START

0016277# 7

August 14, 1991

Meeting Minutes Transmittal/Approval
Unit Managers Meeting: 200-BP-1 Operable Unit
450 Hills Street, Rm 47
July 18, 1991

From/
Appvl.: Allan C Harris Date: 8-15-91
Allan Harris, 200-BP-1 Unit Manager, DOE-RL (A5-19)

Appvl.: Pamela Innis for Date: 8/15/91
Doug Sherwood, 200-BP-1 Unit Manager, EPA (B5-01)

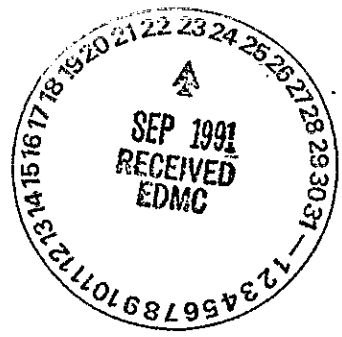
Appvl.: Rich B Hibbard Date 8/15/91
~~Rich Hibbard~~, 200-BP-1 Unit Manager, WA Department of Ecology
Larry Goldstein

Meeting Minutes are attached. Minutes are comprised of the following:

Attachment #1 - Meeting Summary/Summary of Commitments and Agreements
Attachment #2 - Attendance List
Attachment #3 - Agenda for the Meeting
Attachment #4 - Remedial Investigation Work Progress
Attachment #5 - The Final "Safety Assessment for 200-BP-1, Task, 4", Removal of Contaminated Soil from Cribs, Dated July 2, 1991

Prepared by: Doug Fassett Date: 8/15/91
SWEC Support Services

Concurrence by: Mark A. Buckley As Revised Date: 8/15/91
WHC RI Coordinator



200-BP-1 Operable Unit Managers Meeting
July 18, 1991

Distribution:

Donna Lacombe, PRC
Ward Staubitz, USGS
Doug Fassett, SWEC (A4-35)
Linda Powers, WHC (B2-35)
Tom Wintczak, WHC (B2-15)
Mel Adams, WHC (H4-55)
Wayne Johnson, WHC (H4-55)
Rich Carlson, WHC (H4-55)
Brian Sprouse, WHC (H4-22)
Bill Price, WHC (S0-03)
Ralph O. Patt,
OR Water Resources Dept.
Doug Dunster, Golder Assoc.
Mike Thompson, DOE (A6-95)
Diane Clark, DOE (A5-55)
Mark Buckmaster, WHC (H4-55)
Don Praast, GAO (A1-80)

cc. Ronald D. Izatt (A6-95)
Director, DOE-RL, ERD
Donald E. Gerton (A6-80)
Director, DOE-RL, WMD
Roger D. Freeberg (A6-95)
Chief, Rstr. Br., DOE-RL/ERD
Steven H. Wisness (A6-95)
Tri-Party Agreement Proj. Mgr
Richard D. Wojtasek (B2-15)
Prgm. Mgr. WHC
Mary Harmon, DOE-HQ (EM-442)

ADMINISTRATIVE RECORD: 200-BP-1; Care of Susan Wray, WHC (H4-51C)

Please inform Doug Fassett (SWEC) of deletions or additions to the distribution list.

Attachment #1

Meeting Summary and Summary of Commitments and Agreements

200-BP-1 Unit Manager's Meeting
July 18, 1991

1. Mark Buckmaster (WHC) gave an update on the remedial investigation at 200-BP-1 (refer to Attachment #4).

Groundwater well sampling

2. The second quarter of sampling has been completed. The third quarter is to begin in early August. Organic data from eleven wells has been received and nothing greater than detection limits was found. Inorganic data from 19 wells is currently being evaluated, but the cyanide data confirms the location of the plumes. The radiochemical results will continue to arrive. Doug Sherwood (EPA) requested to see the data before the stage two wells are selected. Mr. Buckmaster said the EPA could meet with him in the next several weeks to discuss data and a summary of the data can be provided at the August Unit Managers Meeting.

Hydraulic Pump Tests

3. Transducers have been installed in wells 52-54, 52-57, and 49-57B. Aquifer testing will begin the week of July 22 and continue in early August. It is anticipated that the wells will be pumped dry.

Crib Drilling

4. The safety assessment associated with crib drilling was distributed (see Attachment #5). Drilling has been very slow. A spectral log is planned to be done on Monday, July 22. The bottom of crib 216-B-57 is 18 ft, and nothing was detected with the field instruments. Samples were collected and analytical results are awaited. The maximum contamination (8 mR/hr) was found at about 30 feet. No contamination was detected at a depth of 60 feet. The groundwater is at a depth of about 230 ft. Doug Sherwood (EPA) said the wastes were mostly derived from the three tank farms adjacent to the crib and that they were not very high activity wastes. Mark Buckmaster said approximately 84 million liters of wastes went into the cribs.

5. Mr. Buckmaster stated that ~~all~~ the total activity report for offsite sample shipment ~~investigation derived waste they~~ contained almost ~~detected was shipped offsite and almost all of it was contaminated with~~ all Cs-137. ~~cesium~~. It's less radioactive than they expected in their dose assessments and safety assessments.

6. One to two additional shallow boreholes are planned for crib 216-B-57. Doug Sherwood suggested gamma logging be done at any other boreholes in this crib to determine the vertical profile. This would aid in determining the number, depth and location of the shallow boreholes. Mark Buckmaster replied that he would request that the health physics technicians send all their information to him and that by the August

Unit Managers Meeting they could discuss it more. A total of three deep boreholes are planned in various cribs.

7. Mr. Buckmaster said that the Toxicity Characteristic Leaching Procedure will be done on samples collected from 30 to 38 ft.

8. Mark Buckmaster said that all excavation work was complete. He said that the areas outside the crib were still posted and the areas inside the cribs were posted for subsurface contamination; only radioactive analyses have been done.

Discussion

9. Allan Harris (DOE) asked if they had tied the geophysical data to the analytical data and the geology for the BP Area. Mark Buckmaster replied that they're starting to do that now. Mr. Harris asked about the status of the groundwater modeling. Mark Buckmaster said the modeling was ongoing and that he would arrange for a presentation on the status of the groundwater modeling at the August UMM.

Action Item 2BP1.47: A presentation on progress on groundwater modeling is to be given at the August UMM. Action: Mark Buckmaster (7/18/91).

10. Allan Harris asked if a change to the work plan was needed for the timing of the installation of the casing. Mark Buckmaster replied that the work plan says that logging of the borehole will take place before the casing is put into the well. Mr. Buckmaster said that he thinks that the work plan can be left the way it is.

Attachment #2

Attendance

200-BP-1 Operable Unit Managers Meeting
July 18, 1991

Name	Org.	O.U. Role	Phone
Harris, Allan	DOE-RL	Unit Manager	509-376-4339
Allender, Robert	Brown and Caldwell	Ecology Support	503-244-7005
Cline, Chuck	Ecology	Hydrogeology	206-438-7556
Hibbard, Richard	Ecology	CERCLA Unit	206-493-9367
Sherwood, Doug	EPA	Unit Manager	509-376-9529
Lacombe, Donna	PRC	EPA Contractor	206-624-2692
Drost, Brian	USGS	EPA Support	206-593-6510
Staubitz, Ward	USGS	EPA Support	206-593-6510
Mullen, Richard	Parametrix	Ecology Support	206-455-2550
Kane, William	Parametrix	Ecology Support	206-455-2550
Fassett, Doug	SWEC	GSSC, DOE-RL	509-376-5011
Fryer, Bill	SWEC	GSSC, DOE-RL	509-376-0412
Knox, Kathy	CNES	GSSC, DOE-RL	509-376-5011
Shigley, Diane	SWEC	GSSC, DOE-RL	509-376-5038
Buckmaster, Mark	WHC	RI Coordinator	509-376-1792
Downey, Hal	WHC	ER Program Office	509-376-5539
Mix, P.D.	WHC	Activity Engr.	509-373-2902
Patterson, Jim	WHC	Program Office	509-376-0568

Attachment #3

Agenda

200-BP-1 Operable Unit Managers Meeting
July 18, 1991

Introduction:

Status:

Action Items:

Work Plan:

Remedial Investigation:

- o Groundwater Sampling
- o Hydraulic Pump Tests
- o Source and Vadose Sampling

Issues:

Other Topics:

Agreements and Commitments:

Attachment #4

Work Progress

200-BP-1 Operable Unit Managers Meeting
July 18, 1991

1. The second quarter of groundwater sampling has been completed. The third quarter will begin in August.

2. Analytical Data:

   - Organic results - 11 Wells
     Inorganic result - 19 Wells

   - Initial evaluation of the organic data indicates all analytes less than detection limits. Inorganic data is currently being evaluated.

HYDRAULIC PUMP TESTS

1. Aquifer testing has begun on well 699-52-54, 699-52-57, and 699-49-57B.

2. Field activities have begun by determining baseline water levels in each of wells followed by actual discharges.

3. A purgewater truck will be used to contain water collected at the three test wells, which meet the requirements for purgewater discharges and containment.

