainage basins for various rainfall events, calculation of flow depths and velocities for off-site and on-site flood flows, and calculation of riprap requirements to protect site drainage systems.

These analyses use standard hydrologic techniques and models. HEC-1 is used to calculate flows from off-site basins. Flows from on-site areas generally are calculated from SCS nomographs or estimated using the rational formula. These simple methods provide conservative estimates of flow from small areas such as individual trenches.

2.2. Subsurface Considerations

2.2.1. Phase 1

The primary subsurface requirements for an acceptable site are simple geology, stable geologic environment, adequate depth to ground water, and an absence of valuable resources. Phase 1 subsurface characterization activities used available geologic information to locate potentially suitable areas, and to identify available sites within these areas. The process consisted of the following steps:

1. identification of potentially suitable candidate site areas,
2. identification and exclusion of unsuitable or undesirable locations within the candidate areas,
3. location of potential candidate sites, and
4. ranking of the potential candidate sites.

During Phase 1, the hydrological and geotechnical input to the studies began by using areawide information to identify large areas that potentially could contain suitable sites. Easily identified unsuitable subareas, such as areas with shallow bedrock, were identified within these candidate areas. Geology and hydrology were important in ranking the candidate sites. The rankings were based upon the historic seismicity of the site area, depth to ground water, and the probable depositional environment of the site sediments.

The consideration of probable depositional environment provided an indirect way of assessing the probable complexity of site sediments. The site evaluation criteria lead to the selection of candidate areas within alluvial valleys. The study team determined that the most favorable depositional environment within these valleys probably would exist near the midpoint of the alluvial fan, that is, about midway between the valley drainage and the edges of the valley. Depositional conditions were likely to have remained constant at this location.

Distal (or lower) alluvial fan sediments and lacustrine or playa sediments are most likely to occur together near the valley drainage. Distal fan sediments usually reflect the complexity of the environment within which they were deposited. Dramatic horizontal lithologic variations are common within such deposits. The variations can be so abrupt that their satisfactory characterization is practically impossible. Lacustrine or playa sediments generally are homogeneous horizontally, but vary vertically, and likely are interbedded with distal fan deposits which have strikingly different properties than the lacustrine or playa deposits.

Proximal fan alluvium near the valley edge may be heterogeneous because the nearness to the bounding mountains can lead to the development of channelized drainage, and channels of anomalously coarse-grained materials in the alluvium. The proximity of the alluvium to the source of the sediments can lead to the deposition of poorly-sorted sediments and the deposition of an extreme range of different sizes of sediments representing deposition during smaller and larger flood flows.

Sites located near the middle of the alluvial fan are compatible with other geologic and hydrologic criteria. Bedrock and ground water are likely to be deep away from the valley edges. The mid-fan locations also are compatible with the surface water hydrologic criteria described above.

2.2.2. Phase 2

Subsurface characterization activities during Phase 2 mostly comprised the collection of data to confirm or deny the presumed subsurface conditions at the site. A few wells were constructed in the first saturated zone beneath each candidate site to confirm the anticipated depth to water. Rudimentary soil classifications of soils from the well borings were made to verify qualitatively that the subsurface is homogeneous, and to support an assessment of the probable geotechnical stability of the subsurface materials. Geophysical studies were conducted at the site to verify the basic geologic conditions, such as depth to bedrock, determined from regional information.

Periodic and continuous environmental data necessary to address other aspects of site suitability were collected during Phase 2.

2.2.3. Phase 3

Phase 3 studies comprise detailed subsurface characterization at the proposed site. The Phase 3 studies are designed to provide detailed information necessary to describe the geotechnical and hydrological conditions at the site. The investigations emphasize the subsurface characteristics that influence the behavior of the site.

Geotechnical parameters are being measured by laboratory tests, and by geophysical studies. Hydraulic properties of the most shallow saturated materials and ground-water conditions within this zone have been determined by monitoring water levels in the wells, laboratory analyses of water samples from the wells, and single-well pumping tests in the wells. A canvas of wells and springs in the site area was completed to identify current ground-water users and to allow an assessment of likely future ground-water use.

Although the saturated zone is studied during the Phase 3 program, characterization of the saturated zone is not the major thrust of the program. The site provides multiple barriers to the migration and dispersal of the waste materials to be buried at the site. The first component of the site that is important to the long-term isolation of the waste is the unsaturated zone.

The characterization of the vadose zone is critical to the prediction of future site hydrologic behavior, and to assessing changes in the site hydrologic regime that may result from the construction and operation of the disposal facility. Accordingly, the Phase 3 site characterization program emphasizes the characterization of this zone. Methods of investigation being employed in this program include direct measurement of saturated and unsaturated hydraulic properties of the sediments, analyses of radioactive isotopes in soil moisture, and chemical analyses of soil and water.

Air piezometers have been installed at different depths within the vadose zone. These piezometers have been used to measure the bulk conductivity of the sediments to air. The saturated hydraulic conductivity of the sediments can be determined from these values. The air piezometers also have been used to obtain soil moisture samples for analyses. These analyses provide estimates of the amount of time the moisture has been in the subsurface. These estimates can be used to bound the rate of moisture movement in the vadose zone, and provide a portion of the information necessary to estimate ground-water recharge at the site.

Direct measurements of unsaturated hydraulic properties of the vadose zone are obtained from a large-scale infiltration test. In this test, a large volume of water is placed in a shallow pond, and the migration of the water in the unsaturated zone is monitored using psychrometers and tensiometers. The monitoring of the redistribution of the moisture will continue for several months.

Chemical and mineralogical analyses of site soils and water are being conducted. These analyses provide information necessary to characterize the geochemistry of the vadose zone, and to predict the solubility and migration rates of waste constituents in trench leachate.

A model has been constructed of the vadose zone using the information from the site investigations. The model will be calibrated using the infiltration test data. This model is an important part of the characterization of the unsaturated zone. It will be used to assess the current conditions at the site, and as the primary tool to assess future site behavior.

3. ASSESSMENT OF FUTURE BEHAVIOR

Predictions of future site behavior are based upon computer codes reflecting conceptual models and calibration values determined from the site investigation. The basic philosophy followed in predicting future behavior is to use the simplest models appropriate for a particular task. Different models are used for different tasks. The use of complex, coupled models is avoided when the same task can be accomplished with a series of simpler models coupled by the engineer. This approach provides more understandable models of site behavior than would the use of complex models, and allows the analyst better opportunity during the analysis to review the behavior of site components.

Scenarios selected for evaluation of future site behavior have been selected to be reasonable and conservative. The scenarios are selected to provide pessimistic bounds upon site performance, while remaining representative of actual conditions which could exist at the site. For example, analyses of trench infiltration are based upon a series of realistic, although improbable, assumptions regarding the condition of the disposal unit, and realistic estimates of extreme precipitation events. The results of the analyses are interpreted within a realistic framework. Improbable combinations of rare events are not assumed, and the projected performance of the site is based upon expected, not unrealistic, site conditions.

This realism is essential during site selection. The effect of unrealistic evaluations is to make all sites appear equal. This is contrary to the site selection process, which should evaluate actual site conditions and determine the site best suited for the proposed facility. The same constraints apply during site design. Designs based upon unrealistic assumptions may not be appropriate, and can lead to inferior site performance.

3.1. Flood and Erosion Estimates

The disposal unit is subject to damage by floods. Improperly managed flood flows could concentrate at critical locations on the unit, and erosion damage to the disposal unit cover could result. Analyses have been conducted to support the design of the disposal unit drainage systems, and to determine appropriate erosion protection for sensitive components.

The flood analyses use standard hydrologic techniques to calculate design flows and velocities. Estimates of erosion from small areas such as the tops of the trenches have been made with standard correlations between flow parameters and soil properties. These estimates are used primarily to verify the design of the disposal unit drainage system.

Estimates of sediment yield and cumulative, long-term site erosion have been made using a variant of the CREAMS model developed by the U.S. Department of Agriculture. The particular computer code used is a watershed simulator. Components of the simulator include a rainfall simulator, and flow and sediment routing. The model calculates erosion and sediment yield using the modified universal soil loss equation.

Riprap design generally has followed accepted procedures of the Nuclear Regulatory Commission for erosion protection at uranium mill tailings impoundments and the Corps of Engineers for riprap sizing in flood-control channels. These procedures are adequate and conservative, and yield reasonable thicknesses and sizes for the riprap.

3.2. Subsurface Behavior

Predictions of the behavior of the trench contents and the underlying vadose zone are important to assessments of future site behavior. Estimates of trench subsidence have been developed from estimates of void spaces in waste containers and the density of soil backfill around the waste containers. Backfill compaction estimates are based upon a field-scale test using soils similar to those at the Ward Valley site. Lifts of containers filled with soil were placed in an empty portion of a trench. Backfill was placed around the containers and between the lifts and compacted. The containers and backfill were placed using methods and equipment typical of those which will be used at the Ward Valley facility. After the containers had been placed and covered, the mass was carefully disassembled, the condition of the containers was noted, and measurements of the density of the backfill at various locations within the backfill were made.

The most complex analyses of future site behavior are those simulations of the unsaturated zone. Issues such as recharge rates, flow velocity, potential transport, and the effects upon the hydraulic conditions brought about by the construction and operation of the disposal unit are being addressed in part through these analyses.

The analyses are being completed using a group of analytical and numerical models to simulate infiltration and evapotranspiration of rainfall, the movement of infiltrated water through waste materials, the leaching by the percolating water of radionuclides from the waste materials, and the movement of the moisture and dissolved radionuclides through the vadose zone.

The primary model used in these analyses is a model of the unsaturated zone calibrated to the large-scale infiltration test and the geologic and hydrologic properties of the deeper sediments. This model is used to simulate movement of moisture and contaminants from the trenches through the unsaturated zone. This model also is used, with appropriate modifications, to calculate the movement of moisture through the disposal unit covers.

Analyses of infiltration of rainfall into the disposal unit covers are being performed using a lumped-parameter moisture balance model developed by the U.S.G.S. Subsequent movement of the infiltrated moisture is simulated using the calibrated numerical model or simpler analytical models as appropriate.

Analyses are expected to show that little ground-water recharge occurs under normal conditions. Recharge that does occur is the result of extreme events. After the disposal facility has been constructed, recharge also could result from ponding over damaged disposal unit covers.

Potential infiltration is being examined for a range of climatic conditions and disposal unit cover conditions. Scenarios being examined include an intact disposal unit cover, an intact cover over a portion of the disposal unit and damaged covers over the remainder, and damaged covers over the entire disposal unit. For purposes of these analyses, a damaged cover is assumed to remain intact, but to allow no drainage of rainfall from the covered unit. Estimates of subsidence described above demonstrate that the assumption of an intact cover is appropriate.

A series of analyses of moisture conditions in an open trench also is being completed. The purpose of these analyses is to determine the likelihood of significant changes in the moisture content in the underlying vadose zone during site operation. These analyses will be used to assess the need for extraordinary efforts to remove storm water that might accumulate in a trench, or the need for additional measures to divert rainfall from the open trenches.

Rainfall events simulated include a 6-hour storm occurring under typical summer climatic conditions, and a 24-hour storm occurring under climatic conditions typical of winter. These events simulate large thunderstorm and convective storm rainfalls at the site. A simulation also is being performed using a large, arbitrarily selected amount of ponding over the disposal unit. This simulation is not intended to be realistic, but to provide an upper bound to potential infiltration of moisture into the disposal trenches.

Leaching of the trench contents by infiltrating water is calculated from solubilities of radionuclides observed at other sites, and from site-specific partition coefficients measured for site soils, and water equilibrated with the soils. The fraction of the trench inventory leached by a given amount of moisture is calculated using a model developed for the NRC which considers the effects of sorption on backfill soils, and inventory depletion by leaching and decay.

Travel times in the vadose zone from the bottom of the disposal trenches to the ground water beneath the site are expected to be measured in thousands of years. Because of the expected long travel times, only mobile and long-lived radionuclides have any chance of reaching the ground water in detectable concentrations. Many radionuclides of concern at humid sites, such as tritium, and components of fission and corrosion products, will decay to undetectable levels near the trench under any practical assumptions of quantities and leaching characteristics.

Potential impacts of the site upon the environment and public health are being evaluated through a complex pathways analysis. This analysis considers potential exposure through a variety of routes during and after site operations. The assessments described above are a part of the input to the pathways analysis.

4. ENGINEERED ENHANCEMENTS

The design of the Ward Valley site includes features to enhance the performance of the site. The philosophy of the site design is to provide a disposal unit that complements the existing environment to the extent possible. The design protects those site features, such as the vadose zone, that are important to the long-term isolation of the buried waste.

4.1. Operational Considerations

The importance of the operation of the disposal site is recognized in the design. Operational procedures are being developed that will support the goals of long-term trench stability and protection of the existing condition of the vadose zone. The methods of waste and backfill placement have been developed to provide stable trench contents consistent with radiation exposure control and the condition of the waste containers.

Drainage around open trenches is controlled to prevent the entry of surface runoff in the open trench. The amount of open trench space is maintained at a practical minimum to limit the amount of moisture that might seep into the vadose zone. Analyses are being conducted to determine potential changes in the moisture regime in the vadose zone during site operations. These analyses will provide information regarding the appropriateness of the water management program, and the need for additional measures to remove water or limit its entry into open trenches.

4.2. Closure Considerations

4.2.1. Surface Water Management

Post-closure surface water management comprises the diversion of off-site flood flows around the disposal unit, and the drainage of water from the disposal unit cover. Off-site water is diverted around the site by a low berm that completely surrounds the disposal unit. This berm is constructed before site operation, and is incorporated into the disposal unit cover at closure. The diverted flood water is directed to either side of the disposal unit by the berm.

Calculations show that the Froude number of the flow over the alluvial fan during the PMF is about 0.7. This value is near the lower limit of values where flow may become unstable. Slightly larger flows or flow concentrations in small depressions might show higher Froude numbers, and flow in such depressions might become supercritical. Supercritical flow impinging upon the main diversion dike is not desirable, and so the flood diversion incorporates a series of small training dikes upstream of the disposal unit. The purpose of these dikes is to prevent the occurrence of supercritical flow at the main diversion berm. The dikes also will begin the diversion of flow around the disposal unit; however, that function of the dikes is incidental.

The main diversion dike is constructed over undisturbed areas of the site to prevent damage from trench subsidence. Figure 2 shows the main components of the off-site storm water management system.

The cover of the disposal unit is contoured to encourage drainage and prevent concentration of flow on the cover. The cover is corrugated, with spines running along the center of each trench, and swales running between the trenches. The drainage swales slope to the east, and drain over the eastern section of the main diversion berm. The slope of the disposal unit cover is nearly equal to the slope of the alluvial fan, which averages about 2.5 percent. The depth of flow on the disposal unit cover is less than one foot, and the maximum velocity is less than two feet per second. Protection of the cover from erosion will be accomplished with a thin cover of small gravel.

Erosion of and around the main diversion berm should not occur. The berm itself and adjacent areas subject to erosion will be protected by riprap, and flow depths and velocities are small enough that erosion should not occur. Conservative calculations made to estimate the maximum depth of scour that might occur if flows become concentrated during an extreme flood event show that scour could be as much as 20 feet. No wastes will be buried more shallow than 20 feet below the original ground surface. This design feature has been incorporated to provide additional assurance against dispersal of the buried wastes during extreme flood events. Of course, the deep burial is advantageous to aspects of long-term site performance other than erosion protection.

4.3. Trench and Disposal Unit Cover Design

Wastes disposed at the Ward Valley site will be segregated according to NRC waste classification. Separate trenches will be used to dispose of type A wastes and types B and C wastes. The volume of B and C wastes expected at the site is small compared to the volume of A waste; 90 percent of the trench capacity at the site is devoted to the disposal of A wastes.

A wastes are inherently unstable because of the character of the wastes or the waste containers. This instability makes it difficult to bury the wastes in such a way that the resultant mass is stable. Some subsidence of the A trenches is anticipated; however, because of limits on concentration and half-lives of radionuclides in A waste, the radioactivity in the wastes will decay to innocuous levels within a period of about 100 years or less.

Types B and C wastes are physically stable wastes, and so subsidence in trenches in which these wastes are disposed can be controlled by proper site design and operation. Because of concentrations and half-lives of the radioisotopes in B and C wastes, these wastes will remain radioactive for several hundred years.

The different requirements for sequestering the various types of wastes has been recognized in the design of the Ward Valley facility. Trenches in which A wastes will be disposed are constructed about 20 feet deeper than the single trench (the BC trench) in which B and C wastes will be disposed. Some subsidence of the A trench covers is expected, and this subsidence may result in increased infiltration into the trenches. Constructing the A trenches deeper than the BC trench will prevent the direct movement of water from the A trenches into the BC trench in the event that water accumulates in the A trench.

The trench cover designs are different for the two types of trenches, again in recognition of the different stabilities of the trench contents and different requirements for sequestering the wastes. The cover of the A trench is a simple soil cover which depends upon soil moisture storage and evapotranspiration to limit infiltration. Analyses demonstrate that this cover limits infiltration into the A trenches to below acceptable levels. Figure 3 shows a schematic cross-section of the trench cover.

Subsidence of the A trench covers probably will necessitate repairs during the early life of the site. The simple cover over the A trench will be easy to maintain. Repairs can be made from the top of the cover instead of requiring reconstruction of a variable profile. This design feature is consistent with the requirement to minimize long-term maintenance of the disposal facility.

Most of the radioactivity disposed in the site will be contained in the B and C wastes. The concentrations and half-lives of radioisotopes in these wastes require that the wastes be sequestered for several hundred years, and that amounts of infiltration into the trench be limited. These design goals are achievable without excessive long-term maintenance because the contents of the trench where B and C wastes are disposed will be stable. The cover designed for the trench in which B and C wastes are disposed is a layered cover. Each layer contributes to the isolation of the waste by acting as a barrier to infiltration, erosion, or biotic intrusion. The cover is constructed of natural materials. These materials will be stable over the lifetime of the facility. The amount of infiltration through the intact trench cover is small, and so low-permeability barriers constructed of clay or synthetic membranes are neither necessary nor desirable at this arid site.

5. SUMMARY

The low-level radioactive waste disposal site selection program in California is a three-phase program consisting of regional and local screening, candidate site identification, and detailed site characterization and design. Technical challenges have arisen during this process. During site selection, these challenges relate primarily to comparing and contrasting sites that have different favorable and unfavorable characteristics. The California study team has responded by developing standard site evaluation scenarios and using standard engineering methods to compare probable site performance.

Technical issues that have arisen during the site characterization and licensing phase relate primarily to characterizing storm flows over the alluvial fan on which the site is located, and characterizing the unsaturated zone. Storm flow patterns are difficult to characterize because most flow occurs as sheet flow, and not in defined channels. The unsaturated zone is the primary barrier to the dispersal of waste constituents into the environment, and so characterization of the zone is prerequisite to proper site design and performance assessment.

The study team has addressed the surface water issues using standard methods and conservative assessments of the effects of flooding. The characterization of the unsaturated zone has been addressed through a series of activities including routine geologic characterization supplemented with innovative tests to measure saturated and unsaturated properties of the zone. A sophisticated flow model is used to interpret the test results. The calibrated model is used to predict future site behavior.

6. ACKNOWLEDGEMENTS

The activities described in this paper have resulted from the efforts of a capable and dedicated project team. Don Womeldorf is Chief, Environmental Management Branch, Department of Health Services. Reuben Junkert is the Project Director of the Low Level Radioactive Waste Program for the Department of Health Services. The State has retained consultants who have contributed immeasurably to the success of the program. Roy F. Weston and Envirosphere are the State consultants providing direction to the geologic and hydrologic activities.

US Ecology is the prime contractor to the State, and is responsible for developing and coordinating all selection and licensing activities, and ultimately for constructing and operating the facility. Ronald Gaynor is US Ecology's Senior Vice-President for Development Projects, Stephen Romano is the Project Manager, and Thomas Hanrahan is the assistant Project Manager.

Harding Lawson Associates is the principal geotechnical and hydrological consultant to US Ecology. They and US Ecology are the primary architects of the geotechnical and hydrological characterization studies. Donald Quigley is the Project Manager for Harding Lawson Associates, and Eric Lappala is the Technical Director.

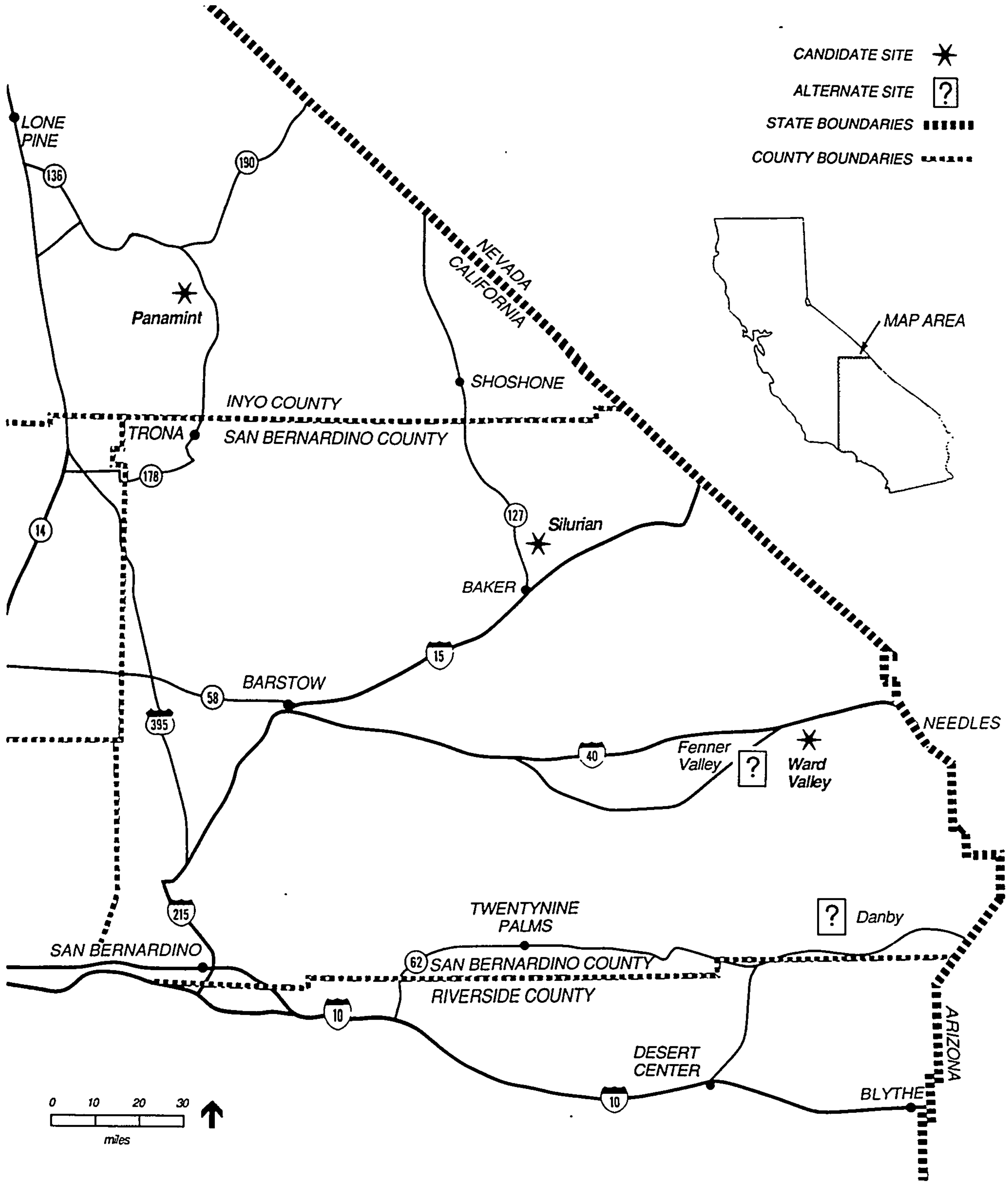


FIGURE 1

Low-level radioactive waste disposal facility candidate and alternate sites

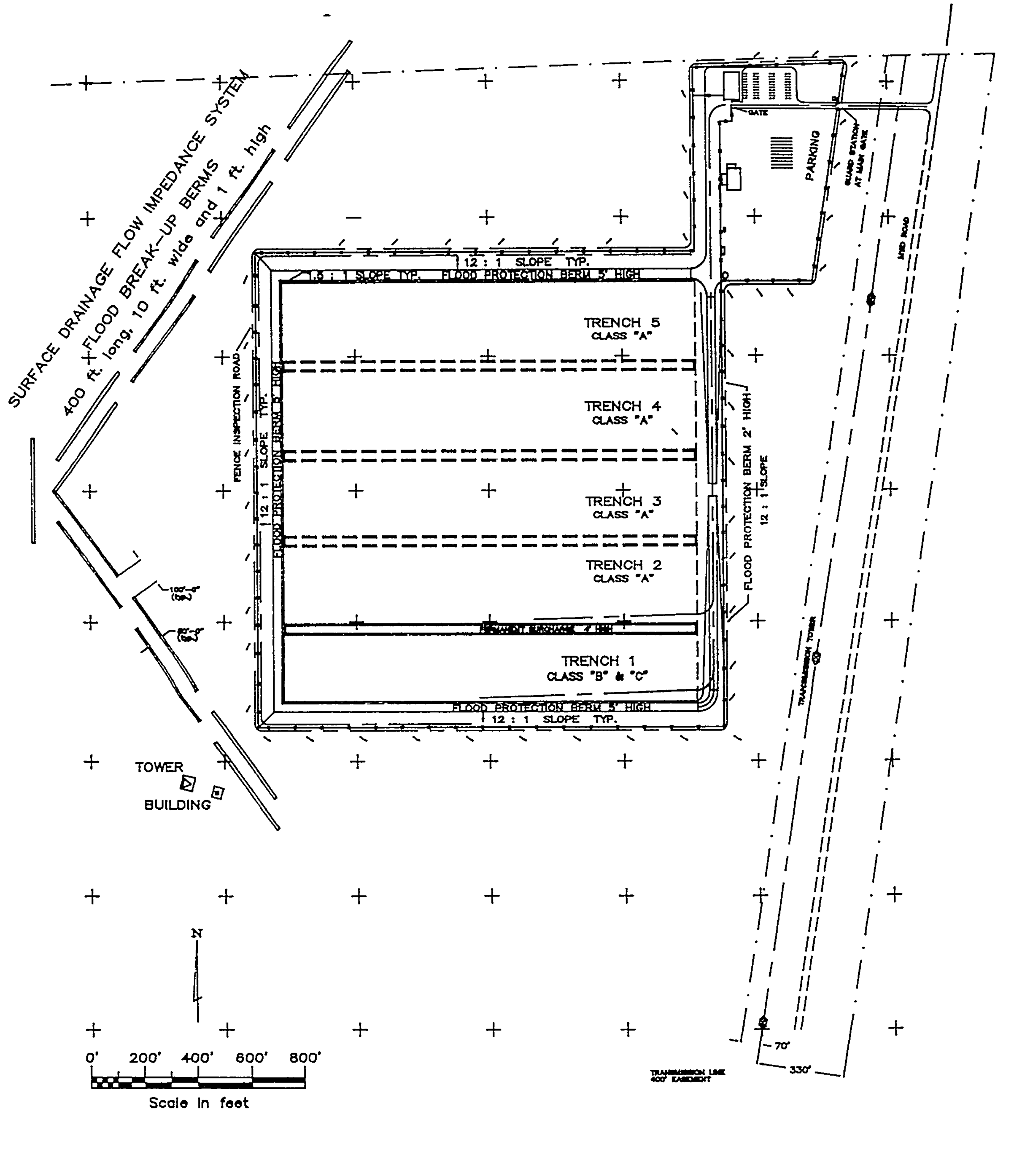
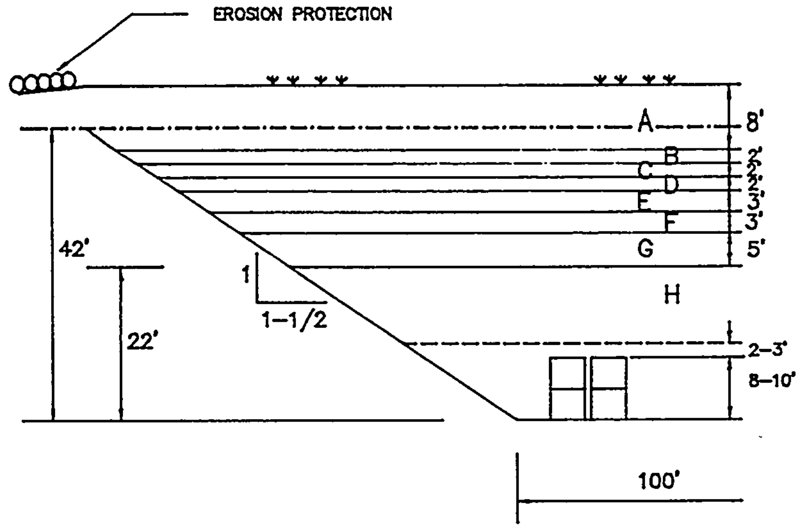


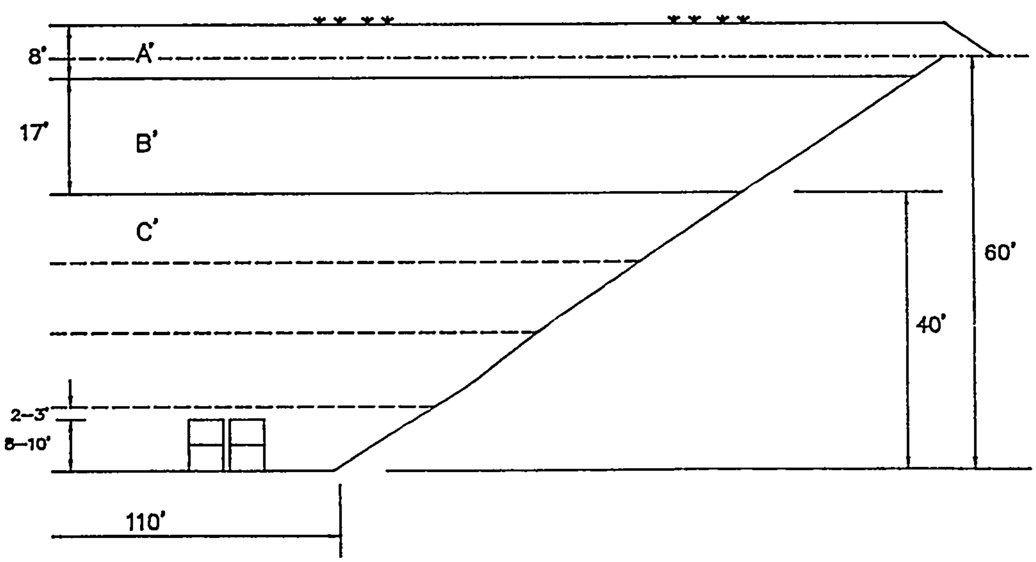
FIGURE 2
Stormwater management system

CLASS "B" AND "C" TRENCH



A = Vegetation/rooting layer (Silty sand and gravels)
B = Infiltration resistant layer (Fine sand)
C = Capillary layer (Coarse sand and gravels)
D = Infiltration resistant layer (Fine sand and cement)
E = Biobarrier (Cobbles and gravel)
F = Erosion resistant layer (Boulders to sands)
G = Common fill
H = Common fill and waste materials

CLASS "A" TRENCH



A' = Vegetation/rooting layer (Silty sand and gravels)
B' = Common fill
C' = Common fill and waste materials

FIGURE 3

Trench cover cross-sections

Challenges In Establishing LLW Disposal Capacity: Pennsylvania's Perspective

William P. Dornsife, Pennsylvania
Department of Environmental Resources

Lawrence J. Saraka, ROY F. WESTON, INC.

Background

The Commonwealth of Pennsylvania is the host state for the Appalachian States Low-Level Radioactive Waste Compact. Pennsylvania knew that it had a responsibility to comply with federal law (Low-Level Radioactive Waste Policy Act of 1980) but it also recognized that being one of the major low-level waste generating states Pennsylvania would most probably be the host state of any compact it joined. Department of Environmental Resources (Department) and elected officials believed that a Pennsylvania controlled compact would be the only compact that would be accepted by its citizens. Consequently the officials prepared legislation identifying Pennsylvania as host state to the Appalachian Compact provided that member states grant the Commonwealth the assurances it needed. States contiguous to Pennsylvania were eligible to join and Delaware, Maryland and West Virginia passed legislation to join the Compact. The United States Congress ratified the Appalachian Compact legislation in 1988.

Even though Pennsylvania is host state for the Compact, state implementing legislation was non-existent until early 1988. In February of 1988 Governor Casey signed the Low-Level Radioactive Waste Disposal Act (Act) into law. The Act incorporates three years of Departmental work and interaction with the legislature, a Public Advisory Committee on Low-Level Waste, many interest groups and the general public. It is a comprehensive Act that: provides the Department with broad powers and duties to manage, license and regulate a low-level waste disposal program; requires implementation of an open public process during the site development phase; and establishes benefits and guarantees for communities affected by the establishment and operation of a low-level waste site.

The Department considers that its powers and duties to manage, license and regulate a low-level waste disposal program begins with interpreting the provisions established by the Act. Interpretation will establish how the Department intends to implement its authority. The Department is communicating interpretations through various methods such as regulation, policy, and written or verbal guidance. Interpretations typically require a mix of technical, policy, and social solutions to clarify concepts established by law.

This paper identifies select items established by law that require technical solutions. Its purpose is to share some creative approaches for solving "unmanageable" legislative requirements.

Items, Issues and Technical Fixes

INTRODUCTION

Three legislative requirements are discussed. These items:

- o Rebuttable presumption
- o Zero release goal
- o Long term care

represent concepts that some groups expect to be carried out to the letter of the law. These same concepts are viewed by others as vague, unacceptable or unachievable. The Department has the responsibility to satisfy the law and create achievable standards.

REBUTTABLE PRESUMPTION

The Pennsylvania Act specifies that it shall be presumed as a rebuttable presumption of law that the disposal facility operator is liable and responsible for all damages and radioactive contamination within three miles of the facility boundary without proof of fault, negligence or causation. In order to rebut the presumption, the operator must clearly prove that it did not contribute to the damage or in the case of radioactive contamination prove that; the contamination existed prior to operations, or the land owner has refused the operator access to conduct pre-operational studies, or the contamination was a result of some cause other than the facility.

The intent of the rebuttable presumption provision is to shift the responsibility of proof from an individual or land owner to the disposal facility operator. This is considered acceptable because the operator has the resources and is required to collect environmental data to show the disposal facility is operating in a manner that protects the public and the environment; an individual or owner neither has the resources or obligation to collect data on facility performance.

Concern over the concept of rebuttable presumption was first raised during the request for proposal process (RFP) to select an operator for the disposal facility. The seriousness of concern was demonstrated by a no-bid response from all interested companies. A meeting was conducted with the companies and they cited two issues concerning rebuttable presumption:

- The phrase "liable and responsible for all damages"
- Evidence acceptable for defense.

The companies indicated that "liable and responsible for all damages" could leave them exposed to countless, frivolous lawsuits that would be time consuming and costly to defend. It was recommended that the phrase be defined clearly. Also, the Act is silent on evidence the operator could use to defend against rebuttable presumption. The companies recommended the Department specify evidence acceptable as defense in rebuttable presumption cases.

The Department has taken the companies' recommendations under consideration and in its second RFP it has committed to promulgate regulations on rebuttable presumption. Conceptually, the regulations will clarify that all damages means physical harm or contamination resulting from release of radioactive materials from or operations at the disposal facility and contribution to damages is intended to mean operations at or contamination from the disposal facility is the primary cause of damages. In addition, the operator can use radiation monitoring data from any person to as defense in rebuttable presumption cases.

Since the operator will be free to use any radiation monitoring data, a solution is completely within his control. The operator can implement as rigorous a monitoring program as it deems necessary for defending against rebuttable presumption cases. The Department envisions that the operator would establish a reliable data base on background radiation levels and community health records prior to facility operation. This would require an extensive, documented and controlled pre-operational monitoring and health studies program.

Once the facility is operating, the operator has multiple levels of monitoring data that can be used. First, there is the disposal unit monitoring system that has the capability to detect radiation prior to release from the facility. Next there is the environmental monitoring program that will include on-site and off-site monitoring stations. Finally, there is the periodic health monitoring program. In implementing this type of program the operator would have a broad range of data for establishing a case to show that the facility did not cause the damages or contamination.

Apparently the Department's commitment and conceptual clarification of rebuttable presumption satisfied some of the companies' concerns. Two companies submitted proposals and agreed to proceed in the Commonwealth procurement process.

ZERO RELEASE GOAL

The Act specifies that the disposal facility shall have the goal of a zero release capacity.

The "zero release disposal facility" concept became an issue during the public comment period for the draft low-level waste regulations. The design section of the draft regulations included a requirement that the design goal for the facility be zero release while the performance objectives included annual dose standards (25 millirems - whole body, 75 millirems - thyroid, and 25 millirems - any other organ) for any member of the public. At public meetings and public hearings, individuals suggested that the Department will ignore the zero release goal, enforce the dose standards cited in the performance objectives and allow controlled release of radioactive materials up to levels specified in the performance objectives. The Department's response during the meetings and hearings was: current technologies can not guarantee a zero release facility; the regulations do not allow the operator to arbitrarily release materials up to the established standards; and the performance objective for protection of the general population is a Nuclear Regulatory Commission (NRC) compatibility item, failure to comply with NRC's requirements may result in denial of agreement state authorization.

After the public comment period the Department considered the comments on "zero release goal" and prepared a strategy for resolving the issue. First, the Department would send a formal request to the NRC asking it to revise performance objective 61.41 (protection of the general population) to specify a zero release standard. Then anticipating a negative response from NRC,the Department would identify additional sections of its draft regulations that could be amended to further promote the goal of zero release. The Department implemented its strategy; NRC responded negatively to the request and the Department proceeded to revise its draft regulations.

The Department clarified its position on zero release through making programmatic and technical changes to the draft regulations. At the program level the Department clarified that the performance objectives establish the minimum overall level of safety that the facility must meet. Furthermore, it stated that operation within those levels are adequate to protect public health and safety. It reaffirmed its commitment to the goal of zero release by: reiterating that the disposal facility shall have a design goal of zero release; and adding that construction, operation and closure activities be planned and implemented in a manner that contributes to the goal of zero release.

The most direct technical requirement addressing the goal of zero release is contained in the monitoring plan requirements. It specifies that, for any off-site measurement that exceeds radiation levels, the operator shall initiate actions to identify and abate the source of the off-site radiation.

When viewed collectively, the technical requirements establish that the disposal facility functions as a system comprised of waste packages, engineered disposal units and disposal site all of which are overseen by multiple monitoring systems. Because there are redundant barriers and monitors built into this system, there is little reason to expect contamination to reach the off-site environment. Consequently an off-site radiation dose of zero is considered achievable.

LONG TERM CARE

The Act specifies that a custodial agency provide for institutional control (continued observation, maintenance, and care) of the disposal facility following transfer of control from the disposal facility operator to the custodial agency. The law further specifies that institutional control shall continue for the hazardous life of the waste. Commonwealth law defines hazardous life as the time period required for the radioactive materials within a given container or package to decay to maximum permissible concentrations as defined by federal law or by standards established by the state, whichever is more restrictive.

The definition of hazardous life establishes a scenario in which custodial care could be required for tens-of-thousands of years, based on consideration of the half-lives of some radionuclides contained in typical low-level waste. However, the provision that enables the state to establish a hazardous life standard does provide flexibility for establishing a specific institutional control period.

The approach for establishing a hazardous life standard became an issue during drafting of the low-level waste regulations. Some individuals considered that the standard should be based on the longest-lived radionuclides contained in the waste while others recommended that the standard be more in line with low-level waste streams.

One of the Department's duties includes creation of a waste classification system that takes curie concentration, toxicity and hazardous life into consideration. The Department decided to adopt the Nuclear Regulatory Commission's waste classification system which is based on waste stream considerations. The Department based a portion of its hazardous life standard on this waste classification system establishing that the hazardous life of low-level wastes is:

- o Class A waste - 100 - years
- o Class B waste - 300 - years
- o Class C and mixed waste - 500 years

The remaining portion of the hazardous life standard is based on a demonstration, by the custodial agency, that public health and safety will be protected. It establishes that the hazardous life of the waste is the amount of time it takes for the disposed waste to decay to levels that demonstrates unrestricted use of the site would result in a dose to a member of the public using the site that is no greater than the dose from the natural background radioactivity in the soil prior to the site being used as a disposal facility.

In demonstrating that the site can be released for unrestricted use (license termination), the custodial agency can use technical data collected throughout the life of the facility. This includes: referencing the facility design and its expected performance; showing acceptable past performance, based on actual data collected from disposal unit and environmental monitoring programs; and predicting future facility performance, based on at least 35 years of monitoring actual material components of the disposal facility. The approach provides the custodial agency with complete flexibility for deciding when to demonstrate that unrestricted use of the disposal site will have no adverse affect on public health and safety.

<u>Lessons Learned</u>

Management of low-level radioactive waste disposal has taken a new direction, as evidenced by several low-level radioactive waste bills enacted by state governments. Many of the mandated concepts are pressing the limits of technology or forcing the market place to revisit how it conducts business. The regulator will play a crucial role in establishing how the new generation of low-level waste disposal facilities will operate and in ensuring such operations will protect public health, safety and the environment.

The Department has learned many lessons while carrying out its duties and establishing the low-level waste program. First, it is necessary for the regulator to understand the concepts embodied by the law and then clarify the concepts by regulation, policy or guidance.

In order to obtain support and ensure a workable approach, the message (regulation, policy or guidance) must be communicated to all segments of the public. This includes explaining the requirements mandated by law and discussing the proposed approach to meeting these mandates. Communication also includes being receptive to all comments and having the flexibility to incorporate constructive recommendations and the determination to refuse unreasonable demands.

Finally, the states face similar challenges and issues. Each state is a valuable source of information and each have contributions for overcoming the obstacles that stand in the way of establishing new low-level waste disposal facilities.

PUBLIC PERCEPTIONS OF LOW-LEVEL WASTE RISKS -- LESSONS LEARNED IN PENNSYLVANIA

WILLIAM DORNSIFE, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

PATRICIA SERIE, ROY F. WESTON, INC.

INTRODUCTION

People in Pennsylvania are no different than citizens of other eastern states, other states, or any place in the world -- they care most deeply about their health, the safety and security of their families, their investments, and their autonomy. How a particular risk is perceived depends on how it is believed to affect those valued possessions. The perception of risk from exposure to the radioactivity contained in low-level radioactive waste is critical to Pennsylvania's program to site and develop a low-level waste disposal facility. The Commonwealth's program, administered by the Department of Environmental Resources, places high priority on public dialogue on this issue.

This paper discusses the Department's program to develop and promulgate low-level waste regulations, provide a framework for selection of a qualified disposal facility operator, contract with the selected firm, and oversee its activities in siting, licensing, constructing, and operating the facility. This facility will meet the needs of the states of the Appalachian States Compact, including, in addition to Pennsylvania, West Virginia, Maryland, and Delaware. The focus of the paper is on the public information and outreach program accomplished to date, and the lessons learned regarding public perceptions of risk.

WORKING WITH REPRESENTATIVES OF INTERESTED "PUBLICS"

Pennsylvania's experience from the inception of the program in the early 1980's has demonstrated the usefulness of working with a small but representative group of interested citizens. The early Public Advisory Committee, or PAC, played an active role in defining the issues that would ultimately be addressed in state enabling legislation and in regulation, and in the coalescence of the Appalachian States Compact with Pennsylvania as the initial host state. Membership on that committee included representatives of industry, academia, interest groups, and government. Members vigorously participated in discussions, studied the issues, and provided their opinions and ideas.

With passage of Pennsylvania's Low-Level Radioactive Waste Disposal Act in 1988, a new group called the Low-Level Radioactive Waste Advisory Committee was constituted. Many of the same organizations remained involved, and the "institutional memory" has been strong. This has been a positive step, because the several years of building background in the state has been an important part of the program's ability to move forward.

Perception of risk was a driving factor in the public's consideration of low-level waste legislation and regulations. Defining acceptable public exposure limits, within the 25-millirem-per-year limit of 10 CFR Part 61, received a great deal of attention. By law, a disposal facility in Pennsylvania must be designed and operated with a release goal of zero. The Low-Level Radioactive Waste Disposal Act sets that goal, and resulting regulations provide a performance framework for demonstrating compliance with it. While technical experts will agree that even a 25-millirem limit is certainly conservative, the imposition of the zero release goal is really not in conflict with the industry ALARA standard. By negotiating it as a formalized, legally-mandated goal, the interest groups that pursued this issue are much more comfortable with the stringency of the regulations.

Monitoring is another area where public confidence was increased. Defense in depth is assured by using redundant monitoring systems that must include:

- Monitoring within each disposal unit to detect movement of radionuclides
- Monitoring the performance of the construction materials used in the facility through a test disposal unit
- Monitoring air, water, soil, and other environmental elements to detect any escape of radionuclides

Contamination found in the vicinity of the facility is to be assumed to be the fault and the responsibility of the operator, unless successfully refuted. Liability for remediation rests with the operator as well. Any residents within five miles of the facility will, upon request, be provided with whole-body monitoring for the presence of radioactivity, once operations begin.

Local inspectors as well as state regulatory personnel will inspect receipt of waste shipments, facility monitoring, and other site activities to assure themselves that all license conditions are being satisfied. Inspectors, including the local ones, will have the authority to close down the facility if an imminent problem arises. Local risk is also to be addressed through the provision of emergency response units, with training for personnel. Local involvement in the overall program will also be accomplished through membership of two local residents on the Advisory Committee, and one on the Compact Commission. Funding will be provided for oversight of facility operation by a local Environmental Advisory Council.

Technical experts who have been involved in the 10 CFR Part 61 regulatory scene for the past decade will generally agree that the regulation relies on the natural features of the selected site to satisfy the performance objectives and ensure environmental safety. The regulations were developed and tested with shallow land disposal as an eminently acceptable option. Public perceptions of the risk from land disposal, however, stem not from a detailed understanding of the environmental impact statement and the analyses supporting Part 61. They are based on each citizen's understanding that their town's municipal landfill is leaching into the water supply, on their belief that Sheffield, Maxey Flats, and West Valley were environmental disasters; from the experience at Love Canal, and from several decades of other highly visible "dump" problems.

This has driven a disposal method approach in Pennsylvania that is similar to results in many other parts of the United States. By law, Pennsylvania's disposal facility must incorporate an "above-grade" engineered disposal design, unless it can be demonstrated that other designs provide greater protection. Traditional shallow land burial is explicitly prohibited. This means that, in many people's opinion, the facility design will be overdesigned, and will exceed technical requirements. Nevertheless, this position was the one strongly pursued by major interests within the Commonwealth, and agreement with it allowed the state legislation to be passed and the regulations to be developed in time to meet other schedule constraints. A compromise position has emerged, adding to the overall acceptance of the concept of having a facility in Pennsylvania at all.

Negotiation has thus proved a useful technique in Pennsylvania, working through the representative group primarily and also with the general public through a statewide public participation program. The Advisory Committee serves as a microcosm of statewide interests, allowing the Department a "captive audience" to educate and test ideas. Negotiation with the committee means that the major interests in the larger arena are consulted in a representative fashion, and has allowed the compromise positions described above. The members of the committee took a lively interest, and continue to do so, in affecting policies and plans for implementation.

In addition to those elements described above that were amenable to negotiated agreements, the committee has also taken a very active role in selection of a qualified private firm to develop and operate the disposal facility. The Department had been consulting with the committee from the beginning of the program about the requirements for an operator and about the overall process for selecting and contracting with such a firm. Preparation of the request for proposals involved input from Advisory Committee members, especially in defining the criteria to be demonstrated in the proposals. The requirements of Pennsylvania's law caused some problems in obtaining response to the original request for proposals, and some additional negotiation went on to refine the requirements sufficiently to obtain at least one qualified bidder.

Advisory committees are often used as review-and-comment bodies only, or as rubber-stamp entities on decisions made by a sponsoring agency. The Department was intent on providing an active and meaningful role for the committee, and put emphasis on structuring activities that met that objective. Their involvement in the operator selection process is an excellent example. Risk in this context relates to confidence that a given firm can handle all aspects of facility development, construction, operation, and closure without risk to the public. This revolves not only around the plans for technically avoiding risk, but also each firm's track record, their demonstrated integrity, and the feeling of confidence that they inspire in reviewers.

Prior to receipt of proposals from potential operators, the Department developed a two-day workshop format for Advisory Committee members. The purpose was to familiarize each member with the evaluation criteria and the practical aspects of actually applying and ranking each criterion. Whereas a general statement about the adequacy of a firm's siting approach would normally warrant only a general evaluation, the members were encouraged to think through the kinds of questions that they should ask to make that judgement. For example, they could include:

- Does the proposal clearly present site selection steps that allow for systematic screening?

- Are the site selection criteria clearly presented and justified? Is it clear which criteria will be used at each step in the process? Is each criterion a definitive measurement of the factor to be evaluated?

- Are personnel with experience and training in the disciplines required for each part of screening proposed and committed?

- What form of public involvement in the screening process is proposed? Are the techniques appropriate? Is the needed information going to be developed and distributed? How will public input be incorporated in decision making?

These are only examples of the types of analysis the committee members were encouraged to go through for review of each proposal. In a workshop setting, they were briefed on the overall proposal evaluation factors, and then broken into small groups to discuss each factor and "walk through" the questioning process. This allowed for discussion of what constituted appropriate treatment of each factor, what the areas of uncertainty might be, and what priority members wanted to personally place on different elements of the proposals.

Committee members continued to work to prepare for proposal review, preparing checklist review forms and creating subcommittees for different areas so that detailed reviews could be performed efficiently. Each subcommittee took responsibility for various sections of the proposals, and focused their review comments and questions on those assigned factors.

Committee members, while representing various public interest sectors, also felt the need to obtain broader public input into their evaluation process. Public meetings were co-sponsored by the Advisory Committee and the Department, where the potential operators presented their approaches and qualifications, the public asked questions, and comments were collected. This input was considered by the committee as well as by the Department in evaluating the proposals. Ultimately, the Secretary of the Department used the report of the Advisory Committee along with other public input and the results of Department evaluations to select an operator.

COMMUNICATING WITH THE GENERAL PUBLIC

Clearly a program that relied totally on a group of 21 individuals to represent an entire state's population would be misguided. Also clear to the Department, however, was the fact that it is not possible to interact in a highly structured and usable fashion with millions of citizens across the entire Commonwealth. To complement the extensive consultation with the Advisory Committee, a statewide program of public information and involvement has been carried out.

Setting the stage for the operator to begin site selection has involved many steps. During development of the regulations, public information on their content was disseminated through the program newsletter and other sources. Public comment was received on draft regulations during a comment period, and public meetings were held statewide to explain their elements, answer questions, and collect comments. Formal public hearings on the regulations themselves thus presented no great controversy.

Statewide public meetings were also used as a general introduction to the program, to the fact that a facility will be developed somewhere, and to the need to select a qualified operator. Such outreach activities are certainly less controversial when no geographic decisions have been made, and attendance is never great at that stage. Nevertheless, the outreach to interested people and the media coverage helped create awareness in citizens that the program was under way and would be making important decisions soon.

They also provided the Department with a good reading on the issues of importance. Health and safety are paramount, and property values are of great interest. Local involvement and control and guarantees and benefits to the host municipality also received a great deal of attention.

As noted above, during the review of operator proposals, public meetings were also co-sponsored with the Advisory Committee to obtain public comment on the proposals. As in all public outreach activities, efforts were made to structure them in informal, two-way communication formats. Open house sessions, walk-around question and answer settings, and models of disposal method proposals all contributed to the informal feeling. The Department maintains a key objective of being accessible to all citizens with an interest, not just savvy activist groups with well-developed knowledge bases and agendas.

That accessibility touches on another key tenet of the Department's program. While the services of a public participation consultant, Roy F. Weston, Inc., are used to assist in designing the program and developing materials, Department staff make all out-front public contacts. Senior and supporting technical staff attend all public meetings, participate in open house sessions, and answer questions posed. A myriad of presentations have been made to date for civic and interest groups, associations, and other organizations. A highlight of the Department's presentations is an emphasis on explaining differential risks of exposure to environmental hazards, and allowing for free dialogue on the subject.

This hands-on approach of Department staff means that not only are citizens satisfied that they are actually meeting and talking to the decision makers, but the Department hears personally about the important issues and concerns that require attention. Those issues can then be addressed as the program proceeds with implementation of the law and the regulations.

LESSONS LEARNED

Woven throughout this paper so far are the key lessons the Department has learned in this effort:

- It is worth it. Resources needed to reach out to the public in all of these ways, especially from the very beginning of the process, are extensive. Time and people must be committed, and they must commit themselves to the philosophy of the program. Results, however, have been excellent, allowing remarkable progress in the state that experienced the Three-Mile Island situation in the last decade.

- Targeting at different levels is necessary. While the Advisory Committee has been invaluable, so too the outreach to the general public was critical. As the operator proceeds to select sites, the Department will oversee the process and ensure that appropriate resources are applied at varying geographic levels as well.

- An advisory committee will be ineffectual, frustrated, and potentially dangerous if allowed to operate without the necessary information, attention, and structure. It is certainly not feasible or advisable to try to manipulate such a group, but it is very feasible to work closely with them to give them what they need to do satisfying work and play a real role in the process. If treated right, the committee will become a real ally and will be a broader base of support for agency decision making.

- The public can assimilate and contribute to complex technical issues if opportunities are presented appropriately. Information on risk, for example, can be provided in a range of different ways to provide understanding. What we consider to be <u>fact</u> may never truly be believed by some members of the public because of various societal and experiential factors. It remains important, however, to have factual information available in a variety of forms. What is equally important is to <u>listen</u> to what the public is saying about these issues, and manage to successfully address their concerns and values.

- Part of the pie is better than no pie at all. Negotiation and compromise are critical elements in a controversial public policy issue such as this. That willingness must be maintained at a technically and regulatorily responsible level throughout the process.

- There is no substitute for the decision makers. Use advisors and consultants and other agencies to support the program, but wade into it personally as decision makers and be prepared to personally defend the results.

RFW827

LLRW DISPOSAL SITE SELECTION PROCESS SOUTHEAST COMPACT - STATE OF NORTH CAROLINA A COMBINED TECHNICAL AND PUBLIC INFORMATION APPROACH

Frederic G. Snider, David C. Amick, Sam G. Khoury
Ebasco Services Incorporated, Greensboro, North Carolina
and
Chrystal Harris Stowe, Paul Guichard
NC Low-Level Radioactive Waste Management Authority, Raleigh, NC

SYNOPSIS

The State of North Carolina has been designated to host the second commercial low level radioactive waste disposal facility for the Southeast Compact. The North Carolina facility is to be operational on January 1, 1993, concurrent with the closing of the present facility in Barnwell, South Carolina. The NC Low Level Radioactive Waste Management Authority and its contractor, Ebasco Services Incorporated, initiated the site selection process in July of 1988. The present schedule calls for the identification of two or more sites for detailed characterization in the latter half of 1989.

The site selection process is following two concurrent and parallel paths. The first is the technical site screening process, which is focusing the search for a suitable site by the systematic application of state and federal laws and regulations regarding exclusion and suitability factors.

In a parallel effort, the NCLL Radioactive Waste Management Authority has embarked on an extensive public information program. In addition to newsletters, fact sheets, brochures, video tapes, and news releases, a total of six regional meetings and 26 public forums have been held across the state. A total of 4,764 people attended the forums, 1,241 questions were asked, and 243 public statements were made.

The combination of a systematic, defensible technical siting process and the concurrent release of information and numerous statewide public meetings and forums is proving to be an effective strategy for the eventual identification of sites that are both technically suitable and publicly acceptable.

BACKGROUND AND SUMMARY

The Federal Low-Level Radioactive Waste Policy Act of 1980 and its Amendments of 1985 require that all states provide for the disposal of commercial low-level radioactive waste, preferably in regional facilities that are shared between multi-state compacts. In 1981, the North Carolina General Assembly established safe low-level radioactive waste management as a top state priority and subsequently participated in the cooperative efforts to establish the Southeast Interstate Low-Level Radioactive Waste Management Compact. The General Assembly voted to join the Southeast Compact, which consists of an eight member group of states (North Carolina, South Carolina, Virginia, Georgia, Alabama, Tennessee, Florida and Mississippi) in 1983. By agreement, all members of the compact are required to host the regional disposal site on a 20 year rotating basis. In this way, no state is required to have a permanently operational site. The Barnwell disposal site, in South Carolina, currently services the needs of the region and is presently scheduled to close at the end of 1992. North Carolina was designated by the Southeast Compact Commission to host the second regional facility, scheduled to open in January 1993 and remain operational through 2012.

The site selection process is following two concurrent and parallel paths. The first is the technical screening process, which is focusing the search for a suitable site by the systematic application of state and federal laws and regulations regarding exclusion and suitability factors. On November 30, 1988, the Authority released the Phase 1 Statewide Screening Report, which outlined all areas of the state excluded from further consideration on the basis of statewide exclusion criteria. Application of these criteria on a statewide basis excluded 62% of the state. The remaining 38% (20,446 square miles), was identified as Potentially Suitable Areas for a LLRW disposal facility.

Subsequent application of statewide suitability criteria further reduced the area under consideration to 9.5% of the state, or 5,054 square miles. These 5,054 square miles have been identified as Candidate Areas. Their distribution was publicly released on March 20, 1989. Presently, more detailed work is being completed within the Candidate Areas to identify Potential Site Areas and, finally, Potential Sites.

In a parallel effort, the NCLL Radioactive Waste Management Authority has embarked on an extensive public information program. A large active mailing list is being maintained, and newsletters, fact sheets, informational brochures, video tapes, and press releases have been published and widely distributed. An 800 hotline telephone number has been established. In addition, a total of 32 public meetings and forums have been held across the state. The Phase 1 study was first released in a series of six statewide meetings in major media centers in December, 1988. Between February 15 and April 27, 1989, a total of 26 additional public forums were held statewide. At each of these forums, the role and charge of the Authority was explained, the results of the siting process were presented, and a panel was available for questions and discussion. Most individual forums lasted between 2 and 5 hours, with attendance ranging from less than 50 to over 900 persons. Total attendance was 4,794. A total of 1,241 questions were asked, and 243 public statements or comments were made. In general, attendance at the forums increased during the 3 month period, with a significant increase in attendance after release of the 9.5% Candidate Area map in March.

The following sections describe the technical methodology used in the statewide screening tasks, and the elements of the public information program.

TECHNICAL SCREENING METHODOLOGY

The eventual selection of a preferred site for the disposal of Low Level Radioactive Waste is based on the application of a multi-phased technical screening process. This process is driven, in large part, by applicable state and federal laws and regulations. Following the format developed in the North Carolina General Statutes GS104G-9, the applicable federal and state laws and regulations and their referenced siting factors are divided into six general categories:

- o Hydrological and Geological Factors
- o Environmental and Public Health Factors
- o Natural and Cultural Resources
- o Local Land Uses
- o Transportation Factors
- o Aesthetic Factors

Within each of these categories, one or more specific factors for consideration were identified. Among those that had application at the statewide screening level, the factors were further subdivided into those that referred specifically to exclusion criteria, and those that are considered suitability criteria.

Exclusion criteria are those that by federal or state law or regulation prohibit the siting of the waste disposal facility. Suitability criteria are those that by law or regulation do not specifically prohibit the siting of the waste disposal facility, but are to be considered during the identification of areas of preference during the siting process, and/or used in the comparison of the relative suitability of one area versus another. In order to be considered at the statewide screening level, specific criteria should apply to sufficiently large areas as to be meaningful. Criteria that apply more appropriately to site-areas or sites are not applied at the statewide level.

It should be noted that virtually all of the criteria applied at the statewide screening phase will be re-applied at a smaller, more local scale during the subsequent steps of the site selection study. Details of the individual screening factors are provided below.

APPLICATION OF SPECIFIC SCREENING FACTORS

Details of each of the specific screening factors applied during the Phase 1 exclusion screening and the Phase 2 Task 1 suitability screening are presented below.

Hydrological and Geological Factors

Hydrological and geological factors are divided into five sub-categories: 1) surface water, 2) ground water, 3) geology, 4) geologic stability, and 5) soil characteristics. A discussion of the sub-categories and their application is presented below.

Surface Water

Surface water considerations are based on the prevention of flooding at the disposal facility. Surface water considerations included coastal zone flooding, wetlands and swamps, lakes, floodplains, and stream density. Each of these considerations is discussed below. The total land area screened on the basis of all the surface water criteria discussed below is 27,535 square miles, or approximately 52% of the state.

Coastal Zone Flooding

Data on the coastal areas prone to flooding was provided by the "Eastern North Carolina Hurricane Evacuation Study" prepared by the US Army Corps of Engineers (1987). Using mathematical storm surge modeling and existing topography, these studies outlined areas prone to flooding during different intensity hurricanes. For the purposes of this study, the area prone to flooding during the most intense hurricanes (Class 5) was excluded from further consideration during the statewide exclusion mapping.

During the statewide suitability mapping, the potential impacts of continued sea level rise due to global warming was considered. Assuming a rate of rise of 3 feet per century yields a possible sea level rise of 15 feet over the next 500 years. Adding this elevation change to the coastal flood areas excluded during the Phase 1 study indicates that areas below approximately 25 foot elevation could potentially be subject to flooding during hurricanes and storms over the next 500 years. Therefore, for the purposes of the Phase 2 Task 1 suitability screening, lands within the Potentially Suitable areas that are near or below the 25 foot elevation contour were mapped on USGS 1:250,000 scale topographic maps.

Wetlands and Swamps

Wetlands and swamps are excluded both from consideration of surface flooding and very shallow groundwater. These areas were mapped using the USGS 1:250,000 scale topographic maps. During Phase 1 screening, all areas of swamps in excess of 500 acres in size were excluded from further consideration. During Phase 2 Task 1 suitability screening, any smaller wetlands and swamps shown on the USGS maps within Potentially Suitable Areas were mapped. Any additional local swamps and wetlands would be considered at the site-area or site specific level of investigation.

As part of the wetland mapping during Phase 2 Task 1 suitability mapping, pocosin wetlands were identified. Pocosin wetlands are defined as fresh water upland bogs, and are indicators of both potential for flooding and very shallow groundwater. Maps of the pocosins were obtained from "Status of Pocosin Wetlands in Coastal North Carolina as of 1980", Duke University School of Forestry and Environmental Studies, 1982.

Lakes

Although not specifically excluded by state or federal regulation, lakes are not considered potential locations for the disposal site. For the purposes of the Phase 1 screening, all lakes larger than 500 acres in size were excluded using the USGS 1:250,000 scale topographic maps and NCDOT county road maps. During the Phase 2 Task 1 suitability screening, all smalier lakes within Potentially Suitable Areas that appear on the USGS maps were mapped. Small lakes and ponds that do not appear on the USGS 1:250,000 scale maps will be considered during the site-area and site specific phases of the study.

Floodplains

Both state and federal regulations require exclusion of the 100 year floodplain from consideration for siting. The 100 year floodplain is defined as that land area adjacent to stream, river, or coastal waters which has a 1% probability of flooding in any given year. Application of the 100 year floodplain exclusion on a statewide level is not feasible, since mapping of these areas (by the USGS and the Federal Emergency Management Agency (FEMA)) is published at scales too large to incorporate in the statewide screening. However, soil association mapping by the US Soil Conservation Service (SCS) can be used to identify, on a statewide basis, land areas and their associated percentage of soils subject to periodic flooding. During the Phase 1 screening, land areas where 100% of the soils are subject to periodic flooding were excluded from further consideration. During the Phase 2 Task 1 suitability screening, all areas where SCS mapping indicates more than 90% of the soils are subject to periodic flooding have been screened, since the likelihood of finding an acceptable site within the remaining 10% is considered extremely low.

Stream Density

During the Phase 1 exclusion screening, the major river valleys in the state were excluded to the extent that they are reflected by the flood-prone soils and swamps/wetlands mapping. As part of Phase 2 Task 1 suitability studies, all perennial rivers and streams and the immediately adjacent areas that are large enough to be shown on the USGS 1:250,000 scale topographic maps were screened.

In addition to those surface water aspects discussed above, state and federal regulations also require the consideration of erosion potential in and around the site, local drainage around the site, and climate. These factors are considered specific to potential sites or site areas, and will be evaluated during subsequent steps in the screening process.

Ground Water

Depth to groundwater is considered in the screening process since it is desirable to maintain separation of the waste from the local water table. Importantly, North Carolina law requires that the seasonally high water table be at least seven feet from the bottom of the facility.

The most appropriate statewide database for evaluation of depth to groundwater is provided by the soil association maps of the Soil Conservation Service (SCS). The SCS database provides depth to water table to a maximum depth of six feet. All areas where the SCS mapping indicated that 100% of the land area has seasonally high groundwater within six feet of the ground surface were excluded during the Phase 1 exclusion screening. During the Phase 2 Task 1 suitability screening, all areas where more than 90% of the land area has shallow ground water were additionally screened, since the likelihood of finding an acceptable site within the remaining 10% is considered extremely low.

The total land area where more than 90% of the land area has seasonally high ground water within six feet of the surface is 14,944 square miles, or approximately 28% of the state. Much of this area overlaps the areas previously screened by surface water criteria discussed above.

Geology

Geologic considerations include existing or potential natural resources such as economic minerals, gas and oil, peat, coal, and phosphate. Mining operations are considered in the evaluation of the risk of intrusion into the disposal facility.

Since regulations do not require exclusion of any of these areas, none were identified during Phase 1 exclusion mapping. However, during the Phase 2 Task 1 suitability screening, areas of exploitation of mineral resources were identified and mapped. These areas include known mines for metal and non-metals, as well as oil and gas exploration locations. A total of 54 square miles were screened using this criteria.

The nature of the bedrock beneath the disposal site is also considered primarily with respect to its effect on groundwater flow and therefore ease of modeling and monitoring. No statewide exclusion or suitability criteria have been applied specifically with regard to bedrock. The nature of the bedrock is considered more appropriately left to site-area and site specific studies.

Geologic Stability

State and federal regulations require that both surficial geologic processes and larger scale tectonic processes be considered in screening. These processes fall into three primary categories for the State of North Carolina: 1) tectonic stability, 2) slope stability, and 3) karst or sinkholes.

With respect to tectonic stability, North Carolina is not considered a tectonically active area. Although some earthquakes have occurred in the state, they are small, and not associated with known geologic structures. There are no active faults in North Carolina, as defined within the regulatory guidelines established by the U.S. Nuclear Regulatory Commission. Large scale tectonic processes such as uplift, folding, or subsidence are not occurring at measurable rates in the state. Therefore, none of the state has been excluded on the basis of these considerations.

Slope stability issues are primarily related to protection of the facility from either intrusion by landslides from offsite, or protection of the facility from degradation due to landslides, slumping, or mass wasting on the site. These issues are considered primarily site-area or site specific. However, insofar as slope stability is partially a function of local topography, a topographic suitability criteria has been applied during the Phase 2 Task 1 suitability screening. The publication "Soil Systems of North Carolina" (North Carolina Agricultural Research Service, 1984) identifies those areas of the state considered as mountainous terrain. These areas have been screened as part of Phase 2 Task 1 suitability mapping. Also, additional areas where slopes exceed 10% have been screened during this task.

The development of karst or sinkholes is specific to limestone or lime-rich sedimentary deposits. Areas prone to karst development in the state have been identified, and are restricted primarily to a single geologic unit (Castle Hayne formation) in the coastal plain. This area has been screened during the Phase 2 Task 1 suitability screening.

The areas identified during the statewide screening on the basis of the geologic stability criteria presented above represent a total of 8,880 square miles, or approximately 17% of the state.

Soil Characteristics

The specific characteristics of the soil at the potential disposal site must be considered with respect to migration of radionuclides and soil chemistry. Regulations require consideration of soil pH, cation exchange capability, and composition and permeability. At the statewide level, no consistent database of soil chemistry or soil permeability data exists. Furthermore, chemistry and permeability can vary considerably with lateral distance and depth within relatively small areas. Therefore, these considerations are more applicable during site specific studies.

Environmental And Public Health Factors

The environmental and public health factors have been divided into three sub-categories: 1) public drinking water supplies, 2) demography and population growth, and 3) air quality. Discussion of these sub-categories, criteria, and their application is presented below.

Public Drinking Water Supplies

The public water supplies referenced in the federal and state regulations include: 1) sole source aquifers, 2) municipal water wells, 3) domestic water wells, 4) surface water intakes, and 5) springs. Each of these types of water supply is discussed below.

The term "sole source aquifer" is strictly a regulatory definition and refers to specific parcels of land that have been designated as such under the Federal Safe Drinking Water Act. There are no properties in North Carolina that are designated sole source aquifers, nor are any applications pending. Further, there are no state or federally protected aquifers in the state. However, considerations of aquifer use, recharge, and extent will be an important part of the site-area and/or site specific evaluations to be completed in subsequent steps.

With respect to water supply wells, state regulations require that the disposal facility be at least 1000 feet from any water supply well that is not controlled by and used exclusively for the facility. Water supply wells fall into two categories: municipal and domestic. As part of the statewide screening studies, 442 municipal water supply wells listed in "A Municipal Water Supply Survey of North Carolina" (1977) were identified. These wells, plus the mandated 1000 foot buffer, were excluded during the Phase 1 exclusion mapping.

During the Phase 2 Task 1 suitability screening, a 2 mile radius was placed around each municipal water supply well. The 2 mile radius was chosen on the basis of licensing requirements, which specify that the applicant will inventory all wells within 2 miles of the facility site. In order to facilitate this aspect of licensing, the Phase 2 Task 1 screening includes the 2 mile radius around each municipal well.

The locations of domestic water wells was not compiled during the statewide screening phases of the study. However, the locations of these wells will be considered as part of the site specific portions of the screening process.

Approximately 225 surface water intakes are listed in "A Municipal Water Supply Survey of North Carolina". Although no regulatory exclusion is required for surface water intakes, the Phase 2 Task 1 suitability screening included a 2 mile radius around each of these intakes in a similar fashion to the municipal water wells. The 2 mile radius has been applied only within the upstream drainage area for each intake, since the downstream area does not impact the water quality for that intake.

Springs are considered very local, site-specific considerations and have not been addressed at the statewide screening phases of the study. They will, however, be an important consideration during the site-area and site specific studies.

The total area screened on the basis of these water supply criteria was 7,531 square miles, or 14% of the state. Many of these areas overlap with other criteria.

Demography and Population Growth

Federal regulations require that the disposal facility be at least 2 kilometers from population centers. As part of the statewide screening study, 555 population centers in North Carolina were identified and their boundaries plus the 2 kilometer exclusion zone were mapped and included in the definition of Potentially Suitable Areas during the Phase 1 exclusion screening. The boundaries of the population centers were defined by a combination of:

- o Municipal Boundaries as defined on 1988 edition NCDOT county maps
- o Boundaries of Census Designated Places (CDP) as defined by the 1980 census
- o Boundaries of Urbanized Extensions as defined on 1988 NCDOT county maps
- o Boundaries of recently developed areas as mapped on recent satellite images

Population density information was also collected as part of the statewide screening studies, as compiled in the 1980 census. No federal or state regulations exclude areas on the basis of population density alone. However, during the Phase 2 Task 1 suitability screening, areas with population density exceeding 500 persons per square mile were screened, as the probability of locating suitable sites in these areas is considered extremely low.

Federal and state regulations do require consideration of population growth patterns in the siting process. Although projected county growth rates have been published for North Carolina, these projections cannot be readily used to predict patterns of population growth, especially in and around urban areas. Therefore, population growth projections and growth patterns have not been included in the statewide screening phases of the study.

As part of the Phase 2 Task 1 suitability screening, an evaluation of possible interstate effects was completed. Interstate considerations include population centers or municipal water supplies in adjacent states that share borders with North Carolina, as follows.

Within the State of North Carolina itself, population centers have been surrounded by a 2 kilometer exclusion zone. Further, a 2 mile radius has been placed around municipal water supply wells and surface water intakes. Therefore, in order to apply the same criteria to population centers and water supplies in adjacent states, a 2 mile buffer has been mapped around the North Carolina state line. The Phase 2 Task 1 screening uses this buffer to minimize potential interstate effects.

The total land area represented by the combined environmental and public health factors presented above is 20,592 square miles, or approximately 39% of the state. Many of these areas coincide with areas previously mapped under other criteria.

Air Quality

Air quality issues are considered local and site-area or site specific. They have not been considered as part of the statewide screening process, but will be addressed in the site-area or site specific studies.

Natural and Cultural Resources

Natural and cultural resource factors are divided into four sub-categories: 1) parks and forests, 2) wildlife protection areas, 3) areas of scenic importance, and 4) areas of historical, cultural, religious, ethnic or racial importance. Discussion of the sub-categories, criteria, and their application is presented below.

Parks and Forests

Applicable state regulations indicate that proximity to National Forests, National Parks, State Forests, and State Parks shall be considered in the siting process. Although not directly stated, it has been assumed during this study that if proximity to these areas must be considered, then the properties themselves should be excluded. Therefore, as part of the Phase 1 exclusion screening, all areas designated as National or State forest or park were mapped and excluded from further consideration. Proximity to these areas will be considered at the site area or site-specific phases of the work.

Regulations also require the consideration of local (county and community) parks and commercial parks during the siting process. As these parks are generally small (less than 500 acres), their consideration is part of the site-area or site specific studies.

Wildlife Protection Areas

Wildlife protection areas referenced in the applicable state regulations encompass all of the following categories:

- o National Wildlife Refuges
- o Wetlands
- o State-Owned Gamelands
- o Wilderness Areas
- o Habitats of Rare, Threatened or Endangered Species
- o Fish Hatcheries
- o Nature Preserves

The first four sub-categories were included in the statewide exclusion mapping during Phase 1. The boundaries of all designated National Wildlife Refuges and State-owned gamelands were mapped and excluded. Wetlands were mapped under the surface water considerations discussed above. All of the federally designated wilderness areas are totally within National Forests and were therefore not separately mapped.

Habitat areas of rare, threatened, and endangered species are very broadly defined in the published literature, and are not appropriately used at the statewide screening level. Therefore, published sighting locations and possible habitats will be considered during the site-area or site specific studies.

Similarly, due to their small size and limited extent, fish hatcheries and nature preserves were not considered in the statewide screening study. Their locations will be considered, however, during subsequent site-area or site specific studies.

Areas of Scenic Importance

Federal regulations require that the proximity to areas of scenic importance be considered in the siting process. For the purposes of the statewide screening study, scenic areas are defined as 1) designated scenic rivers, and 2) shores of lakes. Designated scenic rivers were excluded from further consideration during Phase 1 exclusion mapping. Lakes have already been considered under the surface water criteria. More local, scenically important areas will be considered in later phases.

Areas of Historical, Cultural, Religious, Ethnic or Racial Importance

State regulations require the consideration of these areas as part of the overall siting process. These resources are generally too small and localized to be mapped at the statewide level. Therefore, these areas will be considered in more detail during the site-area and site specific phases of the study. Due to its size, the Cherokee Indian Reservation was excluded from further consideration during Phase 1 of the study.

The total land area screened by the combination of the natural and cultural resources criteria discussed above represent 6,191 square miles, or approximately 12% of the state. Again, many of these areas overlap with areas screened under other criteria.

Local Land Uses

Local land use considerations include: 1) proximity to activities pumping large quantities of water, 2) proximity to areas of quarry blasting, 3) proximity to uses of conflicting sources of radioactivity, and 4) military facilities and lands. In addition, specific consideration is given to the use of: 1) state or federally owned lands not excluded under other factors, and 2) large utility or other industrial land holdings

The only local land use factor considered during statewide screening was the location of military facilities and lands. These areas of the state were excluded during Phase 1 exclusion mapping. These areas represent 687 square miles, or slightly more than 1% of the state. All other categories of lands listed above will be considered during the site-area or site-specific studies.

Transportation

Transportation issues to be addressed during the siting process include: 1) proximity of major highways, 2) proximity to waste generators, 3) route safety, and 4) method of transportation. None of the transportation criteria required exclusion of any land area from consideration during the Phase 1 exclusion mapping. Further, transportation issues were not considered during the Phase 2 Task 1 suitability screening. These issues will be considered in subsequent steps in the siting process.

Aesthetics

Aesthetic considerations, such as visibility, appearance, and noise levels, are not considered at the statewide screening level. However, these issues will be addressed as part of the site-area or site-specific studies.

IDENTIFICATION OF CANDIDATE AREAS

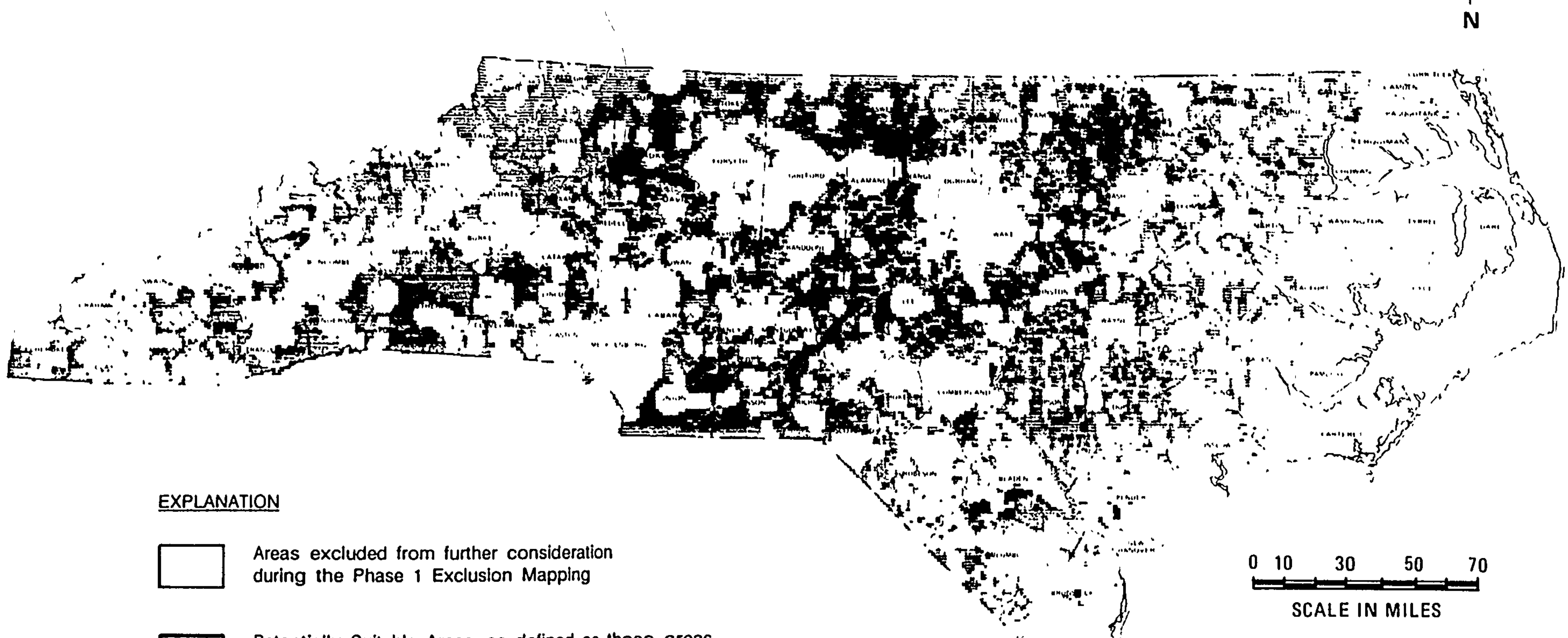
Candidate Areas are defined as those areas still to be considered after application of both the exclusion criteria applied during Phase 1, and the suitability criteria applied during Phase 2 Task 1. Figure 1 identifies the land areas identified during these two screening phases. The Phase 1 exclusion screening excluded a total of 32,899 square miles, leaving 20,446 square miles as Potentially Suitable Areas. The suitability screening of Phase 2 Task 1 screened 15,392 square miles within these Potentially Suitable Areas. The resulting Candidate Areas represent 5,054 square miles (3.2 million acres), or approximately 9.5% of the state.

To summarize the combined result of all the criteria discussed above, the areas identified as Candidate Areas have the following characteristics:

- They are outside the coastal high hazard area, and additionally outside of areas that could potentially be flooded during storms assuming a 15 foot future rise in sea level due to global warming.

- o They contain no swamps, wetlands, lakes, or ponds identified on USGS 1:250,000 scale topographic maps.
- o They contain no pocosin wetlands as mapped by Duke Univ. School of Forestry.
- o They contain no land areas where the Soil Conservation Service soil association maps indicate more than 90% of the land area is subject to periodic flooding.
- o They contain no perennial streams shown on USGS 1:250,000 topographic maps.
- o They contain no land areas where the Soil Conservation Service soil association maps indicate more than 90% of the land area has seasonally high ground water within six feet of the ground surface. (Although North Carolina regulations require a 7 foot separation, the only uniform data set available across the state reports groundwater depth only to 6 feet.)
- o They contain no areas of known mineral exploitation, including metals, non-metals, peat, coal, or areas of oil and gas exploration.
- o They contain no areas mapped as mountainous terrain by the NC Agricultural Research Service, nor do they contain extensive areas of slopes in excess of 10%.
- o They are outside of areas underlain by the Castle Hayne Formation, which is prone to the development of sinkholes or karst.
- o They are at least 2 miles from any municipal water well listed in "A Survey of Municipal Water Supplies in North Carolina".
- o They are at least 2 miles upstream from any municipal surface water intake listed in "A Survey of Municipal Water Supplies in North Carolina".
- o They are at least 2 kilometers from the boundary of population centers, where the boundaries are defined based on combinations of municipal boundaries, census designated places, urbanized extensions, and areas of recent growth as mapped on 1986 to 1988 satellite images.
- o They contain no areas where population density is greater than 500 persons per square mile as defined in the 1980 census.
- o They are at least 2 miles from the North Carolina state line, in order to minimize interstate considerations.
- o They are outside of National Forests, State Forests, National Parks, State Parks, Federal Wildlife Refuges, State-owned Gamelands, designated Wilderness Areas, Scenic Rivers, and Indian Reservations.
- o They are outside the boundaries of Military Facilities and Lands.

STATE OF NORTH CAROLINA
LLRW DISPOSAL SITE SCREENING PROCESS



EXPLANATION

- Areas excluded from further consideration during the Phase 1 Exclusion Mapping

- Potentially Suitable Areas, as defined as those areas outside the Phase 1 exclusion areas. Total area is 20,446 square miles, or 38% of the State. Maps of these areas were released to the public on November 30, 1988.

- Candidate Areas, as defined as those areas remaining after application of Phase 2 Task 1 suitability factors. Total area is 5,054 square miles, or 9.5% of the State. Maps of these areas were released to the public on March 13, 1989.

Figure 1 – POTENTIALLY SUITABLE AREAS AND CANDIDATE AREAS

It is clearly recognized that not all parts of these Candidate Areas will be equally favorable for the location of the disposal facility. Further, the definition of Candidate Areas allows local exclusions within these areas which were not incorporated at the statewide screening level. These local, or "spot" exclusions, however, will be considered during site-area or site specific studies within the overall siting process.

PUBLIC INFORMATION PROGRAM

As part of the siting process, the Authority has embarked on an extensive and ambitious program of public information. This program includes the development of a large active mailing list, and publication and distribution of periodic newsletters, informational brochures, video tapes, fact sheets, and news releases. In addition, a total of 32 public meetings have been held across the state, as shown on Figure 2.

The first six public meetings were held in December, 1988, and were located in the major media centers of North Carolina: Raleigh, Charlotte, Greensboro, Wilmington, Asheville, and Greenville. The meetings were held immediately following the issuance of the Phase 1 exclusion mapping report. Attendance ranged from less than 20 to over 300 people. Newspaper, radio, and television press coverage occurred at each meeting.

An additional 26 public forums were held across the state during February, March, and April, 1989, as shown on Figure 2. The distribution of these meetings was based on the concept that no one would have to drive more than 1 hour to attend a meeting. No meetings were held in the extreme eastern or western part of the state, as these areas were completely excluded during the initial phases of the statewide screening.

The 26 public forums were held weekday evenings in facilities provided by the local community. Each forum lasted between three and five hours, with attendance ranging from less than 50 to over 900. A total of 4,764 people attended the forums, asked a total of 1,241 questions, and made 243 public statements.

Forum Advertisement

Forums were advertised in several ways. First, three weeks prior to each forum, the local non-daily newspapers were provided background information concerning low-level waste and the site selection process, and a flyer announcing the forum location, date, and time. A total of 49 newspapers were contacted in this manner. Subsequently, a half- or full-page advertisement was purchased in a total of 65 daily and non-daily newspapers several days prior to each forum.

In addition to the newspapers, the following groups were also notified of the forums:

- o State Representatives
- o County and City Officials
- o Education Officials
- o Emergency Management Personnel
- o State Senators
- o Civic Organizations
- o Environmental Groups
- o Television and Radio Stations

A total of 9,197 forum announcements were sent.

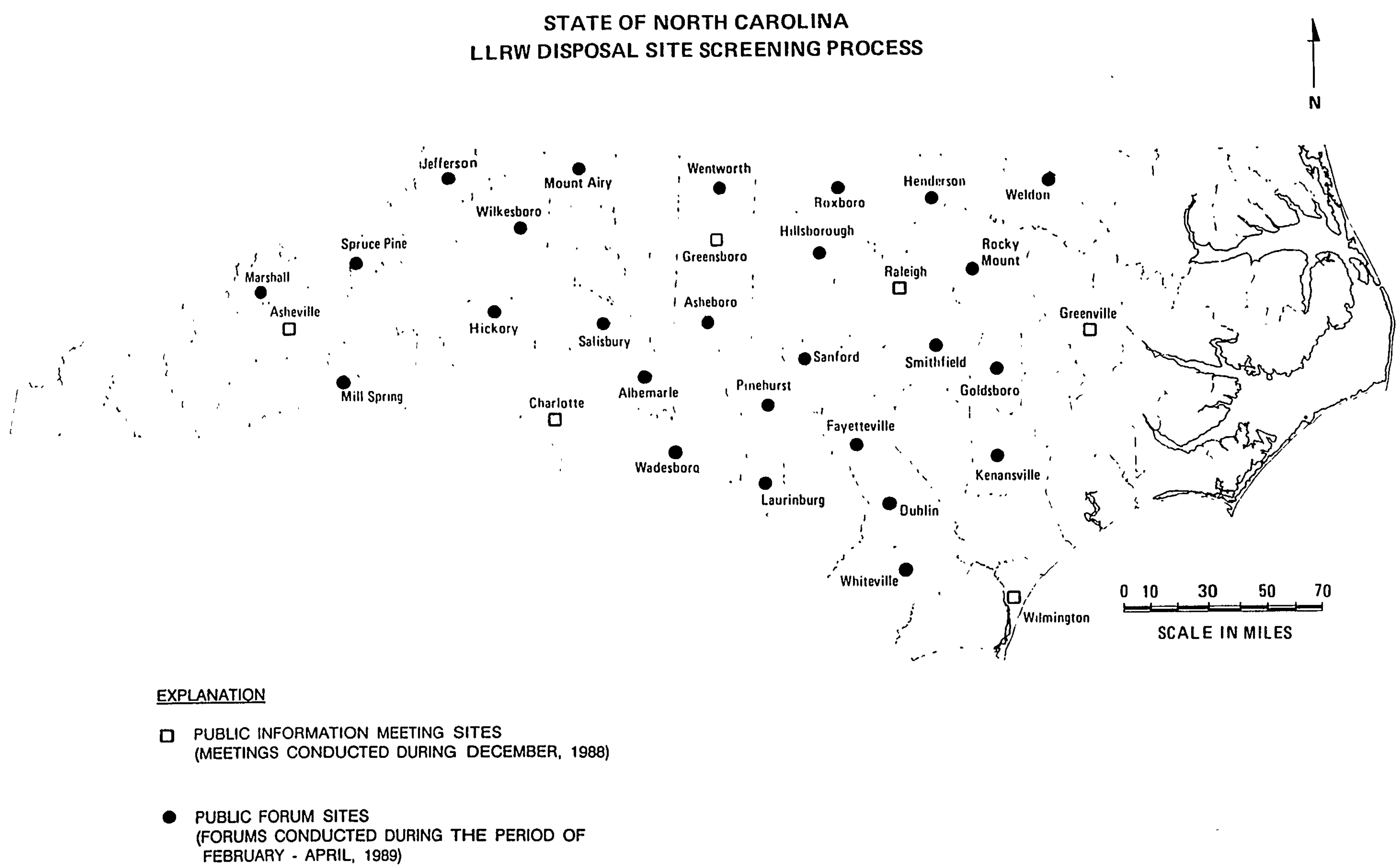


Figure 2 — LOCATIONS OF PUBLIC MEETINGS AND FORUMS

As additional support of these forums, quantities of information fact sheets and brochures were sent to the public libraries in all 26 counties. At the same time, local newspapers were sent notices that the county libraries had these materials available.

Forum Advance Planning

As part of the advance planning for each forum, discussions with local community leaders and potential opposition groups were held to estimate the expected number of attendees. These discussions also provided some indication of the overall reception the Authority was likely to encounter.

Further, the identification of a facility for the meetings was an important part of the planning effort. In all cases, the local community was asked to provide a facility, as well as a moderator. In this way, active support of the program was solicited, and aided in the advertising of the meetings. In general, meetings were held in auditoriums of community colleges or in local elementary or high schools. In all cases, the quality of the meeting location contributed to the overall success of the meetings. The most difficult and boisterous meetings occurred in large gymnasiums with bleachers, where acoustics were poor, and the overall ambiance encouraged disruptive behavior.

Format of Public Forums

The format of all 26 public forums was the same. Forums began at 7 pm. The moderator from the local community provided a brief introduction. A member of the Authority then provided a background on the low-level waste issue, followed by explanation of the NCLLRW Management Authority and its responsibilities. This was followed by a presentation by Ebasco staff describing the site selection process, and explanation of the siting regulations and their impact. Extensive use of computer-driven graphics during this part of the presentation was extremely effective in explaining the site selection process. A volunteer representative of the Health Physics Society then provided a brief explanation of radiation, and discussed the benefits versus risk issues associated with radioactive materials. Total length of the presentations ranged from 1 to 1 1/2 hours.

Following the formal presentation, a panel was available for questions. Panel members included the four presenters, joined by representatives of the two firms bidding on the site operator contract (Chem-Nuclear Systems, Inc., and Westinghouse Electric Co.).

Figure 3 compiles the statistics for the 26 public forums. The Figure indicates the total attendance at each forum, the number of questions that were asked, the number of public statements that were made, and the duration of each forum. Note that there was a marked increase in attendance starting with forum 14. This increase corresponded with the public release of the Candidate Area map, where approximately 9.5% of the state is identified for further study. Prior to this time, the only public release was the Potentially Suitable Area map, which indicated 38% of the state in consideration.

As shown on Figure 3, the number of questions and statements does not directly correlate with the number of attendees. This non-correlation reflects the fact that at

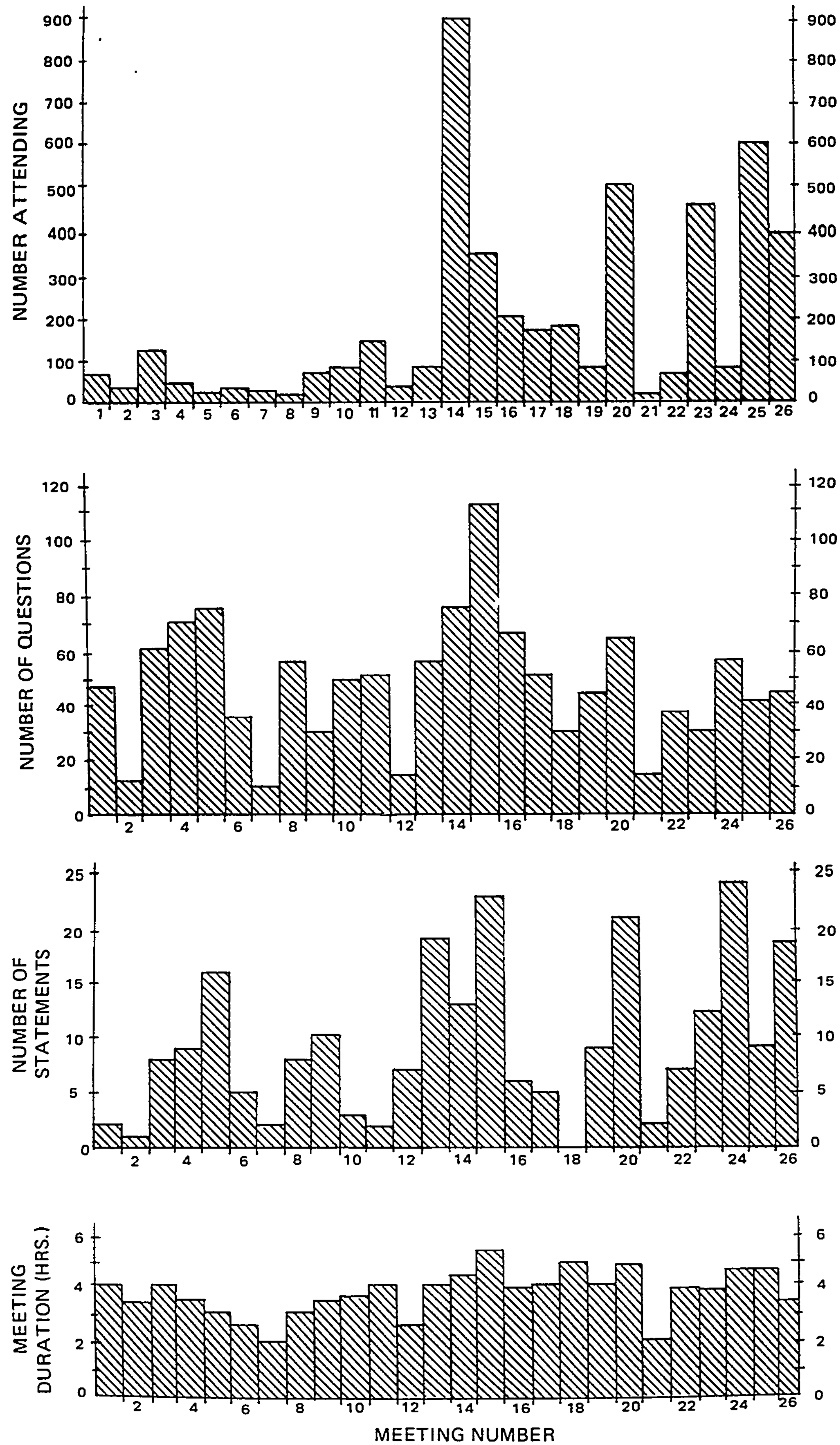


Figure 3 – STATISTICS COMPILED FOR 26 PUBLIC FORUMS

each forum a relatively few verbal individuals generally dominated the question and answer periods, independent of the total attendance. It is important to note that, in general, the majority of the attendees at each forum came to listen and obtain information.

Questions and Issues of Concern

As shown on Figure 3, a number of questions were asked and statements made at the forums. With few exceptions, the questions fell into the following major categories:

- o Legal and Institutional Issues
  - The Authority and its powers
  - The Southeast Compact
  - Financing
  - Benefits
  - Land Acquisition
  - Liability and Insurance
  - Contractors
  - Public Participation
  - Community Involvement
- o Technical Issues - Site Selection
  - Site Selection Methodology
  - Specific Siting Criteria
- o Facility and Operational Issues
  - Facility Design
  - Facility Operation
  - Monitoring
  - Closure and Post-closure
  - Cleanup Contingency
  - Post-closure Land Use
- o Waste
  - Transportation and Regulation
  - Exclusion of Out-of-Compact Waste
  - Waste Type and Forms
  - Waste Minimization
- o Health and Safety
  - Transportation Accidents
  - Regulatory Responsibilities
  - Emergency Response
  - Safety Precautions
  - Health Risks
  - Terrorist Attack
- o Economic Impacts
  - Direct Economic Liabilities
  - Indirect Economic Liabilities
  - Postclosure Economic Redevelopment
  - Direct Economic Benefits
  - Indirect Economic Benefits
  - Experience at Existing Facilities
- o Miscellaneous
  - Utility Responsibilities
  - Nuclear Power

As part of the forum process, all of the questions and answers have been compiled into a summary report. Two major issues arose at virtually all forums. First, many citizens questioned the need for the Southeast Compact, and opposed taking waste from surrounding states. The 'take care of our own' position was widely expressed. Secondly, many felt that the utilities that operate nuclear power facilities and generate the majority of the waste should bear total responsibility for LLRW disposal.

Response Monitoring

The Authority has monitored the response to the public meetings and evaluated the effectiveness of the public information process. The results of these studies indicate that the most effective information dissemination process is word-of-mouth. This fact underscores the necessity of public meetings and forums where misconceptions can be clarified, and rumors and untruths can be exposed and discussed. This is especially true in areas of active, organized opposition, where factual written materials cannot effectively compete with emotionally targeted verbal campaigns.

Monitoring of the newsprint, radio, and television coverage indicates that, with the exception of some headlines, the written press has been the most responsible, unbiased, and factual in their coverage of the issues. Public television and public radio coverage has also been generally informative and unbiased. At the other extreme, commercial television has tended toward limited coverage, and generally focused on sensational and distorted viewpoints. For example, in March of 1989, a local station interviewed a farmer, informing him, on camera, that <u>his farm</u> had been <u>targeted</u> for a 'radioactive dump'. No mention was made that this small farm was in reality but a tiny part of the more than 5,000 square miles that the Authority had just published as Candidate Areas.

Conclusions

Several important lessons have been learned in the NCLLRW disposal site selection study. First, a program of public information, including statewide meetings, is critical for educating the public to minimize fear and blind opposition. Second, the technical screening methodology applied must be relatively straightforward, unbiased, and easily explained to non-technical people. Third, the overall process must be as open as possible for as long as possible. Fourth, the media must be provided with factual material on a regular basis. And finally, the body responsible for the project (in this case the NCLLRW Management Authority) must remain accessible, and have in place an ongoing public information program.

The format and content of the public forums, coupled with the extensive public information program, have served to establish credibility for the Authority and the site selection process and support from a large segment of the population. In many cases, even those adamantly opposed to the project have commended the Authority on its approach to public information and site selection methodology.

It is clearly recognized that the Authority will have to draw heavily upon this credibility and support when individual potential sites are announced. Experience in this and other states indicates that the public aspects of such a project become increasingly difficult as the site selection process focuses on specific land parcels. Nonetheless, the combined technical and public information approach to site selection has proved to be an effective strategy for the eventual identification of sites that are both technically suitable and publicly acceptable.

Low-Level Waste Disposal in Highly Populated Areas

Emil Kowalski, Charles McCombie and Hans Issler
NAGRA - Swiss National Cooperative for the Storage of Radioactive Waste
Baden / Switzerland

ABSTRACT

Nuclear-generated electricity supplies almost 40 % of the demand in Switzerland (the rest being hydro-power). Allowing for a certain reserve and assuming an operational life-time of 40 years for each reactor, and taking into account wastes from decommissioning and from medicine, industry and research, the total amount of low-level radioactive waste to be disposed of is about 175,000 m³.

Since there are no unpopulated areas in Switzerland, and since Swiss Federal Law specifies that the safety of disposal may not depend upon supervision of the repository, no shallow-land burial has been foreseen, even for short-lived low-level waste. Instead, geological disposal in a mined cavern system with access through a horizontal tunnel was selected as the best way of meeting the requirements and ensuring the necessary public acceptance.

OVERVIEW OF THE SWISS WASTE MANAGEMENT STRATEGY

With a current installed capacity of around 3 GWe, nuclear-generated electricity supplies almost 40 % of the demand in Switzerland. Although this results in an amount of radioactive waste which is very small compared e.g. to the U.S.A., due to the present political uncertainty of international solutions, Switzerland has elected to prepare a comprehensive national waste management programme.

According to the overall strategy applied, spent fuel elements are reprocessed abroad. The resulting vitrified HLW and conditioned TRU will be returned to Switzerland after 1992. For these wastes, as well as for the already existing internally produced LLW/ILW from the operation of the power plants and from medicine, industry and research, strategies have been developed for final disposal in suitable repositories. Centralized interim storage is foreseen for HLW or for spent fuel elements for technical reasons, and for TRU and LLW/ILW in the case of delay in repository construction.

Two repository types are foreseen, one for HLW and TRU and one primarily for short-lived LLW/ILW. Waste sorts are defined with regard to maximum allowable radionuclide concentrations for the individual repository types as derived from the regulatory radiation protection requirements. The maximum allowable radionuclide concentrations for the LLW/ILW repository will be derived from safety analyses based upon the actual site data, which will thus influence the effective waste split between the two repository types.

For HLW and TRU, the option of disposing of the waste abroad within a framework of international cooperation is kept open; this would be preferable from an economic point of view and long interim storage allows one to keep all options open. However, because political factors make full preparation for disposal in Switzerland necessary, it is planned to continue the high-level waste research programme at least up to the stage where selection of a repository site is possible. For LLW/ILW, a final repository will be constructed in Switzerland in any case.