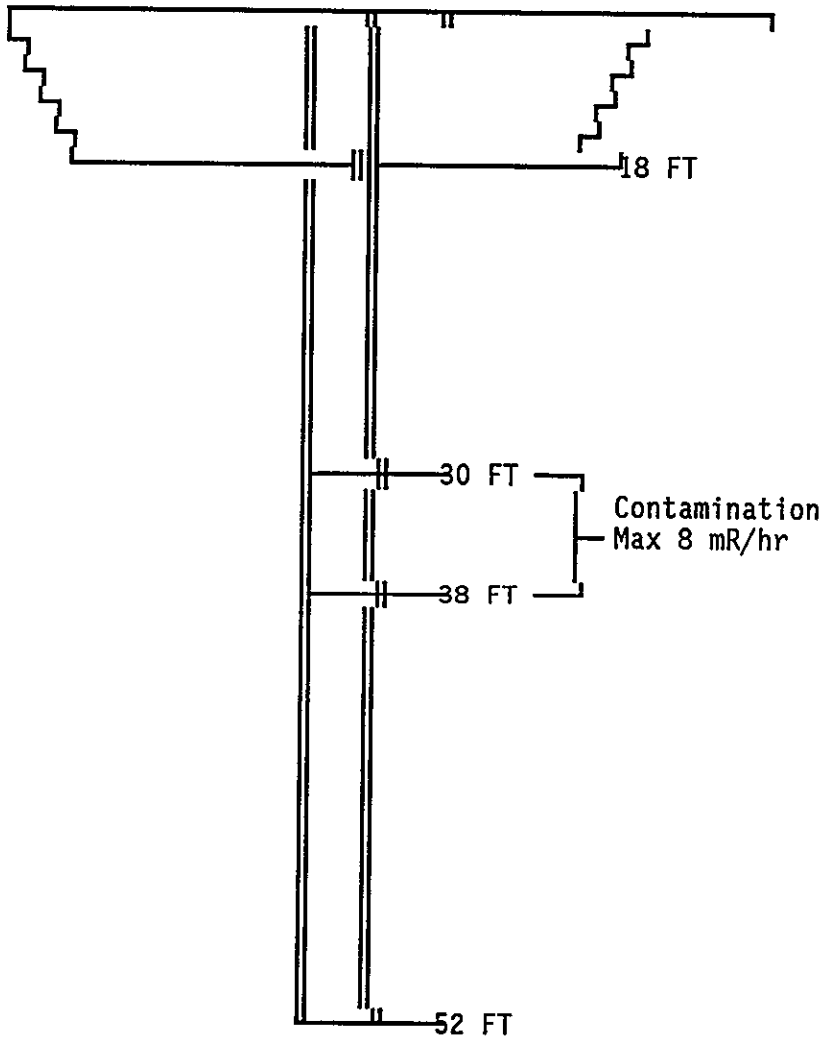
SOURCE AND VADOSE SAMPLING
STATUS-JULY 16, 1991

1. Total depth drilled to date at 216-B-57 is 52 ft.

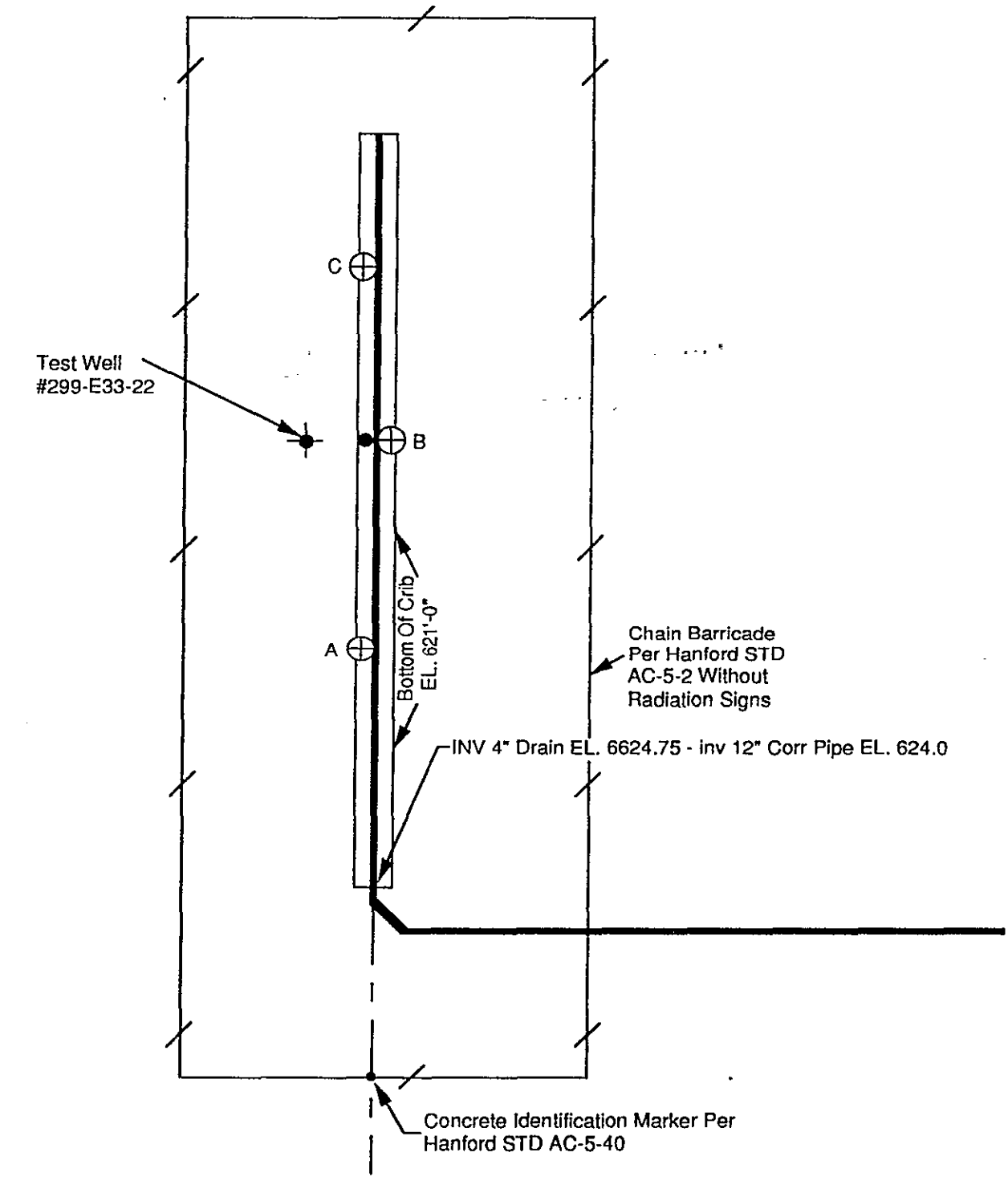
2. Drilling has been very slow. Approximately 4-5 ft/day.

3. A second drill rig is currently being setup on 216-B-49. Scheduled to begin drilling the first of next week.

200-BP-1
Crib 216-B-57
July 16, 1991



Crib 216-B-57



⊕ Borehole Locations

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SUPPORTING DOCUMENT

1 Total Pages 111

2. Title	3 Number	4 Rev No.
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5. Key Words
Environmental Remediation/Investigation
Hazards
200 East Area
216-B cribs
Safety Assessment

6. Author
N. R. Kerr
Name (Type or Print)
R A Carlson for 7/1/91
Signature
29320/LEE3J1
Organization/Charge Code

7. Abstract

The document presents an assessment of the potential hazards and consequences associated with the removal of contaminated soil from the 216-B cribs in the 200 East Area of the Hanford Site. The activities were found to present a low hazard. The document also presents safety functions to be considered in the project and recommendations regarding appropriate controls to be employed in the project activities.

APPROVED FOR PUBLIC RELEASE 7/1/91 Burkland

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Page 1 of 1

1 EDT 129404

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153719

5. Proj/Prog/Dept/Div: Env. Engineering

6. Cog/Proj Engr: M. A. Buckmaster

7. Purchase Order No:
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8. Originator Remarks:
The final "Safety Assessment for 200-BP-1, Task 4" is transmitted for release.

9 Equip/Component No:
--

10. System/Bldg/Facility:
216-B cribs

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(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-EN-HC-004	--	0	Safety Assessment for 200-BP-1, Task 4	2	2	1	

16 KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 see MRP 5.43 and EP-1.7	1. Approval 2. Release 3 Information 4 Review 5 Post-Review 6 Dist (Receipt Acknow Required)	1. Approved 2 Approved w/comment 3 Disapproved w/comment 4 Reviewed no/comment 5 Reviewed w/comment 6 Receipt acknowledged

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1&2		Cog./Proj Eng Mgr. R.A. Carlson			H4-55						
1&2		QA D.G. Parwick		4/29/91	H4-16						
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Signature of EDT Originator — Date

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20 R.A. Carlson — 4/29/91
Cognizant/Project Engineer's Manager — Date

21. DOE APPROVAL (if required)
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☐ Approved
☐ Approved w/comments
☐ Disapproved w/comments

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2 RADIATION WORK CRITERIA
3 ASSESSMENT OF FERROCYANIDE
4 DOSE ASSESSMENT
5 CRITICALITY EVALUATION
6 HAZARD SCREENING EVALUATION
7 FACILITY HAZARD CLASSIFICATION

1.0 INTRODUCTION AND SUMMARY

The U.S. Environmental Protection Agency (EPA) has taken action to include the 200 Areas of the Hanford Site on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The 200-BP-1 is one of several CERCLA operable units identified within the 200 East Area of the Hanford Site. Westinghouse Hanford Company (Westinghouse Hanford) is preparing to perform characterization activities in 200-BP-1 for the U.S. Department of Energy (DOE) with agreement of the EPA and the Washington State Department of Ecology (Ecology). Characterization activities discussed within the scope of this document include soil sampling of cribs within the operable unit.