LEGAL FRAMEWORK AND PUBLIC INVOLVEMENT

The Federal Government Ruling of 1978 on the Atomic Act designates the guaranteeing of "permanent safe management and final disposal" of radioactive waste as a prerequisite to future development of use of nuclear energy in Switzerland. For the 5 nuclear power plants already existing (which are outwith the scope of this Ruling), a specific project offering a guarantee of feasibility and safety of final disposal was demanded. This project - the so-called "Project Gewähr" [1] - was submitted to the Federal Government by Nagra at the beginning of 1985. In 1988, the Government unconditionally accepted the proof of the feasibility and safety of the disposal of (short-lived) LLW/ILW [2],[3]. Accordingly, Nagra has given top priority to implementing an appropriate repository project. For HLW and TRU, the safety analyses (performed for a model site) were also accepted by the Government as a demonstration that safe disposal is feasible. The question of a specific HLW repository site is regarded as still open, however, and further geological investigations - including studies of sedimentary host rocks [4] - have been stipulated.

The safety conditions which the final repositories must satisfy are defined in the Federal Guideline R-21 (October 1980). The Guideline states two objectives:

1. Radionuclides which escape into the biosphere must not at any time lead to individual doses exceeding 0.1 mSv (10 mrem) per year;

2. A repository must be designed in such a way that it can at any time be sealed within a few years. After it has been sealed, it must be possible to dispense with safety and surveillance measures.

The siting and construction of a repository and all preparatory work in general (i.e. all specific geo- and hydrogeological investigations) is regulated by Federal Law. However, even for the investigations, the local authorities of the community and state (in Switzerland Canton) involved must grant additional planning permits which specify the way in which the work is to be performed. These regulate e.g. the construction details for an access road to a drilling site, the details of water supply and sewage or the details of the land-fill strategy to be used for the rock mass from excavation of an exploratory tunnel. Hence, the local authorities as well as the population concerned must accept the investigations and, ultimately, the repository. Without the consensus of the site population, long delays will result which may add up to several years, even though a formal federal licence has been granted.

RESULTING POLICY FOR LLW/ILW DISPOSAL

The mean population density in Switzerland amounts to 154 inhabitants per square kilometre, not dropping below 25 even in the mountain cantons. There are no unpopulated arid areas, the precipitation levels ranging from 600 to 3,000 mm per year. In order to satisfy the requirements of Federal Law and the Guideline R-21 and to ensure the necessary public acceptance in highly populated areas, no shallow-land burial has been foreseen, even for short-lived low-level waste. Instead, geological disposal in a mined cavern system with access through a horizontal tunnel was selected, the concept differring to some extent from the standards accepted abroad, e.g. in France or in the U.S.A. It is realized that this will be a more expensive - and perhaps unneccessarily safe - solution, but it was the only way of meeting the legal requirement that safety of disposal should not depend upon supervision of the repository. It is also hoped that it will help to promote the acceptance of the construction of the repository by the site population, once the site has been chosen and confirmed.

The concept of a repository in a hill, with access through a horizontal tunnel (rather than underground caverns with the access through a shaft or a long ramp tunnel), enables even very heavy waste containers to be moved into the repository without unacceptable technical complications. This complies with the decommissioning concept for Swiss nuclear power plants whereby bulky components and large amounts of low-activity dismantling waste are to be emplaced and solidified in large containers, the final weight of which will be 60 t or more.

REPOSITORY CONCEPT

According to the reference repository project as outlined in "Project Gewähr 1985" [1], the LLW/ILW repository will be characterized by the following:

- Disposal is in underground rock caverns with access through horizontal tunnels and the reception area is also underground.
- The system of technical safety barriers comprises the waste solidification matrix (cement, bitumen, polymers); possible grouting of the waste drums with liquid cement in a concrete container; backfilling of remaining empty spaces with special concrete; concrete lining of the disposal caverns and sealing of access tunnels on closure of the repository. The waste is delivered in conditioned form, i.e. in the solidification matrix. All remaining technical barriers are provided during construction, operation and closure of the repository.
- There exists the possibility of dividing the waste into several toxicity classes in order to maximize the barrier potential of the repository by emplacing waste with higher toxicity levels in areas with longer migration paths to the biosphere.

- The waste is brought to the underground reception area through the access tunnel by road or rail vehicles. The mechanical condition, surface contamination etc. of the delivered waste is checked in the reception area. The radioactivity inventories of waste units are checked primarily on the basis of the accompanying documents; complementary direct measurements can be made if necessary. Waste with nuclide concentrations which exceed maximum permissible values specified for the repository is transferred to the HLW/TRU repository.

- In the repository caverns the waste is emplaced by remote-handling equipment. The empty space remaining in the repository caverns after emplacement of the waste will be backfilled with special concrete. After the repository is filled to capacity, backfilling and sealing of the remaining voids is the final step of repository operation. The method of sealing is not yet specified; relevant experiments will be performed in an underground laboratory at the future repository site.

- An inventory is kept of delivered and emplaced waste. This provides information on the waste in each drum or container and the respective emplacement positions in the disposal caverns. It also gives a continuous overview of accumulated quantities of significant radionuclides in the waste already emplaced.

- The heat production of the LLW/ILW considered is so small that there is no significant temperature elevation over the normal underground values. There will be provisions for any gases produced to escape without an unacceptable increase in the pressure in the repository.

- With regard to the radiation protection and safety considerations, the design goal is that the expected contribution to radiation dose, even for the most highly exposed sector of the public, shall be less than 0.1 mSv (10 mrem) per year, i.e. the value stipulated by the Swiss regulations (cf. Guideline R-21).

- The Project Gewähr 1985 safety analyses indicate that this goal can be achieved. For the model-site, the release of radioactivity into the biosphere was also calculated for an unfavourable transport path to a road tunnel in the neighbourhood (assumed to be collapsed) and from there into small springs and surface groundwater. Even then radiation doses lie below the protection objective.

- Release scenarios which take long-term geological changes into account included complete exposure of the repository by erosion after 100'000 years. The calculated radiotoxicity of the soil mixture formed in this extreme assumption is still below natural values.

- The repository facilities will be fully decommissioned. Final sealing of access tunnels will be done either with concrete plugs or bentonite, the decision on the method still being open.

- Disposal is conceived in such a way that no control and supervision is necessary after repository closure and a high level of long-term safety can nevertheless be ensured (in accordance with the Swiss legal requirements, cf. previous chapters).

- Quality control during emplacement and subsequent backfilling is ensured. Before final closure of the repository, long-term in-situ experiments will be evaluated from a safety viewpoint. A retrieval capability for the waste after closure is not engineered into the system but may be possible, albeit at considerable expense.

SITE SELECTION, STATUS OF THE WORK

The site selection for the LLW/ILW repository proceeded in several stages. First of all, Nagra selected possible host rocks according to hydrogeological and geological criteria and evaluated, in desk studies, a total of around 100 potential sites in the years 1978 - 81. The results led to a selection of 20 potential sites for which additional investigations not requiring a federal licence were undertaken.

Evaluation of these 20 sites was performed in 1982 - 83 and led to the selection of three sites - Bois de la Glaive (anhydrite), Oberbauenstock (Valanginian marl) and Piz Pian Grand (gneiss) - which are being investigated as a first priority. For these three sites, Nagra prepared relevant applications for exploratory boreholes and tunnels and submitted them to the Federal Government at the end of 1983.

The necessary licences were granted in September 1985; however, a decision on Phase II of the work - the construction of exploratory tunnels - was postponed until the results of Phase I have been presented. In the years 1986 - 87, Nagra performed investigations at Oberbauenstock and at Piz Pian Grand and completed Phase I at these two sites. No licensed work has been done at Bois de la Glaive due to severe political obstruction at this site. The reports on the results of Phase I and the applications for exploratory tunnels at all three sites were submitted to the Federal Government at the end of 1988. The Government decision is expected in the first half of 1990.

In addition to the three sites mentioned, a fourth has been selected at Wellenberg in Canton Nidwalden, where the geometry of the Valanginian marl could allow the construction of a horizontally accessible LLW/ILW repository combined with a repository cavern for TRU at a depth of 300 m (or so) at the same site. The necessary applications were submitted to the Federal Government in June 1987. The Government made a positive decision with regard to the horizontally accessible LLW/ILW repository part in July 1988, but declined at present to authorize any work for the deep TRU cavern. Local planning permits are now being obtained and the detailed field work is planned to begin in 1989. Following the first phase of work at Wellenberg, a decision will be made on the site to be characterized by means of a tunnel into the proposed repository zone.

The final site selection and the general application for the construction permit for the LLW/ILW repository is scheduled for 1993/94, waste emplacement in the repository starting at the earliest in 1998, assuming that there are no further unexpected politically motivated delays in the licensing procedures and no geological surprises.

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THREE NECESSARY CONDITIONS FOR PROGRESS IN LOW-LEVEL WASTE MANAGEMENT:

POLITICAL COMMITMENT, MANAGERIAL SKILL, AND PUBLIC INVOLVEMENT

SUSAN WILTSHIRE
JK Associates

INTRODUCTION

Consider a person busy with daily life who reads the newspaper and watches television in a slightly random way. Some days it seems to her that everyone is either cleaning up something noxious that spilled or that leaked or trying to site a facility that no one wants. She wonders why people keep on producing materials that cause so much trouble; why they don't learn to handle them without continually making messes; and how in the world she can be expected to believe that they'll do better in the future since there are so many recurring problems.

She has a point. Her concerns suggest three imperatives for progress in low-level waste management, including siting facilities for commercial low-level waste isolation or for defense industry clean-up:

1. Because there are so many social and ecological problems competing for attention and resources, leadership must be present to get low-level radioactive waste management on the political agenda and keep it there until long-term solutions are implemented.

2. Because there is so little public trust, industry and responsible government agencies must demonstrate management competence--the competence to generate only waste that cannot be avoided and to handle that which must be produced as safely as possible.

3. Because decisions about low-level waste facilities and management are in the public arena, those responsible for finding and implementing solutions must learn to work through the public process to reach decisions the public considers fair and trustworthy.

Carol Williams, consulting editor, contributed significantly to the development of this paper.

Since the late 1970's many people have worked hard to resolve the question of how this nation will manage its low-level radioactive waste. However, many problems persist. No new disposal facilities have been built since the early 1970's and some states do not appear to be making much headway on the problem. The current alignment of states in compacts may lead to the designation of more sites than necessary, thus wasting resources and sites that might be used for something else and causing dissension and disruption in more communities than is really necessary. However, progress has been made: low-level waste is on the political agenda in an effective way in many states; much more management attention and skill are being devoted to waste management; and more experience has increased the understanding and skill necessary for management and government officials to be able to involve the public effectively in waste management decision-making.

What conditions have produced this progress? What have we learned from ten years of work on the problem? How can these lessons be applied to future decisions, including those about the cleanup and isolation of defense waste?

GETTING ON THE AGENDA: THE ROLE OF LEADERSHIP, PENALTIES, AND SECURE FUNDING

Progress in low-level waste management and similar programs is made when political leadership installs an adequate policy framework to deal with the question. Several conditions appear to make a difference:

a. individual politicians willing to assume leadership and make sure the issue keeps getting the attention it needs;
b. legislation or court rulings mandating deadlines for reaching solutions and penalties for failure to meet deadlines; and
c. adequate, reliable funding available from appropriate sources to provide the resources needed to address the problem.

In the late 1970's, with the help of the governors of Washington and Nevada, South Carolina Governor Riley forced low-level waste management onto the national agenda. Working through the National Governors Association and later the State Planning Council and demonstrating the willingness to deny access to the only sites operating in the country, the three effectively kept Congress' attention on the problem. Backed by rising public concern that their states would forever be the national dumping grounds for low-level waste, their efforts led to the 1980 Low-Level Radioactive Waste Policy Act (Public Law 96-573).

The following five years, when the emphasis shifted from development of federal legislation to states' efforts to form compacts, provide a great fund of cases for a study in the difference leadership makes. The amount and level of attention paid to low-level waste management varied greatly from state to state, depending in large part on the presence or absence of leadership. The outcome of compact negotiations varied similarly.

Not surprisingly, it was very difficult to get the public and local officials to pay attention to low-level waste questions during this time. Most people wake up to an issue only after it touches them very directly, such as after a site is proposed for their area. All the work and discussion ahead of time is invisible to them because they haven't been paying attention. It is very difficult to get most people, who are busy with their daily lives or with other political and ecological issues, to pay attention to this apparently distant issue. When a program becomes a concrete proposal that affects them, they pay attention. In addition, some people may avoid thinking about radioactive waste management issues because the topic seems depressing and the problems unsolvable or too large for individuals to effect.

The time and effort it took to form compacts made it clear by 1984 that the 1985 deadline for closing the three existing sites to out-of-compact waste would be missed and that new legislation was needed. Again, the leadership materialized to get Congress' attention and pass new legislation, this time with a different, sharper set of teeth.

That leads to a second point--the need for some kind of forcing function, such as mandated milestones and penalties or court orders, that provides an excuse, a reason, for people to keep pressing the issue. The Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240) established clear milestones and penalties and authorized the three states containing sites and the Department of Energy to enforce them. The Act's goal is steady progress toward developing additional disposal sites. When Governor Blanchard recently said he thought Michigan would pause a while in looking for a site to see if it were really needed, the Governors of South Carolina, Washington, and Nevada (the states with the currently operating sites) were able very effectively and quickly to say, "Oh, no you don't!" by cutting off Michigan's access to the existing sites. Michigan is now back in the looking-for-a-site mode.

As an aside, I think Governor Blanchard was quite right to be concerned about the proliferation of sites. But he wasn't able to alter the script: he lacked the necessary credibility since his state doesn't have a site. The sited states are guardians of the process, and the process' goal is to produce more sites.

The third point about keeping projects on the political agenda is based on a little evidence, some theory, and the knowledge that getting the economics right is important to sustaining any program or solving any problem. Controversial projects need the security and continuity that comes from secure, adequate funding and the legitimacy conferred by an appropriate source. Although not all successful programs have such a funding base, dedicated funding can play an important role in keeping programs out of the main line of fire in the wars over budgets and in being considered reliable by members of the public and public officials whose cooperation is necessary.

Furthermore, having the source of funds be a tax on waste generation builds in an incentive to minimize the volume of waste generated. It also builds in a group of people who want the project to succeed because they are paying for a solution. They will keep the pressure on for progress. In addition, such a funding base builds in a sense of legitimacy, an element of fairness, because the people who are causing the problem are paying for a solution. Note, however, that dedicated funding does not always work exactly as intended. The Nuclear Waste Fund for the civilian high-level waste program has gotten caught up in Graham-Rudman budget wars even though it is funded by a tax on the generation of electricity by nuclear power.

A related program that illustrates these points is the clean-up of Boston Harbor. This is a massive undertaking requiring the siting of a number of unwanted facilities. Siting and construction will last over many years, will potentially inconvenience a lot of people, and will cost an amazing amount of money. The thing that got the clean-up on the agenda and is keeping it there is a court order. A court order is indeed a wondrous thing for forcing action when every one knows a problem needs attention, but no one is willing to expend the political capital necessary to tackle it. The court order provided the necessary political "cover" that allowed the legislature and governor to establish the Massachusetts Water Resources Authority (MWRA) with a clear mandate to meet the deadlines. The Authority has a secure, if regulated and protesting, source of funding--the water rate payers. So far the MWRA is surviving amid constant turmoil and threats. They're siting a headquarters--which everyone wants--as well as two waste disposal facilities and a large staging area for work in the harbor--which no one wants--all at the same time. How effective they will be over the long haul may well depend on the next imperative: management competence.

RESTORING CONFIDENCE: THE ROLE OF THE MANAGER IN AN OPEN PROCESS

> "If you once forfeit the confidence of your fellow citizens, you can never regain their respect and esteem. It is true that you may fool all the people some of the time; you can even fool some of the people all the time; but you can't fool all of the people all the time."
> --Abraham Lincoln (1).

Of course, Abe Lincoln said this well before the advertising and political management industries really got going, but I think the essence is still true. It is very difficult to regain public confidence, once lost; and people can't be fooled over the long haul. In the long run, it's best to act in a way that deserves confidence and to be certain that people get an opportunity to see that you do deserve confidence.

There are, therefore, two aspects to a manager's job in this field: technical and political. The task of managing radioactive material and isolating the waste is a technical job. The public interest will not be served in the long run if decisions are reached that are publicly acceptable but scientifically or technically weak. Nor will it do any good to propose sound technical solutions that are not implementable because they do not take into account public values and political realities.

A good manager in this arena needs to develop:

a. a technically competent program;
b. respect for and understanding of the public decision-making process and a capacity to enjoy that process, as messy as it is; and
c. methods for effective interaction between the technical program and the public, the public being defined as all those outside the program.

Some people may feel that the need for technical competence goes without saying, but it's worth mentioning for two reasons. It's important to remember that a technically sound program is the bedrock on which to build a publicly acceptable program. Smoke and mirrors won't do; eventually people will know if a project is not solidly grounded. Also, a technically sound program is not necessarily an easily attained requirement. The competition for well-trained people in the fields needed by low-level waste programs, already evident, will become increasingly fierce as the Department of Energy Defense Programs' Environmental Restoration Program (2) gears up. People with the needed combination of technical and political skills will always be a rare subset of the available group. States may have difficulty retaining competent people with state salaries and career paths; commitment to solving society's problems can only go so far, especially if people can work on the same problem at the national level or for private industry at higher salaries. This problem needs immediate attention if the availability of trained personnel is not to become a limiting factor in finding solutions (2, page 26).

A manager also needs sincere respect for and understanding of the public involvement process. People will be involved, not just because it is a legislated requirement, but also because they have a stake in the outcome. They will be heard, one way or another. To be successful, managers must perceive the public's interest as an asset that can produce better and more acceptable decisions. Bill Dornsife, who runs Pennsylvania's program, is a convert to the view that public involvement can be used to produce better decisions. The way he conducts his program and talks about the public makes this attitude clear. People know whether a manager expects something useful to come from their involvement or whether a manager is just tolerating public involvement because it's mandated.

Finally, a manager must provide for effective interaction between the technical program and the public involvement process. Technical options and limitations need to be communicated to the public. Technical decisions should be made only after consideration of public preferences, opinions, and requirements. In the next section I will discuss more fully how that can occur, but I'll make one point here. The public has a strong sense of reality and of the finite limits of technology; bland assurances won't assuage concerns about the potential failures of technology. We all live with appliances that sometimes break. We all walk on concrete sidewalks full of cracks. People know that machinery and materials fail, no matter how good their marketing is. People in an area being considered as a radioactive waste isolation site will feel uneasy if the only contact they have with the siting program is through a public relations department, however competent and well meaning. A technically competent person's going out to "kick the tires" with the public can be immensely effective. Field scientists are particularly good at this, because they usually respect and draw on local knowledge. For example, the chemistry began to change in the Salt Repository Project in Texas when field scientists and technicians arrived in Deaf Smith County and were able to talk with people. When the person responsible for sinking the shaft through the Ogalala was able to talk to local people who had experience drilling in the area, real concerns began to be explored and dealt with in a constructive way. We'll never know the outcome, of course, because the project was terminated by Congress. But the public's communication with the technical staff was making a difference.

UNDERSTANDING JEFFERSON, MADISON, ALINSKY: HELPING THE PUBLIC DO ITS WORK WELL

Public participation in government decisions is an integral part of our form of government, not a new invention for this program. This country was built on the idea of self-determination, with citizen involvement in governmental decision-making included as a fundamental aspect of a representative democracy. The Declaration of Independence states that "governments derive their just powers from the consent of the governed," implying that without that consent, the powers of the government are illegitimate and unjust. Thus it is an essential task of government to provide ways for citizens to give or withhold their consent for actions taken in their name and an equally essential task of citizens to hold the government accountable. How that occurs has evolved since Jefferson and Madison's time and it will continue to evolve as times and conditions change.

Greater ease of travel and communication may make the task easier now than then, but other circumstances make "gaining consent" more complicated. The U.S. has a larger, more diverse population and an expanded definition of who as a citizen must consent. Our geographic borders are much greater, and the issues government must address are much more technically complex. An explicit requirement for public involvement has become a standard feature of legislation establishing new programs, beginning with the urban renewal laws in the 1960's and accelerating in the environmental laws of the 70's. In addition, the populist tradition of neighborhood organizing, which arose in urban conflicts with success because of people like Saul Alinsky (3), has now been transferred to environmental and siting conflicts. Increasingly, people have felt powerless to affect large governmental programs that serve the general public or industry interests at local expense. At the same time they feel unrepresented by national environmental organizations with larger or single issue perspectives. During the last six to ten years, community leadership on local ecological issues has been provided decreasingly by representatives from large national environmental organizations and increasingly by grass roots populists using urban organizing principles.

The competing claims of representative and direct democracy contend vigorously in the public arena. People seem less and less willing to give their mandate to anyone else, as witnessed by the proliferation of referenda in states such as California and Massachusetts. This trend must be taken into account by those responsible for involving the public.

So how can programs proceed? The past decade's experience in siting efforts suggests several starting principles:

a. Set reasonable goals and expectations for public involvement and understand the various goals and expectations of different segments of the public.
b. Establish and maintain open, two-way communication.
c. Integrate public involvement into the technical program, allowing adequate time and resources for the public to understand the issues and have an impact on the outcome.
d. Be prepared to recognize and take into account non-technical dimensions of the problem.
e. Share responsibility for the outcome.

Public involvement is not a panacea, a one-size-fits-all cure for program difficulties, nor is it a meaningless ritual, a check list that must be gone through to survive court challenges. Rather, public involvement is a vital part of the siting process that can improve the technical quality of decisions and ensure that they are implementable because they take public values and concerns into account.

Goal-setting. To set goals for public involvement, managers must think first about why the public is to be involved and what they have to offer the decision-making process. They need to consider also why members of the public should be expected to take the time to be involved in the process, what they can hope to accomplish, and whether the public's goals and expectations and those of the program are compatible.

To clarify expectations, managers need to establish how each decision will be made and by whom. In some cases, shared power may be appropriate and possible. For example, a community may negotiate the right to close down a facility under certain conditions and for certain periods of time. But power-sharing is not always necessary, possible, or even desired by the public in all cases. However, unrealistic or vague expectations about decision-making power can be very troubling and cause a great deal of difficulty. The way to make these things clear, of course, is good communication.

Open two-way communication. If people are to be effectively involved in a program, they have to understand it. If a program is benefit from public involvement, its managers must hear the people. If all sides are to work together toward solutions, each must understand the needs of the others. How to communicate effectively has been the subject of numerous studies, books and workshops. One of the most practical is IPP's Citizen Participation Handbook (4). During the past year, I served on the Committee on Risk Communication of the National Academy of Sciences National Research Council, and I think that the committee report (5) will also be very useful for improving communication on low-level waste management programs.

Public and technical program integration. One key element to communication is wanting to communicate for a purpose. Public involvement must be purposeful. To be effective, it cannot be an appendage to a project, an afterthought. Rather, the public involvement program must be an integral part of the project's development, focused on real tasks and decisions rather than fabricated ones. If opportunities for public interaction do not occur well in advance of decisions, they will be regarded, perhaps rightly, as merely a public relations ploy rather than as a real opportunity to be heard and to have public concerns and information taken into account. Adequate informational resources, ample lead time, and technical expertise must be available to assist the public in dealing with complex technical issues. Public participation must receive the same seriousness of purpose, planning, and expectation of quality as the technical program.

Non-technical dimensions. If the public's involvement is to influence the shape of a solution, the program managers must be prepared to understand and take into account the non-technical dimensions of problem--the factors that most heavily effect people's lives. One very powerful example is the equity issue, the issue of fairness. Why should one particular community bear the burden of managing the waste generated for the benefit of other people, other parts of the state or country, or other sectors of the economy? How can a community be treated fairly under those circumstances? William Colglazier and Mary English (6) at the University of Tennessee have done a lot of good work on this question. They formulate the issue in three types of fairness: evidence, process, and outcomes. I recommend their work to those seeking to answer those questions.

Conflicts in values and interests are not new. The Michelin Guide to The West Country of England contains a discussion of lighthouses, their history and construction:

> While the necessity, in some cases, for a light and, therefore, toll rates were hotly contested by Merchant

> Venturers, ship masters and Trinity House, delaying the granting of a building patent for years, other lights came into existence modestly and personally....
>
> Vested interests also delayed construction - to many the winter gales with ships driven in the rocks afforded rich plunder. There was a 50-year delay due to local opposition before the first lighthouse was built on the Lizard in 1619. Its existence was brief: shipmasters refused it tolls, declaring it to be a wreckers' decoy.

So here was a 17th-century conflict of interests: the local interest in having those ships to go on the rocks and the shipping interest in having the ships avoid them. The conflict was further complicated by a misunderstanding about the light's purpose, the ships masters thinking the light's purpose was to lure them in to the rocks, the locals thinking the purpose was to deprive them of the income from plundering.

Shared responsibility. The final point about involving the public is the need to share responsibility for the problem. The legal responsibility for decision-making may be an agency's. That responsibility has to be placed somewhere. But the worst thing that can come across from a program is for the manager to convey, "This is my problem and I'm going to make the decisions and I'm going to solve it all." Low-level waste management is a shared technical, ecological, social, economic problem, and that sense of shared responsibility needs to come across. Management and public have a task to do. Getting people to agree to one particular solution by one particular process is not the goal of public involvement. Sharing the problem, remaining open, and keeping everyone's eye on solving the problem rather than on reaching a particular solution is more likely to work. Managers and public representatives may have to start more than once. This problem has required more than one change in legislation and it may require others. Clearly the proliferation of sites has to be addressed, perhaps in negotiations among states, since the waste of resources and the psychic burden of siting too many facilities is not in the public interest. The existing process is not perfect; none is. We'll have to make adjustments, but those adjustments can occur if we all remember that we are trying to solve a common problem and if we can keep from getting locked into personal ownership or particular solutions.

The management and isolation of low-level radioactive waste is a technical and public policy problem that we--legislators, industry managers, government officials, activists, general public--all of us--need to solve in the best way we can. Progress has been made; it can continue. Experience suggests that three important conditions are essential to further progress: political commitment, managerial skill, and effective public involvement.

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DEVELOPMENT OF AN INTEGRATED STRATEGY FOR THE DISPOSAL OF SOLID LOW LEVEL WASTE AT BNFL'S DRIGG SITE

S G HIGSON

British Nuclear Fuels plc
Risley, Warrington, England

ABSTRACT

During the past 12 months, the first phase of a major upgrading of disposal operations at Drigg has been completed. This has involved the introduction of waste containerisation and orderly emplacement in open concrete vaults. A further phase over the next few years will involve the introduction of compaction of all suitable waste.

Whilst the current upgrade has clearly resulted in a major improvement in the visual impact and management control of the site, the desire to implement such an improvement on a timescale consistent with the short term need for new facilities at Drigg has not allowed sufficient time for a detailed assessment of the full implications of the proposed system.

This paper describes the development of the strategy for upgrading the Drigg site, highlights improvements that have been implemented as the project has progressed and outlines major outstanding concerns, particularly in relation to long term site management, that may eventually lead to a requirement for further optimisation of the overall strategy.

Progress under the Drigg Technical Development Programme is reviewed with specific emphasis on the preliminary results of engineering studies aimed at defining an integrated strategy that will meet the requirements of both acceptable visual impact and long term site stability and safety.

INTRODUCTION

1 During the past twelve months, the first phase of a major upgrade of low level waste disposal operations at the British Nuclear Fuels plc (BNFL) Drigg Depot has been completed. The aims of this paper are to review the evolution of the engineering strategy adopted in support of this upgrade and to outline the potential direction of future developments with particular emphasis on the implications for the long term management of the site.

2 This paper is the third in a series of papers to US Low Level Waste Management Conferences (ref 1 and 2).

SOLID LOW LEVEL WASTE ARISINGS

3 The UK Radioactive Waste Management Advisory Committee has classified low level waste (LLW) as being that material containing radioactive substances, other than those very low level wastes (less than 400 KBq in any $0.1m^3$) acceptable for dustbin disposal, but not exceeding 4GBq/t alpha or 12GBq/t beta gamma.

4 The major source of solid low level waste is from fuel reprocessing operations at the Sellafield site of BNFL. Additional sources include other BNFL production establishments, nuclear power stations, United Kingdom Atomic Energy Authority sites, Ministry of Defence facilities, hospitals, universities, radio-chemical sites and various industrial organisations.

5 The composition of solid low level waste is highly heterogeneous and includes materials such as cellulosics, plastics, metals, soil and rubble. Typically, about 70% by volume of the waste as it arises is suitable for compaction. Raw waste is generally assumed to have a packing efficiency of 10% and an average bulk density of about $0.3t/m^3$.

6 In recent years, the average rate of arisings from Sellafield (prior to any pre-treatment or containerisation) has been about $25,000m^3$/year although this is expected to rise to about $45,000m^3$/year as new plants come on-line. In recent years, arisings from other sources have combined to generate about $13,000m^3$/year. Recent estimates have shown that future arisings from these other sources will fall to some $9,000m^3$/year (prior to any pre-treatment or containerisation) primarily as a result of more careful segregation of very low level waste at source.

CONTROL OF DISPOSALS

7 Consent to dispose of solid low level waste at Drigg was granted in 1957 and disposal operations started in 1959. Authorisation to dispose is issued by the Department of Environment and the Ministry of Agriculture, Fisheries and Food under the terms of the Radioactive Substances Act 1960.

8 The main conditions of the current authorisation are:

(a) that the activity in any one consignment should not exceed 4GBq/t alpha emitting radionuclides or 12GBq/t other radionuclides;

(b) that consignors are required to use best practicable means to compact waste before disposal;

(c) that BNFL is required to use best practicable means to limit the migration of any radionuclides from the waste disposed;

(d) that leachate leaving the site does not exceed certain concentration limits on specified groups of radionuclides;

(e) the imposition of annual limits for certain individual and groups of radionuclides allowed for disposal;

(f) that a minimum soil cover of 1.5m be provided where waste is not yet fully containerised.

In order to meet these statutory requirements BNFL impose certain conditions for acceptance of waste, all aimed at meeting technical and radiological safety criteria as well as legal requirements.

THE DRIGG SITE AND PAST DISPOSAL PRACTICES

9 BNFL's Drigg Depot is located in West Cumbria about 6km south-east of the Sellafield site. The site was formerly a Royal Ordnance Factory that was developed in 1939 but was abandoned soon after 1945. The site has a total area of about 270 acres and runs parallel with the coast, about half a mile from the sea. The ground slopes gently towards the sea, being about 20m above sea level on one side and about 7m at the other. A small stream runs through the site, parallel to the western boundary, and discharges into the mouth of the adjacent River Irt.

10 The geology at Drigg consists of a complex heterogeneous sequence of glacial sediments overlying an irregular surface of red sandstone bedrock. The glacial deposits range from compacted clays through silts to coarse sand and gravels.

11 Only the northern 88 acres of the site are currently consented for disposal of low level waste. Within this area there is an essentially continuous clay layer at about 5-8m depth. Past disposal operations have involved the use of trenches cut so that the clay layer forms a low permeability base. The trench floors are graded in order to direct any infiltrating water to the southern end where it is collected by a series of drains leading to the stream and subsequently into the Irish Sea via the River Irt. Waste was tumble tipped working progressively from the northern end of the trenches. As the level of the waste

approached the prescribed depth below existing ground level, it was covered with earth. A layer of small boulders and a geotextile sheet were incorporated into this layer to form a stable flat surface from which further disposal operations could be carried out.

12 This method of disposal is currently being phased out but still continues on a temporary basis for Sellafield waste.

UPGRADE OF DRIGG OPERATIONS

13 Despite successive assessments which confirmed the safety of trench disposal, BNFL announced in September 1987 that a major programme of improvements was to be implemented at Drigg. This was prompted primarily by:

(a) a need to conserve capacity within that area of the site currently authorised for disposal of LLW;

(b) longer term site closure considerations;

(c) increasing public concern regarding the visual impact of tumble tipping.

14 The programme of improvements included:

(a) capping and provision of groundwater cut-off walls to limit rainwater infiltration and lateral migration of groundwater;

(b) refurbishment of the trench drainage system;

(c) containerisation of waste with compaction where appropriate;

(d) provision of concrete vaults for future disposals.

15 Capping is to proceed in two stages in accordance with good landfill practice. Initially a temporary cap comprising a 1:25 graded earth mound incorporating an LDPE (low density polyethylene) membrane is to be provided. Such a cap has recently been installed over the completed trenches at Drigg. Only when subsidence is largely complete will a permanent cap be constructed. This latter cap will incorporate a thick band of clay and will be designed with the aim that the waste remains covered for at least 10,000 years. A 600m long groundwater cut-off wall has also been installed to isolate a known pathway for leachate migration.

16 Refurbishment of the trench leachate collection system and installation of new proportional leachate sampling equipment has been completed. Work has also commenced on the refurbishment of an existing marine out-fall to permit leachate to be routed direct to the Irish Sea rather than via the River Irt.

17 Development and implementation of proposals for waste compaction, containerisation and orderly emplacement in concrete vaults are reviewed in more detail in the following sections.

DEVELOPMENT OF STRATEGY FOR DISPOSAL OPERATIONS UPGRADE

18 This section reviews the development of the strategy for the upgrade of disposal operations at Drigg which has centred on three inter-related areas:

(a) pre-treatment;

(b) packaging;

(c) trench/vault design.

19 In the early 1980's, it was recognised that volume reduction of low level waste could have significant benefits both in terms of cost and Drigg site longevity. Several assessments were carried out and it was concluded that compaction was preferred to other more advanced volume reduction techniques such as incineration on the grounds of timescale to deployment, cost benefit and technical simplicity.

20 For the compaction of Sellafield waste a low force (about 80t) baling process was initially proposed. High force compaction was not considered as a lead option since the pre-requisite drumming of the feed was inconsistent with existing Sellafield operating procedures. The baling process, however, was compatible with existing operating procedures which involved collection of waste in 5 and 10m^3 lidded skips. Upon receipt at the plant, the skips were to be tipped and the contents sorted to segregate bulk non-compactable items (typically about 30% by volume). The compactable fraction was then to be baled, wired and wrapped. The product from the plant would then be loaded back into skips for transport to Drigg using the existing transport system.

21 Subsequent assessments showed that continued loose tipping of bales could negate some of the volume reduction achieved by compaction and thus consideration of options for the orderly emplacement of waste was initiated. It was concluded that containerisation of both the loose non-compactable waste and the baled waste would simplify the emplacement operation and would also significantly enhance the visual impact of operations at Drigg.

22 In line with the developing plans for Sellafield waste, the concept of orderly emplacement of waste from non-Sellafield consignors was also introduced. Typically, some 70% by volume of non-Sellafield arisings are drummed for handling and transport purposes. It was therefore proposed that the drummed waste should be loaded into stillages for transport to Drigg in a suitable overpack. At Drigg, the stillages

were to be removed from the overpack for emplacement, the empty overpack being returned for re-use. Loose non-Sellafield waste was to be loaded into non-reusable containers.

23 Estimates indicated that waste arisings from non-Sellafield sources accounted for about 25% of the total volume of waste consigned to Drigg. It was apparent, therefore that compaction of this waste could contribute significantly to conserving the capacity of the area of the Drigg site that was authorised for waste disposal. There was also the potential for cost savings for non-Sellafield consignors, particularly in view of the additional costs associated with the introduction of containerisation and orderly emplacement. Since handling arrangements at non-Sellafield consignor sites already provided for drumming of suitable wastes, specification of a high force compaction process was a logical development. Two concepts were considered involving either a fixed central plant at Sellafield or the use of mobile units. The current preference of the major non-Sellafield consignors is the adoption of the mobile system.

24 In parallel with the development of the concepts of compaction and containerisation, the options for waste emplacement at Drigg were also assessed. In order to stack containerised waste in close array it was recognised that a stable, flat base to the trenches would be needed. This would also permit handling of the waste within the trench by fork lift truck which was preferred to the use of overhead or mobile cranes (both of which would limit the size of the trench). A reinforced concrete base slab was subsequently specified. Side walls were also proposed in order to:

(a) provide support at the edge of the "trench";

(b) prevent ingress of contaminated groundwater on to the operating surface;

(c) further enhance the visual impact of disposal operations.

Phased construction of the first such upgraded trench (referred to as Vault 8) commenced in October 1987 with the first phase being handed over in August 1988 and the final phase in January 1989. The total cost of Vault 8 was about £8.6M ($13M). The nominal capacity is about 180,000m^3. As with the trenches, the principal method of containment of leachate is still the underlying clay layer which has been augmented with a specially formulated engineered clay where necessary. Separate surface and under-slab drainage systems are provided which combine at a monitoring station prior to discharge from the site. Details of the Vault are shown in Figure 1.

25 As container and stillage design proceeded, it became apparent that there were a number of shortcomings particularly in terms of cost and effective utilisation of vault space at Drigg. An alternative concept based on the disposal of all waste in either full or half height ISO freight containers was examined and significant reductions in cost and improvements in the effective use of vault space were noted. The ISO freight system was subsequently adopted as the standard for packaging of waste for disposal at Drigg. Figures 2 and 3 show full and half size ISO freight containers respectively.

26 During 1988, the specification of a sorting/baling plant for Sellafield waste was also reviewed to:

(a) determine whether there were any potential cost savings;

(b) examine how operator dose uptake, particularily from sorting line maintenance, could be reduced.

The review subsequently concluded that the adoption of in-container compaction (as used widely in the domestic refuse industry) would eliminate the need for a sorting line with resultant cost and dose uptake savings. Further, in-container compaction was readily compatible with the proposed ISO freight system.

27 In summary, therefore, the strategy that evolved centred on:

(a) packaging of all waste in ISO freight containers;

(b) in-container compaction of unsorted Sellafield waste;

(c) high force compaction of drummed non-Sellafield waste;

(d) loading of loose untreated, non-compactable, non-Sellafield waste direct into containers;

(e) orderly emplacement of packaged waste in concrete vaults.

28 In terms of timing, it was noted that provision of packaging facilities for Sellafield waste was dependant upon the availability of the compaction plant. With the space remaining in the last open cut trench being limited, containerisation of non-Sellafield waste was introduced from January 1988. This waste was held on a temporary hardstanding at the end of the trench and was subsequently transferred to Vault 8 upon its completion. The capacity remaining in the trench was therefore reserved for continued loose tipping of Sellafield waste pending the availability of the compaction plant.

RECENT DEVELOPMENTS

29 Continuing optimisation following the specification of ISO freight containers highlighted that this proposal could reduce the effective use of vault space at Drigg by about 25%. This was due to the space lost to the basic structure of the container and the poor packing efficiency of certain waste streams (eg about 75% for 200 litre round drums) into the containers. Taking into account the relative composition of the waste, the performance of the proposed compaction processes and the impact of containerisation, it has also been calculated that voidage in the vault at emplacement may still be significant.

30 The optimisation studies have therefore taken account of this voidage, together with the estimated durability of the ISO freight containers, and have considered these factors in relation to the stability of the site after capping and the implications for long term site maintenance. As a result, a number of specific engineering studies have been initiated. The view emerging from these studies is that the optimum strategy could be to adopt high force compaction of all suitable waste (Sellafield and non-Sellafield) in conjunction with grouting of the resulting pucks and loose non-compactible waste. A combination of both $1m^3$ boxes and 200 litre drums could be envisaged depending upon the operational practicalites prevailing at individual sites.

31 The implementation of a strategy based exclusively on high force compaction and grouting would have a number of advantages including:

(a) enhanced long term site stability;

(b) minimisation of waste/groundwater contact and hence reduced radiological impact due to leachate discharges;

(c) lower probability of future human intrusion during the post-institutional management period.

32 Whilst even greater benefits could be envisaged with the adoption of, say, incineration rather than high force compaction, timescale to deployment remains a major obstacle. There are also technical uncertainties relating to the high PVC content of the waste (typically in excess of 10% by volume) and the presence of I-129 contamination on some of the waste which could, for example, give rise to off-gas treatment problems.

33 Final decisions on the overall strategy to be adopted for the treatment and disposal of low level waste at Drigg are expected to be taken later in 1989.

DRIGG TECHNICAL DEVELOPMENT PROGRAMME

34 Over the past 12 months, there has been a major expansion of the Drigg Technical Development Programme. The programme, which totals some £1.5M ($2.25M) in 1989/90, is divided into four main areas covering engineering, near field, far field and radiological studies.

Engineering Studies

35 The work under this area of the programme has largely underwritten the recent strategy developments outlined in the previous section of this paper. Specifically, engineering design studies have been carried out into:

(a) the overall engineering development of the Drigg site examining, in particular, the alternatives for vault design, operations and closure, waste pre-treatment and packaging and groundwater management.

(b) the feasibility of modifying an existing non-active incinerator for processing suitable Sellafield low level waste arisings.

(c) the range and order of cost of possible remedial measures that could be required at Drigg up to the end of the institutional management period.

Near Field Studies

36 The aim of the Drigg near field programme is to provide an understanding of the physical, chemical and microbiological conditions within and adjacent to the trenches and vaults. Included within the scope of this programme are studies into waste characterisation, waste degradation, waste leaching, materials ageing, sorption and chemical modelling. The programme will result in the specification of source term data for use in far field studies and radiological assessments.

Far Field Studies

37 The aims of the Drigg far field programme are to predict groundwater movement and associated activity migration in the surrounding undisturbed geology. This well established programme covers hydrogeological characterisation and radionuclide sorption studies. The hydrogeological characterisation work covers both field measurements and computer model development.

Radiological Studies

38 The main aim of the radiological studies programme is the development of a Drigg specific database and methodology. Efforts are also being directed towards improving assessment of human intrusion scenarios by basing them on more explicit recognition of all possible events.

SUMMARY

39 The evolution of the long term engineering development strategy underwriting the upgrade of disposal operations at the Drigg site has been reviewed. Definition of the preferred options is imminent and will be dependent upon consideration of radiological impact, cost, site capacity, timescale and public acceptability.

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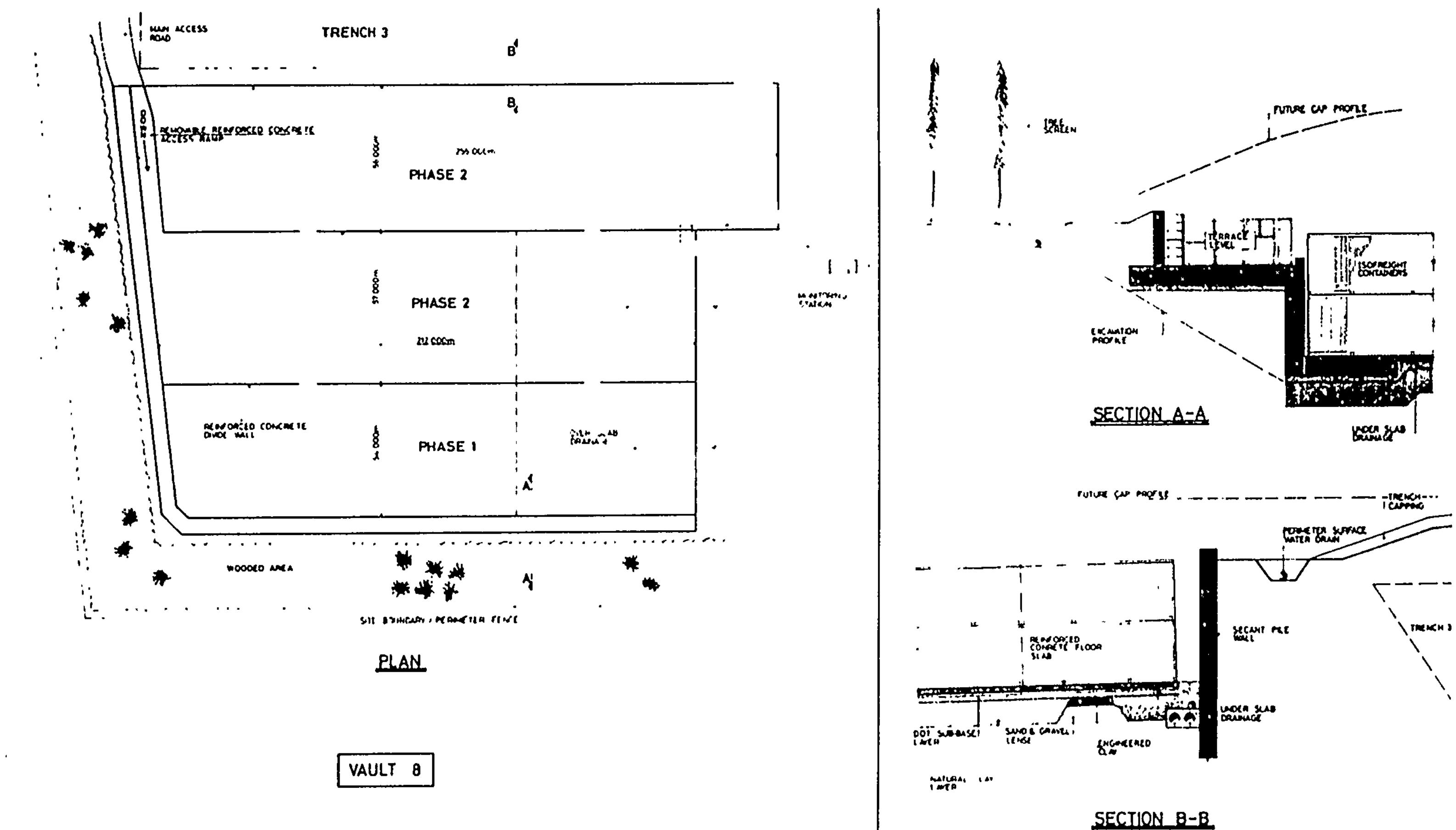

FIGURE 1 : DETAILS OF VAULT 8, DRIGG

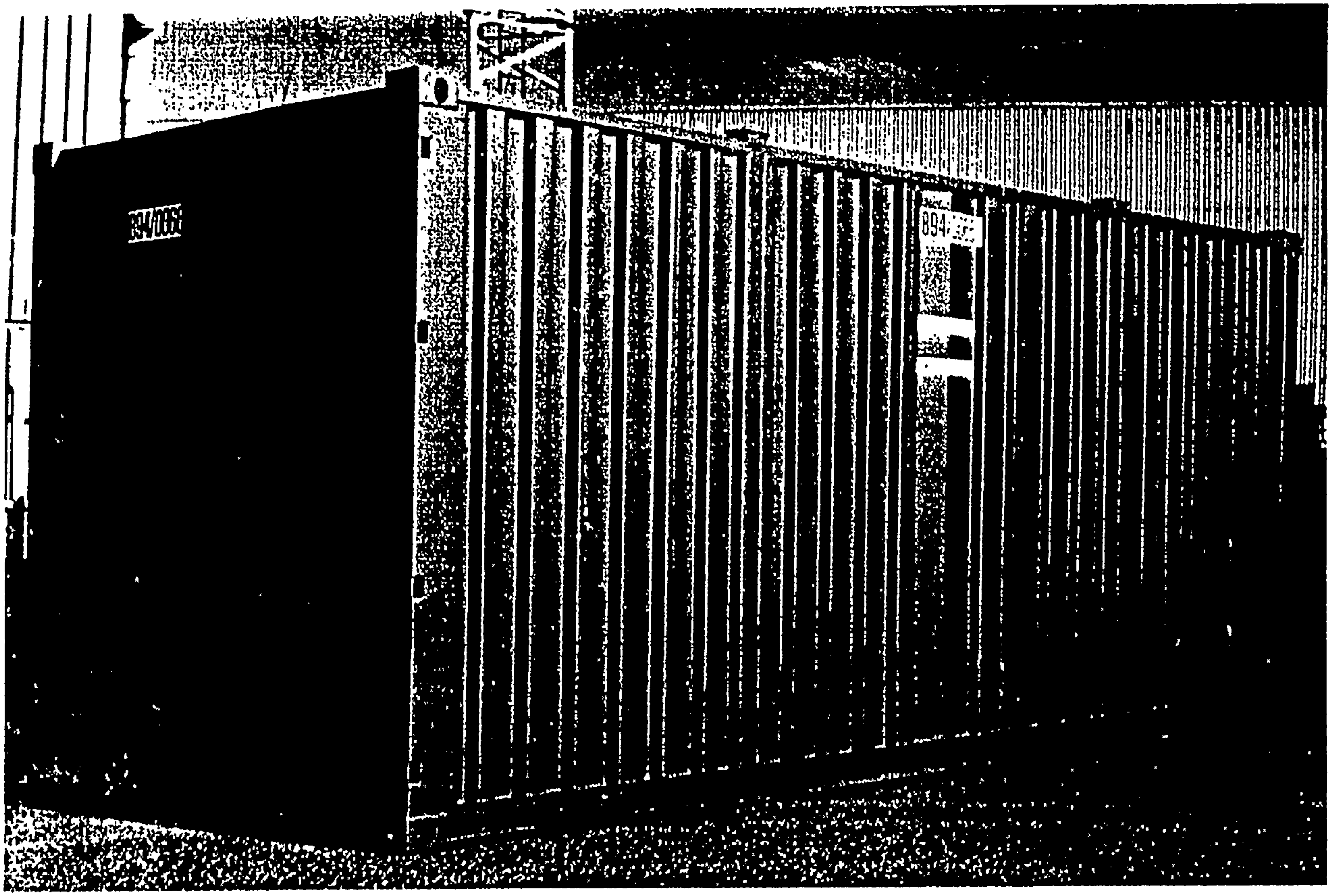

FIGURE 2 : FULL SIZE ISO FREIGHT CONTAINER

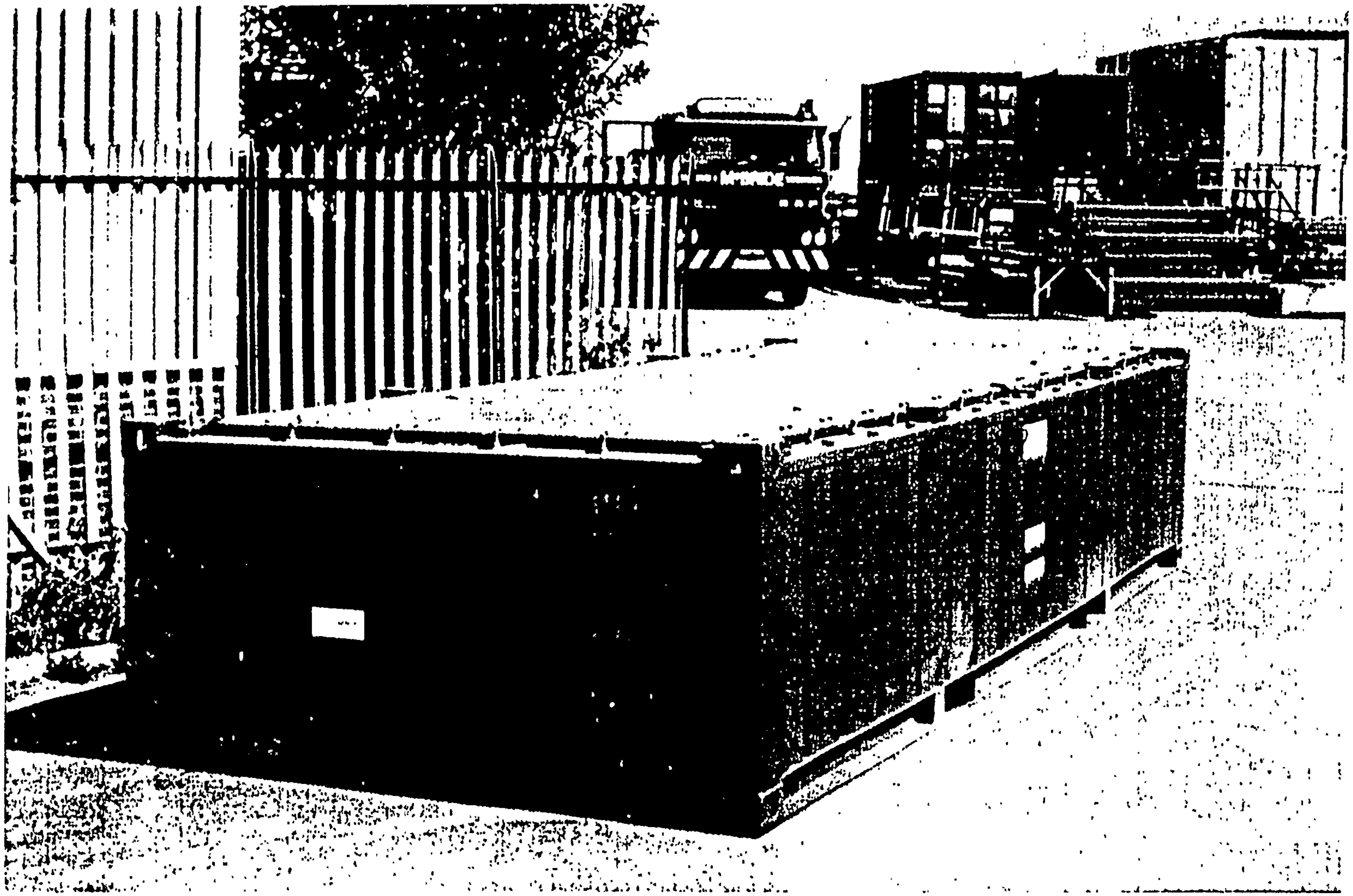

FIGURE 3 : HALF SIZE ISO FREIGHT CONTAINER

HANFORD SITE SOLID LOW-LEVEL MIXED WASTE PROGRAM

JAMES D. ANDERSON
HARLAN C. BOYNTON
WILLIAM G. JASEN

WESTINGHOUSE HANFORD COMPANY
RICHLAND, WASHINGTON 99352

ABSTRACT

Solid radioactive wastes have been managed at the Hanford Site since the early 1940's. Initially solid wastes were disposed of through shallow land burial. Later certain wastes were placed in below-grade areas designated as retrievable storage. Currently, contact-handled mixed wastes are placed in above-grade storage facilities. This paper presents a brief description of past, present, and future mixed waste activities at the Hanford Site.

INTRODUCTION

Historically, solid radioactive wastes have been disposed of through shallow land burial. Mixed wastes (MW) currently comprise a small percentage of the total solid radioactive wastes. In the past, MWs were handled similarly to other low-level wastes. During the 1980's many changes have occurred in the management of MWs. Currently, Hanford Site-generated solid MWs are designated per the Washington State Department of Ecology (Ecology) "Dangerous Waste Regulations," Chapter 173-303, of the Washington Administrative Code (WAC) (Ecology 1989), segregated from other low-level wastes, and placed in above-grade storage facilities. Unless otherwise noted in this paper, the term "mixed wastes" applies to solid low-level wastes that are co-contaminated with hazardous constituents.

DEFINITION OF MIXED WASTES

Mixed wastes are defined as radioactive wastes, whether high-level, transuranic, or low-level, that also contain dangerous and/or hazardous constituents. Mixed wastes then provide an interesting regulatory array. Based upon the May 1987 Byproducts Rule (DOE 1987), the radiological constituents are governed by the Atomic Energy Act (AEA), and the chemical or hazardous constituents are governed by the Resource Conservation and Recovery Act (RCRA). (See Figure 1.)

Solid radioactive wastes are managed in accordance with U. S. Department of Energy (DOE) orders. The DOE Order 5820.2A (DOE 1988) is the principal order that affects solid radioactive wastes. This order also requires compliance with applicable State and Federal regulations. Since Washington

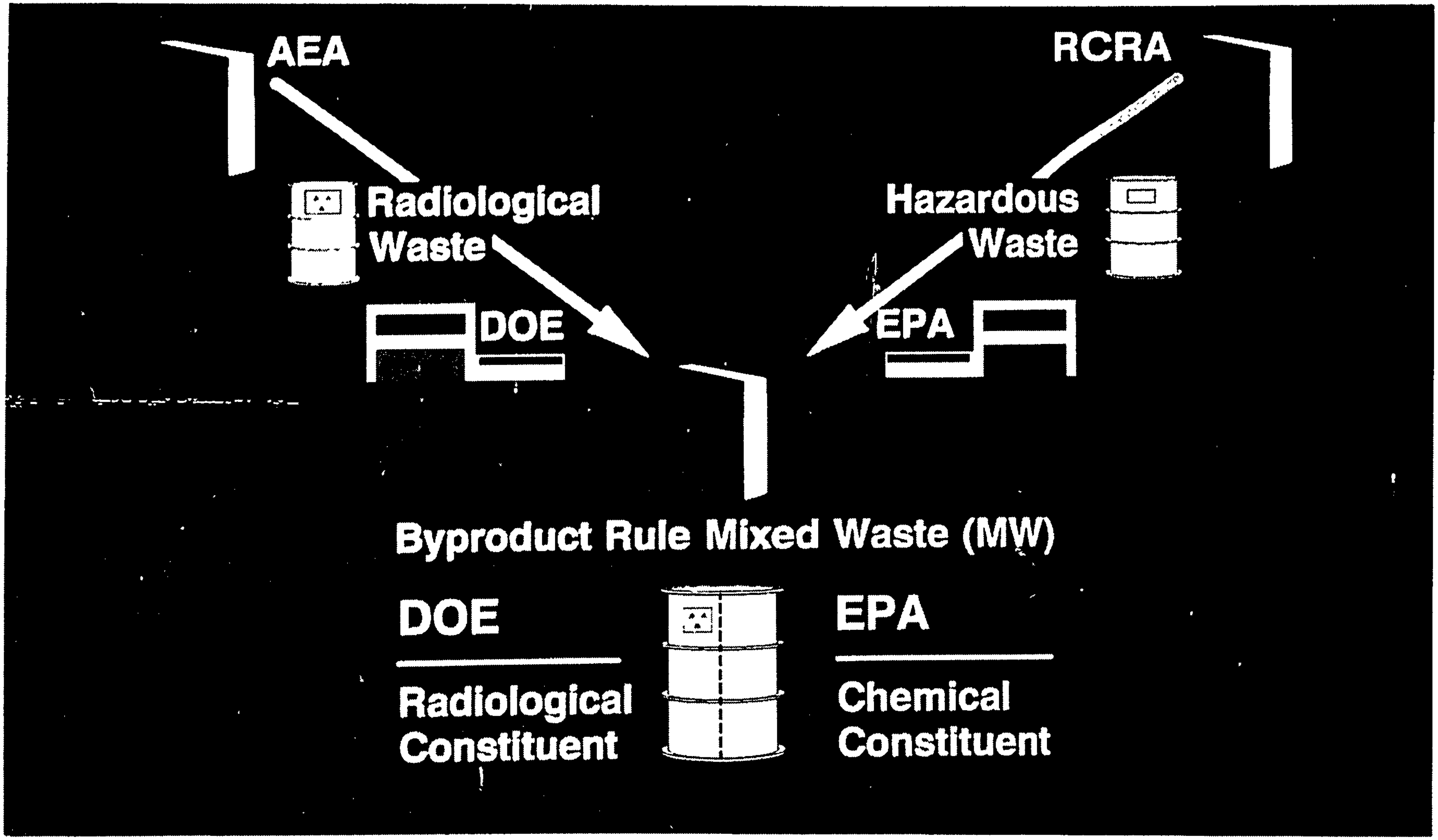

Figure 1. Two Regulatory Regimens Govern Mixed Waste.

State, an authorized state, has been authorized to manage hazardous wastes, the applicable regulation is the "Dangerous Waste Regulations," Chapter 173-303, WAC.

Chapter 173-303 of the WAC implements the Hazardous Waste Management Act of 1976, as amended in 1980 and 1983, and implements, in part, the RCRA. The purposes of Chapter 173-303, WAC, are summarized below:

1. Designate those solid wastes that are dangerous or extremely hazardous to the public health and environment

2. Provide for surveillance and monitoring of dangerous and extremely hazardous wastes until they are detoxified, reclaimed, neutralized, or disposed of safely

3. Provide the forms and rules necessary to establish a system for manifesting, tracking, reporting, monitoring, record keeping, sampling, and labeling dangerous and extremely hazardous wastes

4. Establish the siting, design, operation, closure, post-closure, financial, and monitoring requirements for dangerous and extremely hazardous waste transfer, treatment, storage, and disposal facilities

5. Establish design, operation, and monitoring requirements for managing the state's extremely hazardous waste disposal facility

6. Establish and administer a program for permitting dangerous and extremely hazardous waste management facilities .

7. Encourage recycling, reuse, reclamation, and recovery to the maximum extent possible.

PAST AND CURRENT PRACTICES

Historically, much of the radioactive solid waste was buried near the area where it was generated with no consideration for eventual retrieval or for hazardous constituents. In 1970 transuranic wastes were segregated and placed in areas designated for retrievable storage. By 1972 all low-level wastes were disposed of on the Hanford Site plateau. In the mid 1980's, solid MWs were placed in similar areas designated for retrievable storage. (See Figure 2.)

Certain potentially hazardous constituents in solid radioactive wastes were identified as to their physical characteristics. If identified, the hazardous constituent is tracked on the Richland Solid Waste Information Management System (RSWIMS). Since November 1986, the hazardous constituents in low-level MW have been required to be identified. This requirement was phased in until March 1987 when implementation was completed. In 1987 a program that required the hazardous constituents in low-level waste be identified was instituted. Before 1987 these wastes were managed in accordance with DOE orders and were placed in the low-level waste burial

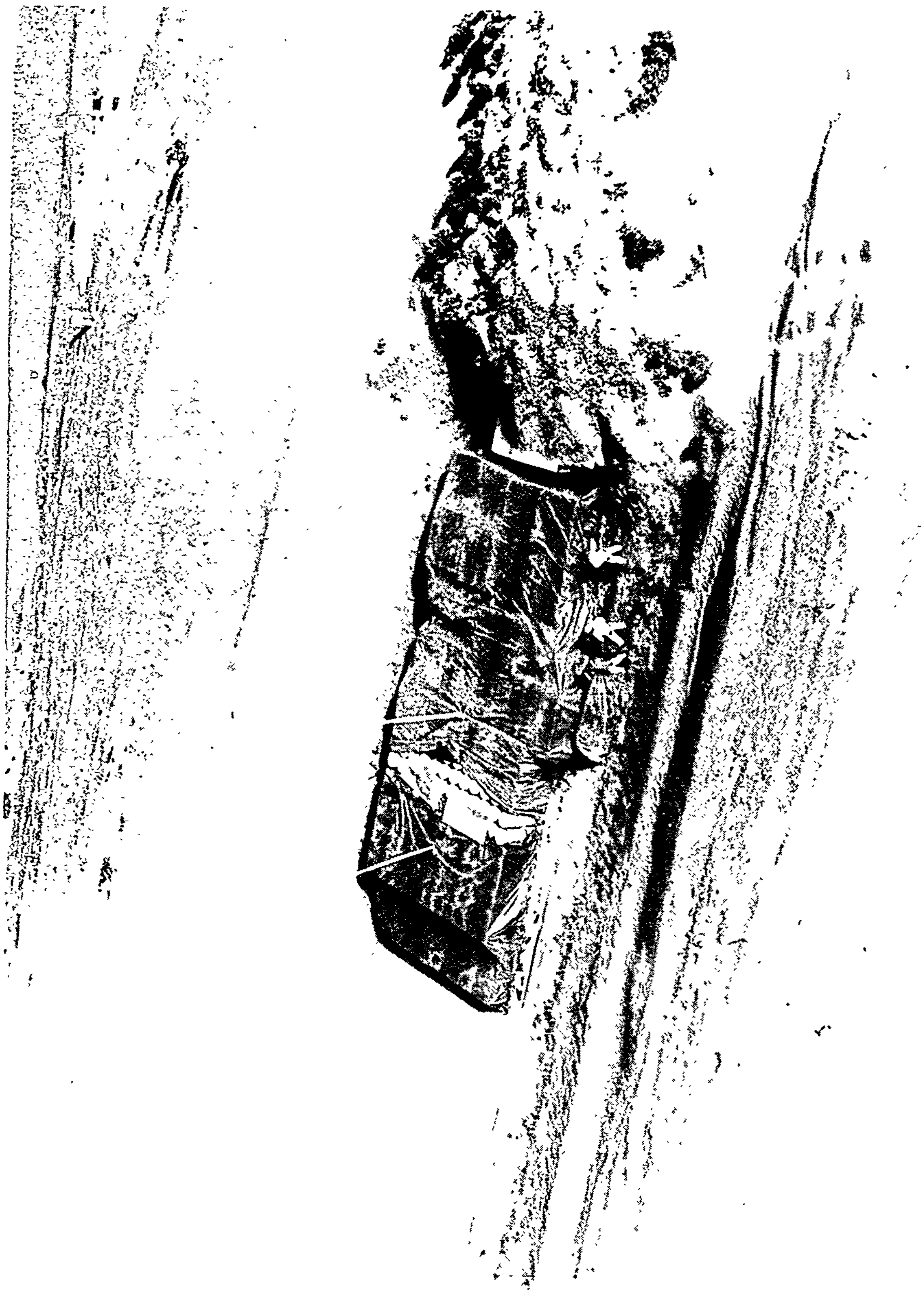

Figure 2. Retrievable Storage.

grounds. Since this time most MWs were placed in trenches designated as below-grade retrievable storage. (See Figure 2.) In November 1987, the Ecology was first authorized by the U.S. Environmental Protection Agency (EPA) to regulate MW. As a result above-grade RCRA-compliant storage facilities were constructed for MW.

WASTE ACCEPTANCE CRITERIA

Solid radioactive waste acceptance criteria are contained in WHC-EP-0063, Hanford Radioactive Solid Waste Packaging, Storage and Disposal Requirements (Stickney 1988). This requirements document is divided into three waste categories; transuranic waste, low-level waste, and mixed waste. The process for waste analysis and acceptance is similar for all three categories.

Upon generation of a MW or knowledge that a waste will be generated, a waste generator uses a chemical waste disposal request form or other pertinent information to request storage or disposal of the waste. Solid Waste management reviews the request and prescribes the proper packaging and shipping instructions along with a waste designation and waste disposition, i.e., storage or disposal. Approval of the waste is documented on the Storage/Disposal Approval Record (SDAR). The SDAR is the formal document that approves the waste generator to ship their waste to the solid waste management facilities.

Mixed wastes at the Hanford Site are designated per the procedures in the "Dangerous Waste Regulations" (Ecology 1989). The "Dangerous Waste Regulations" are more restrictive than the RCRA; consequently, more wastes are regulated by Washington State than are regulated by RCRA. Frequently, well-documented process knowledge is used to provide the necessary information to perform a waste designation. If process knowledge is not sufficient, then samples of the waste are taken, and laboratory analysis provides the required information.

Upon receipt of the SDAR, the generator prepares the manifests necessary to ship the waste. For MWs these documents include the Uniform Hazardous Waste Manifest, the Radioactive Shipment Record, and the Solid Waste Storage/Disposal Record.

SOLID WASTE SEGREGATION

Hanford Radioactive Solid Waste Packaging, Storage and Disposal Requirements (Stickney 1988) has required that MW be segregated by hazard class from other radioactive wastes. Figures 3 and 4 depict the various types of solid waste segregation. Figure 4 shows radioactive waste classes 1, 2, 3, and 3+. Based upon the performance, assessment may be modified and may be significantly different from that shown in Figure 4. These waste classes will not be implemented until finalized.

SEGREGATION PLAN OF ACTION

Currently, solid waste management at the Hanford Site does not have the capability nor the facilities to verify the contents of waste packages. In lieu of physical waste verification, the Hanford Site has adopted the Segregation Plan of Action (SPOA) to emphasize proper waste segregation until the low-level waste certification program is implemented and improved verification facilities can be developed and constructed.

The implementation of SPOA requires that each waste generator develop and implement a plan to ensure that MWs are segregated from other radioactive wastes and nonradioactive hazardous wastes. The SPOA requires each generator to develop hazardous material controls by controlling inventories, researching chemicals, and applying chemical standardization and waste minimization. Then facilities can be prepared with concise procedures and trained staff before job startup to contain and document unavoidable MW as it is generated. Quality assurance programs would be used to verify these system controls. Solid waste management has initiated an overview committee to provide guidance and recommendations and to review and approve SPOA products.

WASTE GENERATOR ASSESSMENT PROGRAM

In 1988 the Hanford Site initiated a solid waste generator assessment program. The purpose of the program is to review waste generator activities in relation to waste packaging in accordance with WHC-EP-0063 (Stickney 1988), which helps ensure compliance with DOE Order 5820.2A (DOE 1988) and Chapter 173-303, WAC (Ecology 1989), and to assess the generator's ability to properly manage solid radioactive wastes. Each year each generator must complete the assessment in order to continue shipping waste to the Hanford Site. In addition, a new waste generator must complete the assessment before the first shipment to the Hanford Site.

RECORD KEEPING AND DATA BASE

As noted previously, MW shipments to solid waste storage and disposal facilities is documented on the Uniform Hazardous Waste Manifest, Radioactive Shipment Record, and the Solid Waste Storage/Disposal Record. Pertinent information from these forms is entered into the RSWIMS, using the NOMAD computer language. Information that is entered and tracked includes a physical description of the waste, volume, weight, waste package information, hazardous constituents, radioactive material content, storage/disposal location, waste designation and manifest number, and pertinent waste generator information.

Information from the RSWIMS is trended and reported as required by Federal and local requirements. The types of reports generated include monthly billing; monthly, quarterly, and annual waste volume reports; the annual dangerous waste report; the hazardous waste receiving and processing (HAZWRAP) submittal; and the integrated data base submittal.

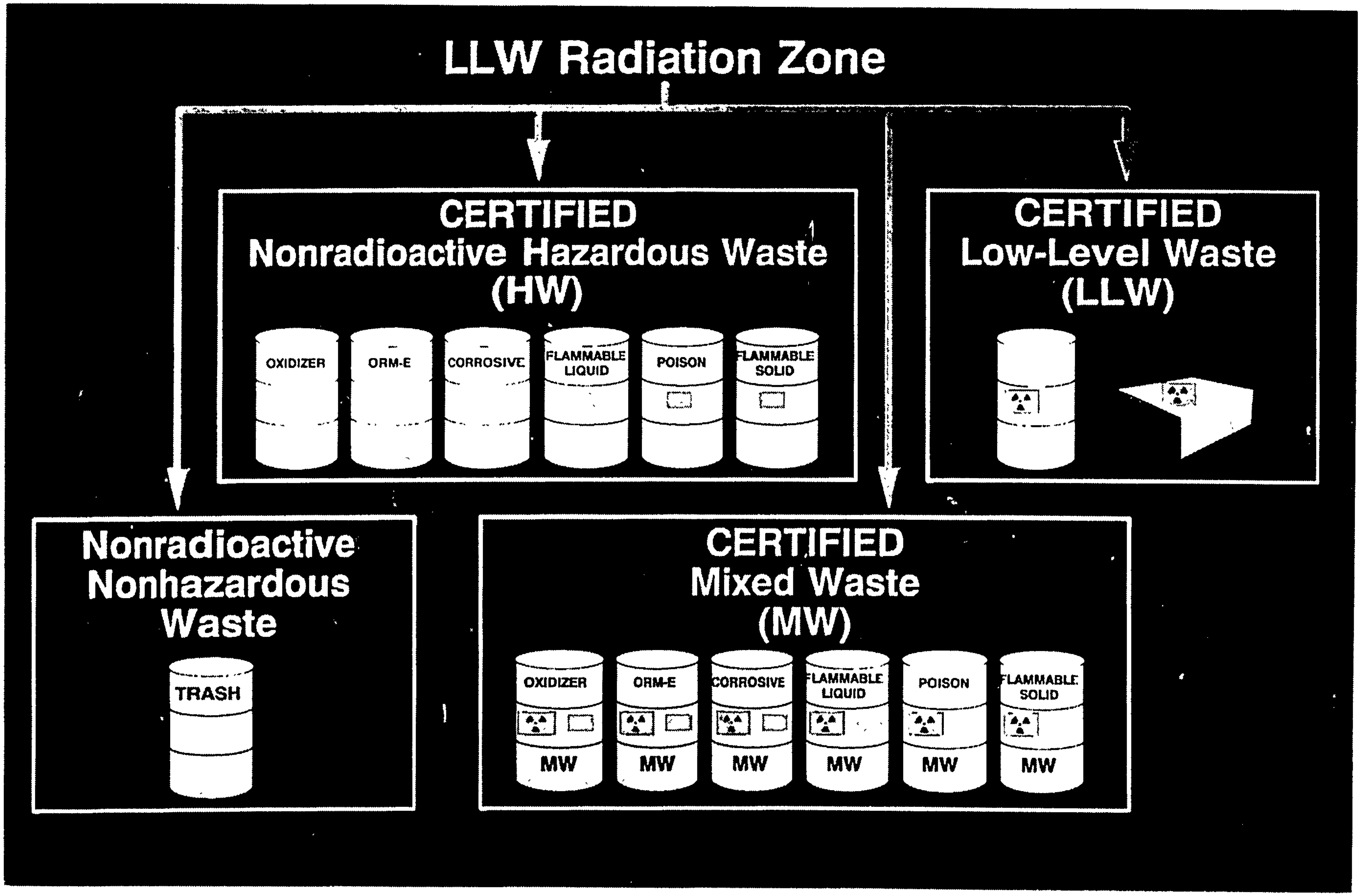

Figure 3. Solid Waste Segregation.

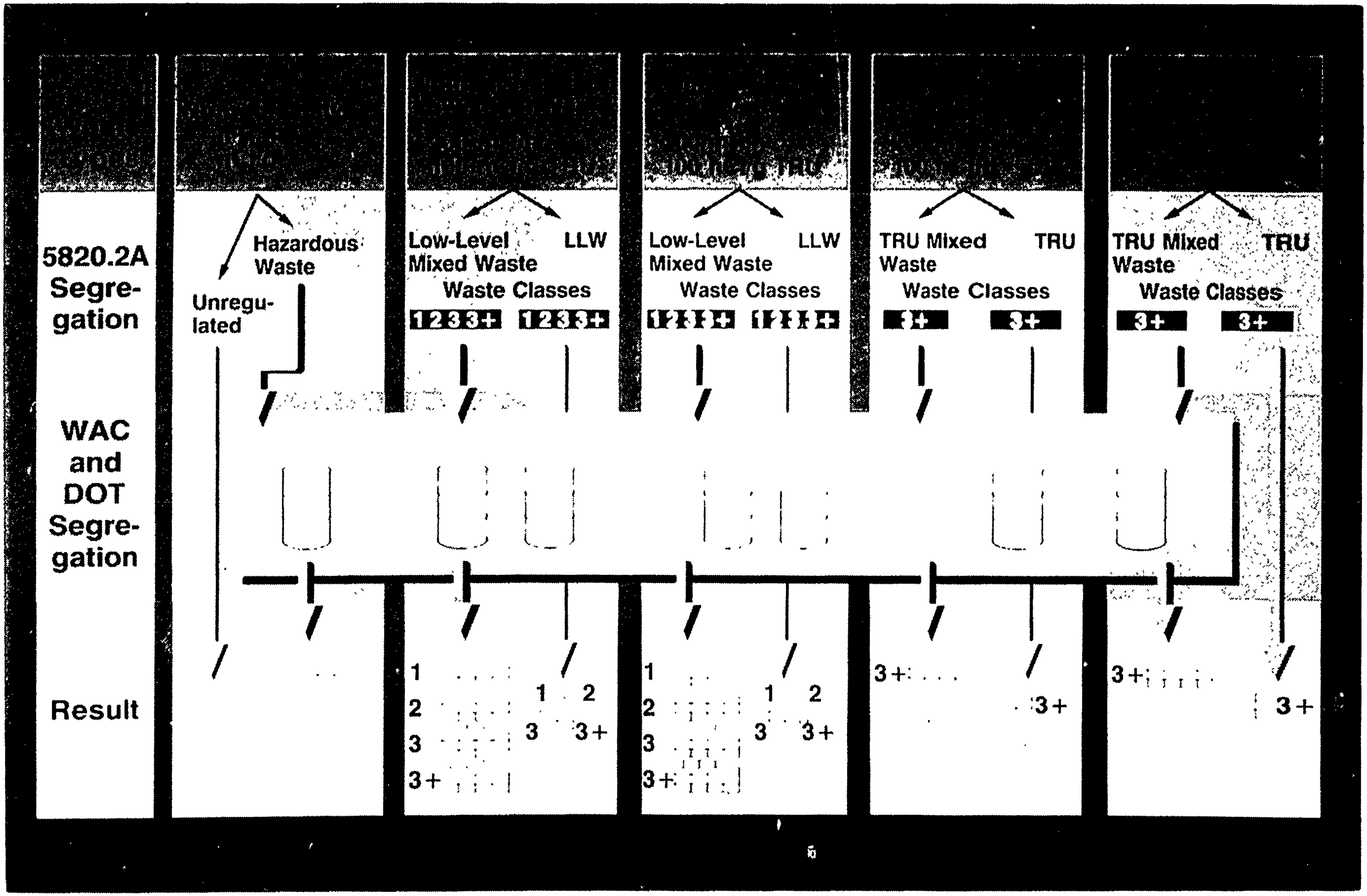

Figure 4. Solid Waste Segregation, U. S. Department of Energy Order 5820.2A.

FUTURE ACTIVITIES

Management of MWs at the Hanford Site is undergoing progressive change as it moves toward full compliance with State and Federal hazardous waste regulations. Both administrative and operational changes are being implemented. The Central Waste Complex (CWC) consists of a series of structures to provide RCRA-, Washington State-, and Toxic Substance Control Act- (where required) compliant storage of MWs. Future facilities, such as the Waste Receiving and Processing (WRAP) Facility, will provide MW processing capabilities. Administrative changes, such as low-level waste certification and cradle to grave computer modeling of waste, are being implemented.

CENTRAL WASTE COMPLEX

Figure 5 depicts a conceptual layout of the CWC. A major purpose of the CWC is to provide RCRA-compliant storage of MWs. Treatment of MWs will be provided in the WRAP Facility. Treated MWs would then be disposed of to a RCRA-compliant disposal facility, if still hazardous.

Currently, the CWC consists of eight, low flashpoint (class I flammable), MW storage modules; a MW receiving pad; and thirteen 4,000 ft^2 metal storage buildings. Future plans for the CWC include the construction of larger 34,000 to 54,000 ft^2 storage buildings.

The 4,000 ft^2 MW storage buildings (Figure 6) are nominally sized to contain one thousand 55-gal drums of waste. Each building is approximately 50 ft wide by 80 ft long with a minimum clear span of 40 ft and eave height of 20 ft. Each has a sealed concrete floor with curbing, ventilation, a fire protection system, and lighting. These buildings are designed to contain 55-gal drums of MW stacked three high, four drums to a pallet.

The low flashpoint MW storage modules (Figure 7) consist of small pre-engineered buildings. Each module has approximately 176 ft^2 of floor space. Each has a spill-containment reservoir with removable panels to allow for visual inspections. The spill-containment reservoir exceeds requirements for secondary containment. Each module nominally holds eighteen to twenty 55-gal drums of waste.

The MW storage pad is a 6-in., curbed-sealed 9,000 ft^2 pad (Figure 8). The pad has a rainwater removal system, which drains to a collection sump. The sump has a key-locked release into a french drain. The area surrounding the pad slopes so that water does not run onto the pad. Currently, the pad is used to stage waste until it can be moved into one of the buildings.

Larger 34,000 ft^2 MW storage buildings are planned. The larger buildings would be similar in construction to the smaller metal buildings. These buildings would be constructed in a phased approach, if necessary, to provide additional storage of MWs until the WRAP Facility is available.

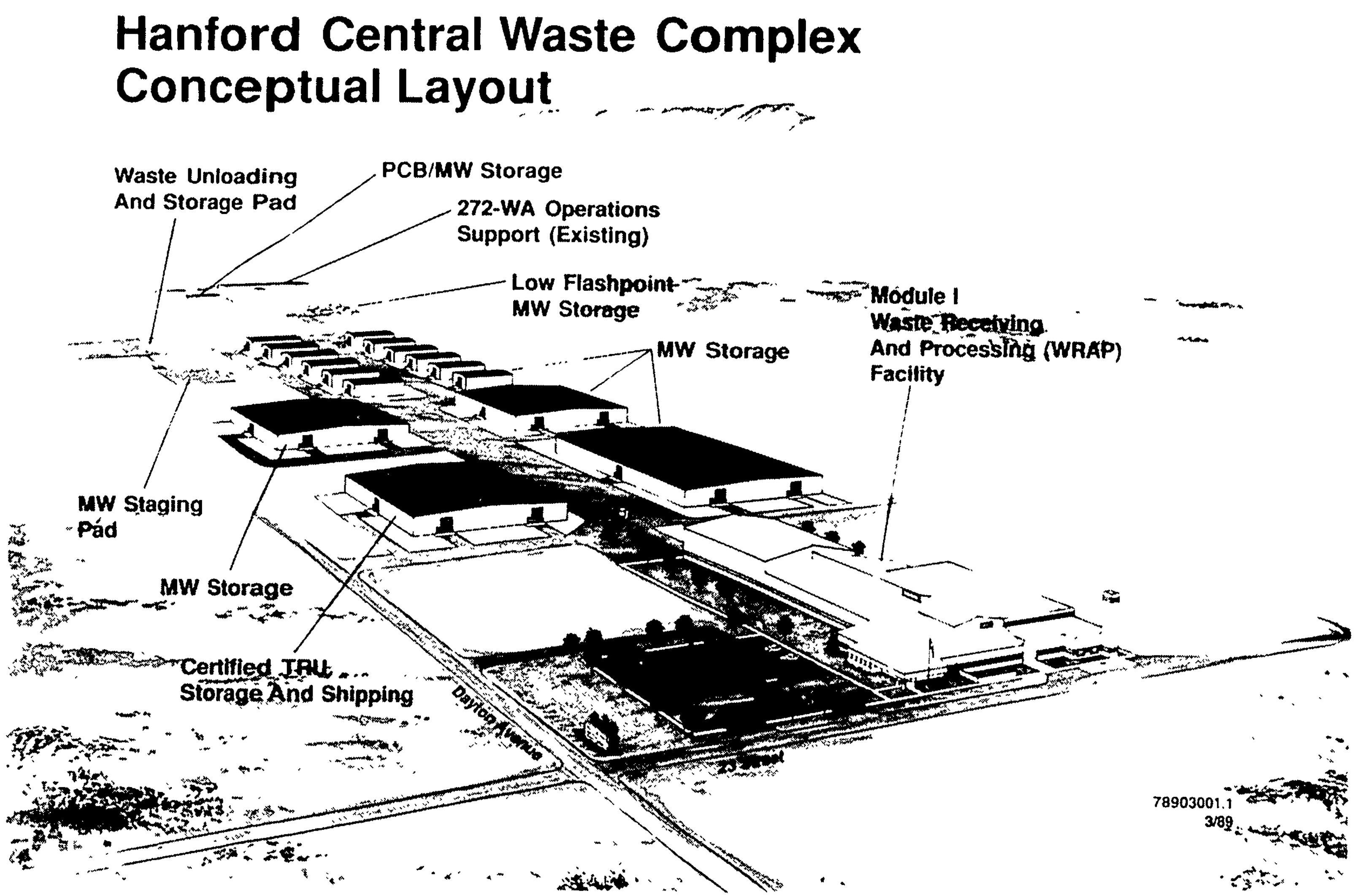

Figure 5. Hanford Central Waste Complex Conceptual Layout.

Figure 6. 4,000 ft^2 Mixed Waste Storage Building.

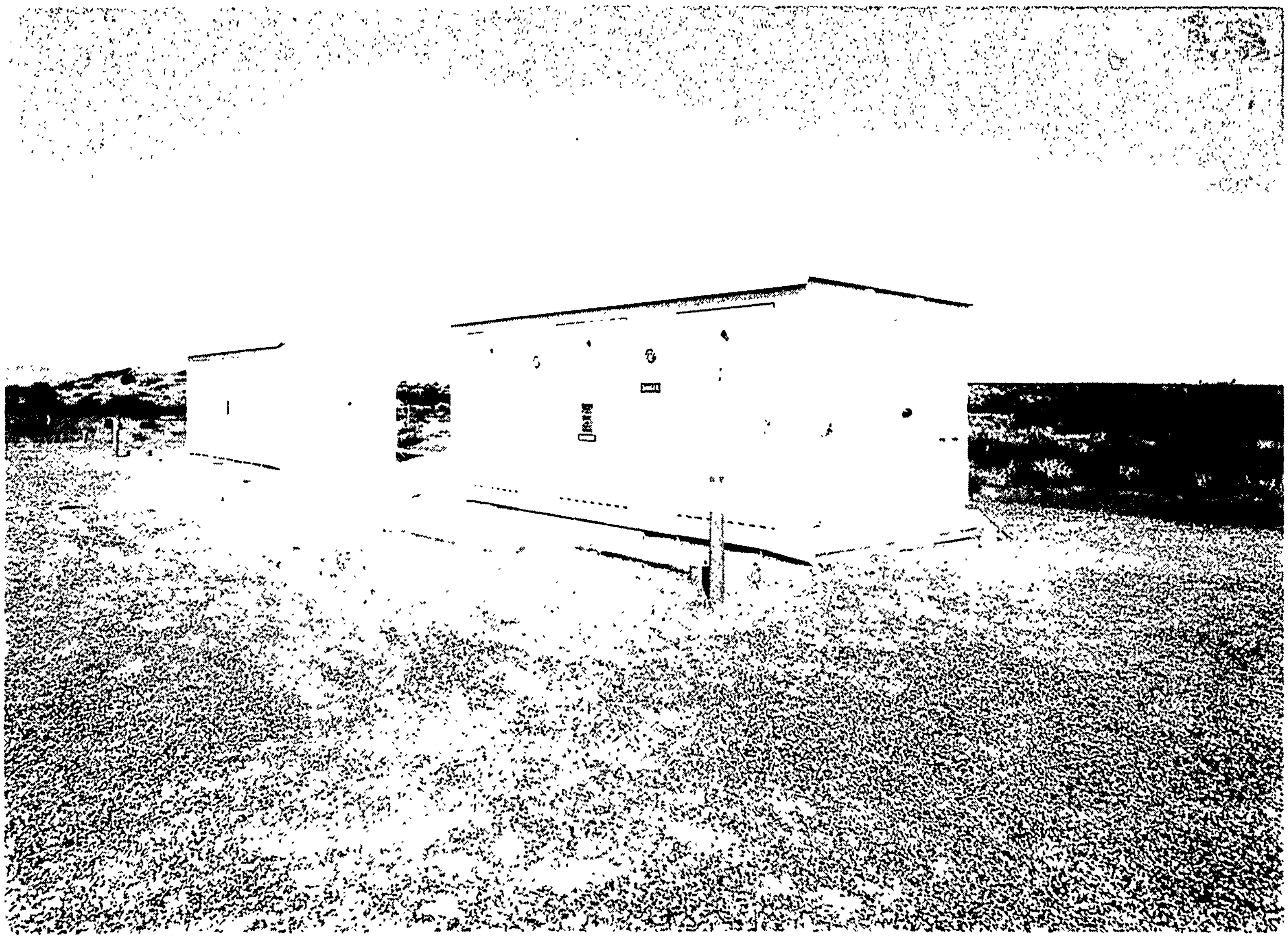

Figure 7. Low Flashpoint Modules.

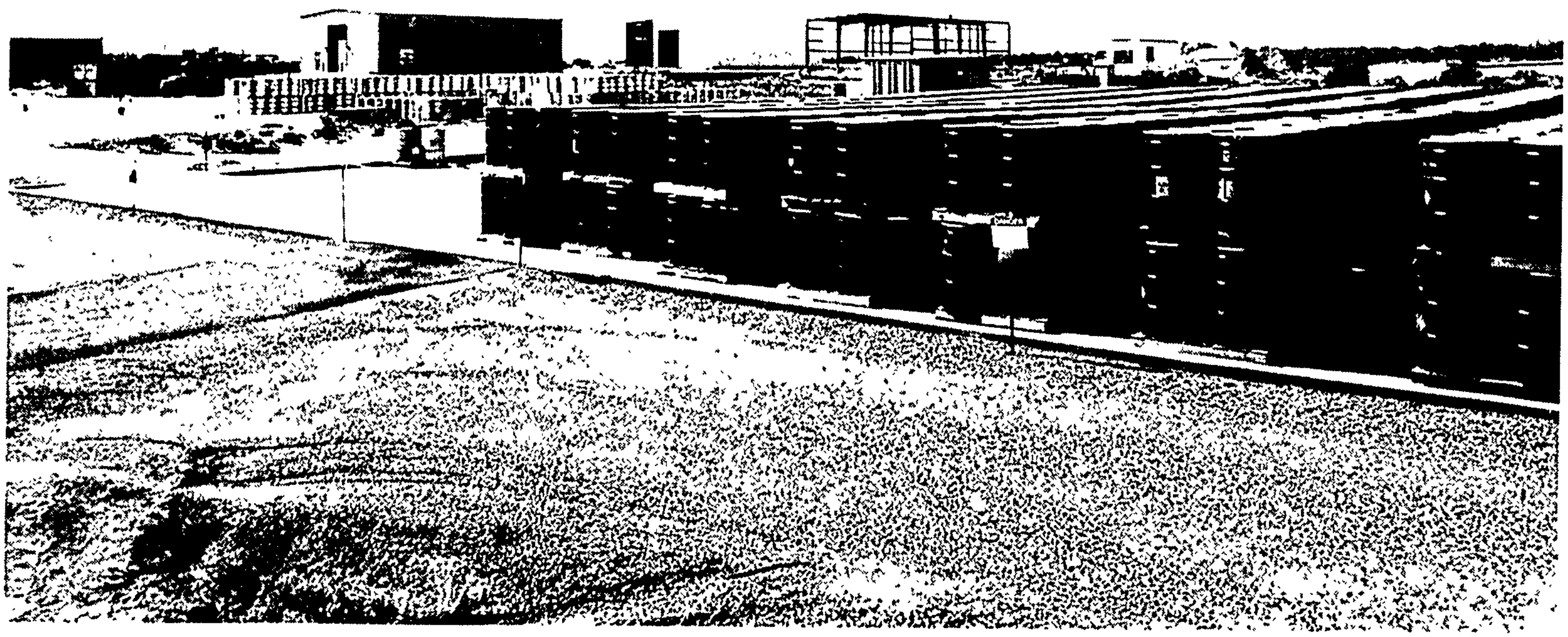

Figure 8. Mixed Waste Storage Pad.

RESOURCE CONSERVATION AND RECOVERY ACT DISPOSAL FACILITY

A RCRA-compliant liner leachate trench for the disposal of mixed wastes is planned for construction on the Hanford Site (Figure 9).

LOW-LEVEL WASTE CERTIFICATION

As prescribed by DOE Order 5820.2A (DOE 1988), a low-level waste certification plan is being developed. The Implementation Plan for Hanford Site Compliance with U. S. Department of Energy Order 5820.2A (DOE-RL 1989) documents these plans.

It is envisioned that the certification plan will be similar in scope to transuranic waste certification. Pertinent aspects, such as nondestructive assay and overview, will be adopted. Stringent waste generator controls, such as a waste contents inventory, peer review of waste generation activities, and quality control, will be adopted also.

DATA BASE MODIFICATIONS

Modifications to the RSWIMS data base are planned. These plans involve the development and implementation of a cradle to grave approach to waste management. A computer network will link the waste generator and waste management operator to the records disposition area. All data transmittal is planned to be done electronically. Only one signed summary document will be maintained in order to meet the State and Federal requirements for waste certification.

Computer modeling of solid waste storage and disposal facilities is also in development. Figures 10 and 11 depict what a model of one MW storage building looks like. This model allows online access to the data base and quick access to the inventory of any waste container. This data base is expected to be useful during audits and inspections and in the response to emergency situations.

CONCLUSIONS

Radioactive solid wastes have been managed on the Hanford Site since the early 1940's. Over the years numerous changes and improvements have been made to the management of these wastes. Evolving State and Federal regulations have been the major cause or instigator of these changes. Specifically, implementation of regulations governing MW has involved major changes in waste management. This paper described some of these regulations and how the Hanford Site adapted and implemented these regulations.

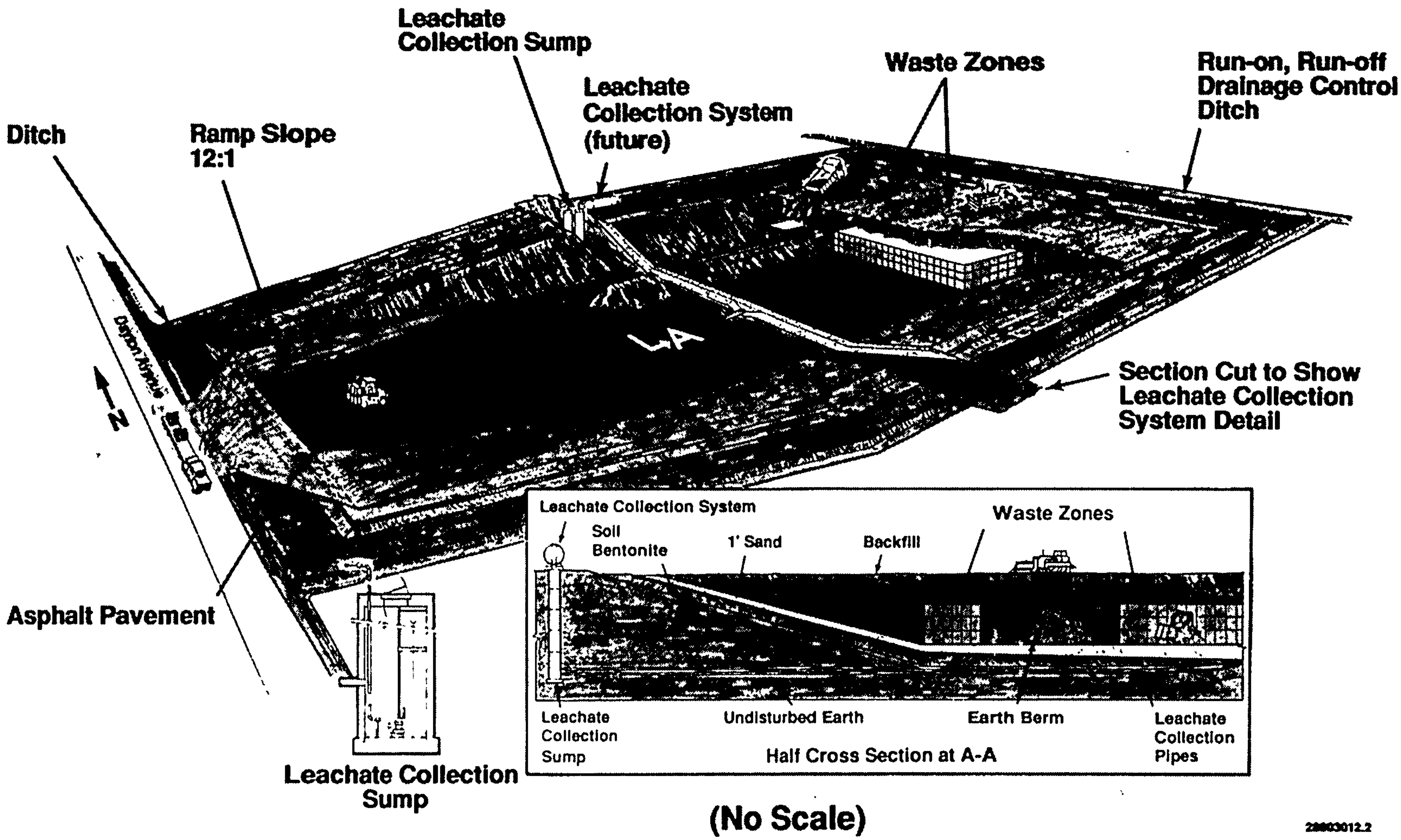

Figure 9. Mixed Waste Disposal Facility.

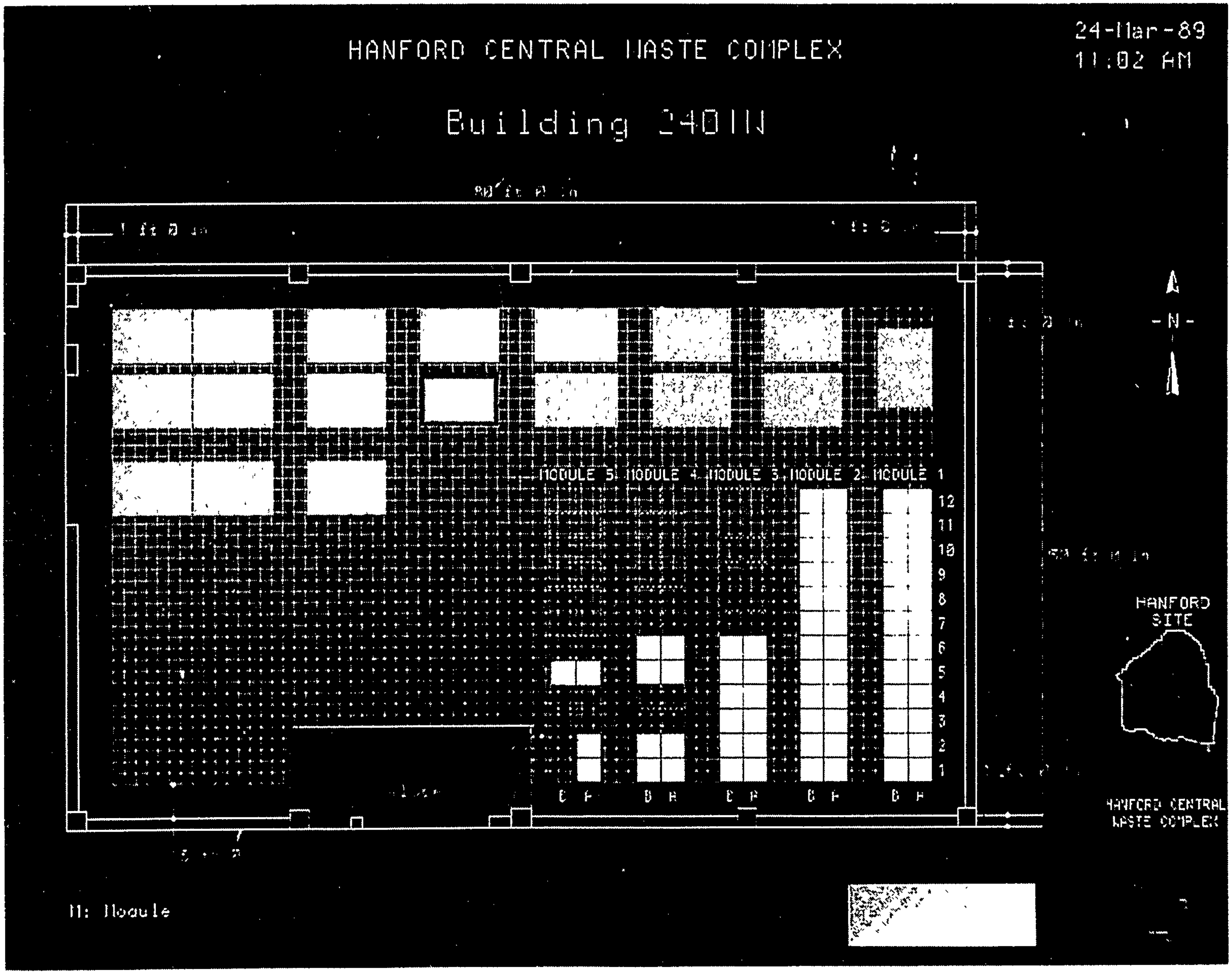

Figure 10. Computer Modeling of 4,000 ft^2 Building.

Figure 11. Computer Modeling of Individual Container.

List of Terms

AEA	Atomic Energy Act
CWC	Central Waste Complex
DOE	U. S. Department of Energy
DOT	U. S. Department of Transportation
Ecology	Washington State Department of Ecology
EPA	U. S. Environmental Protection Agency
HAZWRAP	hazardous waste receiving and processing
LLW	low-level waste
MW	mixed waste
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RSWIMS	Richland Solid Waste Information Management System
SDAR	Storage/Disposal Approval Record
SPOA	Segregation Plan of Action
TRU	transuranic
WAC	Washington Administrative Code
WRAP	Waste Receiving and Processing (Facility)

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DOE ORDER 5820.2A
IMPLEMENTATION STATUS, PROGRESS AND PROBLEMS

Leanne C. Waldo
U. S. Department of Energy
Waste Operations Division
Department of Waste Management and Transportation
Washington, D. C. 20545

Mark D. Shepard
BDM Corporation
20030 Century Blvd., Suite 101
Germantown, Md 20874

and

Elmer L. Wilhite*
Westinghouse Savannah River Company
Savannah River Laboratory
Aiken, SC 29802

ABSTRACT

The Department of Energy's Order governing management of radioactive waste, DOE Order 5820.2A, was revised effective September 26, 1988. Chapter III of the Order contains prescriptive requirements for managing low-level waste. These requirements ensure that all DOE low-level radioactive and mixed waste will be managed in a systematic manner to achieve required performance.