1.1 WORK DESCRIPTION

This document records the safety assessment of the hazards and operational limitations that ensure safe operation of work associated with Task 4 in the *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington.*[2] Task 4 will complete soil sampling of the vadose zone beneath four inactive cribs near 241-BY Tank Farm. The cribs are 216-B-43, 216-B-49, 216-B-57, and 216-B-61.

1.2 ASSESSMENT SUMMARY

The assessment finds the 200-BP-1, Task 4 characterization and investigation low hazard activities. The safety assessment was performed through interactive discussions and analysis by environmental, engineering, safety analysis, and operations personnel with independent review and concurrence from safety. This summary provides the recorded highlights of the assessment.

The hazards associated with the Task 4 activities are found to be those related to the dispersible chemical and radiological contaminants that may be found in the vadose zone beneath the crib surfaces. The assessment considered the anticipated operational period for the activity segments of drilling/sampling, sample preparation, and interim storage and consequences of potential accidents.

The assessment finds that discharges of ferrocyanide to the cribs could be a potential hazard if acid solutions are introduced into the contaminated soils. The discharges could have evolved potassium or sodium cyanide bearing salts, which could release cyanide gases in an acid solution. Acid solutions will be restricted from the 200-BP-1 site until the sample analysis determines that the compounds of concern are not present in the vadose soils.

The potential hazard of fire and explosion is unlikely because of the postulated ferrocyanide and chemical depositions. The conditions to support explosions from the drilling and sampling activities are highly unlikely. Documentation of the ferrocyanide explosion issue is found in Attachment 3.

Hazardous substances from previous liquid discharges are anticipated in the vadose zone. Extracting vadose zone soil samples from the vadose zone provides a source of dispersible hazardous substances that represent potential hazards to individuals and the environment.

1.3 SUMMARY CONCLUSIONS

The control of hazardous material inventory (maximum inventory allowed without additional analyses) will be applied as the operational limitation. To ensure control is maintained, surveys and monitoring (surveillance requirement) of drilling activities will be conducted and recorded (audit point). Acid solutions will be restricted from the 200-BP-1 work site as a precautionary measure to prevent generation of cyanide or other volatile gases from the potential depositions in the soil.

During the course of the assessment, interactive discussions identified prudent actions adopted by line management and implemented by Westinghouse Hanford procedures. These prudent actions are good engineering and safety practices to ensure that potential exposures at the 200-BP-1 work site will be managed as low as reasonably achievable (ALARA). The adopted controls, both required and prudent, are discussed in greater detail in Section 4.0, Safety Functions and Controls.

2.0 WORK DESCRIPTION

A cable-tool drill will be used to extract soil samples. The drill rig will be located within known contamination zones and will extract contaminated soil from past operations. The sample site at 216-B-61 is anticipated to be a noncontaminated site because there have been no known or recorded discharges sent to the crib.

2.1 SITE DESCRIPTION

The Hanford Site is located in the south-central part of Washington State. The Hanford Site is approximately 170 mi southeast of Seattle and 125 mi southwest of Spokane (Figure 1). The 200-BP-1 operable unit is located in the approximate center of the Hanford Site, along the northern boundary of the 200 East Area fence. Cribs 216-B-43 and 216-B-49 are located north of the 241-BY Tank Farm and the 216-B-57 and 216-B-61 cribs located northwest of the tank farm (Figure 2). A typical plan and section view of cribs 216-B-43 through 216-B-50 are included in Figures 3 and 4. The plan and section for cribs 216-B-57 and 216-B-61 are shown in Figure 5. The following subsections summarize the site information found in DOE/RL 88-32.[2]

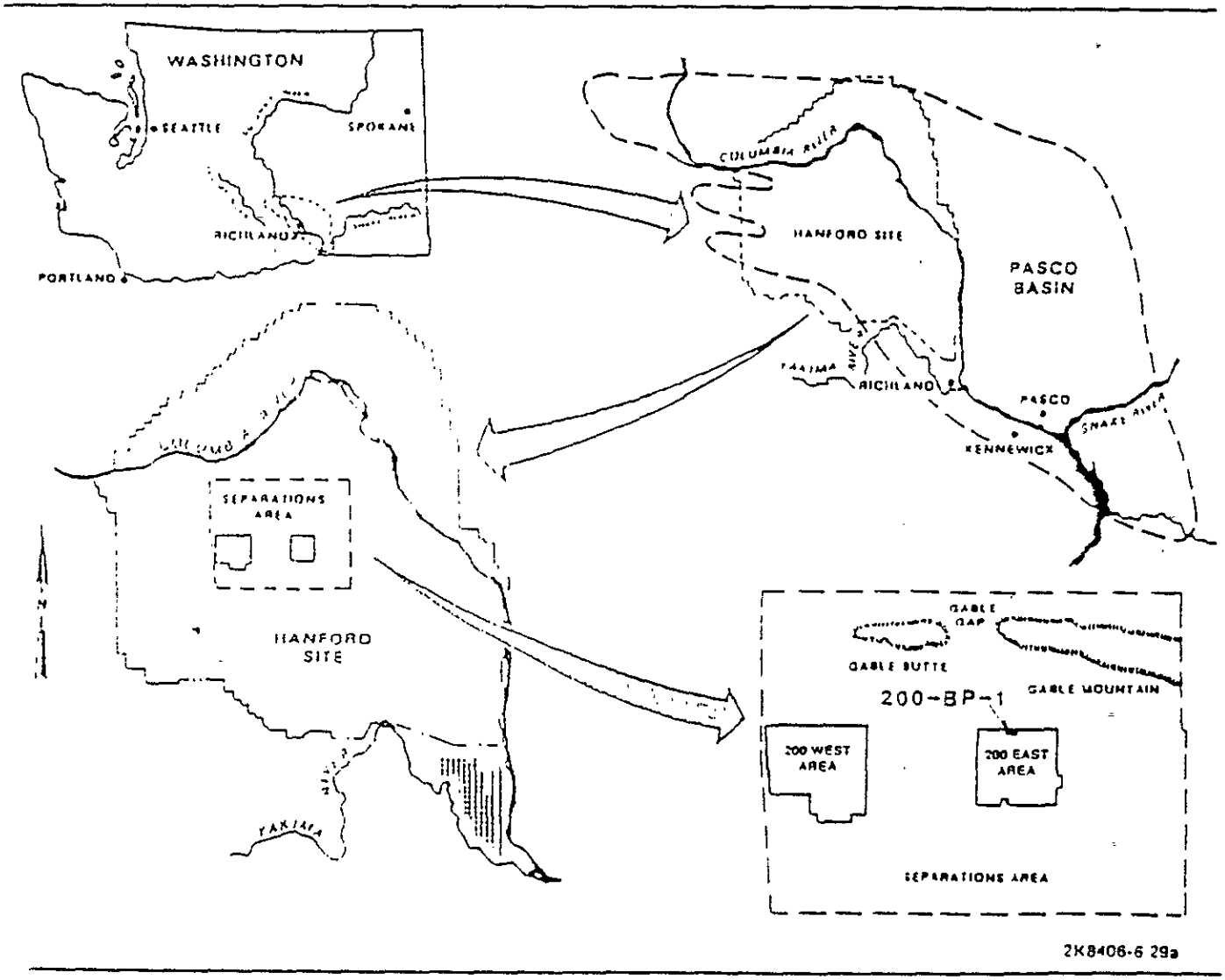


Figure 1. Site Orientation.