The Order defines performance objectives for low-level waste management to limit the dose received by the general public from waste operations, to protect groundwater resources, and to protect inadvertent intruders. For low-level waste disposal operations, the Order requires that a radiological performance assessment be prepared to demonstrate compliance with the performance objectives. The Order also requires that the radiological performance assessments be reviewed by a Peer Review Panel, established by the Order.

This paper will summarize the requirements for radioactive waste management and discuss the degree of compliance achieved to date. The Department's preliminary schedule and anticipated cost to achieve full compliance with the requirements will also be discussed.

* On temporary assignment to U. S. Department of Energy, Washington, D C.

INTRODUCTION

In 1986, the Department of Energy launched an effort to revise the low-level waste chapter of it's Order governing management of radioactive waste, DOE Order 5820.2. The intent of the revision was to make this chapter more detailed and prescriptive in response to criticism that the Order was general and non-prescriptive. The scope of the revision was later expanded to include the chapters on High-level (HLW) and Transuranic (TRU) waste. The chapters on Management of Wastes Containing AEA 11e(2) Byproduct Material and Naturally Occurring or Accelerator Produced Radioactive Material (NARM); and Decommissioning of Radioactively Contaminated Facilities required few changes.

The work of revision was carried out by working groups of contractor personnel from the various DOE facilities and was coordinated at the Headquarters level by Defense Programs' Office of Defense Waste and Transportation Management. Reviews of the draft Order at Field Offices and Headquarters generated some 500 comments. The goal throughout the comment and response cycle was to incorporate as many comments as possible consistent with maintaining the original objectives of the revision. Of the comments received, 75% of the essential, and 65% of the suggested ones, were adopted in principle. The extensive revision effort has resulted in a significantly strengthened waste management Order.

Changes Highlighted

The High-level Waste chapter was revised to reflect current improved practices and plans. The new chapter substantially expands the topics of Interim Storage, Waste Treatment, and Disposal. Requirements for Quality Assurance and Waste Minimization were added. For purposes of regulation, all DOE HLW is considered to be radioactive mixed waste (RMW) and is therefore regulated by the Resource Conservation and Recovery Act (RCRA) as well as DOE Order 5820.2A.

Changes in Chapter II, Management of Transuranic Waste, focus on actions needed to prepare and transport waste for disposal at the Waste Isolation Pilot Plant (WIPP). Thus, detailed requirements for waste certification, packaging, and shipping, which are the prerequisites for acceptance of waste at the WIPP, were included. Also, requirements for Waste Minimization and Quality Assurance were added. TRU wastes that are also radioactive mixed wastes are subject to the requirements of both RCRA and DOE Order 5820.2A.

Chapter III, Management of Low-Level Radioactive Waste, was the most extensively revised and expanded. The changes reflect an emphasis in the Department to conform with the spirit of the NRC's low-level waste regulation, 10 CFR 61. In contrast with the previous version, which was directed almost exclusively toward waste disposal, the revised version encompasses all important aspects of waste management. It includes requirements for waste generation reduction, waste characterization, waste treatment, shipping and storage, environmental monitoring, quality assurance and maintenance of records based on waste manifests.

The most significant addition to the revised Chapter is that performance objectives for low-level waste management, including groundwater protection, are stated. Assessments of the performance of waste management operations are required. The establishment of a Peer Review Panel was required by the Order. The Panel is composed primarily of DOE contractor employees experienced in performance assessment. One member is from DOE's Office of Environment, Safety and Health. Technical advisors, who participate in the Panel's activities, are from the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), and DOE's Office of Nuclear Energy. The Panel is charged with reviewing radiological performance assessments of low-level waste disposal operations to ensure technical adequacy and consistency. These additions are recognized by DOE, as well as the NRC and EPA, as significantly strengthening the Department's regulation of low-level waste management.

Chapters IV and V, management of naturally occurring and accelerator produced radioactive waste and decommissioning of radioactively contaminated facilities, respectively, were revised only slightly. The major focus in chapter IV is consistency with 40 CFR 192. Changes in chapter V reflect the current operational framework of DOE's Surplus Facilities Management Program.

The following table illustrates the more prescriptive nature of the revised Order. In the first three chapters, the number of requirements has increased significantly.

Number of Requirements

Chapter	5820.2	5820.2A
High-level	11	59
TRU	16	70
Low-Level	38	90
NARM	5	5
D&D	28	37

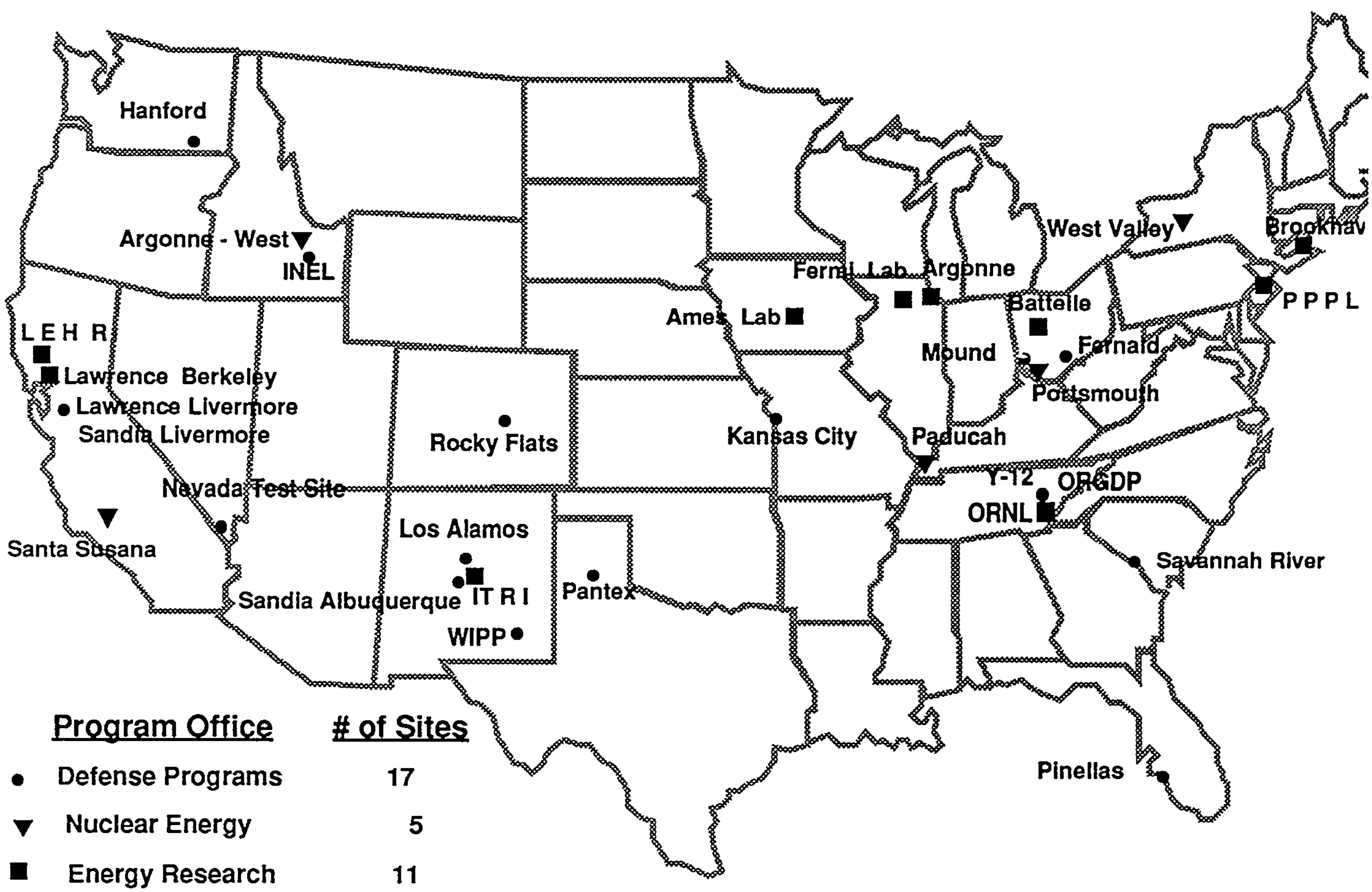
IMPLEMENTATION PLANS

The revised Order, DOE 5820.2A, was effective on September 26, 1988. The Order requires that each DOE site prepare a Plan for fully implementing the requirements of the Order. Plans were to be submitted to Headquarters by April 30, 1989. In developing the Plans, sites were requested by Headquarters to be aggressive in developing schedule estimates. However, schedules for coming into full compliance will be impacted by funding priorities.

Facilities subject to DOE Order 5820.2A are shown in Figure 1. These facilities have submitted Implementation Plans to the Office of Defense Waste and Transportation Management. DWTM is in the process of assessing the Plans for adequacy and, for those sites funded by DWTM, for accuracy. Other DOE Program Offices are also reviewing the Plans for accuracy. In addition, the Office of Environment, Safety and Health is independently reviewing the Plans. Preliminary results of the review are presented below. When the review is complete, a summary report will be prepared for DWTM.

Figure 1

Department of Energy Sites



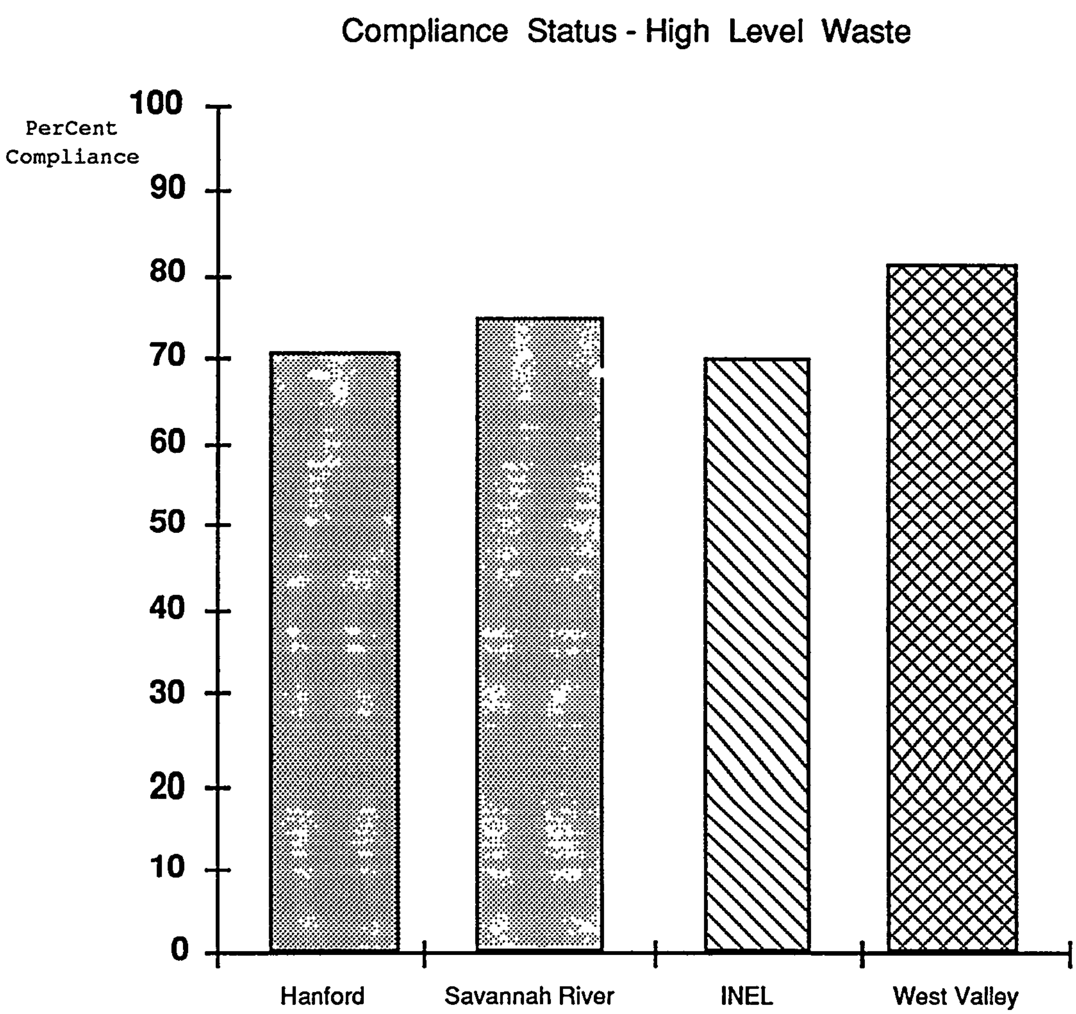
Abbreviations:

LEHR - Laboratory for Energy Related Health Research
INEL - Idaho National Engineering Laboratory
ITRI - Inhalation Toxicology Research Institute
WIPP - Waste Isolation Pilot Plant
ORGDP - Oak Ridge Gaseous Diffusion Plant
ORNL - Oak Ridge National Laboratory
PPPL - Princeton Plasma Physics Laboratory

IMPLEMENTATION STATUS

High-level Waste

The overall status of compliance with the high-level waste requirements is about 75 percent as shown by the following figure.

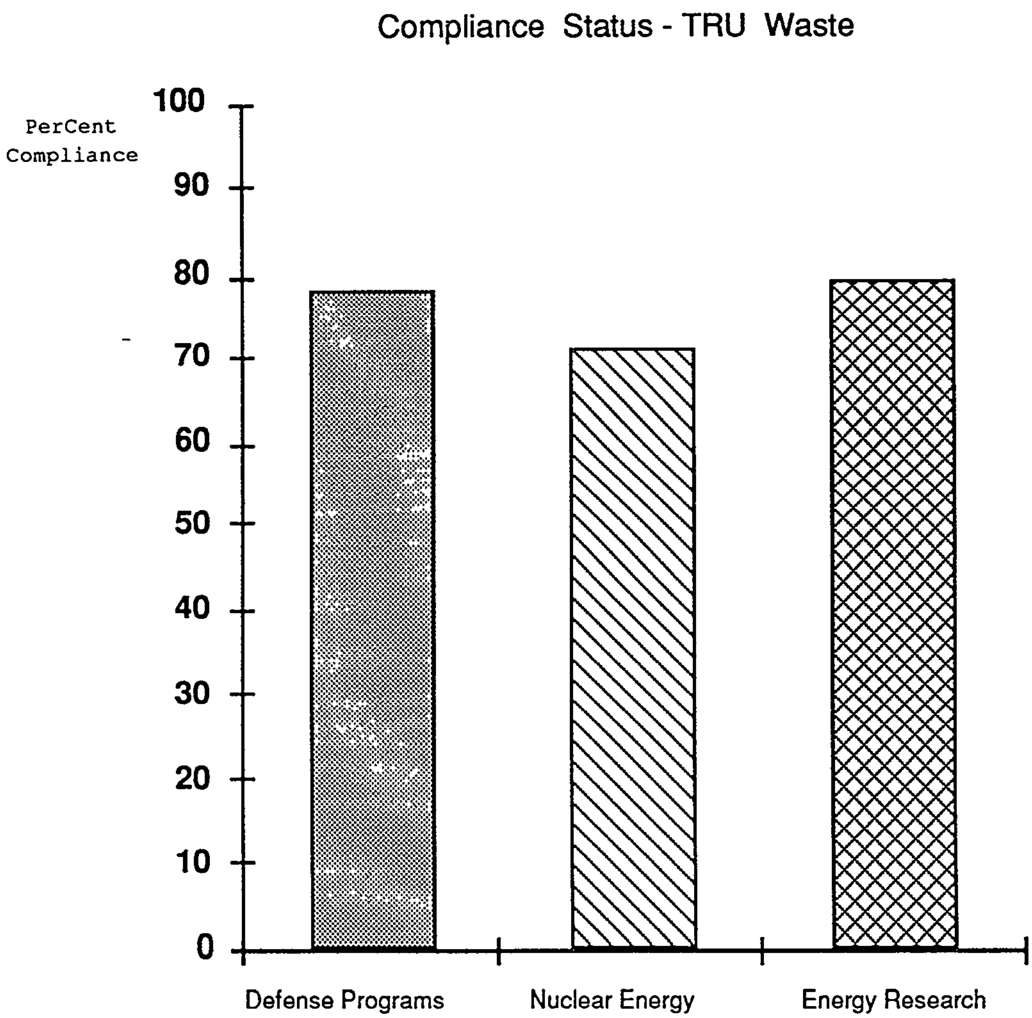


The West Valley site is administered by the Office of Nuclear Energy (NE). The Idaho National Engineering Laboratory (INEL), the Savannah River Site (SRS) and the Hanford Site are administered by the Office of Defense Programs (DP).

Needs to achieve full compliance for high-level wastes include improved analytical capability in the area of RCRA constituents and additional groundwater monitoring capability. Other needs for HLW disposal are the completion of the Defense Waste Processing Facility at Savannah River, the Hanford Waste Vitrification Facility, and a determination of the appropriate waste form for Idaho calcined high-level waste.

Transuranic Waste

The overall compliance with TRU waste requirements is also about 75 percent, as shown below.

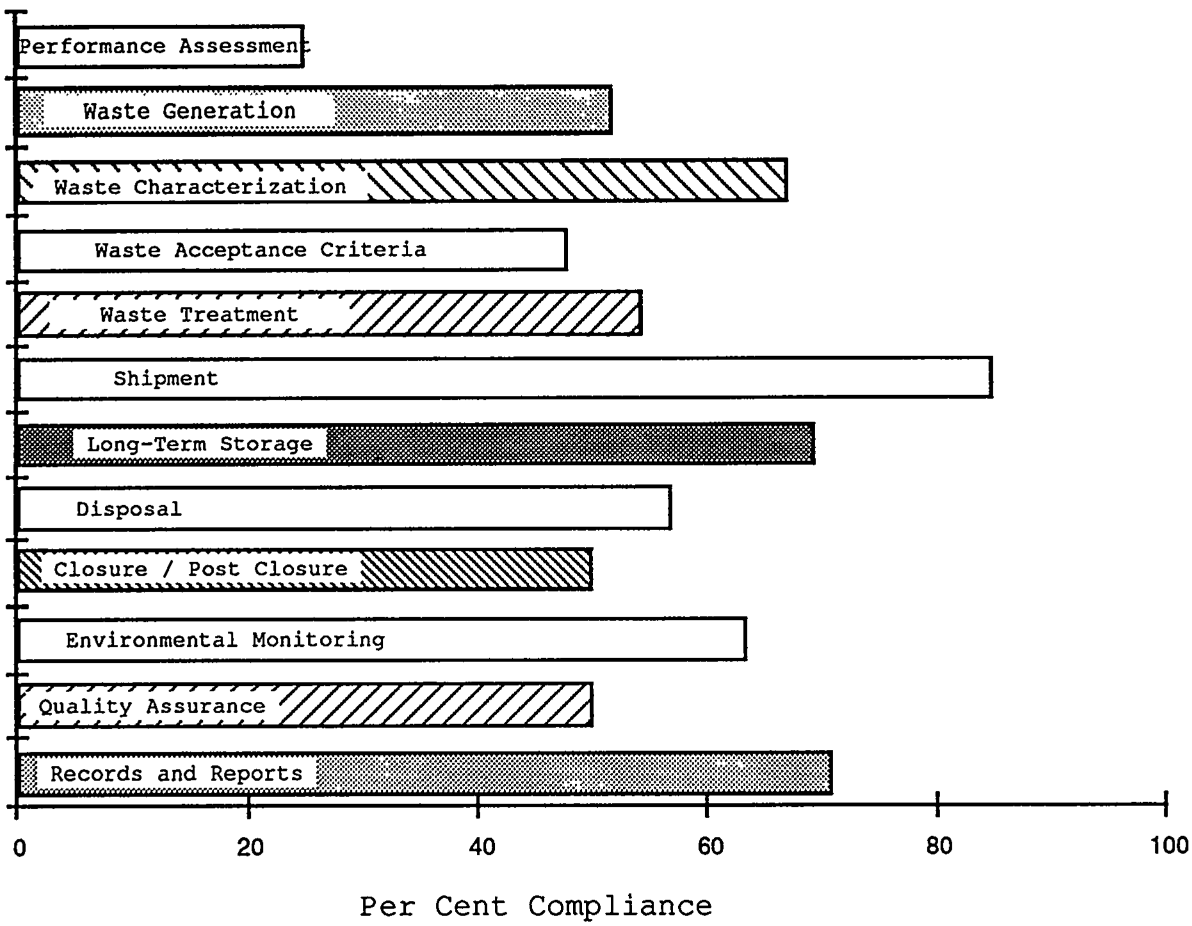


Needs to achieve full compliance for TRU waste management are in the areas of waste treatment, improved analytical capability, quality assurance and improved documentation, and improved storage areas to accommodate RCRA.

Low-Level Waste

The overall level of compliance with the low-level waste requirements is about 60 percent, as shown in the more detailed figure below. The lower level of compliance is expected because of the more extensive revision of this chapter.

Compliance Status - Low-Level Waste



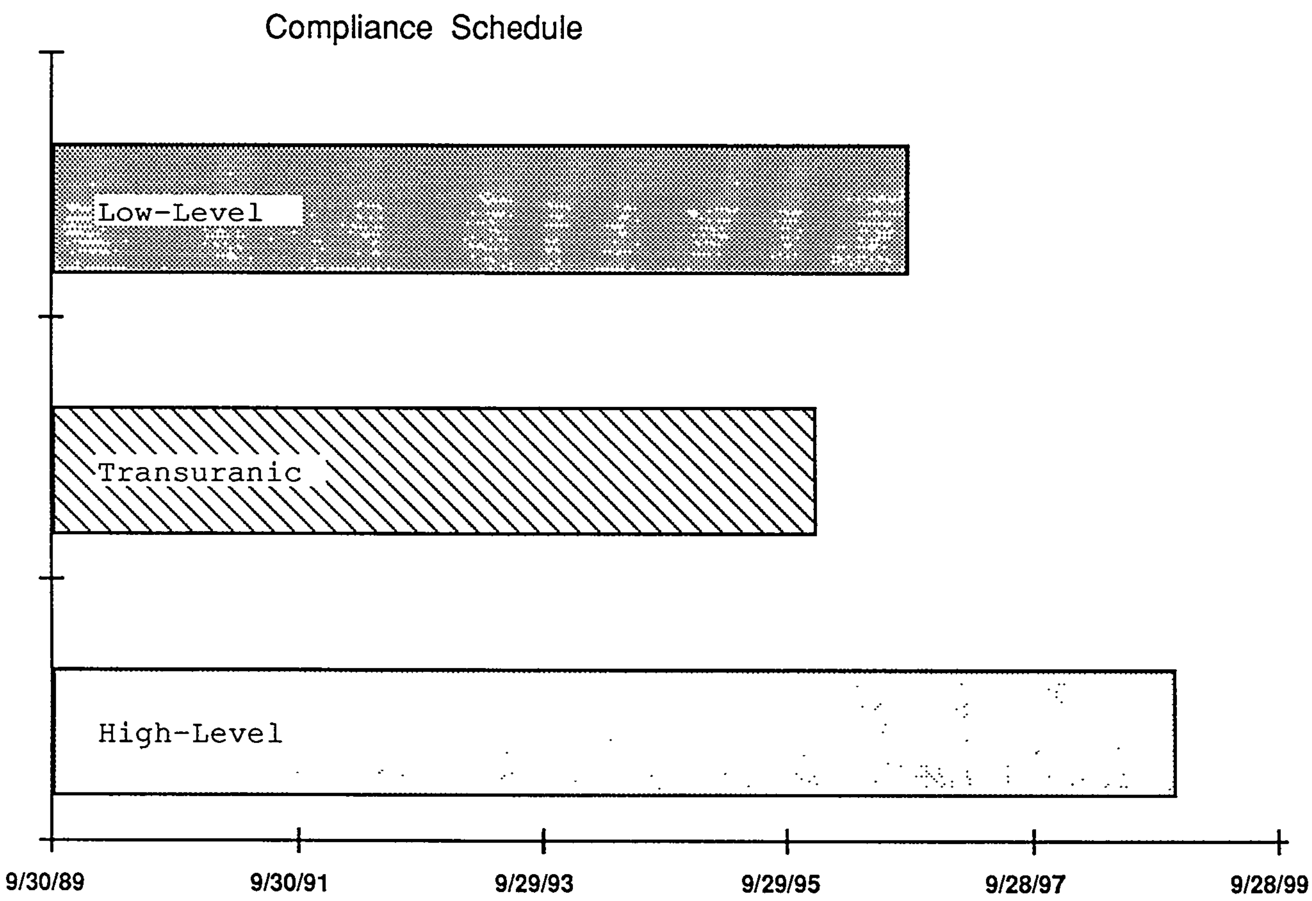
Items needed to achieve full compliance with low-level waste requirements include radiological performance assessments and waste management systems performance assessments, improved waste storage and treatment facilities, waste acceptance criteria, waste characterization, improved quality assurance, and disposal facilities for greater-than-class-C-waste.

Costs of Compliance

Just prior to issuance of the Implementation Plans, the Department entered into an effort to coordinate planning of waste management and environmental restoration activities over a five-year period. Costs and schedules developed for the Implementation Plans must be re-evaluated for consistency with the Five-Year Plan. Therefore, they will not be discussed here in detail.

Compliance Schedule

Once validated by comparison with the Five-Year Plan, the following tentative schedule will better provide an idea of the time required to come into full compliance with Chapters I, II, and III of the Order.



This schedule does not include completion of the Hanford Waste Vitrification Project and determination of the final waste form for high-level waste at the Idaho National Engineering Laboratory; these activities may not be completed until 2000. For transuranic waste, the schedule does not include completion of forecast waste processing facilities at Hanford and Oak Ridge National Laboratories. These activities may not be completed until 2013. For low-level waste, the schedule does not include new disposal facilities forecasted for the Idaho National Engineering Laboratory, Oak Ridge National Laboratory, and the Portsmouth Gaseous Diffusion Plant. These activities are tentatively scheduled to be complete in 1999.

PROGRAM

Information contained in the Implementation Plans will be evaluated for consistency with the Five-Year Plan and adjustments made as necessary. A summary report of all Implementation Plans will be prepared for Defense Waste and Transportation Management.

Beginning in late 1989 or early 1990, a series of compliance audits will be conducted by personnel from Defense Waste and Transportation Management. Audits will be conducted to assess progress versus the schedules presented in the various site Implementation Plans.

Each year, in the annual Site Waste Management Plan, an update of activities relative to compliance with DOE Order 5820.2A will be prepared.

CONCLUSION

Revision of DOE Order 5820.2A has resulted in a more detailed and prescriptive Order. Implementation of the Order has begun, with current compliance with about 60% to 70% of the requirements. Full compliance is anticipated in about 10 years.

INSURING LOW-LEVEL RADIOACTIVE WASTE SITES; PAST, PRESENT, AND FUTURE

George F. Viveiros, III
Nuclear Insurance Consultant
Johnson and Higgins

Thank you for the opportunity to be here today and to speak at this meeting--your Eleventh Annual Low-Level Waste Management Conference. The primary purpose of my talk is to provide information concerning the availability of nuclear liability insurance and coverage under the Facility Form for low-level radioactive waste facilities only.

I imagine, though, that several of the speakers to this conference have started off with some joke or anecdote in order to, as they say, "grease the skid." Well, I'm not one to go against tradition, so...

Monday was my first day back to work after a wonderful honeymoon excursion which included the Finger Lakes (of upstate New York), Niagara Falls, Toronto, and my personal favorite: The Baseball Hall of Fame. Well, you know how newlyweds are: We hold hands, we look longingly and lovingly at each other, and most importantly, because this time alone together has been so very wonderful and invigorating, we promise each other that we will not allow this euphoric bliss to end. In fact, I have since leaned that all newlyweds make the same promise to each other each and every day of the honeymoon: "We'll never let our honeymoon end."

So, as I was saying...Monday was the first day back from almost two weeks of marital bliss. At 6:45 a.m. I arrived at the office feeling great and ready to slowly immerse myself back into work. After all, I had taken care of everything before I left--so what could happen? The very first pink slip in the rather staggering stack of phone messages was from my manager. It simply said: "Welcome back--hope it went well. Low-Level Waste meeting in Pittsburgh on Wednesday--Plan on speaking." Well, with two weeks' worth of mail, suspense work and emergent work piled high on my plate, you can imagine my initial delight upon reading this brief "Welcome Back" note. A bit incensed, I looked to that one person I knew would understand me and support-my Bride. Not really focusing-in on the fact that she was still on vacation, I quickly called "Our Home," and she, who I adore, answered. I guess I practically whined as I told her of my plight. It took a moment for me to realize that the telephone line was awfully quiet. At last she spoke to me from deep under those cozy bedcovers and in a sleepy voice she grumbled... "Oh George, don't you know--the honeymoon's over!"

So, It's back to reality! And, I should tell you, that I am pleased, or rather, relieved to be back--The strain of all that smiling throughout the past two weeks was taking its toll on my facial muscles, you know.

Reality:

Certainly, one cannot describe any of the recent insurance-related aspects of low-level waste management as a "honeymoon." Considering the on-going litigation vis-a-vis ANI/Maxey Flats ad Sheffield, the almost three year underwriting suspension, and the inadequate low-level waste Facility Form limits recently proposed by American Nuclear Insurers (for when the underwriting suspension is lifted)--it seems there just has not been much good news. My talk today will attempt to clarify these points, provide some basic history on the nuclear insurance pools, and speculate a bit about the future. As most of you probably know the history of the nuclear pools, I will provide only a brief outline here.

The Past:

Rather than discuss the nuclear pools' formations, suffice it to say that during their 33 years in existence, the stock insurance companies formulated and merged into what is today called American Nuclear Insurers (ANI) and that mutual insurers developed into what is called the Nuclear Atomic Energy Liability Underwriters (MAELU). Reinsurance agreements between the stock and mutual pools, together with quota-shared reinsurance from reinsures and the foreign pools created an initial liability capacity of $60 million. One question which concerns many of us today is the policy limit that the pools will make available upon their return to the normal underwriting of Facility Forms for the low-level waste facilities. Because of this concern it is noteworthy, that during this early period of the pools, there was no arbitrary cap on the policy limit available to any nuclear facility - the capacity of the pools was the only upper limit. The policy limit purchased was at the sole discretion of the owners/operators. I should also point out, though, that the typical low-level waste site purchased nuclear policy limits only in the range of $5 million to $15 million.

Coverage Afforded:

With respect to coverage, the Facility Form policy was and still is a site specific contract which is issued to the owners or operators (typically the NRC Licensee(s)) of a low-level waste facility. Essentially, the policy provides liability coverage for nuclear incidents which occur within a specified location. That is, the policy was designed to cover an insured's legal liability for damages because of on or off-site bodily injury or off-site only property damage caused by the nuclear energy hazard. In addition, the policy does provide coverage for certain specifically defined "insured shipments" of nuclear material to or from the defined site. One key feature that distinguishes this policy from a 'conventional' Commercial or Comprehensive General Liability policy (CGL) (sometimes called "slip and fall" insurance) is the nuclear policy's broad definition of insured: The "omnibus definition of insured" includes anyone legally responsible for damages because of bodily injury or property damage caused by the nuclear energy hazards, with the exception of the U.S. Government and all but one of its agencies, the Tennessee Valley Authority (TVA). For the policy to apply, the damages must have occurred during the policy period and written claim made against the insured within ten years after the end of the policy period. Also noteworthy is that the policy is continuous until cancelled. For example, the policy has an "inception date" and an "anniversary date," but there is not a "renewal date."

The Underwriting Suspension:

As I alluded to previously, within the past 3 years the pools have become involved in two cases, Maxey Flats in Moorehead, Kentucky and Sheffield, Illinois, each involving coverage disagreements with respect to the low-level waste facilities. The developments alarmed the pools to such an extent that they instituted the current underwriting suspension. In order that we understand what is in discussion, I'll provide a brief description of the Maxey Flats case as publicly known. The intent here is only to provide an overview. There are many legal points and arguments to be made by all parties that are beyond the scope, intent and time limit allowed by this presentation.

The Maxey Flats facility has been used in the past for disposal of low-level radioactive waste. In 1986, the site was placed on the EPA's National Priority List of hazardous waste sites requiring cleanup under the CERCLA statute. In addition to the former site operator, the EPA notified some 832 other entities which it believed generated or transported hazardous waste buried at Maxey Flats. These parties were identified as "potentially responsible parties" (PRP's) under CERCLA for the costs incurred by the EPA to investigate and correct releases and threatened releases at the site, for the cost of a remedial investigation and feasibility study, and for cost of any remedial action which may be required. These costs are collectively referred to as "CERCLA response costs". The facility and the former operator have been insured by the pools since 1958, as have many of the PRP's identified by the EPA.

At Sheffield, Illinois, the state brought suit against the operator for a similar action. The site has been inactive and in a decommissioned status for several years.

As these cases develop, there will undoubtedly be many points that are raised in order to prove or disprove the existence of coverage under the nuclear liability policy. Some major points that have attracted the attention of one or both sides of the debate include the following:

1. The policy provides that the companies shall "defend any suit against the insured alleging such bodily injury or property damage and seeking damages which are payable under the terms of this policy...". There is debate over whether an EPA notice constitutes a "suit" under the terms of the policy.

2. The policies provide that the pools will pay "all sums which the insured shall become legally obligated to pay as damages...". There is debate over whether CERCLA response costs sought by the EPA are regulatory costs and/or injunctive relief as opposed to damages.

3. The policies provide that the pools will pay sums "which the insured shall become legally obligated to pay as damages because of...property damage...". CERCLA response costs do not appear to be "property damage as defined in the policy.

4. Exclusion (f) under the site-specific Facility Form policy excludes coverage for "...property damage to any property at the location designated in Item 3 of the declaration...". It is not clear whether the EPA is concerned with cleanup on or off the insured site. If on-site, then this exclusion would seem to apply.

How the two claims will be resolved remains to be seen. There are court cases holding insurers responsible for on-site cleanup of pollution, with the logic that if they didn't clean up, the pollution would spread off-site anyway and clearly the insurer would then be liable. There are court cases that say "damages" as used in the context of insurance is not an ambiguous term and does not include equitable monetary relief.

In December 1986, the pools put a moratorium on increasing limits under existing nuclear liability policies at waste disposal facilities and on issuing any new policies at waste disposal facilities and on issuing any new policies for these facilities. In the words of the pools, this action was taken for two principal reasons:

"(1) The possible misinterpretation of coverage boundaries which have heretofore been respected for thirty years, and

(2) the expansion of tort liability generally in the U.S. and particularly in the environmental area. The unique uncertainties and liabilities for cleanup costs and remedial action imposed by legislation such as CERCLA is an example of expanding liability."

In the first point, the underwriters see no third party claiming property damage off the insured site as defined by the policy. They claim their insurance contract was not intended to respond to an EPA notice for on-site cleanup. Looking at the legal, regulatory, and economic environment at the time the policy was drafted, there may be validity to this point.

With regard to the second point, there can be little question of the expansion of tort liability in the area of environmental impairment and pollution liability. Virtually every insurer in the U.S. has backed away from this exposure in the non-nuclear area. It's hard to believe the pools, which are made up of the conventional insurers, would not do the same. But note one very significant difference--the pools may not presently be issuing any new policies or increasing limits, but they are not cancelling coverage.

The Future:

For the near future, the nuclear insurance pools are working toward lifting the underwriting suspension. This may very likely happen on January 1, 1990 with the attachment to all nuclear liability policies of what has been termed the "Environmental Endorsements." The pools have stated that this endorsement would reaffirm that the policy applies only to liability for damages because of bodily injury or offsite property damage caused by the nuclear energy hazard. The endorsements as currently drafted also provide a new coverage for government mandated offsite cleanup costs which, as it applies to low-level waste facilities, result from a "transportation incident."

It should also be noted that, following some pretty heavy negotiating by the state insurance departments as well as by the nuclear insurance brokers, it appears that the pools may be considering a higher range of policy limits for low-level waste facilities than previously disclosed. Although the pools would not confirm our information, they may be considering policy limits in the range of $25 million to 100 million, following a thorough review of the exposures related to each individual site. The fear here could be that if the nuclear insurance pools cite across-the-board maximum available limits, a few well intentioned, but less technically informed legislatures may arbitrarily choose the maximum liability limit without regard to the exposures involved. This could place an unwarranted financial responsibility burden on the Licensee as well as further drive up the cost disposing/storing of these materials.

In conclusion, the low-level waste facilities and the nuclear insurance pools may not yet have plans for their "honeymoon" together, but it appears that in some respects, one may look forward to better times ahead.

DECONTAMINATION AND DECOMMISSIONING

Decontamination & Decommissioning of Shippingport Commercial Reactor

John Schreiber
U.S. Department of Energy--Pittsburgh

(The following text has been summarized from the taped transcription of Mr. Schreiber's speech.)

Shippingport is located on the south bank of the Ohio River northwest from its confluence with the Allegheny and the Monongahela Rivers. Shippingport comprises about seven acres and is a pressurized water reactor.

To a certain degree, the decontamination and decommissioning (D&D) of the Shippingport reactor was a joint venture with Duquesne Light Company. The structures that were to be decommissioned were to be removed to at least three feet below grade. Since the land had been leased from Duquesne Light, we had an agreement with them to return the land to them in a radiologically safe condition.

The total enclosure volume for the steam and nuclear containment systems was about 1.3 million cubic feet, more than 80% of which was below ground.

Engineering plans for the project were started in July of 1980 and the final environmental impact statement (EIS) was published in May of 1982. The plant itself was shut down in October of 1982 for end-of-life testing and defueling. The engineering services portion of the decommissioning plans was completed in September of 1983. We moved onto the site and took over from the Navy in September of 1984. Actual physical decommissioning began after about a year of preparation and was completed about 44 months later in July of 1989.

Decommissioning started with training the decommissioning operations contractor (the DOC), which in this case was General Electric. The DOC spent a one-year caretaker period familiarizing themselves with the site and the facility. One of the reasons for the one-year caretaker period was the low level of funding from Congress. That turned out to be fortuitous, because it gave General Electric the opportunity to spend that year getting most of the control systems they needed in place. This included getting paperwork, such as emergency plans, project instructions, and radioactive survey plans written and in place. Therefore, when they were ready to let subcontracts, they were in a position to do so immediately.

The decommissioning plan laid out a four-pronged parallel attack that provided for the disposal of all on site liquids as well as the packaging, shipping, and storing of solid wastes removed from the system. The logic of the decommissioning process suggested that the decontaminating would begin with removing asbestos, followed by removing the system and components, and finally the building. This would free up the reactor pressure vessel and neutron shield tank. It had been decided early to make this a one-piece shipment rather than cut it up into small parts. It was planned that the reactor pressure vessel and neutron shield tank would be lifted in March of 1989 and then shipped to Hanford for burial along with the other radioactive waste being shipped there. We would then proceed through the completion of decontaminating and decommissioning the buildings to site restoration, and then finally the release of the site.

The decommissioning plan indicates that we should finish the D&D project in April of 1990. The last physical decommissioning work occurred in July of this year (1989), and we expect to have the DOC leave the site in September rather than January.

One of the first problems encountered was with the asbestos removal. The plan called for the components and piping to be removed with the asbestos still attached. We examined that approach very closely and then decided to complete all the asbestos work first. There was a heat dump exchange system outside. The reason for that was that the reactor had had three cores during its lifetime, rated roughly at 70, 120, then back to 70 megawatts. When the power output at Duquesne Light was upped, the turbine could not handle the steam supply and therefore had to have a heat dump system available. The heat dump system was double bricked, asbestos-coated, banded all around, and had to be disassembled.

We placed a greenhouse with an airlock over the system, suited up the workers, who then went in and loosened and bagged all the fiber materials. Workers then sprayed an encapsulate material to prevent the fibers from becoming airborne. The basic criteria for this operation were: no dust, no dirt, no asbestos fibers. The area was to be white-glove inspected before the contractor was allowed to leave, so the contractor did everything he could to control the asbestos as it was being removed. The asbestos was bagged and double bagged in 9-mil polyethylene bags; put in 4- x 4- x 8-foot plywood boxes; loaded onto trucks (which were checked before being sent to Hanford); and shipped. They finally were disposed of in a burial trench at Hanford.

The original estimate of the amount of contaminated asbestos to be disposed of was about 300 cubic yards; checks made just prior to starting the decontaminating project and while this work was underway forced us to revise that estimate upward to 500 cubic yards. By the time we removed it all and packaged it and put it in boxes, the final figure was closer to 1400 cubic yards. The lesson learned here is that D&D operators must allow for expansion of estimated figures.

Simultaneously with the asbestos project, work proceeded on cutting up the materials, tools, racks, and other artifacts that were left behind from reactor operating days to be packaged and shipped for disposal. After being released from the different auxiliary equipment rooms, these materials were packaged in boxes designed for burial at Hanford. The boxes were 4- x 4- x 8-foot steel boxes and handpacked as tightly as possible. Materials, some compacted, were also put in drums. The drums were surveyed prior to being put on trucks and shipped. Surveying was required in order to provide necessary information for the "traveler" that went with all these boxes indicating where they were loaded, the type of material that was in the drums, and the radioactivity levels involved. A regular flatbed truck could accommodate eight of these boxes; we made 200 such shipments to Hanford.

The larger components were the next part of the D&D project. The walls of the concrete enclosures surrounding the steel chambers were from four to seven feet thick. The steel chambers that enclosed all the operating parts were about an inch thick and 60 feet in diameter. Some spot shielding was used for hot spots. The auxiliary chamber had the pressurizer, flash and blowoff tanks, which were contaminated and had to be cut free and lifted out through a hatch. The pressurizer and the flash and blowoff tanks were the first three pieces out. These two tanks had sufficient contamination on the inside that they could not be shipped as LSAs, so they had to go through a decontamination program prior to our official shipment to Hanford. The other components were sealed, thus becoming their own shipping containers to contain any contamination that was inside them. All of these were lifted out through hatches. This was a four-loop system, two loops on either side of the reactor. The terms AC and BD mean that loops A and C were on one side and Band D on the other.

In order to remove the heat exchanger, a 200-ton crane was driven up the hatch so that it could reach inside. It was rather congested in the chamber, and the crane had to be rotated 90° in order to move the heat exchanger into a vertical position and out through the port.

The release of the initial material known to be contaminated in a contaminated system was simple; we simply packaged it for shipment and burial at Hanford. However, as we approached the remainder of the site, it became more important to know: "What are the release criteria; what do you consider unrestricted use; what do you measure so which materials can be released; and which ones that you now uncover have to be further declared radioactive waste and sent for burial?"

When we began the project, the original criterion for a worst case scenario site release was 500 mr/year, maximum dose to the maximally exposed individual. However, as we started the program, it changed from 500 to 100 and we therefore had a new problem. We then had to decide how to meet this new criterion by determining the allowable scenarios and doses or sources that could be left behind.

We arrived at the decision to determine what could be left behind in the top three meters of soil, which would be the greatest contribution to a farming scenario. These determinations were based on the releasability of material. We decided that, if we could develop a swipe and contact reading program that guaranteed that 95% of the time, 95% of the areas would be less than 75% of that limit, then the probability of anything above the limit being released would be extremely small.

Before we could release the rest of the buildings and structures, we had to be able to tell the demolition contractor that he was dealing with releasable material. We found there was contamination at the bottom of the chambers, which did not wipe or wash off and was later found to be embedded and painted over in the paint on the inside. So it became important before we could release these tons of steel for scrap that it be decontaminated. One of the approaches we used for such decontamination was vacuumblasting, where the material is shot blasted and then immediately vacuumed back up again. This presents a filtration and sorting problem, but it can be done. The bottoms of those chambers were all cleaned up to 12 feet off the bottom.

Another problem area was in the canal and certain other concrete enclosures where radioactivity had become deposited either on the walls or had penetrated slightly, on the order of 1/4 inch, into the concrete in order to meet the occupancy scenario, that material also had to be removed. We used a scabbler with a telescoping rod to reach the far side so we could push against the opposite wall and get a reaction. In the head there was a series of pistons with hardened points that could knock the concrete off.

It was difficult to tell precisely how much concrete was being removed, but it was easily 1/4 inch; in some cases it was 1/2 inch. We could get within about a foot to 18 inches of the corner. At that point we just rotated the head, getting to within about four inches of a corner. We would then go back using a handheld scabbler either to treat the corner or to get any hot spots found in the post-scabbling survey. We used a shroud to control the dust problem associated with this scabbling operation; the shroud created a flow control problem, but it did work fairly effectively.

After that work was completed, the DOC people surveyed it. And then we called in the independent verification contractor from Oak Ridge, RAU, who performed their statistical check of all the information and then corroborated the DOC surveys. We did this immediately upon opening up these areas, because the intent was to backfill; in certain cases we had to backfill because we needed the area for structural use later on.

In the radioactive waste processing yard, work was proceeding on taking out four underground tanks. They were in concrete enclosures, which later had to be scabbled. There were two tanks loaded with ion-exchange resins that had been used on the water. These were also loaded and sent to Richland.

At this same time, the first demolition work began in the B and D loops where the large crane was lifting out components. A hydraulic ram hoe broke in through the four-foot-thick concrete. Twenty-one containers were removed from these two tanks and sent to Richland.

Before release of the fuel-handling building for normal demolition work, many surfaces had to be checked and sampled. Workers were raised and lowered into and out of the building via a cherry picker parked above on a bridge over the canal.

The reactor pressure vessel had to come out through the walls of the AC chamber, so preparations for this phase of the work had to be carefully done. The work began by breaking into the roof of the AC chamber. It was important not to damage the administration building, so in this particular case we used a cutoff saw to cut through about 12 inches of the top surface of the concrete, thus taking it through the top two layers of rebar and disconnecting the roof from that building. We then pounded down that whole building without damaging anything inside the cement block (administration) building.

The BD chamber had to be completely emptied and backfilled because it formed a foundation for the west end of the lifting tower. The reactor pressure vessel had to be lifted up out of its belowground enclosure and then put down on a transporter before it could be moved. A large 37-foot-diameter steel enclosure was around the reactor pressure vessel. After removing the outlet piping, whip restraint cable, and stop valve from the steel enclosure, the enclosure itself was removed, and the vessel was prepared for shipment.

As the water was being drained, the metallic components of the cooler that were used for the reactor internals were exposed. Metallic components were left behind. These were all put in Vandenberg liners that were expected to be shipped to Hanford. We decided to put those parts back in the reactor pressure vessel. We essentially put four of the liners in the reactor pressure vessel and then unloaded the other seven and put the parts down in the cusps between them. The reactor head was then put in place above that.

In preparation for shipment, we filled the inside with a lightweight grout (no aggregate) to fix all the parts in place and to acquire some additional shielding. We emptied the water out of the reactor pressure vessel and then filled it back up with concrete, leaving the water in the neutron shield tank around the outside. The reading taken at that nozzle prior to filling was 60 mR; it dropped down to 15 mR after it was filled with concrete.

The next step was to put the lifting beam in place. The reactor head had been put on, but only 26 of the 42 stud bolts were put in place; 16 extended bolts were used to run through the lifting beam and act as a means of lifting the pressure vessel (we also had a skirt design, so the package had a redundant lift path). The pressure vessel was about 18 feet in diameter, 41 feet long, and about 1,000 tons. Interior activity was about 16,000 curies, the greatest amount of radioactivity associated with this job...one half cobalt-60 and one half iron. The entire vessel was lifted out through a hole, about 77 vertical feet in all. There were four center-hold jacks, each capable of lifting 600 tons.

After traversing to the west side, it was laid flat on the transporter. A 320-tired vehicle was driven down right onto the barge, where everything was battened to the deck and inspected in place.

The biggest environmental insult on the entire project was the dumping of about two gallons of hydraulic fluid during the effort to dock in Benton, Washington, after an entirely uneventful trip south through the Panama Canal.

During the course of this project, we took some specimens. The NRC was conducting an aging study, and some of the New England utilities were interested in embrittlement of the neutron shield tank, so we were able to allow them to take specimens of the inner and outer pressure vessel wall and take them back to the laboratory for analysis.

The final configuration of the site had to be clean to at least three feet below ground. We used some of the concrete rubble at the bottom, but we had to bring in a lot of fill. Therefore, we used some of the existing surface as fill and brought in entirely clean fill for the upper portion.

The project decontamination values ended with anywhere from 10% to 40% of the mean allowable limit. Examining the remaining activity in the soil and structures, and calculating the dose to people in a residential scenario, the most restrictive but plausible one is 3 mrem per year. Our limit was 100 mrem per year.

All appropriate surveys, documentation of release (including as many as 100 different rooms and 30 buildings), and preparation of documented proof of the radioactivity remaining support the Post-Remedial Action Report. All of this information then follows the appropriate regulatory/approval route. After appropriate approvals, a Federal Register notice, stating that the site is to be released.

During the course of the project, technical support contractor personnel numbered about nine, and the DOC about 100. Subcontractors numbered about 100, for a total of about 210 people.

The exposures predicted in the plan were 1,000 manrems for the entire job. General Electric set a goal for themselves of 500 manrems. In 1986, they reset their goal to 250 manrems. They have remained below that goal, and will complete the project at about 155 manrems rather than the 1,000 manrems that had been predicted. General Electric treated the job as though it was any other badly contaminated area. Procedures were of paramount importance; ALARA was important. For example, General Electric examined the subcontractors' procedures prior to letting them start work to be certain they took into account possible unexpected encounters with radioactivity.

The cost breakdown for engineering planning was about $6 million. The technical support throughout the life of the job was about $7 million. Two Duquesne Light people familiar with the plant remained to work with our staff. We requested that they leave behind some knowledgeable management people as well as maintenance and technical types, which they did.

The amount of money was roughly $72 million allotted for the decommissioning activities themselves, with about $11 million in contingency. The project will come in at about $6.3 under budget.

DECONTAMINATION TECHNOLOGY OVERVIEW (U)

W. Nevyn Rankin and James F. McGlynn
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

ABSTRACT

This paper consists of an overview of the decontamination technology program being carried out at the Savannah River Site and discusses the use of state-of-the-art equipment and techniques for decontamination and removal (D&R) applications. The purpose of the program is to minimize personnel radiation exposure, minimize the potential for uptake of radioactive material, and reduce the volume of contaminated waste. Implementation of technology and the status of new applications are discussed.

INTRODUCTION

The Savannah River Site's program to investigate and implement state-of-the-art decontamination technology is composed of three parts: 1) Evaluation of existing technology, 2) Development of new technology, and 3) Providing technical assistance. Examples of the type of work being done are given below:

EVALUATION OF EXISTING TECHNOLOGY

Concrete Scabbling (Figures 1 and 2) In this operation the surface of contaminated concrete is removed. This is accomplished by both mechanical and super-high-pressure water techniques. Super-high-pressure water scabbling is more easily operated remotely.