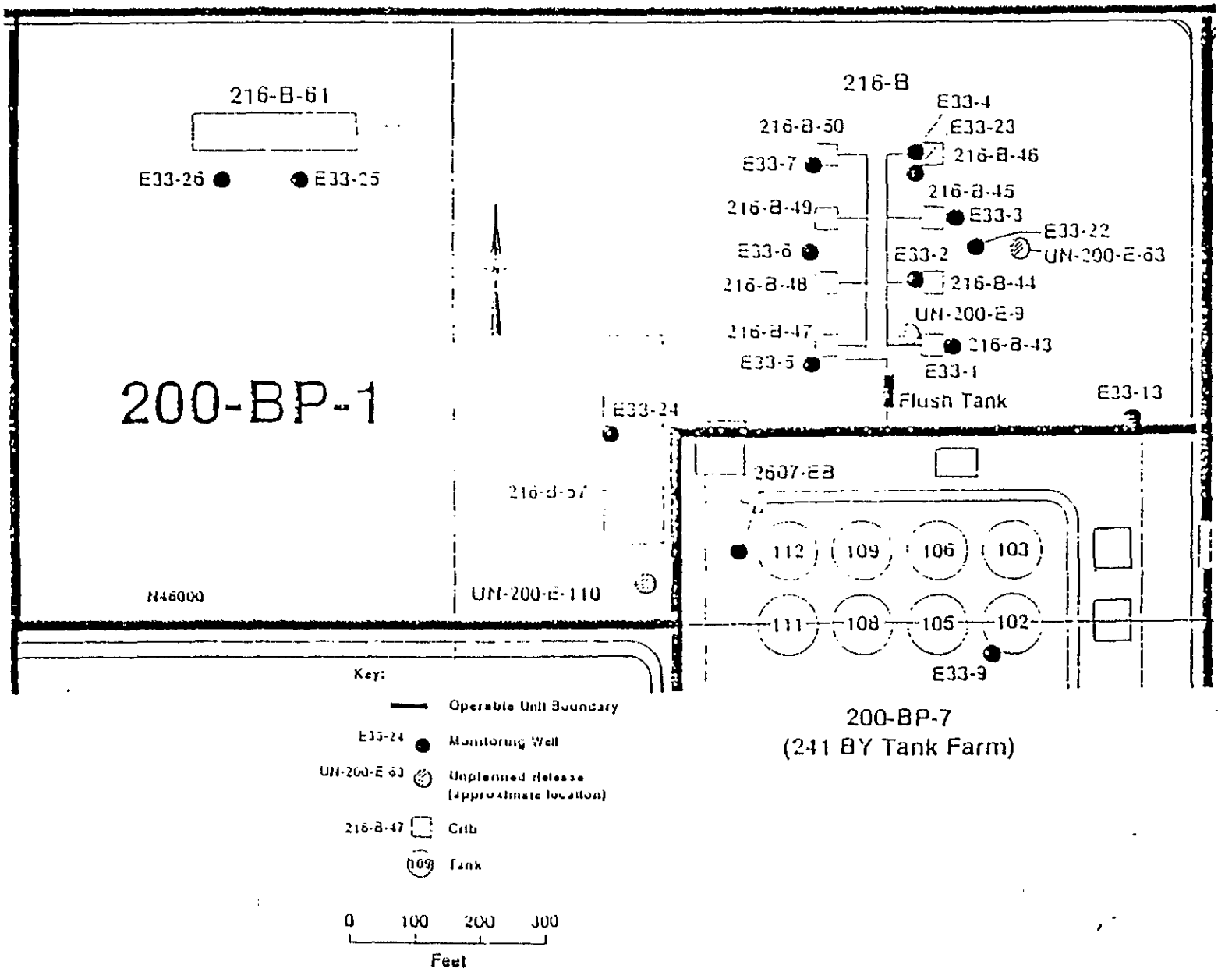


Figure 2. Site Layout.

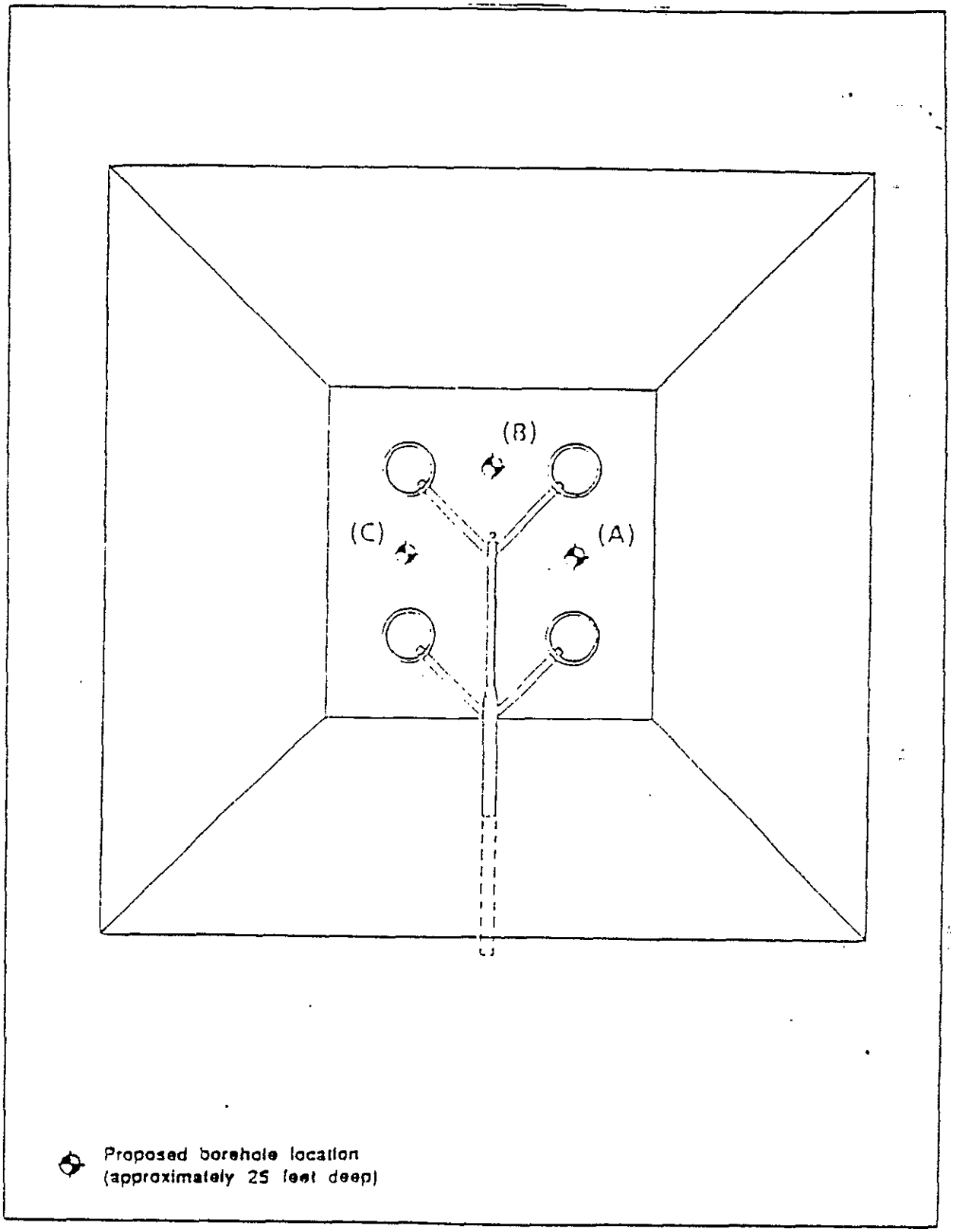


Figure 3. Plan and Section Views, Cribs 216-B-43 Through 216-B-50.

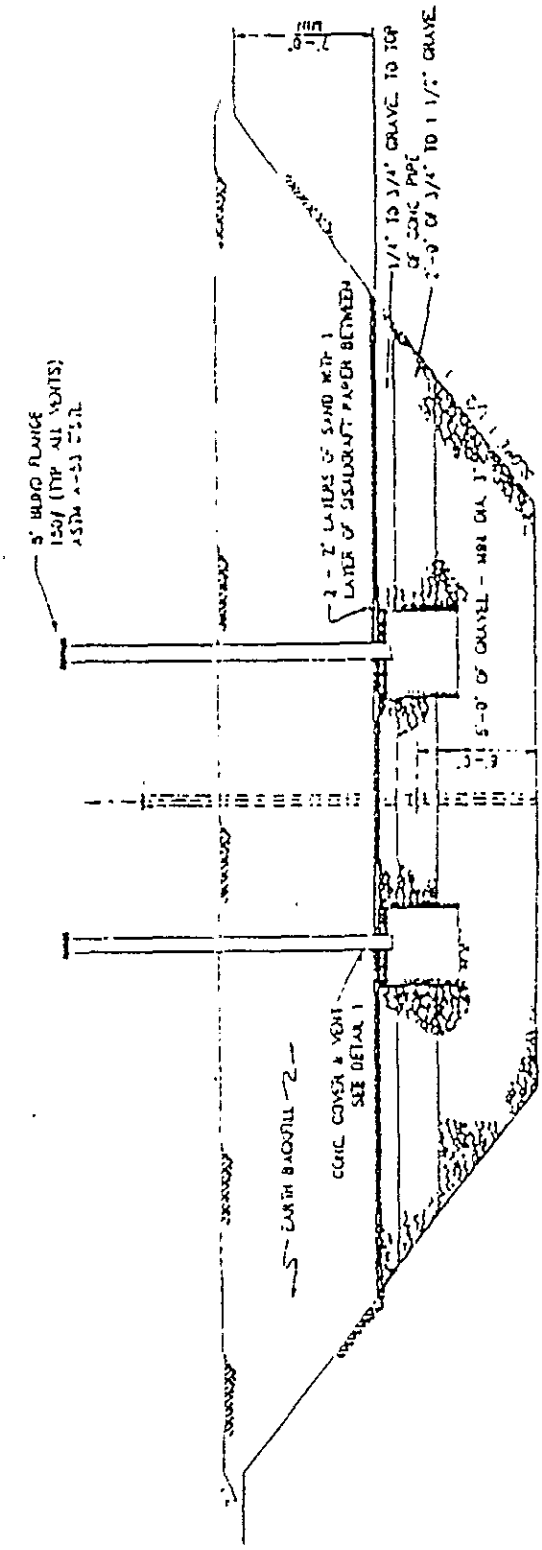


Figure 4. Plan and Section Views, Cross Section of Cribs 216-B-43 and 216-B-49.