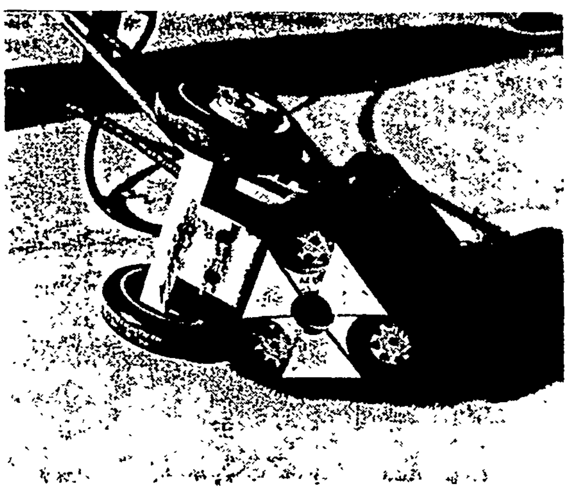


FIGURE 1. Mechanical Scabbler

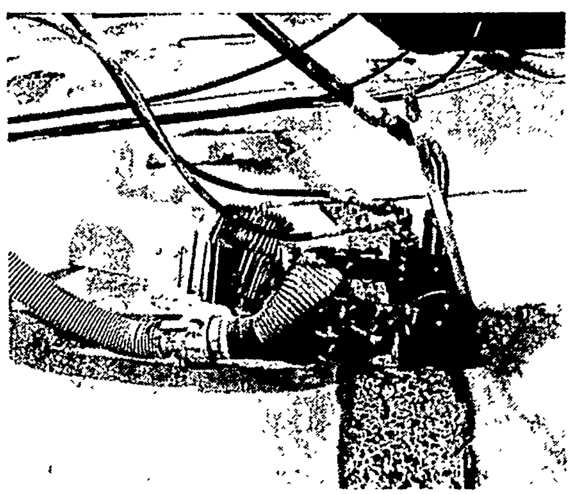


FIGURE 2. Scabbling Concrete with ADMAC

Decontamination Chemicals (Figures 3 and 4) A laboratory-scale evaluation of commercially available decontamination chemicals was conducted.[1]

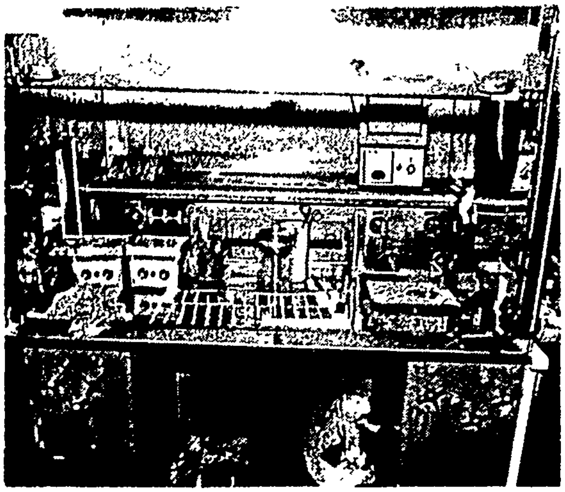


FIGURE 3. Equipment for Evaluating Decontamination Chemicals

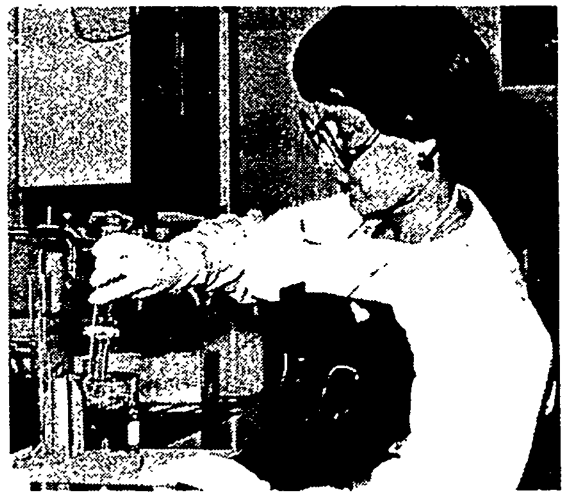


FIGURE 4. Evaluation of Commerically Available Decontamination Chemicals

Foam and Gel Decontamination Techniques (Figure 5) Foam and gel applicators produce solutions that adhere to the surfaces being decontaminated, and provide a means to clean surfaces where a soaking action is required.

- Foam

  Foam is produced by a pressurized applicator. The solution is applied to the surface, and decontaminates it through contact and chemical removal. The units will be used to perform tests on the adherence properties and decontaminability using various chemicals.

- Gel

  The gel works using the same principles that the foam does, but the gel has the property of being able to adhere to the surface for a longer period of time then the foam. This will increase the decontaminability due to a longer soaking time.

FIGURE 5. Evaluation of Foam

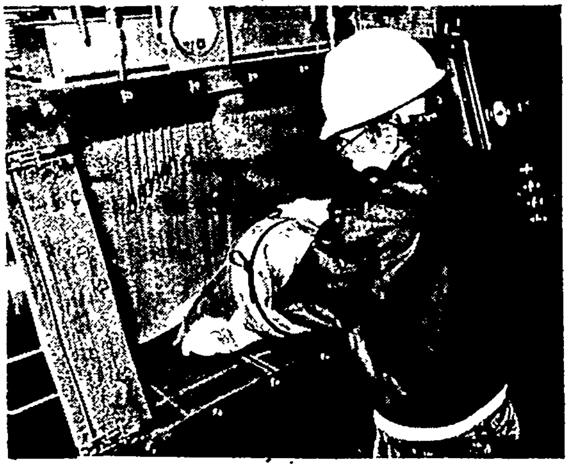


FIGURE 6. Freon Spray Chamber

Freon™ Spray Decontamination (Figure 6) A high pressure Freon™ spray is used to remove smearable contamination from small parts and tools.

Decontamination of Lead Technology is being developed to decontaminate lead for reuse.

- Chemical Techniques

  The effectiveness of chemical decontamination of lead was demonstrated in both lab-scale and larger-scale tests. There is a problem, however, in removing the lead from the used solution. Precipitation techniques are ineffective. Ion exchange techniques require an unreasonable amount of media. A decontamination technique with fewer waste disposal problems was desired.

- Abrasive Blasting Technique

  The effectiveness of this technique has been demonstrated on a wide variety of materials, including lead. There are fewer waste disposal problems than encountered with chemical decontamination techniques. Plans are to conduct a pilot-scale demonstration.

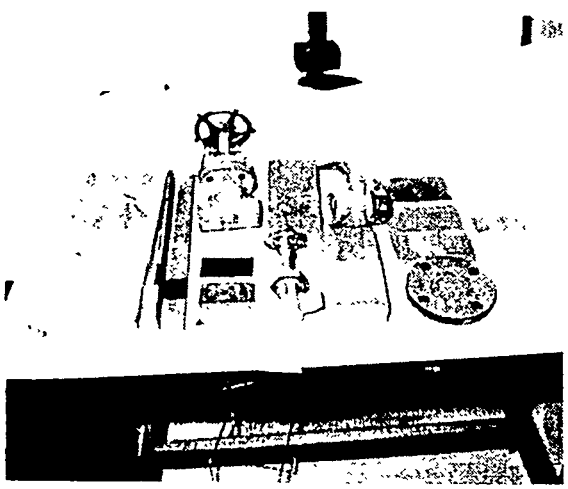


FIGURE 7. Abrasive Blasted Materials

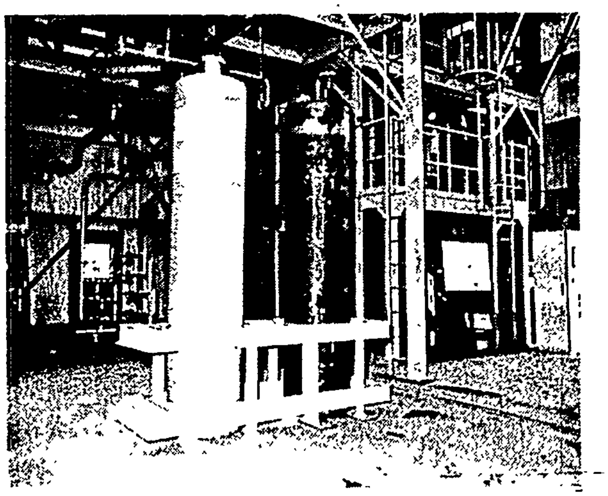


FIGURE 8. Waste Glass Canisters

Abrasive Blasting Decontamination (Figures 7 and 8) This technique removes both smearable and fixed contamination. The contaminated surface is mechanically removed by abrading it with a water slurry containing glass frit as the abrasive. All wastes from the process can be fed to a waste glass melter for disposal. This decontamination technique was developed to decontaminate the waste glass canisters in the Defense Waste Processing Facility (DWPF). Because the glass frit is needed to produce waste glass, this decontamination is effected with the generation of no additional radioactive waste.[2]

Kelly Machine (Figures 9 and 10) Superheated water chemically and mechanically removes smearable contamination. This equipment has performed well in a wide variety of applications at the Savannah River Site.

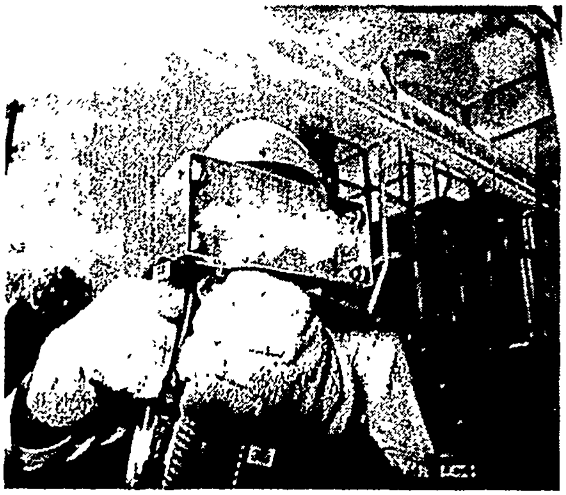


FIGURE 9. Kelly Machine Wall Tool

FIGURE 10. Training Class for Kelly Machine

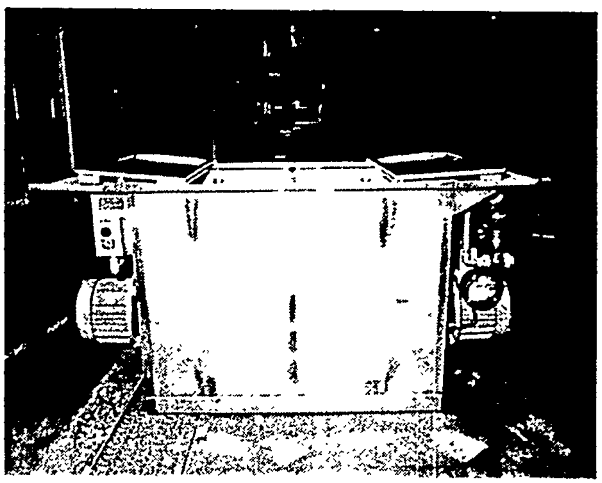


FIGURE 11. Turbulator Tank

Turbulator (Figure 11) Increased agitation of chemical solutions increases the removal rate of smearable contamination from small parts and tools. Four distinctive flow patterns allow the chemical solution to come in contact with all portions of the item being decontaminated. This unit will be used to conduct tests on how agitation increases the decontamination factors of certain solutions, as well as comparing the cleaning ability of various chemical decontamination agents.

Water-Jet Technology (Figures 12 and 13)

- Water-Jet

Water at 60,000 psi removes fixed contamination from concrete and asphalt surfaces by mechanically removing the top layer of the material.

- Abrasive Water-Jet

  Water/abrasive slurry systems can be used to cut and clean surfaces. At pressures up to 60,000 psi this technology can be used to cut virtually any material; however, both time and cutting depth vary depending on the material being cut. This technology can be used for size reduction and waste minimization.

Size-Reduction and Decontamination of Decommissioned Waste Glass Melters Abrasive water-jet cutting of windows in the materials of construction of a melter shell has been demonstrated. The use of a Hydrex impact tool to dislodge the refractories is being investigated. This tool is charged with 50,000 psi water. When it is discharged it produces an impact of 40,000 ft-lb. This amount of energy applied to the refractories exposed by cutting windows in the melter

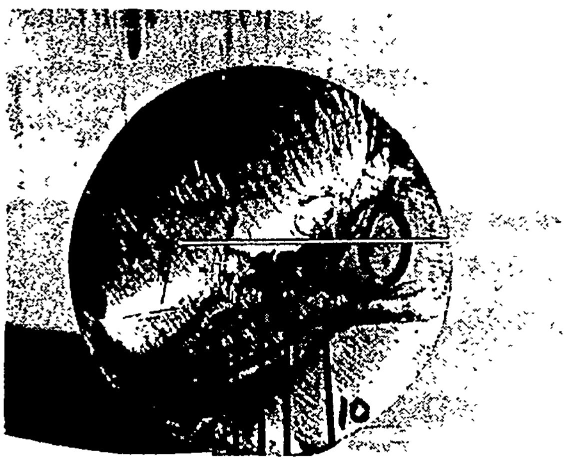


FIGURE 12. Inconel 690 Cut with Abrasive Water-Jet

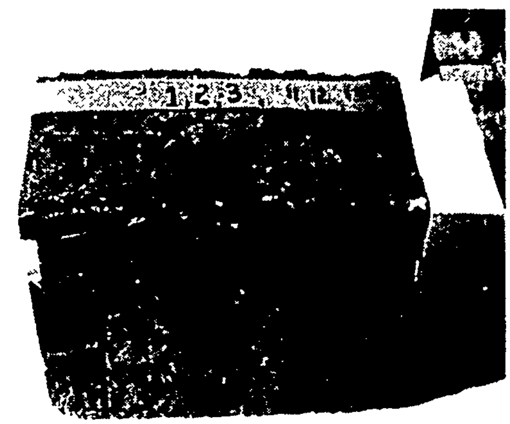


FIGURE 13. Monofax K-3 Cut with Abrasive Water-Jet

is expected to break the refractories apart at the joints. They could then be removed and tightly packed in containers for disposal. After the refractories have been removed, the metal parts of the melter could be cut into small pieces for disposal using an abrasive water-jet.

Portable Heat-Sealers This hand-held device is used for heat-sealing plastic. It is being evaluated for use in sleeving techniques used to separate gloveboxes without breaking containment.

Electropolishing This electrochemical technique removes fixed contamination. In addition, it can be used to prepare a metal surface to minimize the sites where particles of contamination can become entrapped. Electropolished metal surfaces are easier to decontaminate. Electropolishing can be done through immersion or *in situ*(wand) techniques.

Alternative Steam Injector (Figure 14) A device was identified that the manufacturer claims is more efficient than the Sellers injector presently used sitewide for decontamination by washing. Evaluation is underway.

Robotic Decontamination (Figure 15) The use of robotic equipment in decontamination applications is being developed. This is a joint effort with SRS's Robotic Technology Division.

FIGURE 14. Sellers Injector

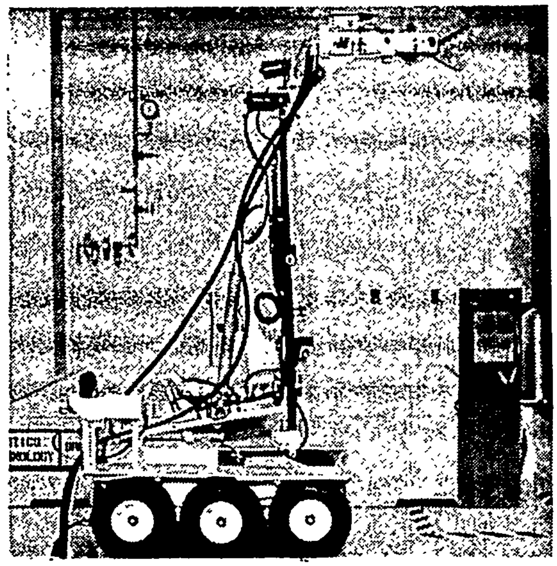


FIGURE 15. Robotic Decontamination

Polyurethane Foam The use of this material has two applications.

- Fixing Contamination (Figure 16 and 17)

  A device was developed that allows foam to be injected into pipes without breaking containment. The foam stabilizes any radioactive material inside the pipe. This minimizes the potential for airborne radioactive material when the pipe is cut during decontamination and removal (D&R) operations.

- Immobilization (Figure 18)

  In this application foam is used to stabilize equipment inside a glovebox in order to avoid shifting, which could cause a broken window and result in release of contaminated material during D&R operations.

Expandable Pipe Seals These devices are used to seal the ends of pipe removed during D&R operations. The seal prevents any radioactive material inside the pipe from escaping.

Personnel Mounted TV Camera A television camera was identified that is small enough to be mounted on a person. It would transmit a picture of what the person is looking at. It would be useful in critical quality assurance applications.

Heat-Shrinkable End Caps These devices are also used to seal the ends of pipes removed during D&R operations. The seal prevents radioactive material inside a pipe from escaping. In addition these devices protect workers from the rough edges of the pipe.

Penetration Sealing Several materials for sealing penetrations through walls were identified. The use of these materials will allow increased control of air flow in critical facilities.

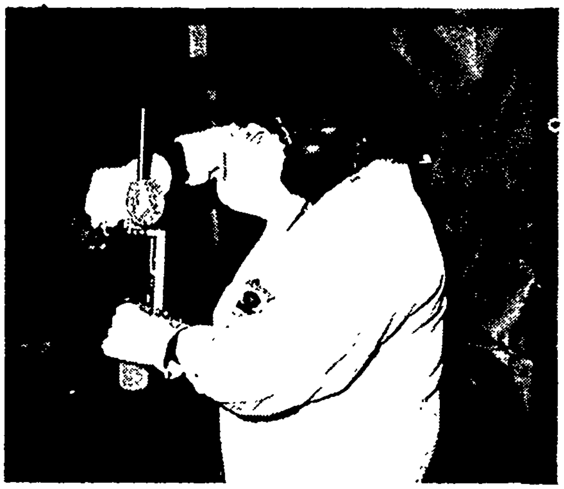


FIGURE 16. Foam Injection Clamp

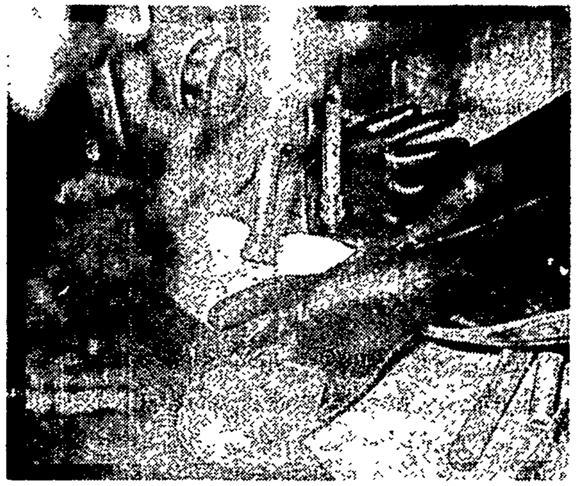


FIGURE 17. Fixing Contamination with Foam

FIGURE 18. Stabilized Equipment using Foam

Ultrasonic Ranging and Data System This equipment provides a documented, reproducible survey of radioactive contamination within an area. An onsite demonstration is planned.

Evaluation of Laydown Materials (Figures 19 and 20) Blotting paper was evaluated as an alternative to kraft paper for laydown applications.

Evaluation of Strippable Coatings These materials were evaluated for both decontamination and surface protection applications.

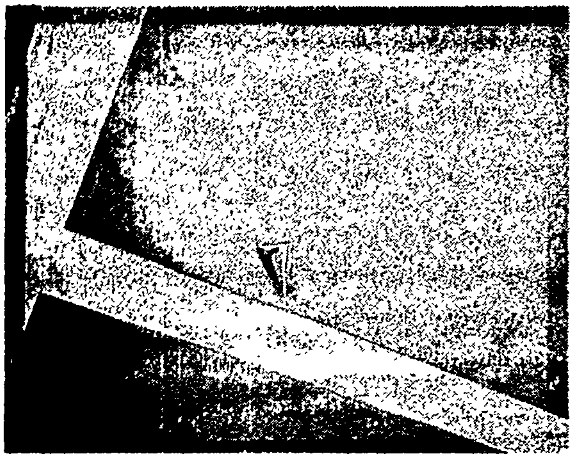


FIGURE 19. Evaluation of Kraft Paper

FIGURE 20. Evaluation of Blotting Paper

DEVELOPMENT OF NEW TECHNOLOGY

Low Pressure Sprayer (Figures 21 and 22) This equipment is used for applying strippable coatings. It is safer, less expensive,and increases the application rate by more than a factor of 10 over the application equipment recommended by the coating manufacturer and used at other sites. This equipment was designed, fabricated, and evaluated in nonradioactive and radioactive applications. Patent rights are being investigated.

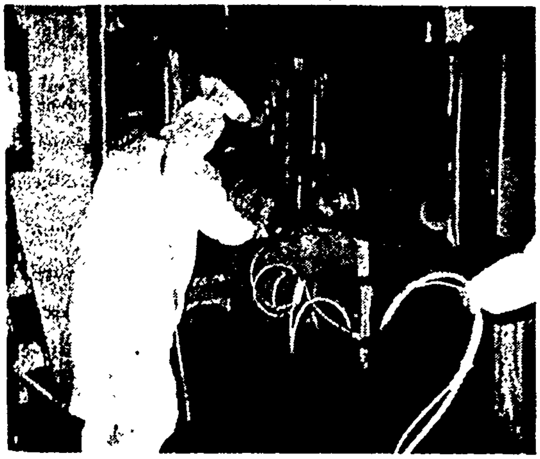


FIGURE 21. Spraying Alara using SRS Low Pressure Sprayer

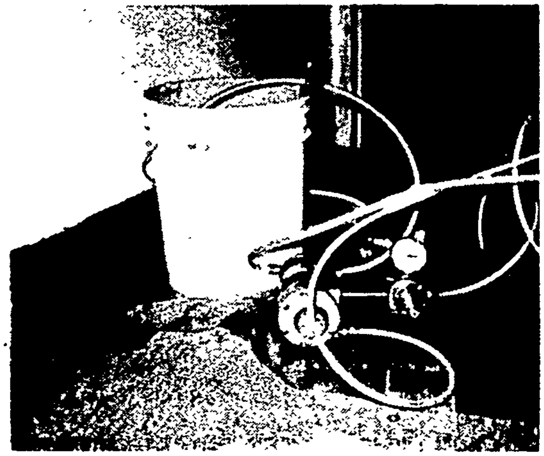


FIGURE 22. SRS Low Pressure Spray Equipment

Coating of Lead (Figure 23) Technology is being developed to coat lead for use as shielding in contaminated areas to prevent it from becoming contaminated.

Treated Polyester Wipes (Figure 24) These wipes are treated by a textile chemistry process to increase the sorption of the fiber. They are being investigated as an alternative to "atomic wipes" for decontamination by wiping and sorption. The advantages are: 1) Compatible

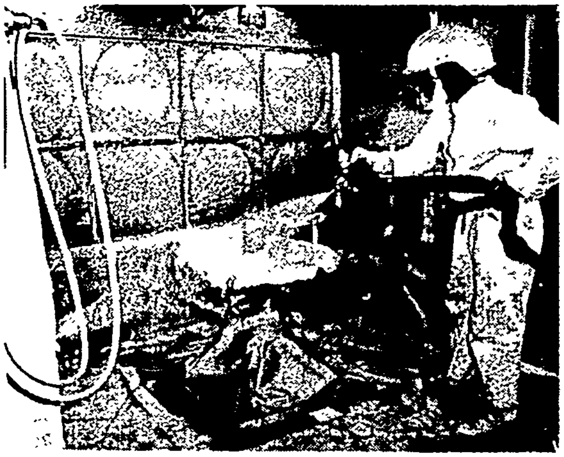


FIGURE 23. Coating Lead Brick

FIGURE 24. Evaluation of Sorbents

with nitric acid, 2) More fire resistant, 3) Less volume of radioactive waste generated, and 4) Recovery of product possible.[3]

Small Critically-Safe Solvent-Assisted Vacuum Cleaner (Figure 25) This device uses a liquid spray to dislodge particulate contamination. Then the liquid plus the radioactive material can be collected in a critically-safe sump. This material could be processed to recover product.

Atomic Wipe Holder (Figure 26) This device was developed to improve the effectiveness of "atomic wipes" in decontamination by wiping.

FIGURE 25. Small Solvent-Assisted Vacuum Cleaner

FIGURE 26. "Atomic Wipe" Holder

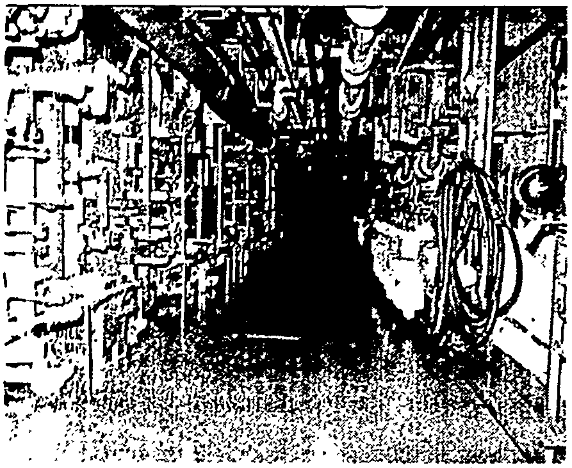


FIGURE 27. Hot Gang Valve Corridor

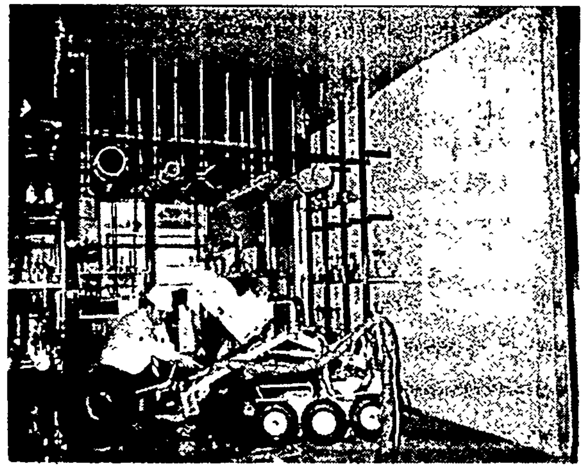


FIGURE 28. Mockup of Hot Gang Valve Corridor

PROVIDING TECHNICAL ASSISTANCE

Two divisions of the Savannah River Site, Interim Waste Technology and Robotics Technology, combined their expertise to provide technical assistance in two applications where robotic decontamination techniques were required to minimize personnel exposure.[4]

221-F Hot Gang Valve Corridor (Figures 27 and 28) Radioactive liquid migrated into the 221-F Hot Gang Valve Corridor (HGVC). The valves in this area are used to control canyon processes. Radiation levels up to 1000 rad/100 R/hr resulted. Equipment maintenance under these conditions was impossible. The Kelly spray/vacuum decontamination equipment was recommended for this application. A Pedsco robot was modified to remotely operate both the spray wands and the spray/vacuum tools. A full-size mockup of a portion of a HGVC was constructed. First, the ability to perform all operations in the mockup facility was demonstrated. Then operations were started in the contaminated area. Results were that radiation levels were reduced by a factor of 10. Personnel exposure of 1.65 rem resulted. The robot received an exposure of 37 R gamma, 113 rad beta.

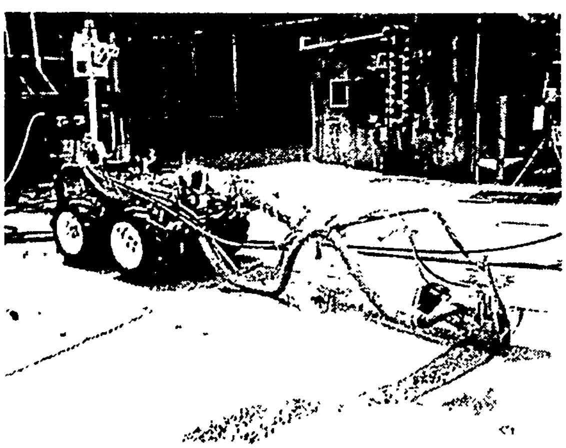


FIGURE 29. Mockup of Tank 13

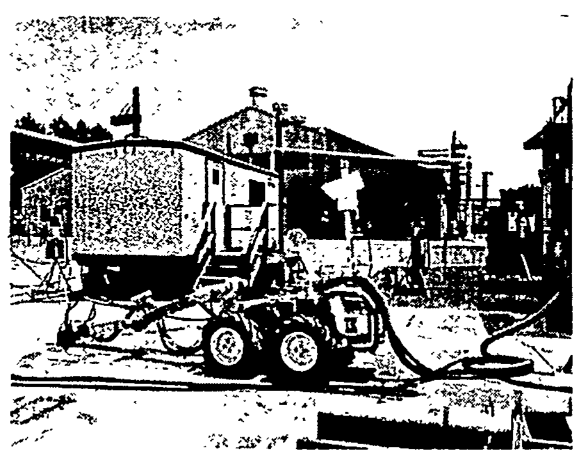


FIGURE 30. Control Trailer

Robotic Decontamination of Tank 13 (Figures 29, 30 and 31) Radioactive liquid spread across a portion of the top of Tank 13 (an 85-ft-diameter, high-level liquid waste tank) and into the soil. Radiation levels on the tank top were several hundred mR/hr and the severity of the soil contamination was unclear. Decontamination techniques involved scabbling the surface of the concrete to remove the contaminated portion using Admac ultra-high-pressure water equipment.

FIGURE 31. Control Trailer

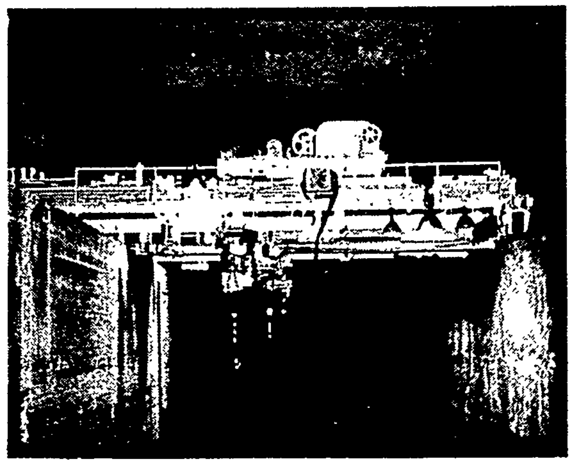


FIGURE 32. 221-H Hot-Canyon Crane

The cutting head was shrouded to minimize airborne contamination. A Wasp mobile robot was used to manipulate the scabbling head. A radio-controlled BOBCAT 743 skid-stear loader was readied to excavate the soil surrounding the tank top. A trailer was outfitted with a control panel for a multiple TV camera surveillance system used to position the robot. First, the ability to scabble concrete on an uncontaminated concrete pad was demonstrated. Then operations were started in the contaminated area. Results were that radiation levels were reduced 50%. Personnel exposure of 1.7 rem resulted.

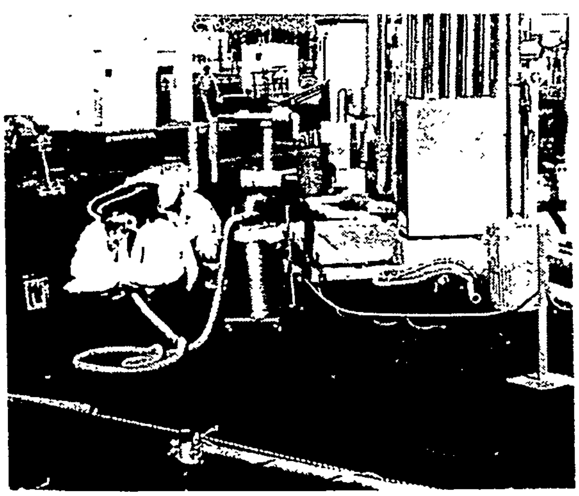


FIGURE 33. Kelly Machine in Tank Farm

FIGURE 34. Communication in Hazardous Environments

H-Area Hot-Canyon Crane (Figure 32) Freon™ spray techniques were used to decontaminate this crane.[5]

Decontamination in Tank Farm Operations (Figure 33) The Kelly machine is used almost daily in tank farm operations.

Communications in Hazardous Environments (Figure 34) State-of-the-art radios were identified and evaluated in sitewide applications.[6]

FUTURE OUTLOOK

Future demand for the technology being investigated is expected to increase.

- There has been an increase in the site's desire to decontaminate using state-of-the-art rather than 20-year-old techniques.
- Maintenance requirements of existing facilities will increase as they continue to age. Decontamination before maintenance reduces personnel exposure, reduces the potential for uptake, and increases safety.
- Decontamination and Removal (D&R) of existing site facilities is expected to increase. In the 1984 Long Range Plan, D&R projects were identified that total approximately $400 million over the next 10 years. SRS needs to be in a position to provide technical assistance in planning and implementing this work so that it will be done in the most cost effective manner.

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ACKNOWLEDGMENT

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ELEVENTH ANNUAL DOE LOW-LEVEL WASTE CONFERENCE

DECONTAMINATION AND DECOMMISSIONING OF THE MAYAGUEZ (PUERTO RICO) FACILITY

Prepared by: P.K. Jackson and R.L. Freemerman, Bechtel National, Inc., Oak Ridge, Tennessee

Presenter: P.K. Jackson

On February 6, 1987 the U.S. Department of Energy (DOE) awarded the final phase of the decontamination and decommissioning of the nuclear and reactor facilities at the Center for Energy and Environment Research (CEER), in Mayaguez, Puerto Rico. Bechtel National, Inc. was made the decontamination and decommissioning (D&D) contractor. The goal of the project was to enable DOE to proceed with release of the CEER facility for use by the University of Puerto Rico, who was the operator. This presentation describes that project and lesson learned during its progress.

The CEER facility was established in 1957 as the Puerto Rico Nuclear Center, a part of the Atoms for Peace Program. It was a nuclear training and research institution with emphasis on the needs of Latin America. It originally consisted of a 1-megawatt Materials Testing Reactor (MTR), support facilities and research laboratories. After eleven years of operation the MTR was shutdown and defueled. A 2-megawatt TRIGA reactor was installed in 1972 and operated until 1976, when it too was shutdown. Other radioactive facilities at the center included a 10-watt homogeneous L-77 training reactor, a natural uranium graphite-moderated subcritical assembly, a 200KV particle accelerator, and a 15,000 Ci CO-60 irradiation facility. Support facilities included radiochemistry laboratories, counting rooms and two hot cells. As the emphasis shifted to non-nuclear energy technology a name change resulted in the CEER designation, and plans were started for the decontamination and decommissioning effort.

Criteria for completion of the project were based upon "The USDOE Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program (SFMP) Sites". CEER performed limited decon in 1980 and 1981, achieving the then applicable decontamination levels. These generally followed criteria specified in NUREG 1.86.

Following initial engineering and procurement activities in Oak Ridge and a Readiness Review there, mobilization began in April 1987.

Radiological characterization activities preceded the main mobilization. In mid-April background radiation and soil concentration levels were determined in the vicinity of the site. Gamma radiation was in the range of 2-4.5 uR/hr, averaging 2.8 uR/hr. Soil concentrations averaged from less than 0.01 pCi/g to 1.12 pCi/g for the radionuclides of interest. The data was used to establish background conditions, seen on viewgraph 2, for the project. Using this information, project personnel then prepared site-specific guidelines for residual radioactivity upon project completion. With DOE approval the guidelines, in viewgraph 3, were used as release criteria, keeping in mind that the basic dose limit to an individual member of the general public is 100 mrem/yr above natural background for extended periods.

Sample data acquisition and control were, as for any project of this nature, of utmost importance. Careful adherence to the to guidance given in Formerly Utilized Sites Remedial Action Program (FUSRAP) procedures ensured a sound basis for data analyses for site release. Use of these proven methods and techniques permitted the project to proceed without the added effort and cost of developing new procedures for this activity.

Soil excavation requirements were determined by using walk-over surveys to locate any area with unacceptable dose rates. Areas with increased readings were identified for "hot spot" surveys and possible excavation. Hot spot surveys were then conducted in the identified areas to clearly define the area to be excavated.

As soil removal progressed, in-situ gamma measurements were made to monitor and guide the effort. Following soil removal a post remedial action survey was taken, using a 2 x 2 meter grid for data point location. Direct gamma readings, gamma exposure rates at one meter above ground (using a proportional ion chamber, PIC) and soil sampling was performed at each data point. For small areas a proportional number of samples was taken. Soil samples were taken to a depth of 15 centimeters and underwent an on-site gamma spectrometry analysis. Once the on-site analyses indicated that an area met the site release criteria, backfilling could commence. Approval to backfill was required from the independent verification contractor (IVC). Soil samples were shipped off site, to the Bechtel Service Center in Oak Ridge, for final analysis. Movement of soil from Puerto Rico required a permit from the Department of Agriculture, since that organization controls the movement of all agricultural products into the country from Puerto Rico. They readily agreed to permit movement of the soil and subsequent radioactive material and waste shipments into the country with minimal inspection at the ports of debarkation in Puerto Rico and entry in the United States.

To determine remedial action needs within site buildings and structures, seen on viewgraph 4, areas of known or suspected contamination were surveyed. Other areas received brief scanning surveys, or no survey, depending on current and/or past uses. Grids were made for all interior survey areas. As with soil sampling and survey methods, a walk-over survey determined the location of areas with higher radiation levels, which were marked for further survey and remedial action. Floors and walls up to two meters above floor level were completely scanned at one centimeter from the surface. Direct and removable contamination surveys were made. Remedial action progress was monitored by further contamination surveys. When an area was felt to have reached the release criteria it was prepared for a "release survey".

The release survey included scans of the entire grid location with NaI and G-M detectors and removable contamination smear analysis. After analysis of the release survey data, the Site Health and Safety Officer identified those areas deemed releasable according to the established site-specific criteria. He then advised the Project Manager that the area was ready for independent verification surveys and data checks, to determine if release criteria were achieved and if the location could be released.

Remedial actions included soil excavation, equipment removal or decontamination, building/structure removal or decontamination, piping decontamination and/or removal, packaging and removal of all radioactive material, and processing of the on-site radioactively contaminated water for discharge.

Soil excavation techniques were dependent on location and extent of the contaminated area, and varied from the use of shovels to backhoe and grade-all excavator operations. Some contaminated areas were small enough to be totally removed when the characterization soil sample, 10-15 cm diameter and 15 cm deep, was taken. The major excavations were conducted behind the main building where the buried hot waste storage tanks and pump pit were located. Overflow from the hot waste pump pit during facility operation caused contamination in an area requiring excavation of approximately 2500 cu. ft. soil. The removed soil was placed either in B-25 radioactive material shipping boxes, 95 cu. ft. each, or on an asphalt parking lot adjacent to the excavation. Placement of the soil was dependent on its radiological condition and "clean" soil only was placed on the parking lot. Prior to replacing the soil a release survey was performed in the excavation and on the clean soil, ensuring that all radioactivity above the criteria was removed and that none was returned during the backfill operation. Another significant excavation was made for removal of the serpentine line, a 360 ft. decay loop in the pool water cooling and treatment system. This excavation resulted in no identified contamination of the surrounding soil, the clean soil was replaced after a release survey of the pit was made to ensure that all criteria were met. All contaminated soil was loaded in radioactive shipping containers, either exclusively or as filler around other contaminated materials to minimize voids.

Remedial action for equipment, tanks and piping consisted of either decontaminating the item or removing it for disposal as radioactive waste. Decontamination was accomplished using various commercially available decon solutions, soap and water or chemical mixtures, high pressure and ultra-high pressure water spray decon systems, HEPA-filtered wet-dry vacuum systems, abrasive materials, and water-handling/ion exchange systems, as appropriate to the item and to the type and level of contamination present. This approach enabled many pieces of material to be released and removed from the site as non-radioactive waste, resulting in decreased radioactive disposal volumes and cost. One example of this was the disassembly and disposal of the L-77 reactor seen in viewgraph 5. This task was accomplished by first removing all external fittings, opening the outer shield tank manway and surveying the tank internals, removing the tank top and cutting away the secondary shield supports. This enabled the workers to commence closing and sealing all openings on the secondary shield, effectively turning it into an acceptable strong-tight container for shipment as radioactive LSA material. A significant savings in radwaste volume was achieved by this effort as the entire outer tank and secondary shield supports were disposal as non-radioactive. The hot waste storage tanks, serpentine line, retention tank drain and vent lines and some pool water cooling piping were also disposed as non-radioactive. This was accomplished by removing the items from their locations, cutting with gas cutting or electric arc air-gouging equipment and decontaminating the surfaces with ultra-high pressure water. Items not releasable were disassembled or cut-up and shipped in LSA packages for disposal.

Building and structure release was achieved by standard hands-on decontamination, HP and UHP water spray, surface removal and in-depth removal of activated materials. In laboratories it became necessary to remove sections of benchtops, hoods, piping drain lines, and floor coverings. Some hand decon was successful in these areas. In the hot cells, considerable effort was required to release the rooms. This included removal of storage tubes, floor protectors, and some concrete where contaminants had gotten below the stainless steel cell floors.

Decontamination of the 40 ft. by 40 ft., 16 ft. deep underground retention tank was a reasonably easy task after removal of the approximately 180,000 gallons of radioactive water placed there during the pump-down of the reactor pool and various other water holding tanks or pits. No surface material removal was needed within the tank.

The pump room and the reactor pool required the most aggressive material removal operations at the facility. The pump room had undergone several spills during operation which had resulted in considerable contamination of the concrete surfaces, as well as in the soil surrounding the 1500 gallon sump tank. Concrete removal was accomplished with pneumatic scabblers and jackhammers, while soil removal was a handshovel operation. All materials were removed through the equipment access hatches above the underground room.

The reactor pool, viewgraph 6, remedial action work easily accounted for the major portion of such activities. Initially, activated components were removed from the pool and loaded into a Type A radioactive material shipping cask. Then the contaminated reactor pool water was transferred to the retention tank, the pool surfaces being deconned by high pressure water during the pump down. After the water level was below beam tube level it would be possible to commence beam tube and activated concrete removal. The beam tubes were removed by unbolting the liner and tube from its embedment, these components were then prepared for disposal. The embedments would be removed with the activated concrete remaining around them i.e., as a radioactive cylinder. Preliminary surveys indicated that an area surrounding each tube at a radius six inches greater than tube radius would have to be removed to account for all the activated concrete outside the 80 inch radius sphere projected as the likely activation range around the core location. In actuality, the concrete removal around the beam tubes was in the range of 28 to 50 inches, 10 to 32 inches greater than anticipated. This was a result of neutron experiments conducted in some of the tubes. A somewhat larger than expected volume of activated concrete was also removed in what could be considered the activation sphere. Concrete removal was accomplished by stitch drilling through the six-foot thick concrete pool walls with core boring equipment. Inner wall surfaces were drilled to a depth of about one foot and the concrete then broken away with jackhammers. A graphite-filled thermal column also had to be removed. After removal of the graphite it became obvious that the boral liner and steel embedment were activated and would require that a considerable part of them be removed. This activity entailed cutting the metals with the air-gouge and sawing them with carborundum-blade saws. Completion of these three tasks; beam tube removal, thermal column removal and activated concrete removal, in addition to surface decon and tile removal completed the reactor pool remedial action.

One of the more challenging tasks was the removal of the now 2700 Ci CO-60 source. This source had been kept in a 14 ft. deep pool in the laboratory building. Its location made removal difficult because the laboratory building was in daily use throughout the project. Further complicating this task was the fact that the "gamma room" was not an outside room and access was down a personnel corridor, there was no lifting device in the room. A local machine shop fabricated an A-frame hoist assembly which was then erected in the room. This hoist had to be capable of lifting the approximately 6000 pound General Electric IPO-200 Type B shipping cask arranged for transport. Procurement of such a cask proved difficult because of the facility location, Puerto Rico, and the resultant shipping requirements. Movement of the cask within the building turned out to be a manual operation.

This source was ultimately donated to, and accepted by Louisiana State University.

Other sources and controlled radioactive materials removed from the site were either disposed of at the Hanford site or shipped to other DOE facilities for recovery or interim storage. Packaging and shipping the solid radioactive waste, viewgraph 7, resulting from this project was complicated by the fact that the destination for radioactive waste was at the DOE Hanford reservation in Washington. DOE Richland personnel and Hanford Disposal Site personnel were very helpful in sorting out the numerous Burial Compliance Certificates needed for shipment of the radwaste. Because the route was over water as well as land each shipment became an intermodal shipment. A total of about 6200 cu. ft. weighing nearly 461,000 pounds was transported by truck from Mayaguez to San Juan, transferred to a ship and sent to Jacksonville, FL. At Jacksonville the shipments were put on railcars and transported via Chicago to Pasco, WA where it was again put on trucks for the final movement into the Hanford site. This route was selected to minimize the potential hazard to the public and large population centers. A total of fifteen individual seavan shipments made this trip, one travelled from Jacksonville to Oak Ridge by truck and two passed through New Orleans enroute to Los Alamos. The CO-60 source shipment also entered through the Port of New Orleans.

Treatment and disposition of the large volume of radioactive water at the facility caused several problems. A significant problem was getting permission to discharge the water after treatment, because of restrictions in place on water discharges throughout Puerto Rico. This problem prevented water discharge until this year, although all water had been treated and met release criteria by November 1987. Keeping such a large inventory on site while proceeding with the D&D effort was a problem. To allow work to proceed, cleaning of the retention tank was postponed and all water was transferred to it as necessary. Water pumped to the tank was treated on ion exchange beds. When project progress reached a point at which the retention tank had to be deconned, another transfer campaign was made, pumping the water to an above ground water tower that had been part of the original facility systems. Because the tower was non-contaminated the water was again processed during the transfer, additional storage capacity was made available by rental of tank trailers (5000-6000 gallons each). Once the retention tank was deconned using the HP water system, the water was returned to it for storage pending authorization to discharge.

Some valuable lessons learned on the project are seen on viewgraph 8, they are:

- Careful and thorough characterization of the site is essential to a project of this type.

- Detailed descriptions of the facility's operating history will minimize un-anticipated work by more clearly enabling project personnel to understand the extent of potential contamination.

- When planning the project, particular attention to defining all permitting requirements and restrictions can prevent problems and subsequent work-arounds made necessary by them. All such permits should be in place or certain to be issued prior to mobilization.

- Scheduling of these projects must allow time for thorough review of site characterization and operating history data.

- Use of non-radiologically experienced craft and labor personnel from the local area can be beneficial not only for cost but because of the input they bring to bear regarding local support organizations. This type project does require staffing with experienced managers and supervisors as well as a cadre of technical specialists with experience in the technologies applied.

- Inter-agency relationships will influence the ease with which operations can be accomplished when tasks require approval of the other entities.

Further information regarding this project are available in the reference documents identified below.

1. Final Report, Decontamination of the Center for Energy and Environment Research (CEER) Mayaguez Facility at the University of Puerto Rico prepared for the USDOE ORO by Bechtel National, Inc.

2. Verification of Remedial Action, Center for Energy and Environment, Mayaguez, Puerto Rico prepared for Facility and Site Decommissioning Projects USDOE by Oak Ridge Associated Universities

3. Decontamination Plan for the Center for Energy and Environment Research, University of Puert Rico, Mayaguez, Center for Energy and Environment Research

COMPLIANCE MONITORING

Environmental Monitoring at the Barnwell Low Level Radioactive Waste Disposal Site

F. Ann Ragan
South Carolina Department of Health and Environmental Control
Columbia, South Carolina 29205

ABSTRACT

The Barnwell site has undergone an evolution to achieve the technology which is utilized today. A historical background will be presented along with an overview of present day operations. This paper will emphasize the environmental monitoring program: the types of samples taken, the methods of compiling and analyzing data, modeling, and resulting actions.

BACKGROUND

The Barnwell Low Level Radioactive Waste Disposal Facility is located about 5 miles west of Barnwell, South Carolina. The site is one of only three commercial facilities currently operating in the United States, and has been in operation since 1971. The site operator is Chem Nuclear Systems Inc. (CNSI). In addition to the burial site CNSI has several auxiliary operations such as an environmental laboratory, a mobile operations facility and a Department of Defense Consolidation Facility. All of these hold a license with and are regulated by the South Carolina Department of Health and Environmental Control (DHEC), Bureau of Radiological Health Agreement State Program. CNSI also has an NRC license for special nuclear material in excess of 350 grams.

The site occupies 300 acres measuring roughly 4950 feet north-south and 750 feet west-east. The site employs the shallow land burial technique, which utilizes engineered trenches and natural barriers which will contain the waste to allow sufficient time for its decay to a harmless activity. This burial technique is well suited to this area due to its geologic nature. The natural soil is a clayey sand which has a low permeability. The groundwater table at the site is contained within the Hawthorne formation and ranges in depth from 9.1 to 18 meters, with a mean of 12.2 meters. Fluctuations in the water table are a function of varying soil permeabilities and the inclination of the peizometric surface.

After the implementation of 10 CFR 61, the site initiated a three trench system. The class A trenches are approximately 100 feet wide and 1000 feet long, and 22 feet deep. Depth is a function of the highest recorded watertable. These trenches are sloped 1% north-south and 1% east-west to a French drain with sumps placed every 125 feet. The B-C trenches are essentially the same design as class A except that the width is narrower 30 feet at the top and 18 feet at the bottom to reduce scatter radiation exposure due to the higher radioactive concentration of these materials. The third type of trench is a slit trench. It is used for wastes which require special shielding consideration to protect personnel.

There are several means by which the integrity of the site is assured by DHEC. The most important way is to closely regulate the material that is buried. This includes the prohibition of substances by license conditions, assuring the integrity of packaging and waste form, and regulating the burial techniques. Every waste shipment that arrives at the site is inspected independently by both DHEC and CNSI. To provide the assurance that the integrity of the site is maintained, DHEC and CNSI both have an extensive monitoring program.

GROUNDWATER

Due to the fact that the Barnwell Site utilizes the shallow land burial technique, the groundwater would be the most probable means for transport of radionuclides. There exists series of wells at the site to closely monitor groundwater. These consist of 101 onsite wells, 252 trench sumps, 28 boundary wells and 78 offsite wells. Most onsite and boundary wells are located in clusters of three: one deep well to the water table and one to each of the sand layers greater than 1 meter encountered in digging the deep well. The onsite wells can be used to track any migration onsite. Boundary wells serve to verify that there is no migration offsite, and offsite wells provide background levels.

Radiological groundwater samples are taken on a quarterly basis for all onsite wells, boundary wells, and sumps when obtainable. Offsite samples are taken twice yearly on a rotating basis. Split samples from all wells are analyzed jointly by DHEC and CNSI. All samples are analyzed for specific radionuclides by gamma-ray sectrometry and for tritium by liquid scintillation counting. Results are logged in databases and trends established. The only radionuclide which has been detected is tritium. An extensive groundwater modeling program is currently ongoing. This program involves taking core samples to determine soil conditions and groundwater transport.