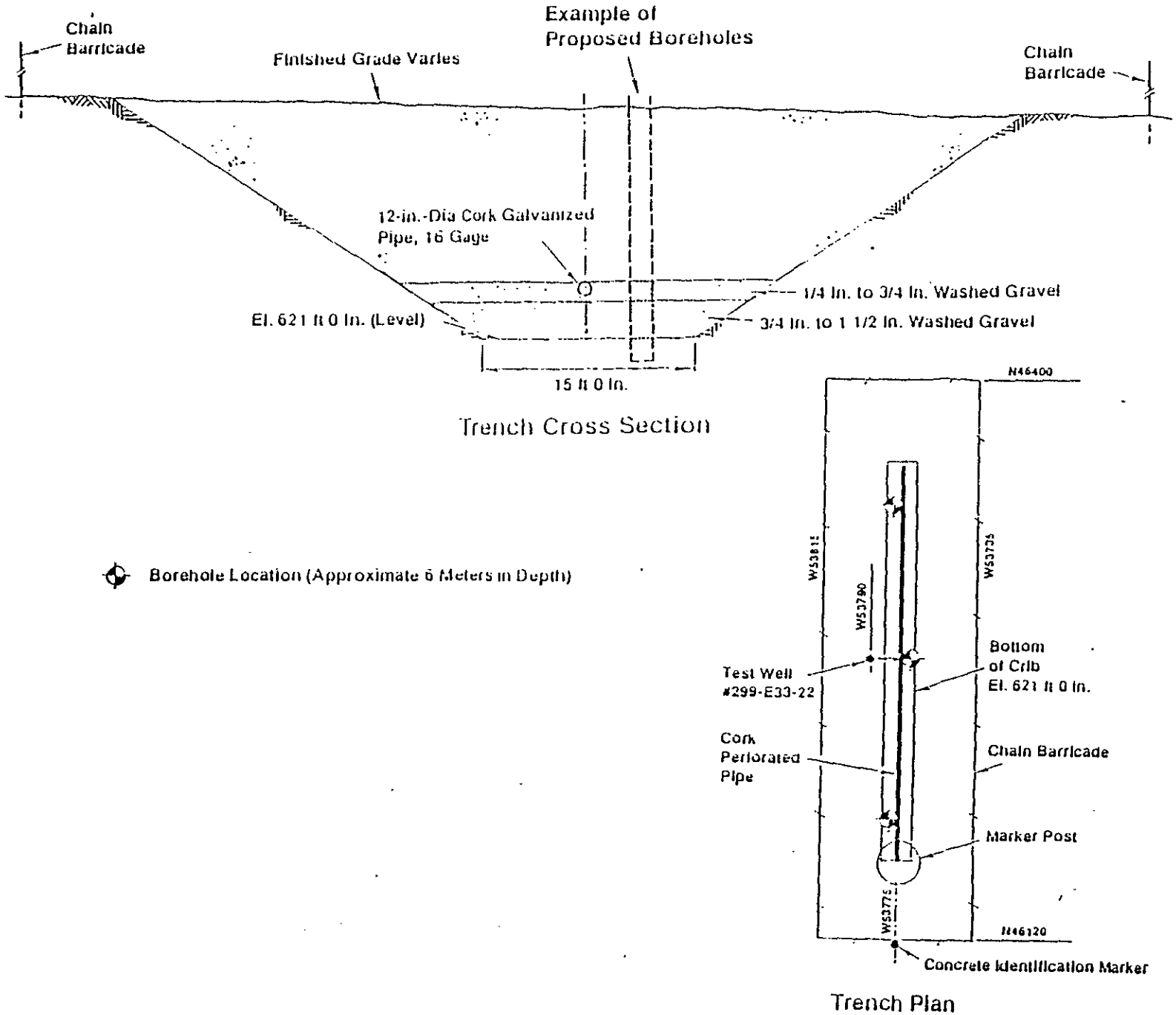


Figure 5. Plan and Section Views, Cribs 216-B-57 and 216-B-61.

2.1.1 Topography

The 200-BP-1 is approximately 650 ft above sea level on a terrace called the 200 Areas Plateau. The terrace decreases in elevation to the north, northwest, and east toward the Columbia River. The terrace escarpments are steep, with elevation changes between 50 and 60 ft.

2.1.2 Geology

The stratigraphy beneath the cribs consists of Miocene basalts overlain by Pliocene and Pleistocene sediments (the Ringold Formation). Overlying the Ringold sediments (the vadose zone) are glaciofluvial sediments called the Hanford formation. The water table is in the Ringold and Hanford sediments at approximately 400 ft above sea level.

2.1.3 Meteorology

Prevailing wind directions are from the northwest in all months. Secondary wind directions are indicated as southwesterly winds. Northwest winds occur most often in the winter and summer. Southwesterly winds are associated with spring and summer months. The average summer wind is approximately 10 mph and the average winter winds are approximately 7 mph. The high winds are usually associated with the southwesterly winds. The summer southwesterly high winds are usually those associated with the dust storms experienced in the region.

2.1.4 Temperature and Humidity

The average relative humidity is 54% with average ranges between 35% and 75%. The average monthly temperatures range from a low of -1.5°C in January to a high of 24.7°C in July.

2.1.5 Precipitation

The annual average precipitation at the Hanford Meteorological Station is 6.3 in. Annual rainfall is from 3 to 11 in. with most of the precipitation occurring in the winter months. The record snowfall is 24 in. and the second highest snowfall is less than one-half that amount.. Average snowfall ranges from 0.3 in. to 5.3 in.

2.1.6 Demography

Approximately 110 people live within 10 mi of the 200 Areas. No person resides within a 1-mi radius of the 200-BP-1 operable unit. The city of Richland is approximately 18 mi south. The working population for all shifts in the 200 Area is approximately 2,400. The site boundaries are approximately 7 mi northwest at the Columbia River and 6 mi south at Highway 240.

2.2 ACTIVITY DESCRIPTION

The activities that are addressed in this assessment are associated with the soil sampling in cribs near the BY Tank Farm (216-B-43, -49, -57 and -61). The activities include cable-tool drilling and split spoon sampling, sample preparation and interim storage of the soils extracted from the drilling activities. One borehole would be drilled to an elevation above ground water in cribs 216-B-43, -49 and -57, and one borehole to 25 ft will be drilled through crib 216-B-61 to verify that it never received waste.

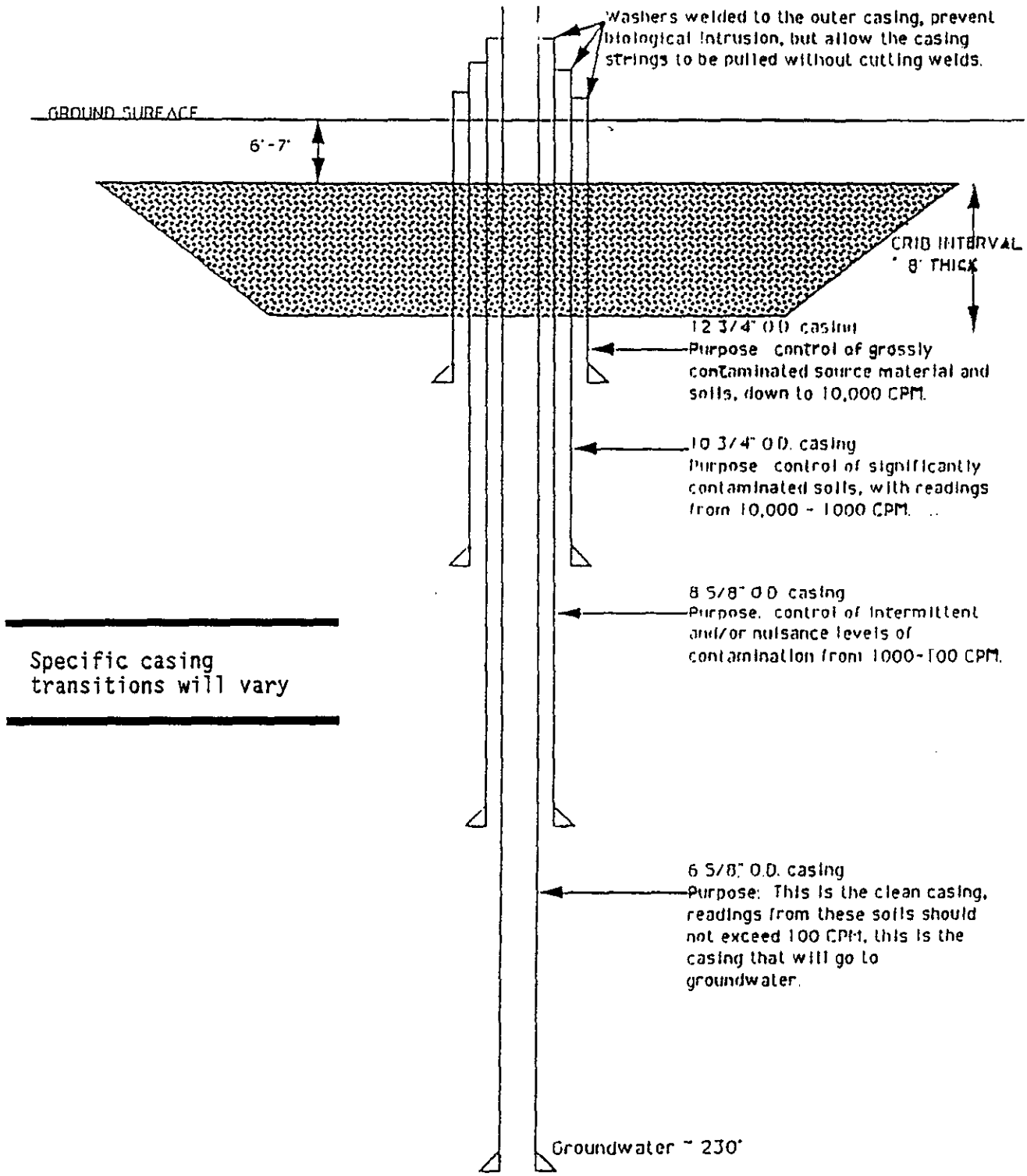
The scope of this hazard assessment excludes the transportation of the prepared samples to the analytical facilities and the transportation of waste materials to long-term storage or disposal facilities. Also excluded are the analytical activities and long-term storage of the soil samples. These activities are covered or will be covered by other hazard and safety assessments.