Key wells are also sampled quarterly for non-radiological contamination. To date, there have been no levels of non-radiological concern detected.

In addition to groundwater sampling, the groundwater level is measured monthly. The data is used to construct a peizometric map to assure that the water table is not at the trench bottoms. This has never occurred. This data is also used for trench constructions. Trench Bottoms must be constructed at a minimum of 5 feet above the highest recorded water table.

SURFACE WATER

It should be noted that the Barnwell Site is adjacent to the Department of Energy Savannah River Site and that the offsite monitoring program for that area encompasses both facilities. Therefore the extent of our offsite program is very extensive, considering that there has been no release of radioactivity from the site.

DHEC takes surface water samples at a minimum on a monthly frequency at 19 locations at and around the site. A raw water monthly sample is also taken at the North Augusta Water Plant. Additionally fish, sediment, and aquatic vegetation are taken annually at 15 of these locations. Annual collection of oysters is also performed at the mouth of the Savannah River. CNSI also takes four yearly soil vegetation sediment and water at designated locations at surrounding springs or creeks. As part of their standard operations after any rainfall, samples are taken from any water standing in the open trenches and in the holding ponds. Samples are also required before, during, and after any transfer of water onsite. All water samples are analyzed for gamma activity and gross alpha/beta.

SOIL AND VEGETATION

Soil and vegetation samples are taken annually at 11 locations onsite and at 62 locations offsite. It is also required that soil core samples be taken to characterize any area prior to trench construction. These are also analyzed for gamma isotopic and gross alpha/beta.

AIR

The site utilizes 11 continuous air monitoring stations and DHEC utilizes 3 stations. The air sampling device is equipped with a particulate filter to trap airborne particulates similar to those encountered in the breathing zone, followed by a charcoal canister for a radioiodine. The samples are collected weekly and the particulates are analyzed for specific radionuclides by gamma ray spectrometry, and the charcoals are analyzed for I-131. In addition to the routine air samplers, portable air samplers are placed near any onsite disposal operation to monitor the immediate area for increased air activity and thereby evaluate exposure risk to operating personnel. To monitor for external gamma, CNSI has 137, TLDs at the site boundary and at operations facilities at the site. DHEC also has 28 TLD's onsite and 15 TLD's offsite. All TLD's are collected quarterly.

CLIMATIC

To account for any climatical conditions which might affect the site, CNSI operates a weather station. Data is kept on wind conditions as well as precipitation.

CONCLUSIONS

The results of the environmental monitoring have been favorable. Some radionuclides have been detected in air samplers, however these maybe directly attributed to releases from the Savannah River Plant. The monitoring program which has had the most influence on the site is the groundwater program. As mentioned previously, the only radionuclide which has been detected thus far is tritium. The migration of tritium has provided an indicator for modifications and remediations at the site. For instance some of the earlier trenches indicated elevated levels of tritium in the sumps, and remediation around these trenches have been performed. Additionally, trench designs have been modified to minimize water infiltration. The groundwater modeling program is also currently of upmost importance for evaluating closure of the site, and will allow the state to assure that the integrity is maintained for long term care.

ENVIRONMENTAL RADIATION MONITORING OF LOW-LEVEL WASTES BY THE STATE OF WASHINGTON

A.W. Conklin
R.R. Mooney
J.L. Erickson

Environmental Radiation Section, Division of Radiation Protection, Department of Health, Mail Stop LE-13, Olympia, WA. 98504.

Abstract

The Washington State Department of Health, as the state's regulatory agency for radiation, monitors several forms of low-level radioactive wastes. The monitoring is done to assess the potential impact on the environment and on public health. The emphasis of the monitoring program is placed on the solid and liquid wastes from defense activities on the Hanford Reservation, commercial wastes at the site located on leased land at Hanford and uranium mill tailings in Northeastern Washington. Although not classified as "low-level waste", monitoring is also periodically conducted at selected landfills and sewage treatment facilities and other licensees, where radioactive wastes are known or suspected to be present.

Environmental pathways associated with waste disposal are monitored independently, and/or in conjunction with the waste site operators to verify their results and evaluate their programs. The Department also participates in many site investigations conducted by site operators and other agencies, and conducts it's own special investigations when deemed necessary. Past investigations and special projects have included allegations of adverse environmental impact of I-129, uranium in ground water, impacts of wastes on the agricultural industry, radioactivity in seeps into the Columbia River from waste sites, identifying lost waste sites at Hanford, differentiating groundwater contamination from defense verses commercial sources, and radioactivity in municipal landfills and sewers.

The state's environmental radiation monitoring program has identified and verified a number of environmental problems associated with radioactive waste disposal, but has, to date, identified no adverse offsite impacts to public health.

Introduction

Washington State's health agency has conducted radiological environmental monitoring since 1961. The early program looked primarily at atmospheric fallout and at offsite environmental impacts of Hanford operations with emphasis on the Columbia River. Later activities around commercial nuclear reactors, 3 uranium mills and the nuclear navy were included. Monitoring of commercial low-level radioactive waste began in 1978, with monitoring of other licensees taking place as licenses have been issued.

In 1985, the Department's role was significantly expanded by the legislature to encompass radiological activities statewide, concentrating on the monitoring of Hanford activities, verifying the adequacy and accuracy of federal and licensee environmental radiological monitoring programs, evaluating active and inactive waste disposal activities and conducting investigations as necessary (ref.1) The statewide environmental radiological monitoring program is illustrated on figure 1.

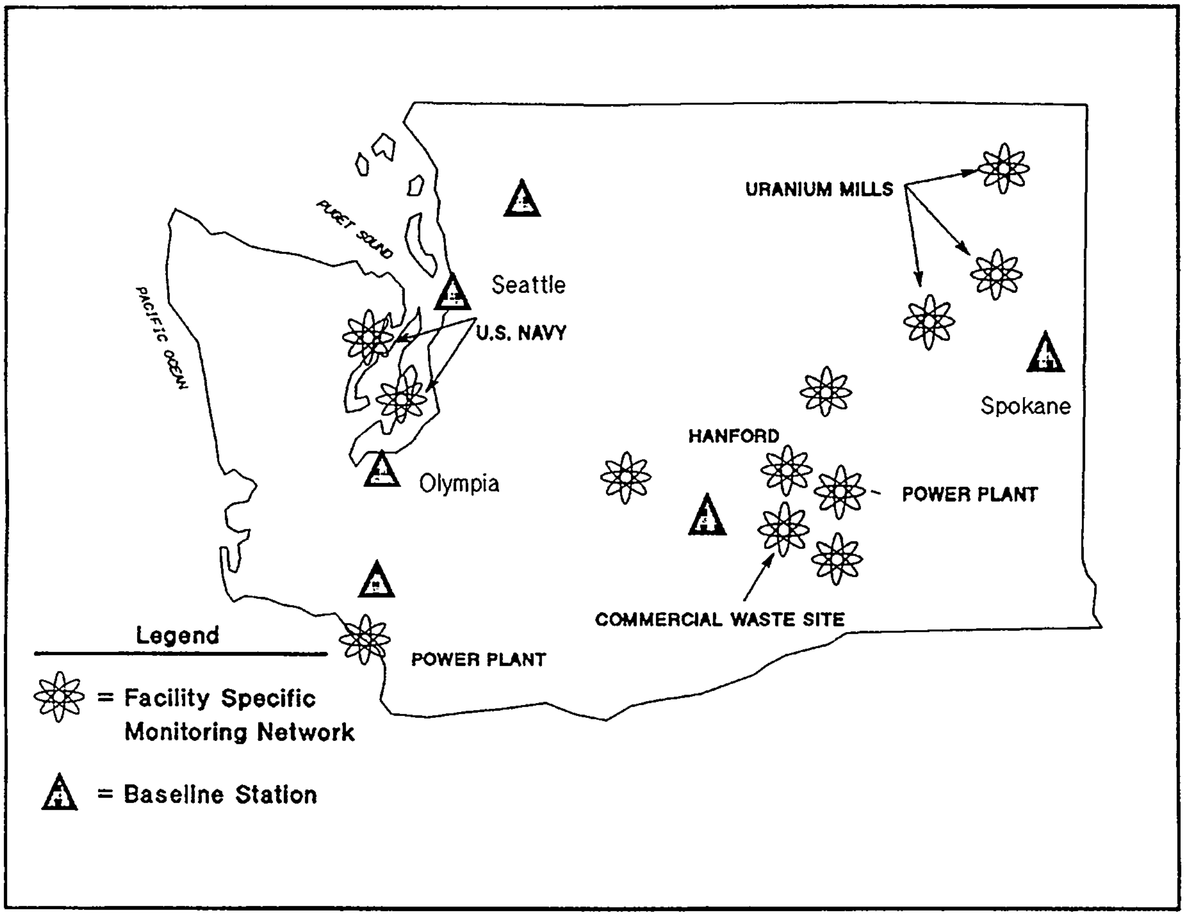

Figure 1: Environmental Radiation Monitoring By the State of Washington

Although radiological activities are numerous in the state, the Department's monitoring efforts are concentrated around waste disposal activities. The state's role on the Hanford Reservation was enhanced, beginning in March 1985, with funding obtained through the Nuclear Waste Policy Act for baseline characterization of Hanford as a potential high-level waste repository. This characterization included the monitoring around existing low-level wastes, which were (or had the potential of) migrating away from the disposal site.

The value of the state's involvement went beyond the repository program, which was eliminated in December 1987. Activities of continuing value have included:

- an increased involvement and presence of the state as an independent radiation monitoring agency on the Hanford Reservation;

- the establishment of an environmental monitoring network centering around current waste management activities;

- investigations of alleged problems associated with past and current waste disposal practices;

- the enhancement of laboratory analytical techniques;

- the ability to provide the public with credible information because of the recognition of this agency as an objective participant representing their interests; and,

- improved quality assurance through the coordination of regional environmental monitoring programs through the Environmental Radiation Quality Assurance Task Force for the Pacific Northwest.

Discussion

The primary objective of the state's environmental radiation monitoring program is to ensure the health and safety of the public. To accomplish this objective, it is necessary to not only monitor independently, but to verify other programs by assessing their data and splitting samples.

The environmental pathways associated with waste disposal are the water pathway (ground and surface), and the air pathway for potential releases from waste handling and storage facilities and for potential resuspension of wastes on the surface.

The air pathway is now under the auspices of the state's Radioactive Air Emissions Program. This program was established to ensure compliance with the federal Clean Air Act, which requires federal facilities to comply with applicable state laws. The U.S. DOE has now accepted the state's regulatory authority over Clean Air Act issues. The scope of the program will include:

- reviewing source registrations and issuing permits;
- reviewing new and modified source plans;
- conducting environmental monitoring of the air pathway;
- reviewing and inspecting stack monitoring systems;
- reviewing emission data;
- evaluating models used for dose assessments;
- evaluating environmental monitoring and emissions reports;
- issuing periodic reports;
- investigating anomalies and accidents that potentially affect the public via the air pathway; and, most importantly,
- keeping the public informed.

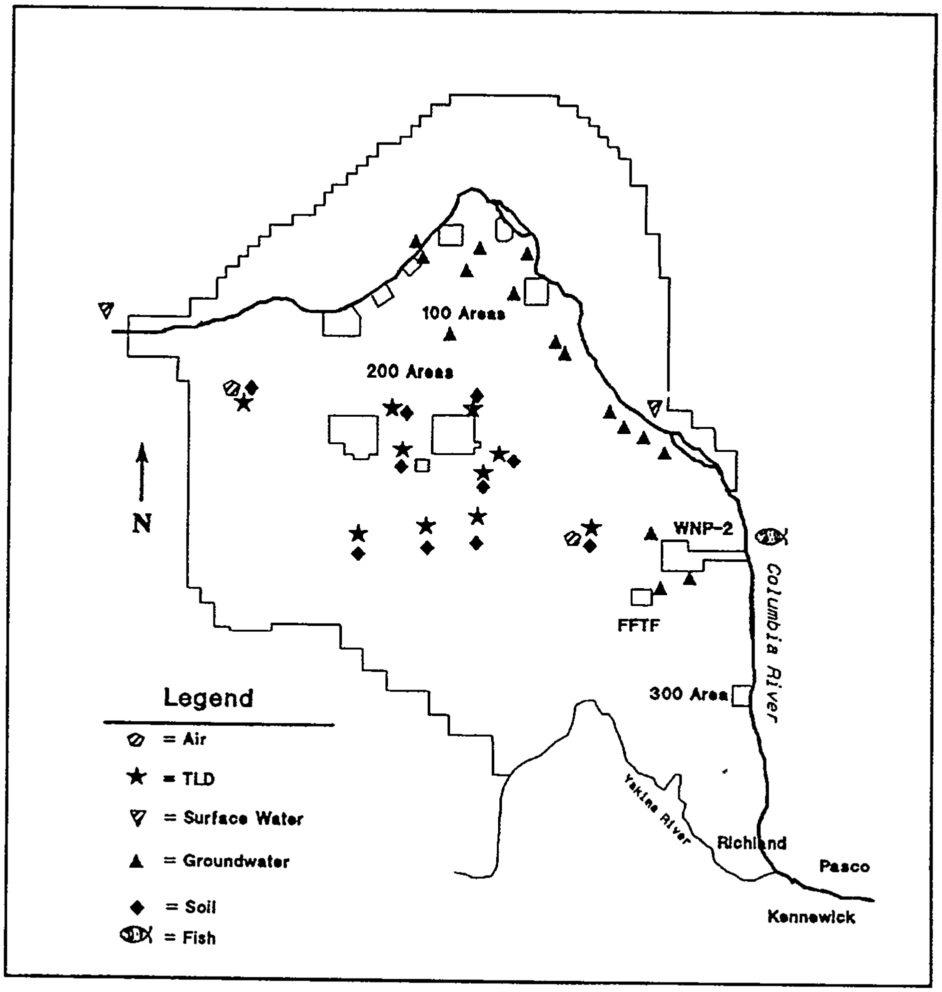

Figure 2: State Monitoring Stations on the Hanford Reservation

Implementation of this program is now in progress.

The current Hanford monitoring network is illustrated on figure 2. The state's monitoring of the commercial waste site operated by US Ecology, also located on the Hanford Reservation, is illustrated on figure 3. Several Hanford groundwater wells have been utilized for monitoring the commercial site. These wells are now being replaced by onsite wells. Uranium mill monitoring is illustrated on figure 4.

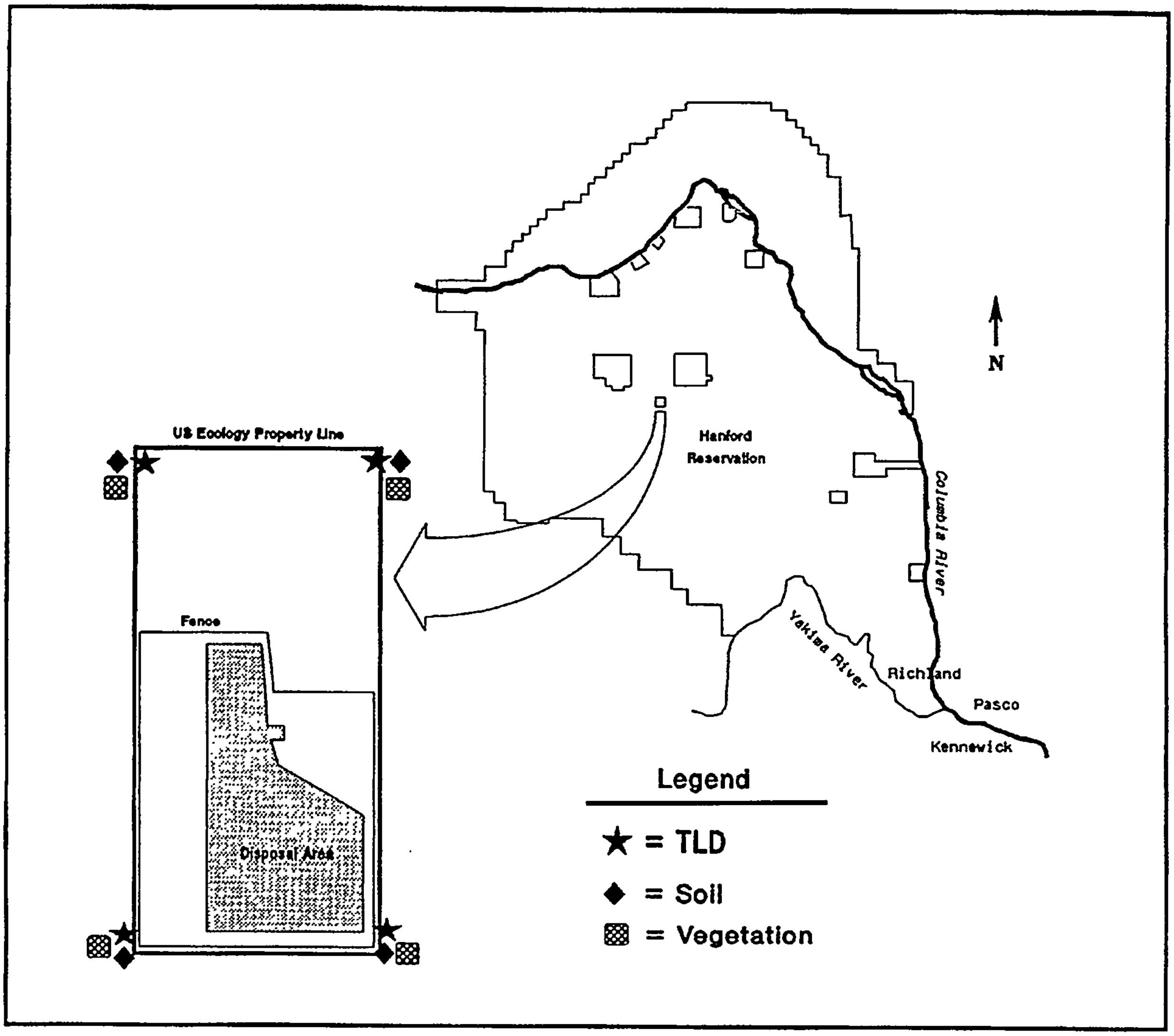

Figure 3: The Commercial Waste Site Operated by US Ecology

A primary difference between defense wastes and commercial wastes is that a significant portion of low-level defense wastes are liquids, and as such, are subject to potential migration offsite. All commercial wastes are solids, so have a very low potential of migration through the groundwater. Regardless of this low potential, a major challenge of the state's monitoring program at Hanford is to differentiate between natural, defense and commercial sources in the groundwater. Although the primary contamination

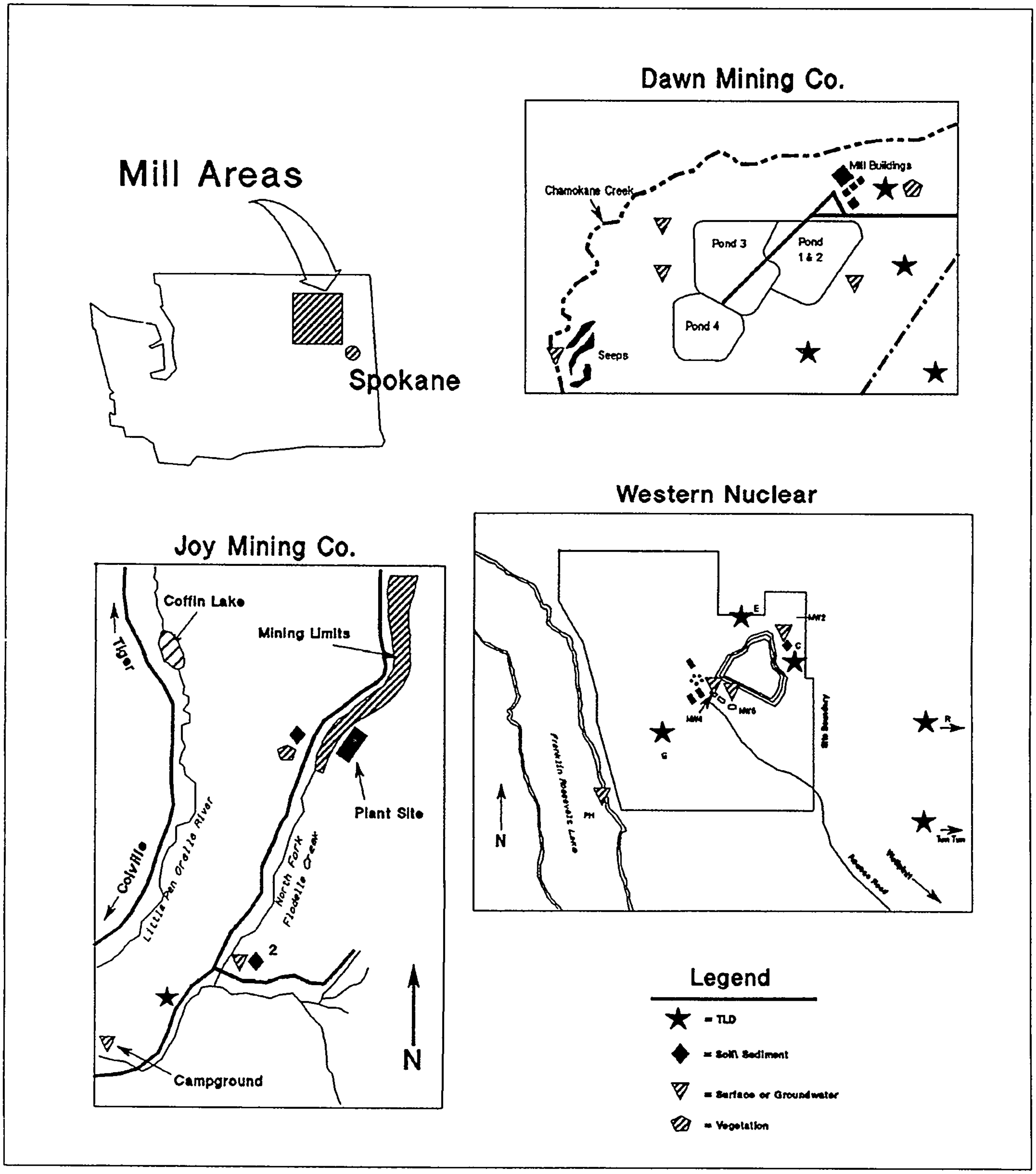

Figure 4: State Monitoring at Uranium Mills in Washington

plumes originating from defense wastes generally flow away from the commercial site (ref.2), some very low-level uranium contamination is present (ref. 3), resulting in the need for US Ecology to repeatedly report that action levels in the groundwater are exceeded (to comply with their license requirements). The source could be natural uranium. The potential sources and action levels are currently being evaluated.

The level of effort of the monitoring program at Hanford concentrates on defense wastes due to the nature of the wastes, as well as the fact that most wastes on the Hanford Reservation are related to defense activities (table 1).

Table 1: Curie Comparison of Commercial and Defense Wastes

		Total Curies
US Ecology -	1965 to Present solid - low-level	= 1,804,000 (4)
U.S. DOE -	1944 to Present solid and liquid high-level and low-level	= >70,000,000 (5)

Three uranium mills have operated in the state in the past. All three are now inactive due to the slump in the uranium market. One is now the subject of an Environmental Impact Statement on closure. Uranium mill tailings in Northeastern Washington represent both a threat to the groundwater and a potential airborne hazard due to resuspension (ref. 6). Both pathways must be monitored.

Additional attention must be given to sanitary landfills, sewers and state licensees due to public concern over allegations of radioactive wastes.

In order to ensure that environmental radiation data are of the best quality, and to verify other programs, the state legislature authorized the health agency to organize an Environmental Radiation Quality Assurance Task Force for the Pacific Northwest (ref. 7).

The Department, through this task force, aims to achieve economical use of resources and encourage input from all interested parties, which may have questions or concerns about environmental radiation monitoring, and to enhance and maintain the credibility of results obtained by all programs. Membership has been expanded to include most organizations involved in environmental radiation monitoring in the Pacific Northwest. Others have been invited. Currently the membership consists of:

- the State of Washington,
- the Oregon State Health Division,
- the Washington State Public Health Association,
- the U.S. Department of Energy,
- the Washington Public Power Supply System,
- Portland General Electric,
- Battelle Pacific Northwest Laboratories,
- the Yakima Indian Nation,
- the Nez Perce Tribe,
- the Confederated Tribes of the Umatilla Indian Reservation,
- US Ecology,
- the Nuclear Regulatory Commission,
- the Environmental Protection Agency, and
- Advanced Nuclear Fuels.

Significant accomplishments of the task force have included the sponsoring of an

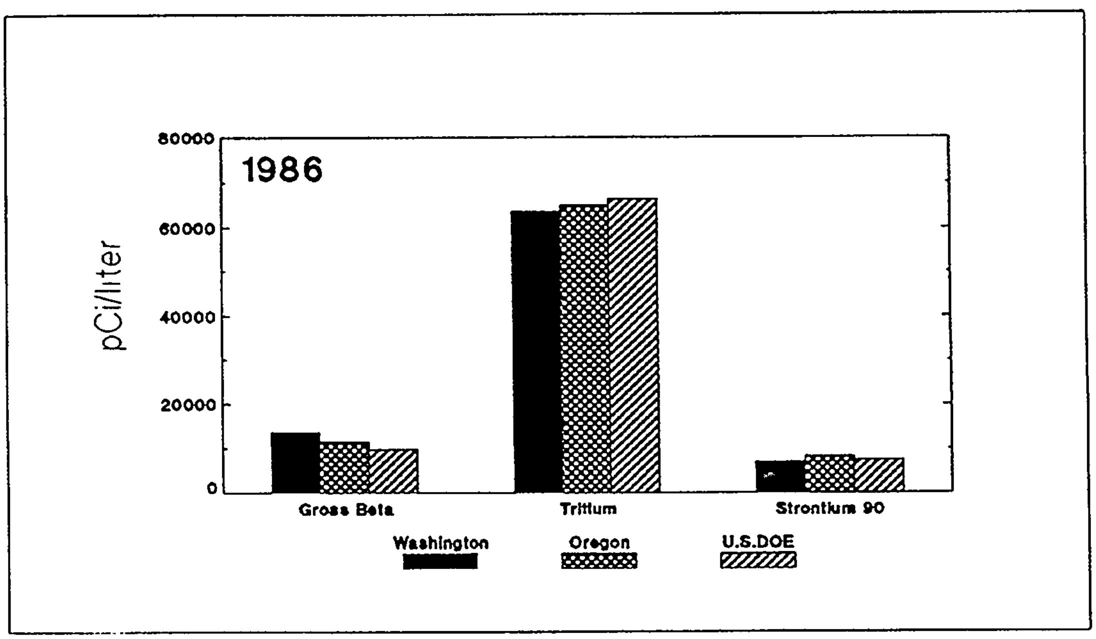

Figure 5: Split Sampling Results of Columbia River Seeps

independent review of regional programs, improved uniformity of data reporting formats, improved communication and coordination, and split sampling efforts.

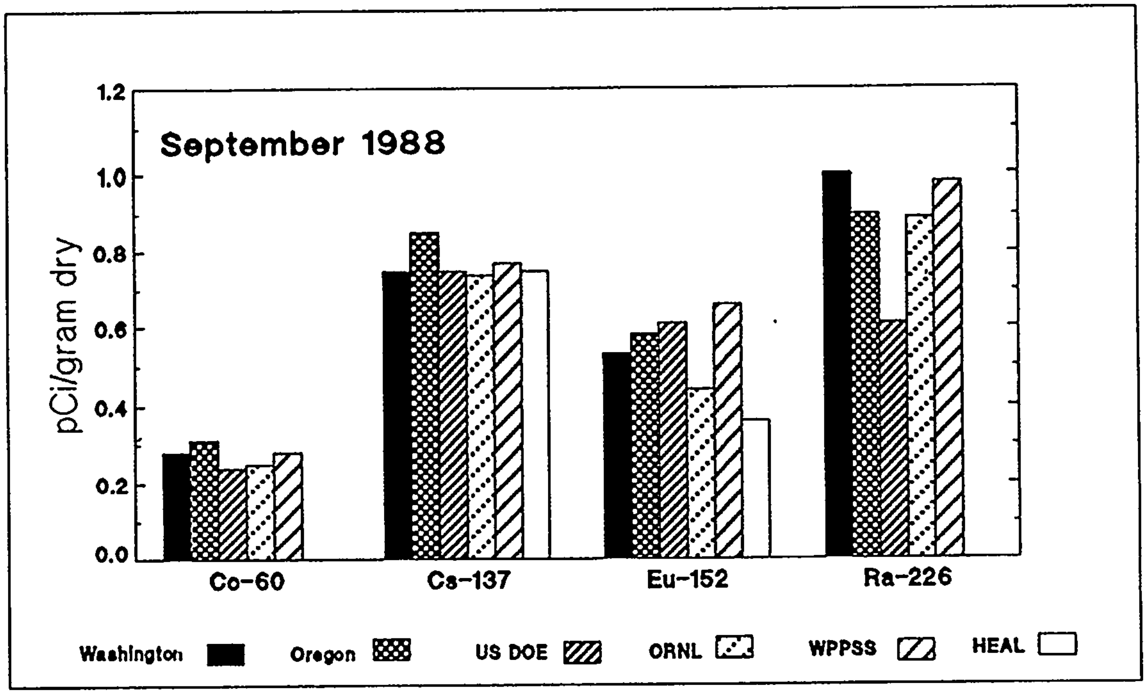

Figure 6: Comparisons of Radioactivity Measurements in Columbia River Sediments by Six Organizations

One of the most significant of the continuing split sampling efforts involves the routine sampling of Columbia River seeps, where low-level waste water from U.S. DOE waste disposal activities empties into the river. Results of recent seep sampling by Washington, Oregon and the Department of Energy are illustrated on figure 5. In 1988, the sampling was expanded to include sediments (figure 6) and comparisons of Thermoluminescent Dosimeters and Portable Ion Chambers. In addition to task force members, representatives of a public interest group (the Hanford Education Action League) were also invited to participate in split sampling. The split sampling has demonstrated comparability of the results, thus adding credibility to all the programs.

In addition to task force sponsored activities, the Department splits samples or collects samples side-by-side wherever possible for verification of environmental programs. On the Hanford reservation, waste site monitoring concentrates on groundwater and river seeps, as illustrated in figures 5 and 6. This monitoring demonstrates a problem with continued soil disposal of liquids, but due to the dilution factor of the Columbia River, does not represent a current public health problem. Current monitoring of the air pathway is minimal. Expansion is planned as the Radioactive Air Emissions Program is implemented.

Additional specialized sampling of waste activities was conducted in 1987 along with a U.S. DOE headquarters survey. The Department split 10% (60) of the samples collected. Results are not yet available from DOE.

Monitoring of US Ecology's commercial waste site does not indicate any migration of wastes from the disposal area.

The uranium mills represent a problem somewhat similar in nature, if not in magnitude, to Hanford's defense activities, in that liquid stored in basins is seeping into the ground

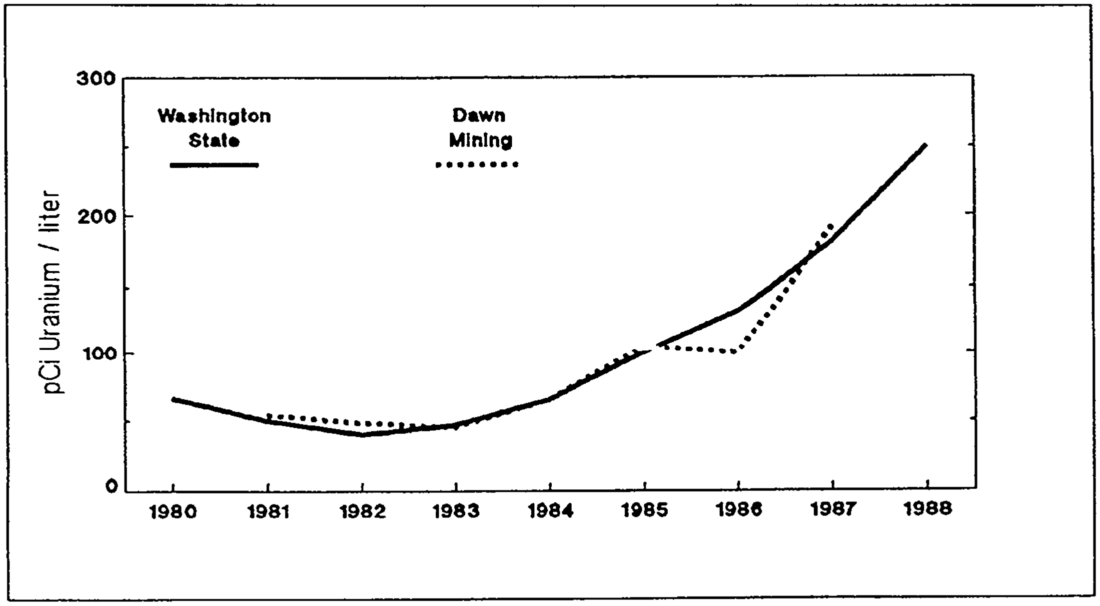

Figure 7: Sampling of Groundwater Seep SW2d at Dawn Mining Co.
Natural Uranium Analysis.

and into nearby streams as illustrated in figure 7. These mills are currently not being operated, with one, the Dawn Mining Company's mill, being scheduled for closure in the near future.

In addition to routine environmental monitoring, special investigations are conducted by the department as required. At Hanford, these investigations have included:

1. <u>The presence of I-129 in the environment</u>. Allegations were made that aquifer intercommunication was occurring potentially affecting the suitability of Hanford for a repository. The Department assessed the data to ensure that their was no potential adverse health impact from I-129.

2. <u>Uranium in the Groundwater</u>. The Department evaluated contamination that occurred when water from an active waste site flowed to an adjacent retired site driving uranium to the groundwater. The investigation continued until the Department was assured that removal of the contaminated water was eliminating further impact.

3. Uranium in Drinking Water. Uranium was also found in groundwater used for drinking across the river from Hanford. The Department investigated to assure the public that this uranium did not originate from Hanford. The isotopic analysis concluded that the uranium was natural.

4. Lost Waste Sites. Following a request from a legislator concerning whether the location of all Hanford wastes was known, the Department evaluated records, concluding that selected wastes could not be accurately accounted for, and were, therefore, lost. U.S. DOE committed to evaluate these wastes along with other wastes.

5. Wastes seeping into the Columbia River. The Department, along with other organizations represented on the Quality Assurance Task Force, has continued to investigate the impact to the Columbia River from contaminated groundwater from the waste management areas in the center of the reservation and from waste sites located adjacent to the river.

Apart from defense waste related investigations, others have included:

1. An evaluation of uranium in a sewage treatment plant. A fuel fabrication plant routinely released very low levels of uranium into the city sewers. There was a gradual build-up in the sludge in the treatment plant that resulted in a question of proper disposal when the plant was being dismantled. An initial sample indicated a potential problem. A detailed investigation revealed that levels were low enough for disposal in a landfill.

2. An allegation of buried drums containing radioactive wastes. Following allegations made to the media and state and federal agencies of buried radioactive waste in a landfill in Western Washington. The Department, along with the state Department of Ecology, investigated, finding no indication of any radioactivity present.

3. Decontamination waste water washed into a stream. A state licensee, while decontaminating equipment, washed contaminated water into a storm drain, which emptied into a nearby stream. A Department investigation resulted in a need for decontamination and a detailed characterization of the surrounding environment to ensure other releases have not occurred. This issue remains open.

Conclusion

Radioactive waste disposal, in any form, is a publicly sensitive issue requiring the presence of an independent monitoring organization representing the public. This is especially true on the Hanford Reservation, where the vast majority of low-level wastes are stored or disposed, and where a loss of control of some wastes has been observed. This independence is also required when investigating non-Hanford waste issues, when public assurance is required.

The Washington State Department of Health, as both the radiation control agency and the public health agency, provides a necessary level of independence in the disposal of any wastes that are radioactive, resulting in the verification of other environmental radiation monitoring programs, and the assurance to the public that they are not being harmed.

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A DOE Contractor's Perspective of Environmental Monitoring Requirements at a Low-Level Waste Facility[a]

T.W. Ferns, Idaho National Engineering Laboratory

ABSTRACT

Environmental Monitoring at a low-level waste disposal facility (LLWDF) should, one, demonstrate compliance with environmental laws; two, detect any spatial or temporal environmental changes; and three, provide information on the potential or actual exposure of humans and/or the environment to disposed waste and/or waste by-products. Under the DOE Order system the LLWDF site manager has more freedom of implementation for a monitoring program than either the semi-prescriptive NRC, or the prescriptive EPA hazardous waste programs. This paper will attempt to compare and contrast environmental monitoring under the different systems (DOE, NRC, and EPA), and determine if the DOE might benefit from a more prescriptive system.

1. DOE Environmental Monitoring Requirements

DOE directs low-level radioactive waste management under Order DOE 5820.2A (9/26/88), Chapter III. Order 5820.2A gives generic guidance on the goals of the monitoring program, and less specific guidance on the means of program implementation. DOE Order 5820.2A states that the monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. Additionally the monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meet the requirements of applicable EH Orders [DOE Order 5820.2A, Chapter III, 3k (4)].

The DOE Orders also give broad brush requirements, but neglect to provide a mechanism for accomplishing the requirement. An example of this type of order is, "DOE low level waste shall be managed to protect ground water resources, consistent with Federal, State and local requirements" [DOE Order 5820.2A 3a (3)].

And finally, even when DOE guidance attempts to be more specific, it is still generic. For example, Order 5820.2A states that based on the characteristics of the facility being monitored, the environmental monitoring program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and, in the subsurface, soil and water, both in the saturated and the unsaturated zones [DOE Order 5820.2A, Chapter III, 3k (3)]. Although this sounds specific, because there is no prescriptive guidance the manager at one site might use outdated equipment which has known precision or accuracy problems, when compared to newer equipment being used at another site.

a. Work supported by the U.S. Department of Energy under Contract No. DE-AC07-76ID01570.

2. Other Regulator's Environmental Monitoring Requirements

Under EPA hazardous waste regulations, monitoring programs are very specific. EPA regulations prescribe detailed engineering design features for the monitoring program, whereas the DOE and NRC leave these decisions to the owner/operator of the facility. For example RCRA ground water monitoring is performed at a specific type of well, at a specific time interval, for a specific set of parameters (Appendix IX), using a standardized method (SW-846), with standards for quality acceptance given by the EPA (QAMS-80). Measurements for parameters monitored under Clean Air Act (CAA) and Clean Water Act (CWA) permits also have similar prescriptive provisions.

Under NRC regulations, groundwater monitoring is required during the construction, operation, and postclosure period, but little guidance is given on how to implement the monitoring program. Neither NRC nor the DOE specify how frequently groundwater must be monitored.

3. Advantages of Prescriptive Regulations

The EPA's Charter is to protect the population from hazardous pollutants. Alternatively DOE's charter has been one of production, from weapons to energy. Environmental protection in the DOE system was once thought of as an externality only to be minimized. With the inception of RCRA in 1980, however, those in the environmental profession have seen a remarkable turnaround in how all government agencies are conducting business with respect to the environment.

Why not gain from studying the past experiences and policies of EPA? Over time the EPA has migrated towards a prescriptive method to regulate monitoring. There must be a reason for this trend in the EPA.

The advantages of a prescriptive system are: improved data quality, improved data comparability among sites, improved legal defensibility, improved public acceptance of the data, and economies of scale.

4. Disadvantages of Prescriptive Regulations

The biggest problem with prescriptive regulations is that they are usually written without foresight. Overly prescriptive regulations eventually result in a waste of money because what is appropriate for monitoring in the humid southeast may not be appropriate for monitoring in the cold desert west due to differences in relevant pathways.

5. Special Needs of the Nuclear Industry

One of the reasons prescriptive regulations have not been pursued within the nuclear industry is the unique concept of "as low as reasonably achievable" or ALARA. There is a good reason for the ALARA concept when dealing with radioactive materials. Certain types of environmental monitoring procedures may cause unacceptable risks to workers. Environmental monitoring programs will need to be evaluated with respect to the potential for hazardous and radiological exposure of the worker and the public, and to the ALARA goals.

ALARA is a viable exposure goal because of the concept of effective dose equivalent (rem). The effective dose correlates the dose of all types of radiation to different organs with biological damage in the generic human body. Thereby the effective dose is a common end point for all radiation damage which can be additive. The risk assessment procedures of non-radiation hazards are considered to be more complex because of synergistic effects.

DOE references the effective dose and ALARA concepts in monitoring low-level waste. The Low-level waste site operator is to assure that, exposure to the waste and concentrations of radioactive material released into surface water, groundwater, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. And, reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonable achievable [DOE Order 5820.2A, Chapter III, 3a (2)].

The NRC guidelines also use the effective dose and ALARA concepts. The NRC monitoring guidelines read that concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Here too, reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable [10 CFR 61.41].

This reliance on ALARA principles is also evident in the NRC corrective action guidance. EPA regulations on corrective action are much more detailed than those of NRC; however, the objectives of EPA and NRC corrective action programs are similar. DOE does not specify regulations on corrective action.

6. Should DOE Implement Prescriptive Regulations?

Although there are several guidance documents such as DOE LLW-13Tg which present alternative methods for environmental monitoring, DOE headquarters has yet to write a prescriptive environmental Order.

DOE could gain from a prescriptive Order system. The standardization of analytical procedures alone would bring about an increase in overall data quality as measured by the EPA's PARCC (precision, accuracy, representativeness, comparability, and completeness) parameters. If DOE published standardized analytical procedures, the private analytical labs might be more inclined to make the investment necessary to do radiological analyses. The private analytical labs once established would result in improved quality and cost breaks due to economies of scale. The establishment of method detection limits and expected recoveries would greatly enhance the confidence of the data we give to the performance assessment modelers, and improve the comparability of the model results. As things now stand, all too often the phrase "garbage in, gospel out" applies to our reliance on a performance assessment model based on poor quality data. Assumptions, which are currently made because the environmental monitoring program provided incomplete or inappropriate information for the assessment model, may not be tolerated in the future.

I do not think that DOE LLW-13Tg should be incorporated into a DOE Order because it is not specific enough. It is my opinion that the DOE system should begin the work which will create a prescriptive monitoring system through DOE Orders. Creating a system of Orders and specific reference documents needed to implement these Orders will take approximately three years. It is my opinion that, without prescriptive regulations in house, EPA will eventually foist them upon us. The initiative is therefore on those within the nuclear industry to start compiling the necessary standardized procedures. If those people within the industry have standardized procedures available, then the opportunity to emplace procedures as standards will have been the industry's-- and not EPAs.

RECOMMENDATIONS FOR EVALUATING ENVIRONMENTAL MONITORING PROGRAMS FOR ALTERNATIVE LOW-LEVEL WASTE FACILITIES

D. H. Denham
Pacific Northwest Laboratory[a]
Richland, Washington 99352

ABSTRACT

Licensing of low-level radioactive waste disposal facilities requires the review of the proposed environmental monitoring and surveillance programs, which is why the U.S. Nuclear Regulatory Commission (NRC) Division of Low-Level Waste Management and Decommissioning has developed a draft Branch Technical Position paper, "Environmental Monitoring of Low-Level Radioactive Waste Disposal Facilities."[b] In support of these program reviews, Pacific Northwest Laboratory prepared recommendations for NRC staff to use in evaluating the adequacy of proposed environmental monitoring programs during the preoperational, operational, and postoperational phases of low-level waste facility operations. These recommendations are documented in an NRC-sponsored report that includes review checklists for NRC staff to use in evaluating environmental monitoring and surveillance program compliance with applicable regulations, including both radiological and selected nonradiological parameters. The criteria applied to establish these review checklists were based on the requirements established in the U.S. Code of Federal Regulations, Title 10, Part 61, "License Requirements for Land Disposal of Radioactive Waste," and in Title 10, Part 20, "Standards for Protection Against Radiation." The topical areas addressed in the review checklists include program requirements, objectives, and administrative organization; program implementation, including equipment, instrumentation, and facilities; data recording and reporting, and statistical analyses; and quality assurance and control.

This paper highlights the review criteria recommended by PNL, including a summary of regulatory requirements, suggested environmental monitoring program objectives, and considerations for the design of environmental monitoring and surveillance programs for alternative low-level waste disposal facilities as identified in the NRC-sponsored report.

INTRODUCTION

The Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974 gave the U.S. Nuclear Regulatory Commission (NRC) the responsibility for licensing and regulating commercial nuclear facilities. The licensing requirements for

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(a) Pacific Northwest Laboratory is operated by the Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-ACO-76RLO 1830.

(b) The Branch Technical Position paper is currently being reviewed and revised by the U.S. Nuclear Regulatory Commission.

near-surface disposal of low-level wastes (LLW)[a] are in 10 CFR 61. The licensing requirements related to environmental protection are in 10 CFR 51. The environmental monitoring program required in 10 CFR 61.53 has to be submitted as part of a license application, along with the Environmental Report (ER), required in 10 CFR 51. The NRC is also responsible for ensuring licensee compliance with the provisions of the National Environmental Policy Act (NEPA) of 1969.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 required the NRC to identify methods for the disposal of LLW other than shallow-land burial, to establish relevant technical information regarding those alternative methods, and to publish the requirements that must be met for a state or regional compact LLW disposal facility to be licensed by the NRC. In the years just prior to and subsequent to the 1985 Amendments Act, the NRC took several steps to provide timely assistance to potential licensees.

The first step was to evaluate six alternative disposal methods (Bennett et al. 1984) from which the NRC concluded that only three alternatives were acceptable: earth-mounded concrete bunkers (Miller and Bennett 1985), below-ground vaults (Warriner and Bennett 1985), and augered shafts (Bennett 1985). The other actions taken by the NRC included reviewing and revising several previously published NRC documents that provide guidance for format and content (NRC 1988a) and standard review plans (NRC 1988b and 1988c), as well as issuing a new quality assurance (QA) guide (Pittiglio 1988), a draft environmental monitoring Branch Technical Position for LLW facilities (NRC 1988d), and an NRC-sponsored report on recommended review criteria for environmental monitoring and surveillance programs at alternative LLW disposal facilities (Denham et al. 1988). The last two documents provide only general guidance although they both provide insight with respect to expectations of the NRC for the acceptance review of an applicant's environmental monitoring program.

The availability of the draft Branch Technical Position on "Environmental Monitoring of Low-Level Radioactive Waste Disposal Facilities" was announced in 52 FR 42486 in November 1987, at which time the NRC requested public comments. Subsequently, a number of organizations/agencies, individuals, and the NRC's Advisory Committee on Nuclear Waste have commented on the draft Branch Technical Position and the NRC is revising the Branch Technical Position, taking into consideration the comments received. The purpose of the NRC Branch Technical Position is to provide general guidance, developed in accordance with 10 CFR 61, to applicants, their consultants, and regulatory authorities on environmental monitoring for LLW disposal facilities.

The purpose of the report by Denham et al. (1988) is to provide recommendations for sets of criteria against which the NRC staff can review and judge the adequacy of an applicant's environmental monitoring program as described in their license application documents. An overview of this report (henceforth referred to by its number, NUREG/CR-5054) is given in the balance of this paper, which describes the main report sections, the types of radiological environmental monitoring program activities and media addressed,

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(a) "Low-level waste" as used in this paper refers to low-level radioactive waste.

and provides a sample list of the review checklists recommended by the Pacific Northwest Laboratory (PNL) for the NRC's use in evaluating the environmental monitoring and surveillance programs proposed by license applicants for alternative LLW sites. The criteria applied to establish these review checklists are based on the regulations in 10 CFR 61 and 10 CFR 20. Additionally, the review criteria include guidance from the NRC documents referred to above, as well as that from the NRC Regulatory Guides; the American National Standards Institute (ANSI) standards; and the reports of the National Commission on Radiological Protection and Measurements (NCRP), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA).

REPORT CONTENT

To document the development of the review criteria for environmental monitoring programs, the main text of NUREG/CR-5054 includes applicable regulations and guidance and environmental monitoring activities in each of three operational phases (preoperational, operational, and post-operational), as described in the following paragraphs. Three appendixes to the report provide environmental, meteorological, and hydrological monitoring guidelines that are discussed later in this paper.

A specific itemized list of the NRC regulations (from 10 CFR 61 and 10 CFR 20) applicable to LLW disposal facilities, a list of applicable NRC Regulatory Guides and technical position statements, and a similar list of industry standards and other general guidance documents is included in the report. Guidelines for acceptable field equipment and laboratory instruments are provided in NRC Regulatory Guides; ANSI standards; and in publications of the DOE (Harley 1986; Corley et al. 1981), the EPA (1976, 1982), and others, such as the American Public Health Association (1977) and the NCRP (1985).

Specific environmental monitoring program goals and objectives throughout the three operational phases include the need to document environmental conditions, assess public exposure, demonstrate compliance, and evaluate site closure.

The environmental monitoring activities specifically addressed in NUREG/CR-5054 include the collection and analysis of samples of air, water (both surface ponds, lakes, streams, and rainwater, and subsurface, primarily from wells), soil, sediment, flora and fauna, and the measurement of ambient radiation levels. The items to be reviewed within each medium include:

- Air--Both off-gases and particulates, radiological and nonradiological constituents, sampler design, and the appropriateness of the sample
- Ground water (including that from the vadose or unsaturated zone)--Primarily dissolved radiological and nonradiological constituents, sampler design, sample collection, and sample preservation
- Surface water, precipitation, and runoff--Both dissolved particles and particulates, radiological and nonradiological constituents, sampling procedures, sample preservation, appropriateness of the sample, and adequacy of the sensitivity of the analysis

- Sediment and soil--Solids only for both radiological and nonradiological analyses; sampler design and spacing, sample appropriateness, and sample preservation

- Vegetation and other biota--Appropriateness of sample for constituents sought, as well as relationship to potential human exposure, and sample preservation and analysis.

Radiological environmental monitoring programs are emphasized in NUREG/CR-5054, although some selected nonradiological parameters, especially for ground water, and site surveillance activities are also mentioned. The nonradiological parameters selected are based on the ground-water section of the NRC Environmental Standard Review Plan (NRC 1988c). They include parameters that might influence radionuclide transport, including concentrations of major inorganic constituents and dissolved gases; concentrations of major organic constituents, such as dissolved and total organic carbon, total organic halogens, and water quality organisms; pH, total dissolved solids; turbidity and the nature of colloidal-sized materials; and temperature.

REVIEW CRITERIA CHECKLISTS

Review criteria for each of the three program phases, preoperational through post-operational, were developed for the seven key implementation areas previously defined in the NRC Standard Review Plan (NRC 1988b). They include:

- program requirements and objectives
- program administrative organization
- equipment, instrumentation, and facilities
- monitoring program implementation
- data recording and statistical analyses
- data reporting
- quality assurance and control.