2.2.1 Cable-Tool Drilling

The cable-tool drilling method will be used to drill these vadose zone investigation boreholes because it is most suited for the contamination control measures necessary under the anticipated radiological conditions. Cable-tool drilling is a method in which the drilling tools are pounded into the soil to advance the borehole to a desired depth. Two techniques are used to advance the hole dependent upon the lithology of the soil. Hard tool drilling uses a drill string that consists of a drill bit, a drill stem, and a swivel socket that connects the drill string to the cable. The drill string is driven into the soil by dropping the drill string (1,250 lbs hard tool and 750 lbs drive/sample barrel) a distance of 24 to 28 in. approximately 50 times a minute. Downhole materials are broken up by the pounding action of the bit and then retrieved from the hole with a bailer. When drilling through gravels, hard tool drilling is the preferred method. An alternative method for drilling and retrieving cuttings from the borehole is the drive barrel technique in which a core barrel is attached to the cable and pounded into the soil, thereby filling and compacting the barrel with soil. The borehole is advanced and cuttings retrieved intact, inside the core barrel, in a one-step process. The cable-tool method is preferred for drilling in sands and allows for a more accurate geologic interpretation of the borehole. This is possible because downhole materials are not broken by the abrasive action of the bit. The drive barrel method is anticipated for the boreholes of 200-BP-1 based on previous drilling experience in this area (outside the contamination zone). When sampling, a split spoon sampler replaces the drill bit of the drive barrel.

All equipment and soils that are brought out of the boreholes will be monitored by the Health Physics Technician (HPT) using Hanford Site standard field instruments. These field instrument readings will be used as the criteria for changing the size of the casing in the borehole. Telescoped casing techniques will be used to prevent dragging radionuclides from the source cribs down to the water table (Figure 6).

Figure 6. Typical Sample Borehole Design.



Initial drilling will use a 12 3/4 in. outer diameter (O.D.) carbon steel casing to maintain an open borehole while drilling and sampling through the 6- to 7-ft soil cover, the approximate 8 ft of crib gravels, and into the contaminated soils directly under the cribs. This casing will be utilized for hole advancement until the soils removed from the borehole register readings lower than 10,000 Counts/Minute (CPM). If the field instrument readings never exceed 10,000 CPM while drilling through the crib gravels, the casing diameter will be reduced at the discretion of the Field Team Leader (in consultation and agreement with the Remediation Investigation Coordinator), but not before the borehole has advanced completely through the crib/soil interface.

Once soil contamination levels are below 10,000 CPM, the borehole will be advanced using an 8 5/8-in. (O.D.) carbon steel casing to maintain an open borehole through the soils contaminated with intermittent or 'nuisance' levels of radionuclides. This casing will be used until the soils removed from the borehole register readings lower than 100 CPM.

Once soil contamination levels are below 100 CPM, the borehole will be advanced using 6 5/8-in. O.D. carbon steel casing to maintain an open borehole through the remaining soils above the water table. This is the clean casing that will be taken down to the water table. Soils removed from this section of the borehole should not exceed 100 CPM. If the soils removed from this section of the borehole exceed 100 CPM, one size smaller casing (5 1/2-in. diameter) is available to further telescope the casing once the soil readings drop below 100 CPM again, to avoid dragging any low levels of contamination to the ground water. This smaller casing is very difficult to sample through, and has a limited depth capability. It is not anticipated that this casing will be necessary, but it is available if needed.

Past experience with drilling in cribs has shown that once the borehole is advanced through the crib, the radiological contamination drops off drastically. If, as an example, the radiological readings were to drop from 10,000 to 200 CPM (or less) within a short drilling interval, the casing would only be reduced one size, and the borehole would be advanced with 10 3/4-in. casing. Then there would be one more reduction of casing size (to 8 5/8-in. diameter) after radiological readings dropped below 100 CPM, this 8 5/8-in. casing would then be considered the 'clear string' of casing and could be advanced to the ground water without dragging radionuclides with it. This choice of casing sizes would allow more flexibility in contamination control, so that if the borehole encountered an unanticipated zone of higher radiological readings, the casing could be reduced another size after passing through that zone and encountering lower readings again.

As each new casing string is placed into the borehole, a washer will be fitted over the new casing and welded to the larger diameter casing to prevent any biological intrusion while the borehole is open.

During drilling operations, the borehole is advanced with a drive (core) barrel or, if necessary, by hard tooling and then bailing a slurry out of the hole. All borehole cuttings are handled in accordance with procedure EII 4.2 of WHC-CM-7-7.[3] When cuttings are radiologically contaminated, as designated by field instruments, special handling techniques are invoked.

- Short lengths (5 ft) of casing are used to prevent overhead work operations.

- Contamination is controlled by wiping the cable down as the tools are withdrawn from the borehole.

- Low-Level Drive Barrel Techniques: As the drive barrel clears the casing, it is wiped and surveyed, and then a heavy gage plastic bag is slipped under and up over the drive barrel. The drive barrel is then transferred to the lined waste drum and the contents are emptied into the bag. The bag is horsetailed shut. Separate plastic bagging is used for each drive run.

- High-Level Drive Barrel Techniques: If more control is required, heavy gauge plastic sleeving (approximately 6 ft lengths) is slipped around the outside of the casing. As the drive barrel is brought up, the plastic sleeving is pulled up with it and gathered at the top. As the barrel clears the top of the casing, the plastic sleeving is horsetailed at the bottom. The drive barrel is kept over the casing at all times, thereby allowing loose material to drop back into the borehole. The drive barrel is pushed over to the waste drum (shielded as necessary) and lowered inside. The cuttings are then tapped out and collected inside the horsetailed sleeving. The drive barrel is wiped and surveyed as it is removed from the waste drum and contaminated cloths are deposited in the drum along with the cuttings. The drive barrel is returned to the casing for the next run. The HPT monitors the soil cuttings and then the plastic sleeving is horsetailed at the top.

- Hardtooling/Bailing: Contamination control techniques as described for the drive barrel method will be invoked. The materials obtained from the borehole will consist of a slurry and, therefore, the potential for airborne contamination is minimal. Tools will be wiped down and plastic sleeving will be used when necessary.

- Split Spoon Sampling: Characterization samples are collected from a split spoon sampler at selected intervals during drilling operations. As described earlier, plastic sleeving will be used to control contamination as the sampler is brought up out of the borehole. The plastic sleeving will be pulled back slightly from the top of the sampler to allow the drive head to be broken off from the drill string at the swivel socket. Sleeving is then pulled up over the drive head and horsetailed. The sampler is then transferred to the breakdown table (lead blankets are available if any shielding is necessary) and the drive head and shoe are removed from the sampler. Extra plastic sleeving is used if necessary to confine contamination. At this point, based on a survey by the HPT, the criteria for opening the split spoon sampler, as cited in the reference memo, (G.F. Boothe 1990, Attachment 2) are invoked. For high external radiation rates (>10 mrem/hr at contact), the sampler will be opened and containerized in a field glovebox to control contamination. If external radiation rates exceed 1,000 mrem/hr at contact, drilling/sampling will be shut down immediately and alternative sampling methods used, such as extracting and containerizing the sample at a hot cell facility.

Following completion of the borings to final depth, each borehole will be geodetically surveyed and geophysically logged using gross gamma and high resolution spectral gamma probes. The borehole will be abandoned following the sampling and logging. All steel casings will be removed and the entire borehole annulus will be grouted to the land surface. Casing removed from the borehole will be decontaminated in the field or, if necessary, transferred to an appropriately controlled decontamination facility.

Table 1 provides a listing of the activities and proposed controls associated with cable-tool drilling and sampling. Typical cable-tool drilling equipment is shown in Figures 7 and 8.