Review criteria checklists, in tabular format, were provided for each of these seven implementation areas. A summary of the environmental monitoring program review checklists by implementation area and by subject--especially for those items tied directly to the regulations (10 CFR 61 or 10 CFR 20)--is provided in Table 1. In NUREG/CR-5054, checklists include each review subject (itemized in the left-hand column) followed by a list of the applicable regulations, NRC Regulatory Guides, or other controlling documents and a summary of those "requirements" or recommendations. These checklists are intended for use by the NRC in evaluating the applicability of an applicant's proposed environmental monitoring program, but are also expected to be used by state and regional compact organizations in planning their environmental monitoring programs for alternative methods of LLW disposal.

In general, environmental monitoring, whether radiological or nonradiological, is concerned with quantitative measurements or analyses, while site surveillance activities are mostly qualitative. Although three alternative disposal methods were considered, the only environmental monitoring program differences are expected to result from the site-specific differences associated with the geology, hydrology and climatology (e.g.,

TABLE 1. Summary of Review Topics for Preoperational through Post-Operational Environmental Monitoring Programs at Low-Level Waste Disposal Facilities

Program Objectives/Management/Content	
Bases for program	Appropriate sampling media
Administrative organization	Appropriate sampling/ measurement locations
Early warning of releases	Adequate detection sensitivities
Administrative action levels	Sampling/measurement frequency
Corrective action plan	
Data Reporting/Recording/Statistical Analysis	
NRC notifications	Statistical validity of sampling
Records maintenance	Precision estimates
Annual reporting to the NRC	Handling outliers
Units and significant figures	Normality Tests
Estimates of uncertainty	
Quality Assurance and Control	
Organization	Quality control in sampling and in the laboratory
Authorities	Computational checks
Personnel qualifications	Review and analysis of data
Written procedures	Audits

arid versus humid sites) rather than with the functional and operational characteristics of the alternative disposal methods. These are reflected in the review criteria topics listed in Table 1.

An example of the application of these review criteria for program content would lead to the following questions by a reviewer:

- Are there plans to provide early warning of releases?
- Are appropriate media included and are the locations and sensitivities adequate?
- Are the sampling and measurement frequencies appropriate?
- Are administrative action levels and corrective action plans included?

Additional examples of regulatory assurances that must be provided in the environmental monitoring programs of potential licensees are provided in the following excerpts from specific portions of 10 CFR 61 and 10 CFR 20:

- Protection of the general population - from 10 CFR 61.41: ". . . concentrations of radioactive material . . . released to the general environment . . . must not result in an annual dose exceeding . . . 25 mrem to the whole body . . . of any member of the public."

- Pathways to be evaluated - from 10 CFR 61.13(a): ". . . air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals."

- Duration of preoperational program - from 10 CFR 61.53(a): ". . . data must cover at least a twelve-month period."

- Location of sampling - from 10 CFR 61.12(l): ". . . provide data to evaluate potential . . . impacts and the plan for taking corrective measures if migration of radionuclides is indicated."

- Minimum sensitivity of sampling program - from 10 CFR 61.13(a): ". . . exposure to humans from the release of radioactivity will not exceed the limits set forth in § 61.41;" from 10 CFR 61.53(b): ". . . the licensee shall have plans for taking corrective action if radionuclide migration from the site indicates that the performance objectives of Subpart C (parts 61.40 through 61.44) may not be met;" and from 10 CFR 20.106: ". . . the release of radioactive materials to unrestricted areas shall not exceed the concentrations specified in Appendix B, Table II."

ENVIRONMENTAL, METEOROLOGICAL, AND HYDROLOGICAL GUIDELINES

In addition to the review criteria checklists provided in NUREG/CR-5054, the three appendixes to the report contain more detailed guidance in each of three areas associated with environmental monitoring programs at LLW disposal facilities. These include guidelines for surface environmental monitoring programs, meteorological monitoring programs, and surface-water and ground-water monitoring programs.

The first appendix, "Designing and Implementing Environmental Monitoring Programs," includes guidelines for program design and implementation, environmental measurements and media, and environmental monitoring programs. Each section provides guidance in designing and implementing the different program aspects with respect to choosing appropriate media to sample, measurements to make, the types and numbers of samples/measurements, methods for doing so, where and how many of these should be included, for the three (preoperational, operational, and post-operational) phases of LLW disposal facility operations.

For the purpose of this paper, an environmental monitoring program consists of the collection of samples and the measurement of radioactive concentrations or direct radiation, chemical concentrations, and other physical properties of specific media in the environs of a LLW disposal site, during all phases of facility operation. The scope of the monitoring program referred to here is broader than those for other existing nuclear facilities that essentially consider only the measurement of radiological components in the environment. The regulations in 10 CFR 61.53 require a broad range of monitoring, covering the three phases of operation for a new LLW disposal site. Nonradiological and physical parameters are included in the monitoring, because they serve as indicators for waste migration and site characterization; however, their compliance with environmental standards is subject to the regulations of the EPA or individual states.

The principal objectives of each operational phase of an environmental monitoring program for a LLW disposal facility are also discussed. These objectives are summarized below in Table 2.

TABLE 2. Principal Environmental Monitoring Program Objectives, by Operational Phase, for a Low-Level Radioactive Waste Disposal Facility

Preoperational
Provide site characterization information Demonstrate site suitability and acceptability Obtain background or baseline data
Operational
Demonstrate compliance with applicable environmental radiation standards Obtain data on critical pathway parameters to allow more accurate evaluation of radiation dose to the general public Provide records for public information
Postoperational
Demonstrate compliance with site-closure requirements Provide data to support long-term impact evaluation, such as long-term impact on groundwater Provide records for site closure and for public information

In designing an environmental monitoring program for a LLW disposal facility, one must first establish site-specific goals and objectives, assess effluent pathways and radionuclides, and perform a critical pathway analysis to arrive at an appropriate mix of samples and measurements.

While it is essential that the environmental monitoring programs for LLW disposal facilities be designed in accordance with the requirements and objectives of 10 CFR 61, it is also imperative that the environmental monitoring program be reviewed periodically and modified as program and/or regulatory requirements change. Each review and/or modification should be documented, with the subsequent documentation maintained in an Environmental Monitoring Plan or associated environmental surveillance files. Secondary environmental monitoring program objectives, beyond those required by 10 CFR 61, should provide public information, distinguish site radiation contributions from those from other local sources, acquire data for consequence assessment in the event of an accident, and identify changes in the relative importance of environmental transfer parameters.

A separate discussion of good monitoring practices for each of the radiological measurement/monitoring activities expected to be included in LLW disposal facility environmental monitoring programs is provided in Appendix A. For each measurement and sampling medium there is a discussion of the basis for monitoring and locations (including placement criteria, when available or applicable), frequency of sampling or measurement, sampling methods and criteria, and sampling and/or analytical precautions to assure representative data are collected. Meteorological program objectives, parameters, and measurement criteria are provided in Appendix B, including guidance for implementing a site-specific program or for using meteorological data from existing local sources. Meteorological program objectives include the need to assess the consequences of potential releases, actual releases, or accidental releases, and to demonstrate compliance. The measured meteorological parameters include wind speed and direction and atmospheric stability, as derived from temperature differences at selected measurement elevations above ground level. Guidance is also provided for instrument mounting, measurement recording systems, and measurement system accuracy; for inspection, maintenance, and calibration frequencies; for the use of supplementary instrumentation; for meteorological data processing techniques; and for data summarizing and archiving.

Because the hydrologic portion of an LLW environmental monitoring program is so essential for evaluation of the performance of an LLW disposal facility site, Appendix C is devoted to that subject. As previously noted, water sampling/monitoring includes three regions: the surface, the unsaturated vadose zone, and the ground-water aquifers.

Development of the water monitoring program must also take into account specific ground- and surface-water regulations including:

- the Safe Drinking Water Act of 1974, which set limits for certain chemicals in water used for consumption and the more recent National Primary (40 CFR 141) and Secondary (40 CFR 143) Drinking Water Regulations

- the Federal Water Pollution Control Act and amendments of 1972 in which the EPA established the list of priority pollutants

- Executive Order 12088, established in 1978, which requires that federal agencies comply with state pollution regulations.

The ground-water monitoring program objectives include the need for background water quality, rate and direction of ground-water flow, whether contamination reaches ground water, the source and extent of ground-water contamination when detected, as well as an indication of those areas threatened by ground-water contamination. Specific ground-water monitoring parameters include the measurement of the depth to the water table, temperature, specific conductivity, and pH.

The Appendix C discussion of ground-water sampling (and surface-water sampling, too, especially for maintaining integrity of samples and results) includes an itemized list of sampling precautions; collection methods, such as submersible pumps, air lift, and bailing methods; equipment cleaning; and chain-of-custody procedures.

SUMMARY

In summary, several NRC documents have been or are being revised that provide environmental monitoring guidelines for LLW disposal facilities. The subject of this paper, NUREG/CR-5054, provides: a list of applicable regulations; a set of review criteria to be used by the NRC staff in reviewing the environmental monitoring program portion of license applications for LLW disposal facilities; and an itemization of the sampling and analysis activities for preoperational, operational, and post-operational environmental monitoring programs for alternative methods of LLW disposal.

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FIELD TESTING AND APPLICATIONS OF THE ULTRASONIC RANGING AND DATA (USRAD) SYSTEM[1]

K. S. Dickerson, D. A. Pickering, M. S. Blair,* M. L. Espegren, and J. E. Nyquist

Health and Safety Research Division
**Instrumentation and Controls Division*
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

ABSTRACT

The Ultrasonic Ranging and Data (USRAD) System is a patented, computerized data-acquisition system developed to relate the radiological surveyor's precise physical location to instantaneous radiation data taken during walk-on surveys. The USRAD System incorporates three technologies: radio frequency communications, ultrasonics, and microcomputers. Initial field testing of the USRAD System has resulted in several improvements to walk-on radiological surveys including real-time position data, reproducible survey results, on-site verification of survey coverage, on-site data reduction and graphics, and permanent data storage on magnetic media. Although the USRAD System was developed specifically for use with a gamma-ray detector, it is adaptable to other instruments. Applications of the USRAD System may include verification of remediated and uncontaminated areas, emergency response in mapping pollutant locations after accidents, and characterization of hazardous waste areas.

INTRODUCTION

The Pollutant Assessment Group (PAG) of the Health and Safety Research Division at Oak Ridge National Laboratory (ORNL) is the inclusion survey contractor (ISC) for the Uranium Mill Tailings Remedial Action (UMTRA) Project. The role of the ISC is to conduct radiological surveys on over 11,000 properties potentially contaminated with uranium mill tailings. The PAG has developed advanced field survey techniques for characterizing these UMTRA vicinity properties. The USRAD System was developed in an effort to better manage and compile the survey data, and to conduct the radiological surveys in a more cost-effective manner. The USRAD System technology also automates much of the radiological survey process and provides tabular and graphical survey data output in the field or in the office for report generation.

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The purpose of this paper is to identify the benefits and limitations of the USRAD System as determined by field testing. Further applications of the USRAD System can be identified through an understanding of the USRAD System and its benefits.

BACKGROUND

From the early 1940s through 1970, uranium ore was processed at mills owned by private companies under contracts with the Manhattan Engineer District and the U.S. Atomic Energy Commission (AEC) to be used in weapons, reactors, and research. As the demand for uranium oxide decreased, many of the mills were deactivated. Large quantities of processed ore residue (tailings) were deposited in stockpiles and were left uncontrolled. The public was allowed to access some of the tailings piles for use as an aggregate or as backfill in construction activities. Properties that used the tailings are termed vicinity properties (VP) and include residences, commercial buildings, schools, and open lands.

In 1972, Congress passed Public Law 92-314 to provide funds for cleanup of VPs under the Grand Junction Remedial Action Project (GJRAP) in Grand Junction, Colorado. Also in 1972, the AEC, in cooperation with the U.S. Environmental Protection Agency (EPA), initiated a program to determine the radiological inventory and public health effects associated with the mill tailings. In 1978, Congress passed Public Law 95-604, the Uranium Mill Tailings Radiation Control Act (UMTRCA), requiring the federal government to perform remedial actions at the sites and associated VPs that had been used by the federal government.

The Department of Energy (DOE) was tasked with conducting remedial actions at the 24 inactive sites under the auspices of the UMTRA Project. Thus, the DOE is responsible for overseeing all aspects of the UMTRA Project, from identifying candidate VPs to certifying that properties and sites have been remediated in compliance with the EPA standards set forth in 40 CFR Part 192. All activities are coordinated with the appropriate federal, state, local and tribal governments, and with the Nuclear Regulatory Commission (NRC).

Once a property has been identified, ISC conducts a radiological walk-on survey. The objective of the survey is to locate regions of contamination and determine if the contamination exceeds the EPA Standards (EPA 1982) (Fig. 1). The amount of contamination is investigated by a direct measurement of the gamma exposure rate at the surface. When the exposure rate is above a threshold value, a soil sample is taken and laboratory analysis performed for ^{226}Ra concentration.

The initial step has been to generate a map of the property by hand or by computer-aided drafting. The gamma measurements have then been manually recorded on the map. All subsequent data reduction and report writing have been performed by field technicians. Based on this data, a final inclusion recommendation is delivered to the DOE.

HARDWARE

The USRAD System incorporates three technologies: radio frequency (RF) communications, ultrasonics, and personal computers (PC). RF is used for system timing, communications, and data transfer. The propagation time of an ultrasonic signal serves as a device to measure the distance travelled while scanning. The PC is used to calculate the surveyor position; reduce, store, and display data; prepare reports; and transfer data into electronic data bases. Hardware included in the USRAD System consists of a surveyor's backpack

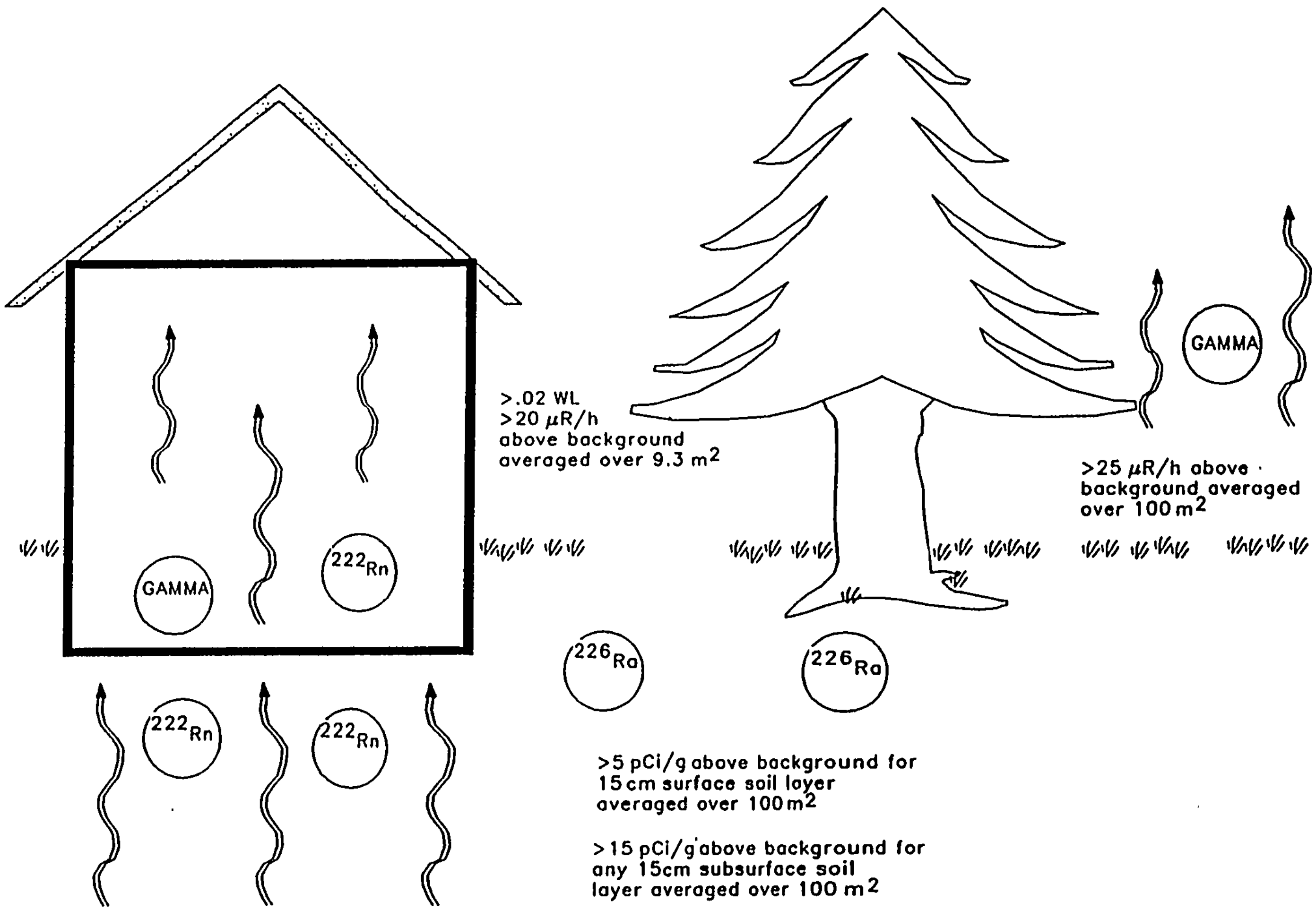

Fig. 1. EPA standards as set forth in 40 CFR 192 UMTRCA.

(SB), 15 stationary receivers (SR), a master receiver, custom computer interface or counter time module (CTM), and a PC (Fig. 2).

The SB contains an ultrasonic transmitter, an RF transmitter and receiver, a survey instrument interface, and a hand-held terminal and microcomputer chip. The ultrasonic transmitter emits a characteristic ultrasonic signal once each second to locate the surveyor's position. The RF transmitter and receiver provide two-way communication between the SB and the PC and provide a signal for system timing. The survey instrument converts input from the survey instrument to a digital signal for transmission to the PC. The microcomputer chip is the master timing device for the entire system; it is operated through the hand-held terminal. The microcomputer chip and terminal in the SB also encode and decode messages from the personal computer and allow the surveyor to remotely control several survey functions.

Each of the 15 SRS contains an ultrasonic receiver, ultrasonic signal identification electronics, and an RF transmitter. The ultrasonic receiver detects the signal from the surveyor backpack. The ultrasonic signal electronics identifies specific ultrasonic signals from the surveyor backpack and trigger the RF transmitter. The RF transmitter sends a signal to the master receiver on a frequency assigned to each stationary receiver.

The master receiver contains 16 RF receivers and 1 RF transmitter. Each receiver is on a characteristic frequency corresponding to 1 of 15 SRs plus 1 for the SB. The transmitter, also on an assigned frequency, enables communication from the PC to the SB.

The CTM is a customized interface board which plugs into the PC. The module times the ultrasonic signal from the SB to each SR, processes that data, and transmits that information to the PC. The CTM also connects the PC and the system, enabling other communications.

The PC is presently a Compaq portable, which is an IBM compatible.

OPERATION

The distance between two points can be measured by the length of time it takes sound to travel from one to the other. To measure this distance, the speed of sound in air [normally 1100 ft/s (335 m/s)] must be known. This method is used in the USRAD System. The time it takes a signal transmitted from the backpack to reach each of the 15 SRs is established, and this relationship is then used to calculate the surveyor's location on the property. The surveyor's location and survey instrument response are determined once each second during a scan, providing detailed information about the property which is then stored and interpreted.

Setup of the USRAD System begins with placing the SRs in appropriate locations over the property (Fig. 3). The surveyor backpack is then used to input (or code) the location of each of the SRs into the system and to determine the speed-of-sound-in-air at the time of the survey.

As the surveyor begins to scan the property, the surveyor's backpack emits an ultrasonic pulse once each second. At the same time, the SB transmits an RF signal to the PC. Receipt of this RF transmission at the PC initiates the timer in the CTM card. When each stationary receiver detects a valid ultrasonic signal, the SR immediately transmits an RF signal to the PC. The RF signal from the SR stops the timer for that particular SR. The characteristic frequency transmitted by the SR is coded in the CTM card for that specific

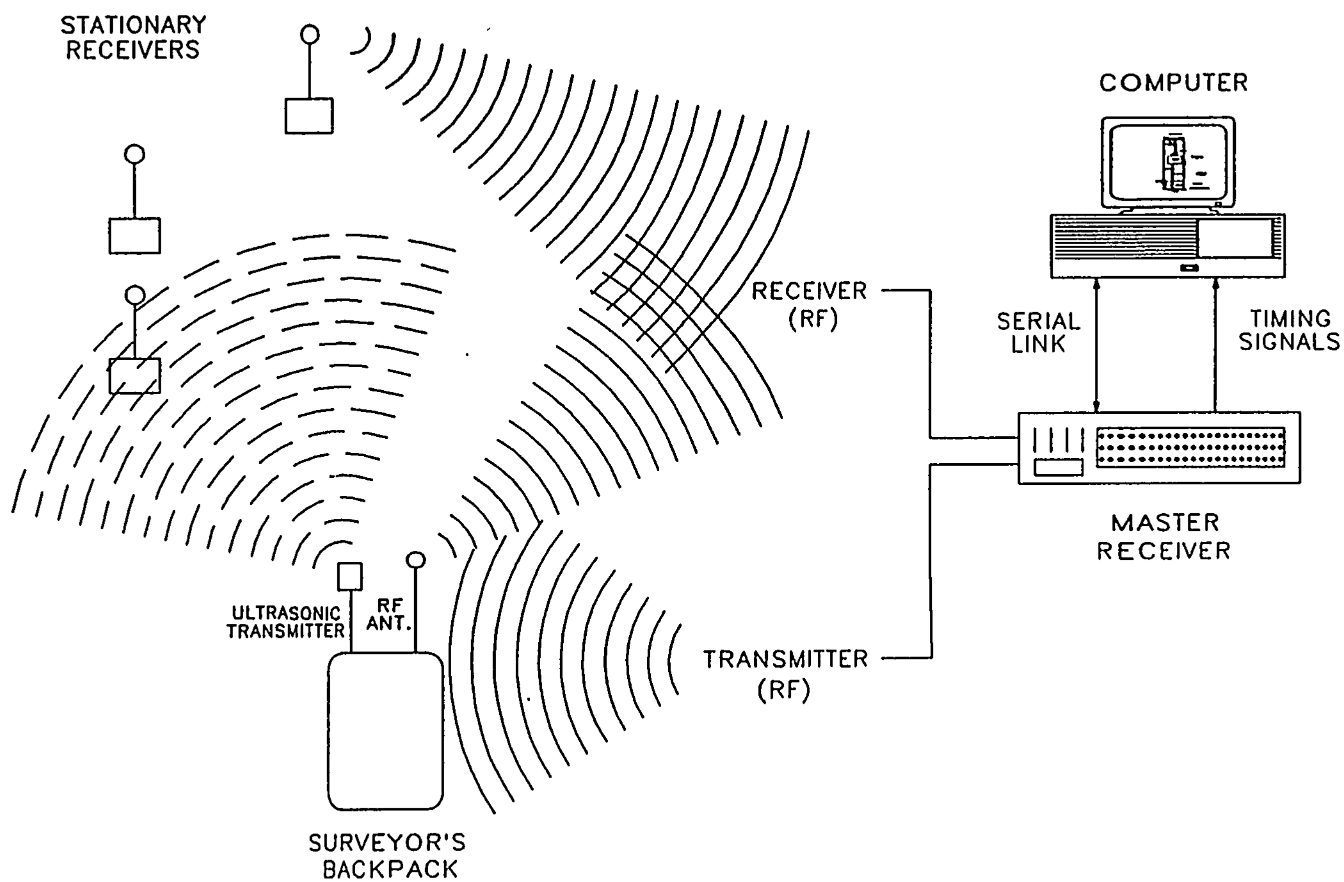

Fig. 2. Diagram of the USRAD System hardware.

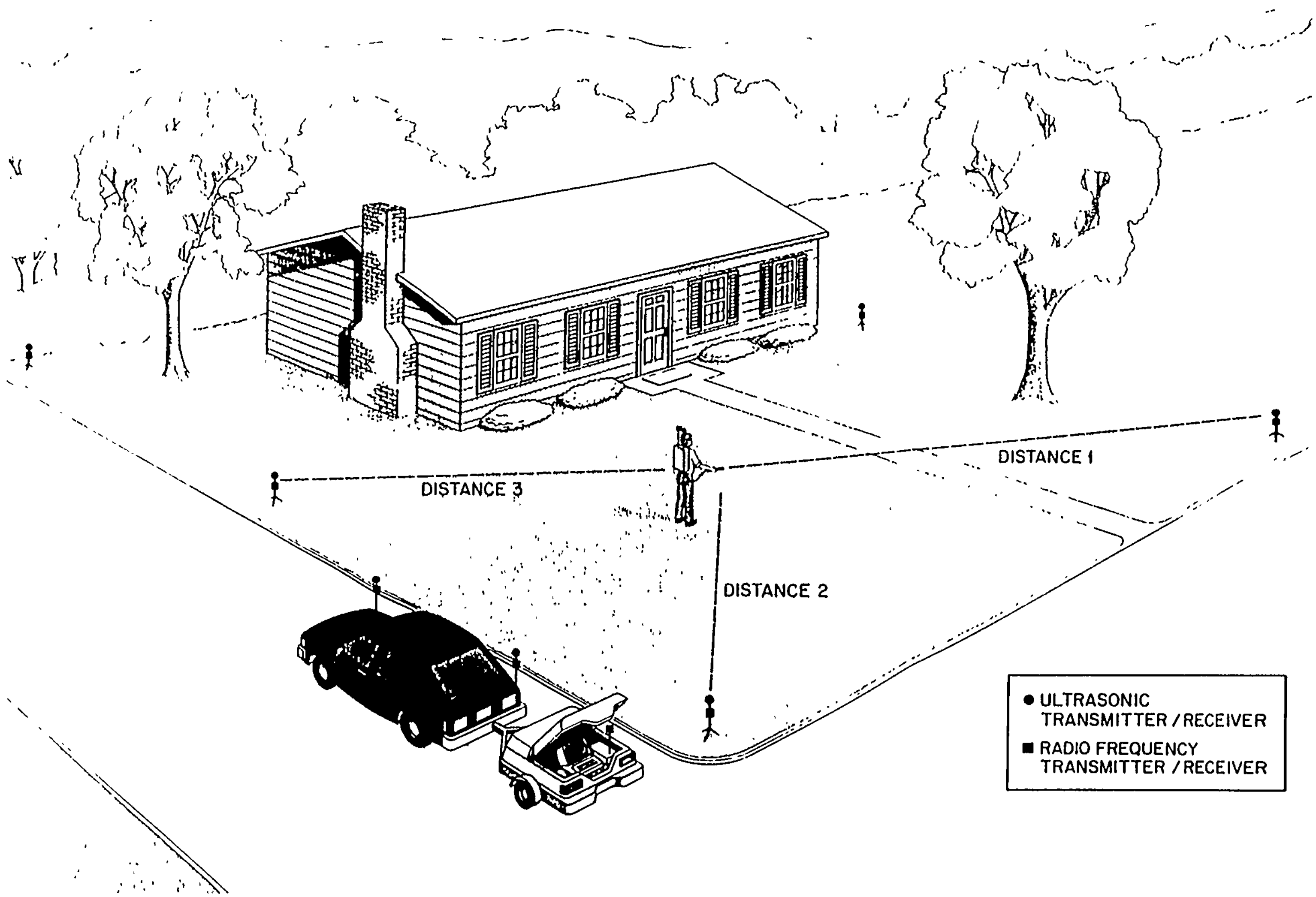

Fig. 3. Diagram of the USRAD System set-up.

instrument. The stop signal establishes the length of time the sound traveled and enables the PC to calculate the distance from the surveyor to the SR. As each SR detects the ultrasonic signal, corresponding stop signals are sent and distances are calculated. From this information, the PC can determine the location of the surveyor within the array of SRs.

To associate the surveyor's location with the survey instrument data, the RF start signal is encoded with the value from the survey instrument collected the previous second. This automatically connects the instrument measurement with the proper location. As each 1-s position is calculated by the PC, a dot is plotted on the PC screen in correct relation to the SRs that have been placed on the property. The plotted position remains on the screen creating a track-map showing the surveyor's coverage of the property. At any time during the survey, the surveyor may look at the track-map to determine if any areas have been missed; if so, the surveyor may return to those areas and obtain the needed coverage.

The surveyor, through the hand-held terminal and microcomputer chip in the SB, can transmit certain commands to the PC by way of the RF link. This allows the surveyor to remotely control data collection and allows communication with the PC. The surveyor may suspend data collection to observe the track-map and then resume data collection after identifying areas in need of further coverage.

FIELD TESTING

The USRAD System underwent extensive field testing during 1986 and 1987. The testing was performed under varying conditions such as weather, terrain, temperature, number of buildings, and size of property to determine the benefits and limitations of the system and to determine what factors influence the system.

Over 50 vicinity properties were radiologically surveyed. Multiple setups were tested at each vicinity property to determine which configurations provided the best results and to determine the optimum number of SRs for property coverage. The majority of properties tested were residential properties ranging in size from 581 m^2 (6250 ft^2) to 6975 m^2 (75,000 ft^2) with one to five structures. The USRAD System was also tested on flat open land and on properties with steep slopes. Testing was performed throughout the year with temperatures ranging from 25°F (-4°C) to 100°F (38°C). These tests provided information on reproducibility of the measurement data and surveyor location.

RESULTS

Results of the USRAD System testing indicate both benefits and limitations compared to current manual methods.

Benefits:

- Real-time position data – Real-time position data enable the technician to view the scan while it is conducted (Fig. 4). The track-map shows regions which may have been missed or inadequately covered. If the survey has been terminated, the surveyor can resume the survey and cover those regions which need additional data.

- Verification of survey coverage – Because the USRAD System allows the survey to be viewed while it is being conducted, regions that need further investigation are identified before leaving the site. This eliminates returning to the site for additional data. During

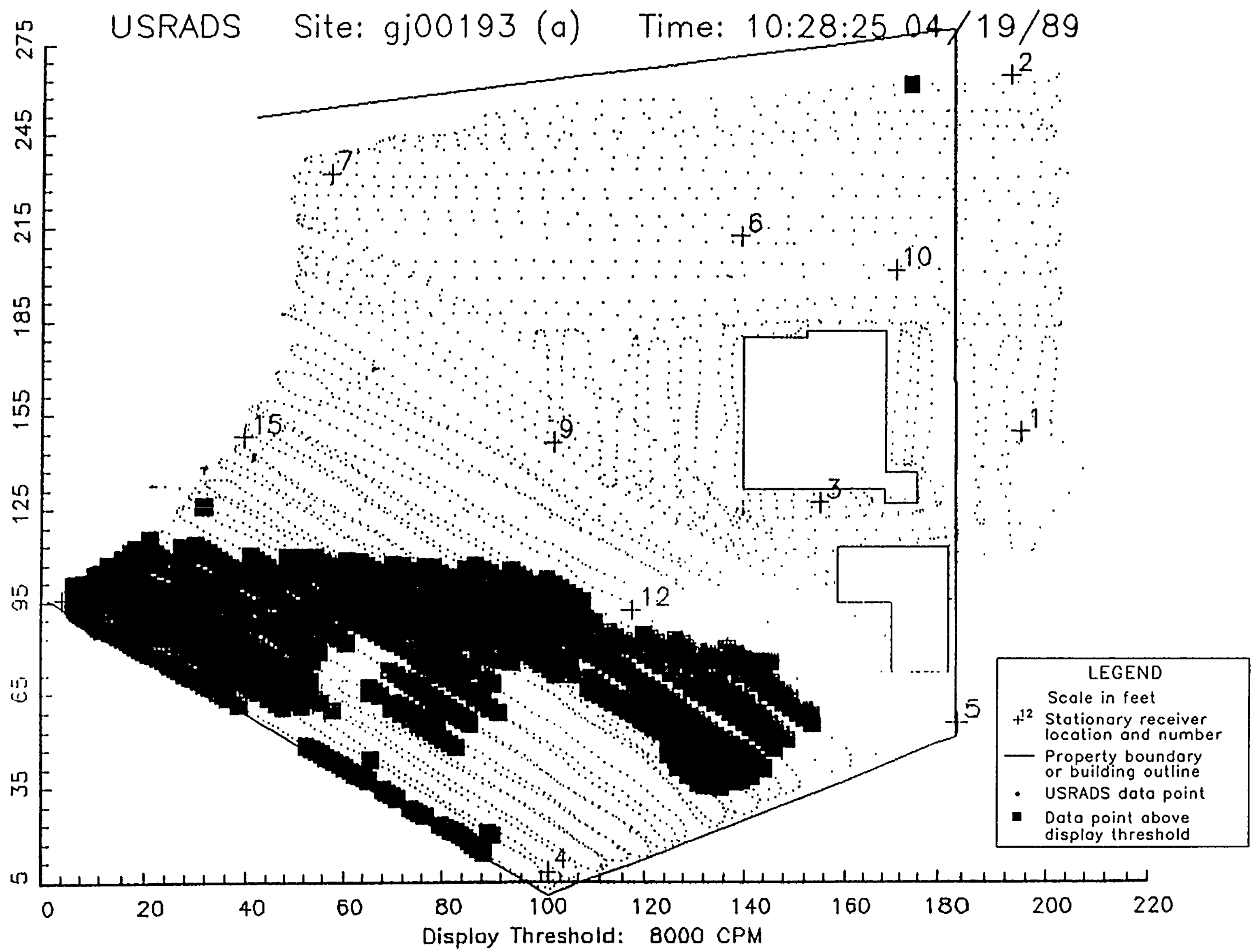

Fig. 4. Survey track-map generated by the USRAL System.

nonautomated scans, portions of a property may be missed because of the lack of documentation of scanned regions. The USRAD System highlights all data points above a chosen threshold (Fig. 4), showing areas of possible contamination that may need further data to better characterize the area. The electronically stored track-map is available for future verification of property coverage.

- Reproducibility – Because the data acquisition and surveyor location are automated, the USRAD System gives highly reproducible survey results. This is extremely important for quality assurance programs and for ensuring that correct decisions are made about the property.

- Reduction of error – Previous walk-on surveys relied on visual interpretation of an analog meter. This allowed for variations in recorded instrument data based on the personal interpretation of the instrument reader. Because the USRAD System collects data automatically and in digital form, errors in reading the instrument are eliminated.

- Data reduction on-site – Because the USRAD System collects and compiles the data on-site, data may also be reduced to generate various maps in the field. Figure 5 is a contour map with three regions of contamination defined above the chosen threshold. Generating the maps in the field allows a better understanding of the property and extent of the contamination before leaving the site. In addition, problems with data or survey coverage are usually easier to spot in graphic form.

- Relative interpretation through 3-D plots – The USRAD System can generate 3-D plots at the site. These plots provide excellent immediate interpretation of the site and of the contamination. Figure 6 is a 3-D plot of a property showing the relative relationship between contaminated and background regions. Although absolute data values are difficult to determine, varying views of the same plot allow evaluation of complexly contaminated sites.

- Electronic data storage – Data are collected and stored electronically by the USRAD System. This eliminates the time required to generate archive copies since all data are saved through daily backup procedures. The data can also be viewed later or reprocessed using different contamination thresholds without returning to the property for further measurements.

- Manipulation of data – Since the system collects and stores a measurement each second, statistical analysis of the minimum, maximum, and mean values, as well as the standard deviation, can be performed on a large data set. Figure 7 shows the statistical evaluation of the property as displayed on the monitor screen by the USRAD System.

Limitations:

- Property size – The USRAD System was designed to be used on residential properties in a populated area. Thus, the system had to be intrinsically safe with no high-power transmitters or potentially hazardous technologies (e.g., microwave emission). These factors limit the size of the property that can be surveyed with one setup to about 7 or 8 acres of open ground. Buildings and topography will reduce the size of the property that can be surveyed. However, the setup time is minimal, and moving the system to an adjacent section of property is not difficult.

- Field time – Actual time at a property using the USRAD System is usually increased over former methods since one surveyor must cover the entire property. Previous nonautomated gamma radiation surveys could be performed by as many as three field

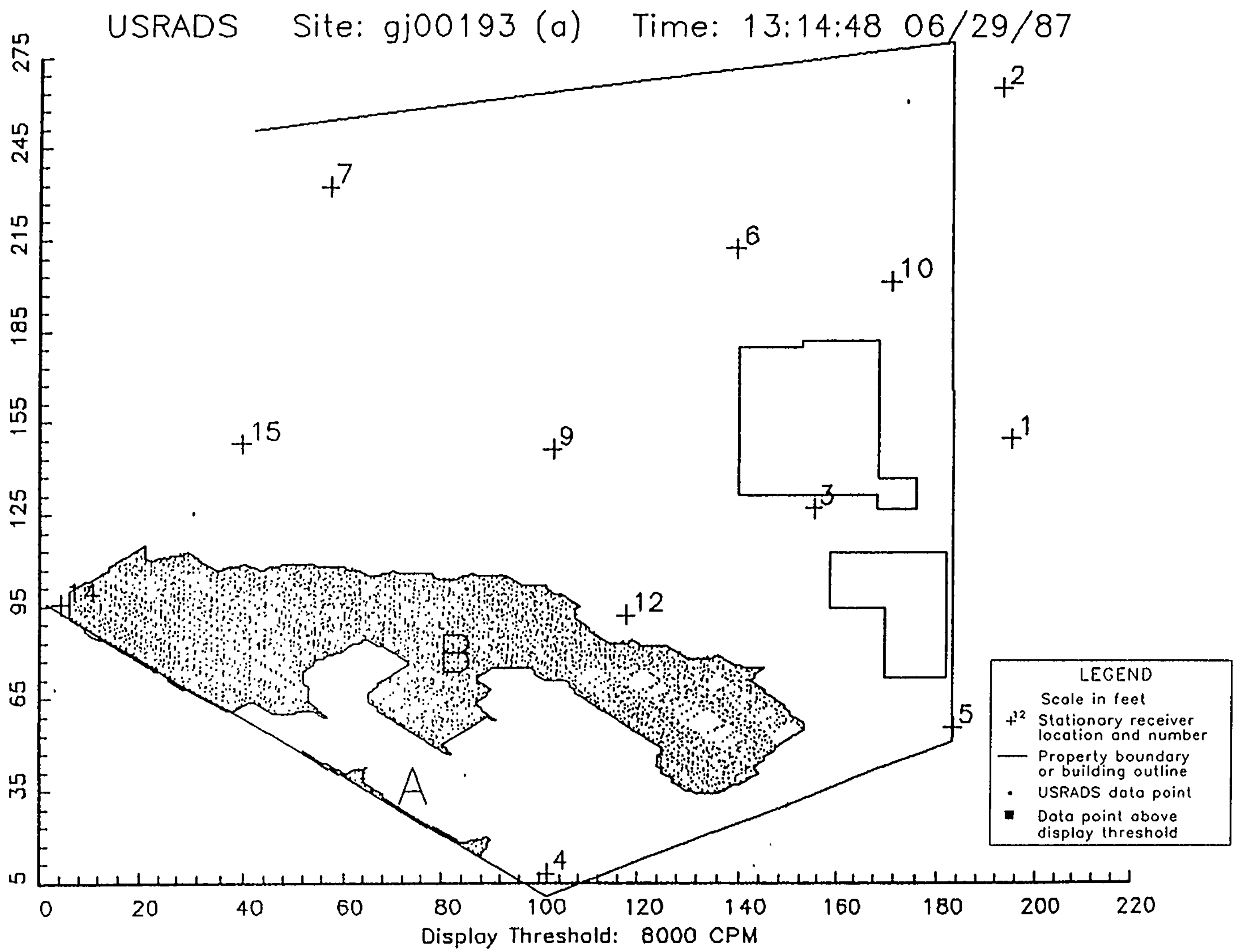

Fig. 5. Contour map generated by the USRAD System.

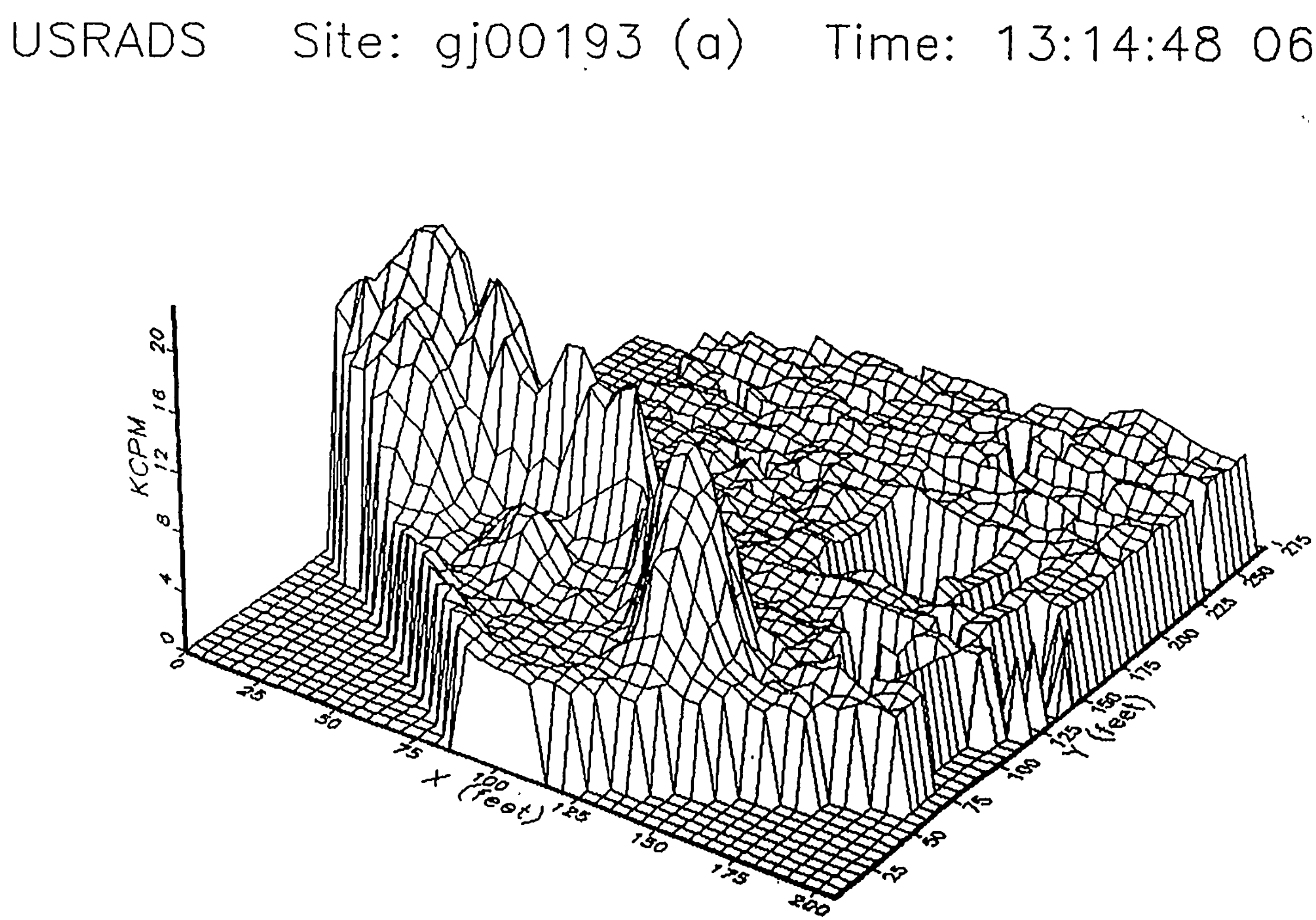

Fig. 6. 3-D plot generated by the USRAD System.

— USRADS v3.0: Contour Area Statistics Summary —

File: c:\usrads\gj00193a.SRV

Date: 06/29/87 Time: 13:14:48

Comment:

Display Threshold (CPM): 8000

	Area Location				Radiation Statistics (in CPM)			
ID	(X)	(Y)	Npts	Sq Ft	Min	Max	Mean	Stdev
A	71	31	39	90	7500	9240	8312	373
B	79	74	973	5134	7140	24180	13723	4237

Fig. 7. USRAD System statistical evaluation as generated on the monitor screen.

personnel at one time. This would not be a limitation with other types of survey instruments, which can only be utilized by one surveyor at a time even during a manual survey. The increased field time is mitigated by reduced data reduction time in the office.

FURTHER APPLICATIONS

Although the USRAD System was developed specifically for use with a gamma detector, it is adaptable for use with other instruments. Examples might be portable instrumentation measuring physical, chemical, geological, or biological conditions. Applications may include verification of remediated and uncontaminated areas, emergency response in mapping pollutant locations after accidents, and characterization of hazardous waste areas.

The adaptation of additional types of instruments allows for multiple surveys and analysis of different parameters at a single site. Multiple surveys of a property, using different instruments for each survey but using the same system setup, would provide a wealth of information. Correlation of survey data would be simplified because all the surveys could be performed using one coordinate system. Property "gridding" would not be required to correlate different instrument measurements. Since all the data are stored electronically using the same coordinate system, the data are ready for computer mapping and interpretation.

Work is currently in progress to adapt the system for the EPA to assess heavy metal contamination with an x-ray fluorescence detector. This adaptation of the USRAD System will also provide transferable technologies for characterization and assessment of many radiological and chemical soil instruments. The USRAD System has also been adapted for use with geophysical equipment, the Geonics EM31. Initial field testing of the system has yielded excellent results in detection of underground conductivity contrasts (e.g., buried metals). Figure 8 shows the relationship between a 3-D plot and corresponding contour maps generated by the USRAD System using the EM31. The quadrature data is the conductivity of the studied area. The two linear anomalies are caused by dirt roads that are less conductive than the surrounding soil. Along the right side of the right-hand road was a buried utility such as an electric cable or conductive pipe that created the peak.

The capability of the USRAD System to document background areas will be beneficial in verification of noncontaminated sites or sites that have undergone remediation. The "negative" documentation obtained verifies that no contamination is present above the chosen threshold. The data obtained can be reanalyzed using any threshold. The electronic track-map documents that the site was adequately surveyed.

With the combination of the USRAD System and robotics, it is also possible that highly contaminated areas could safely be surveyed. These areas may include nuclear reactor cores or other areas too hazardous for human access.

CONCLUSIONS

The USRAD System has proven to be useful for automating walk-on radiological surveys. The system compiles and manipulates large data sets electronically in the field. The system also provides real-time survey coverage and graphics generation in the field, assisting in evaluation of the property while the surveyor is on-site. This method of data acquisition can provide important information to many types of surveys, including characterization of

QUADRATURE DATA -- VERTICAL DIPOLE

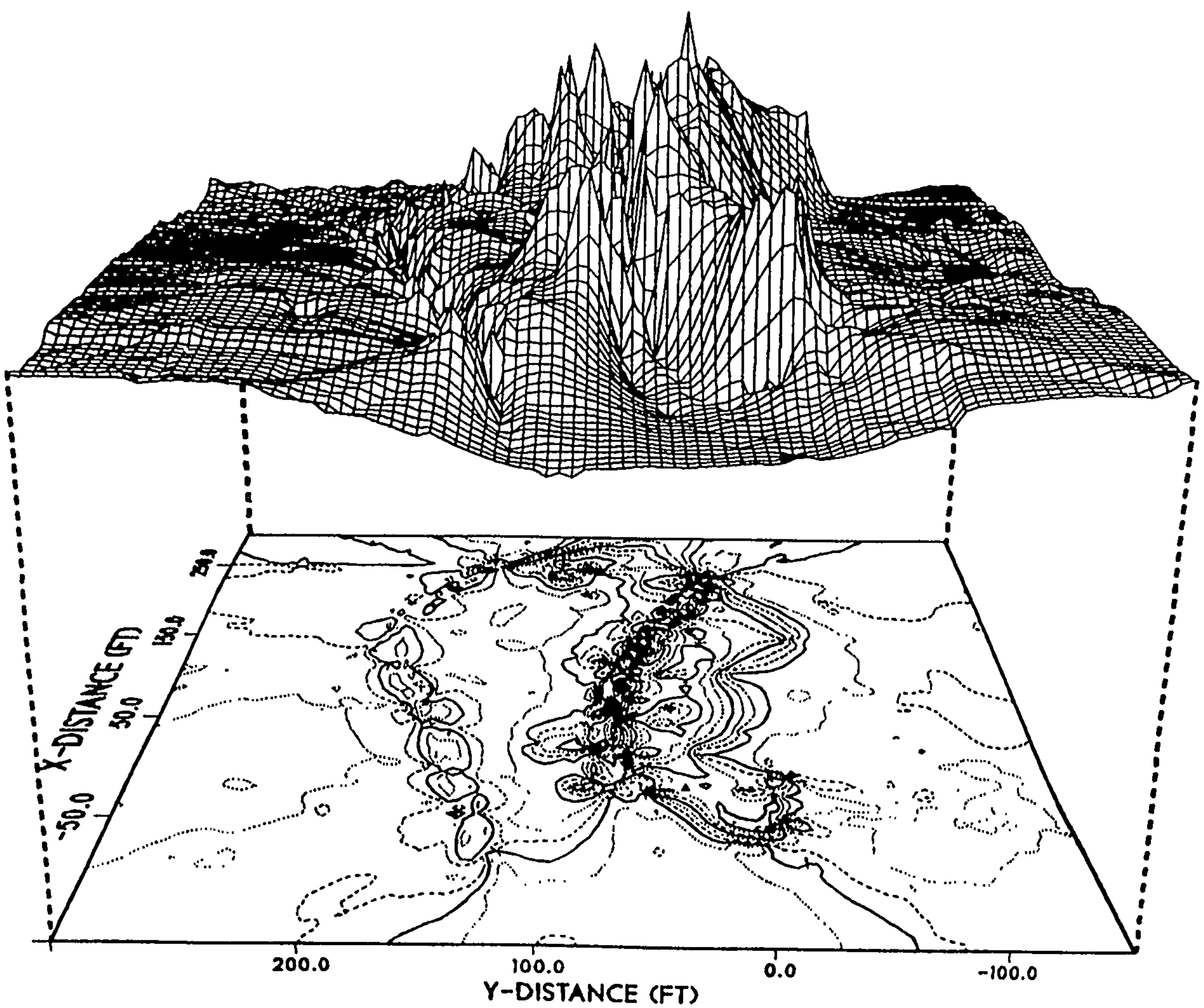

Fig. 8. Contour map and 3-D plot generated by the USRAD System using the EM31 (quadrature data — vertical dipole).

radiological and chemical sites, verification of remediated or uncontaminated sites, and emergency response contaminant leaks or spills. Further use of the USRAD System will lead to more adapations of the system to different types of surveys.

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