Table 1. Procedures Listing of WHC-CM-7-7.[3]

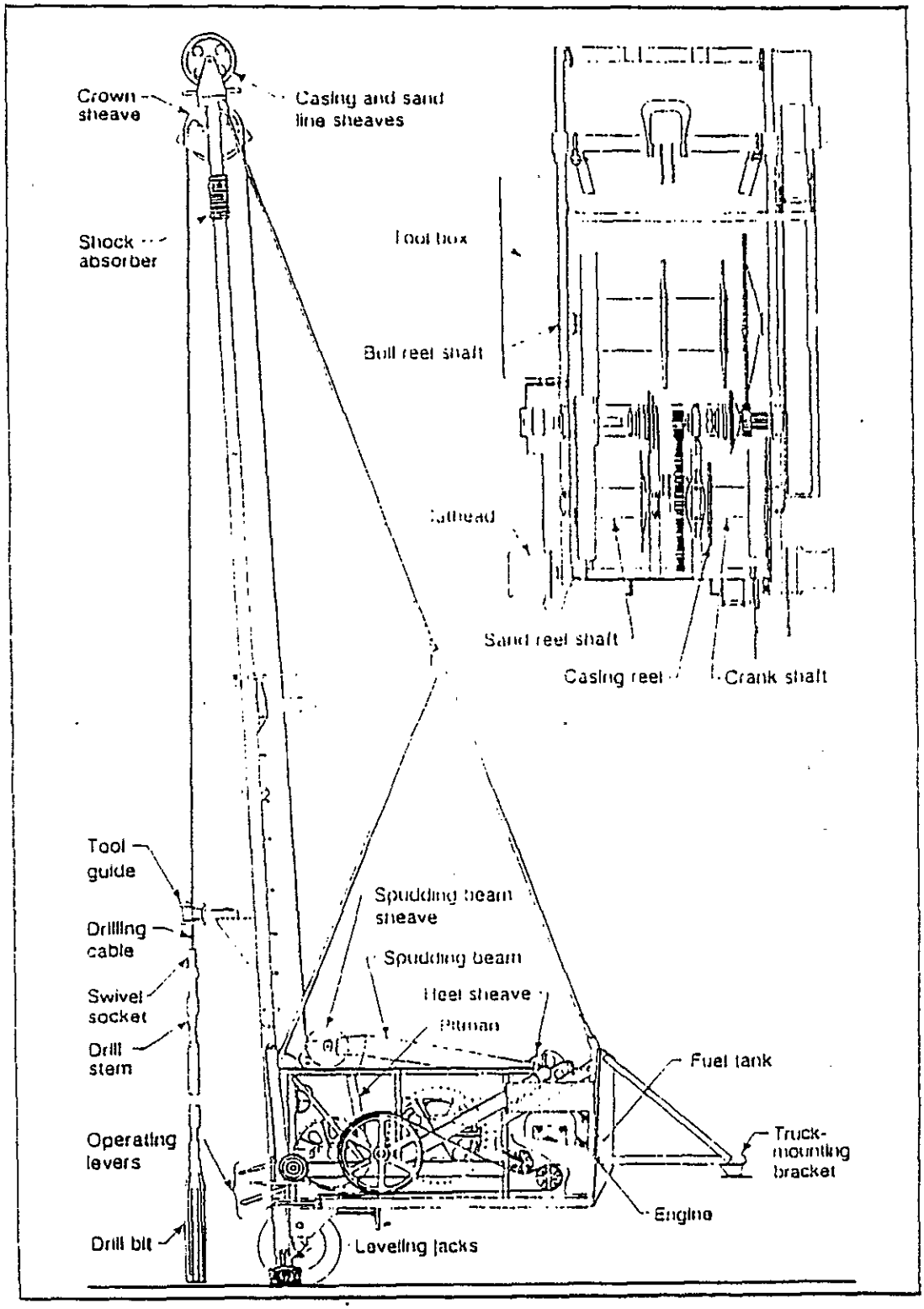
Procedure	Title	Description
EII 6.7	Ground Water Well and Borehole Drilling	Issue appropriate permits to conduct work-cultural resources review, environmental assessment, excavation permit, start cards, hazardous waste operations permit (welding and cutting).
EII 1.1	Hazardous Waste Site Entry Requirements	Conduct pre-job safety meeting and ensure personnel are trained.
EII 2.1	Preparation of Hazardous Waste Operations Permits	
EII 6.7	Ground Water Well and Borehole Drilling	Mobilize and set up drill rig.
EII 5.2	Soil and Sediment Sampling	Drive sampler to obtain sample.
WHC-CM-4-12 and WHC-CM-4-13	Operational Health Physics Practices Manual and Health Physics Manual; and Site-Specific Hazardous Waste Operations Permit and Radiation Work Procedure.	Pull sampler to ground level and survey/bag sample.
EII 5.2 and WHC-CM-4-13	Soil and Sediment Sampling; and Site-Specific Hazardous Waste Operations Permit and Radiation Work Procedure.	Open sampler/containerize sample.
EII 5.11 and WHC-CM-4-13	Sample Packaging and Shipping; and Site-Specific Hazardous Waste Operations Permit and Radiation Work Procedure.	Package and transport sample to laboratory
	Laboratory procedures	Analyze samples.
EII 4.2 and WHC-CM-4-13	Interim Control of Unknown Waste; and Site-Specific Hazardous Waste Operations Permit and Radiation Work Procedure.	Excess borehole and sample material placed in drums.
EII 4.2	Interim Control of Unknown Waste	Drums stored per Washington Administrative Code and site-specific radiation zone requirements.
EII 6.7	Ground Water Well and Borehole Drilling	Casing advanced and terminated in ground water.
EII 11.1	Geophysical Logging	Perform geophysical logging.
EII 6.5	Plugging and Abandoning of Characterization Boreholes	Abandon borehole per Washington Administrative Codes.
EII 5.4 and EII 5.5	Field Decontamination of Drilling Well Development and Sampling Equipment; and Decontamination of Equipment for RCRA/CERCLA Sampling	Decontaminate equipment.

Figure 7. Typical Cable-Tool Drill Rig.

WALKER-NEER DATA
The weights of the drill tools, i.e., bit, stem, and jars, are estimated at 1,250 lbs. when hard tooling and 750 lbs. when core barreling or split-spoon sampling. The diameter of the split-spoon samplers and drive barrel is approximately 5 in. The stroke of the tools will be 24 to 28 in. and approximately 50 strokes per minute.

Figure 8 depicts a standard cable tool drill unit with tools suspended from the derrick.

Engineering drawing of a Bucyrus-Erie Model 22-W shows how the drill line is reeved in a typical cable tool rig. The spudding action is imparted to the drill line by the vertical motion of the spudding beam. The shock absorber mounted beneath the crown block helps control the impact of the bit on the rock. (Bucyrus-Erie Company)



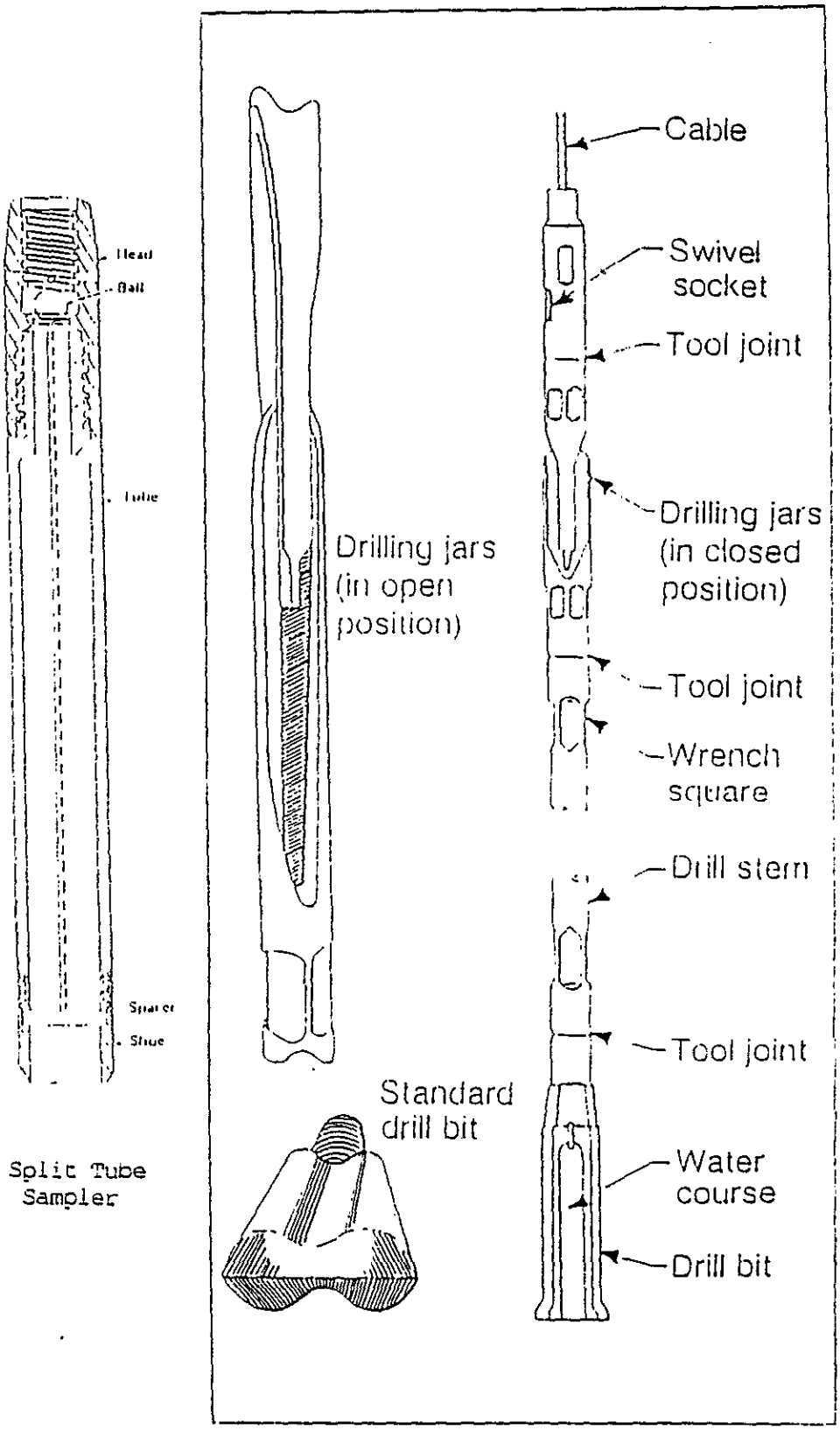


Figure 8. Typical Borehole Tools.

2.2.2 Sample Preparation

A sample core will be extracted inside a sampling truck or trailer if any toxic or radiological contamination (in excess of 10 mrem/hr at contact) is present or suspected to be present. The sample core (barrel) and its contents will be placed in a glovebox and opened, and its contents removed. The contents will be processed in a manner determined in a site-specific sampling plan. A portion of the core sample will be removed and placed into a specially prepared container for transport to a designated laboratory. The glovebox has an ancillary confinement system consisting of an air supply from the inside the vehicle. Air flows through an inlet high-efficiency particulate air (HEPA) filter and is discharged through an exhaust HEPA filter then through an activated charcoal cartridge before exhausted through the wall outside the vehicle. A variable control allows adjustment of the volumetric flow rate maintaining a negative atmosphere through the glovebox. A differential pressure gauge will monitor the pressure drop across the exhaust filters. The glovebox is equipped with an airlock on one end. The glovebox will have a bag in/bag out feature for the airlock to contain the sampler during entry and exit of the sampler. The inside dimensions of the glovebox, excluding the air lock, nominally are 30 in. wide, 18 in. deep, and 24 in. high. The glovebox is a commercially available item for this type of use. The excess soil is removed from the sampler and deposited in the appropriate container with the drill cuttings from that soil depth. No chemical or radiological additions will be added to the sample material during the sample preparation. Solid or liquid waste generated as a result of decontamination of work areas will be added to the drilling waste with the excess barrel material. Figures 9, 10, 11, and 12 show a typical sample trailer (preparation unit).

2.2.3 Interim Storage

The containers (55 gal) will meet U.S. Department of Transportation (DOT) regulations. The drill cuttings would be packaged in a plastic bag or other appropriate liner. The waste drums will be segregated according to suspected radioactive, nonradioactive waste or unknown waste. Shielded waste drums will be used if necessary to control radiation exposures. A location at or near the drill site would be used to store the waste containers while waiting for laboratory analysis to confirm the designation of the waste contents. The interim storage areas will be roped off and signs will be installed to provide the appropriate waste identification. The containers will be stored on drum pallets.

Containers of mixed waste will be properly labeled and will be placed in a metal building designed for hazardous and radioactive mixed waste. The containers will be stored in the building until laboratory and other engineering work has been completed to determine the required storage or disposal. The interim storage building has the storage capacity of 27 55-gal containers. The building interior has a chemical resistant coating, a grated floor covering and a chemical resistant containment sump with the capacity of approximately 500 gal. The building has a passive air vent. The drums will be stored compliant with EPA and Ecology policies and regulations or negotiated agreement.

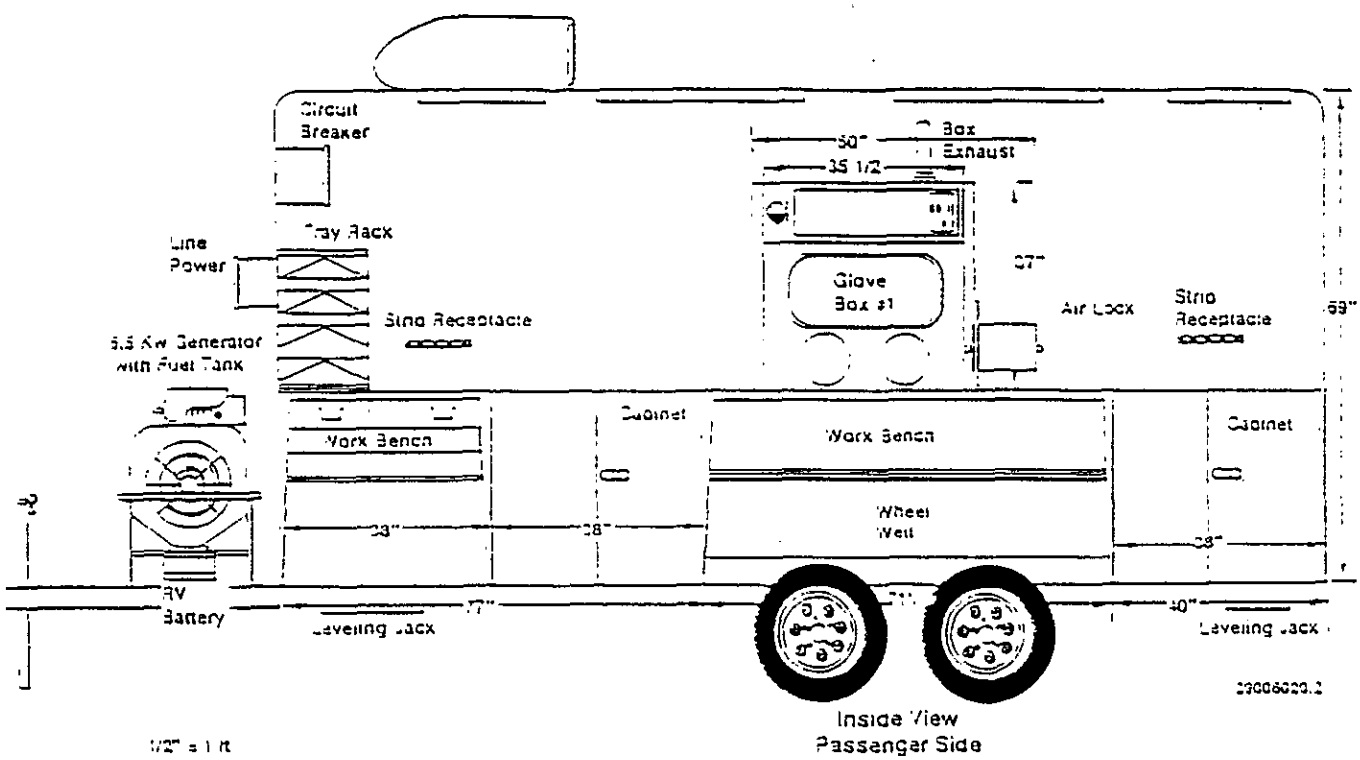


Figure 9. Sample Trailer.

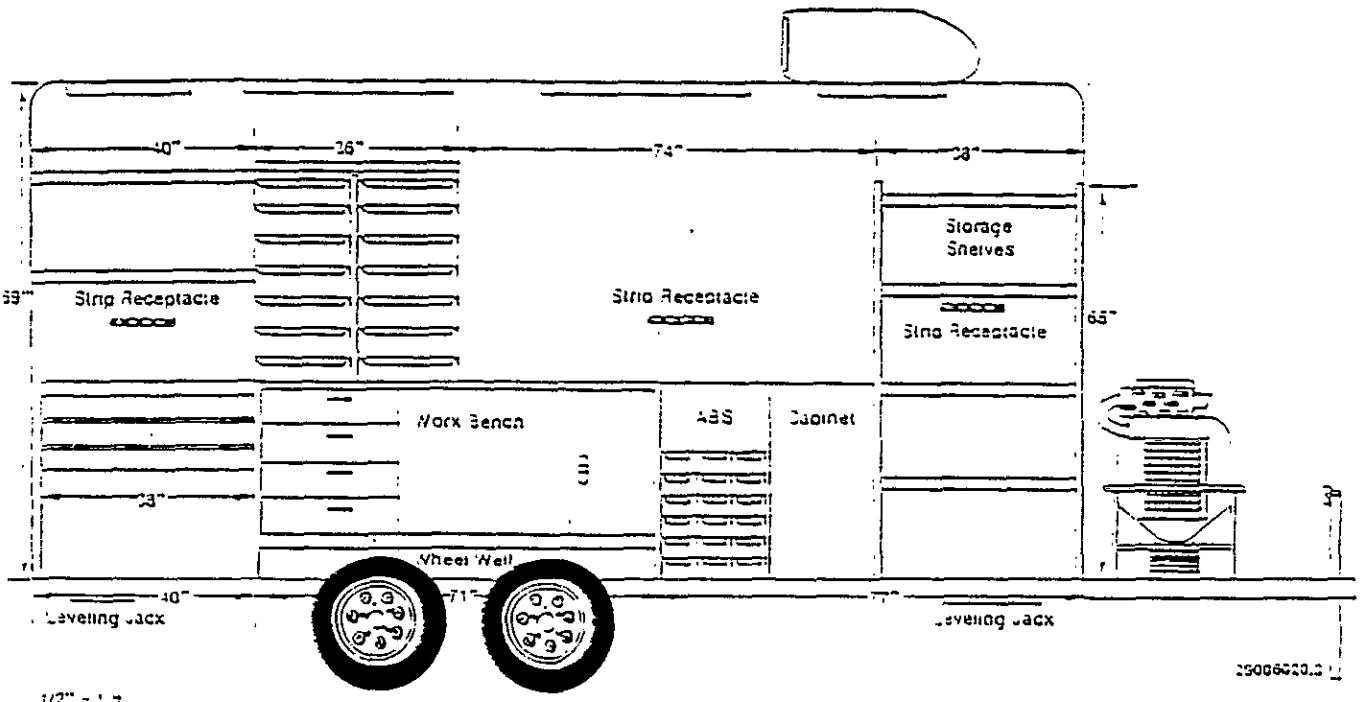


Figure 10. Sample Trailer.

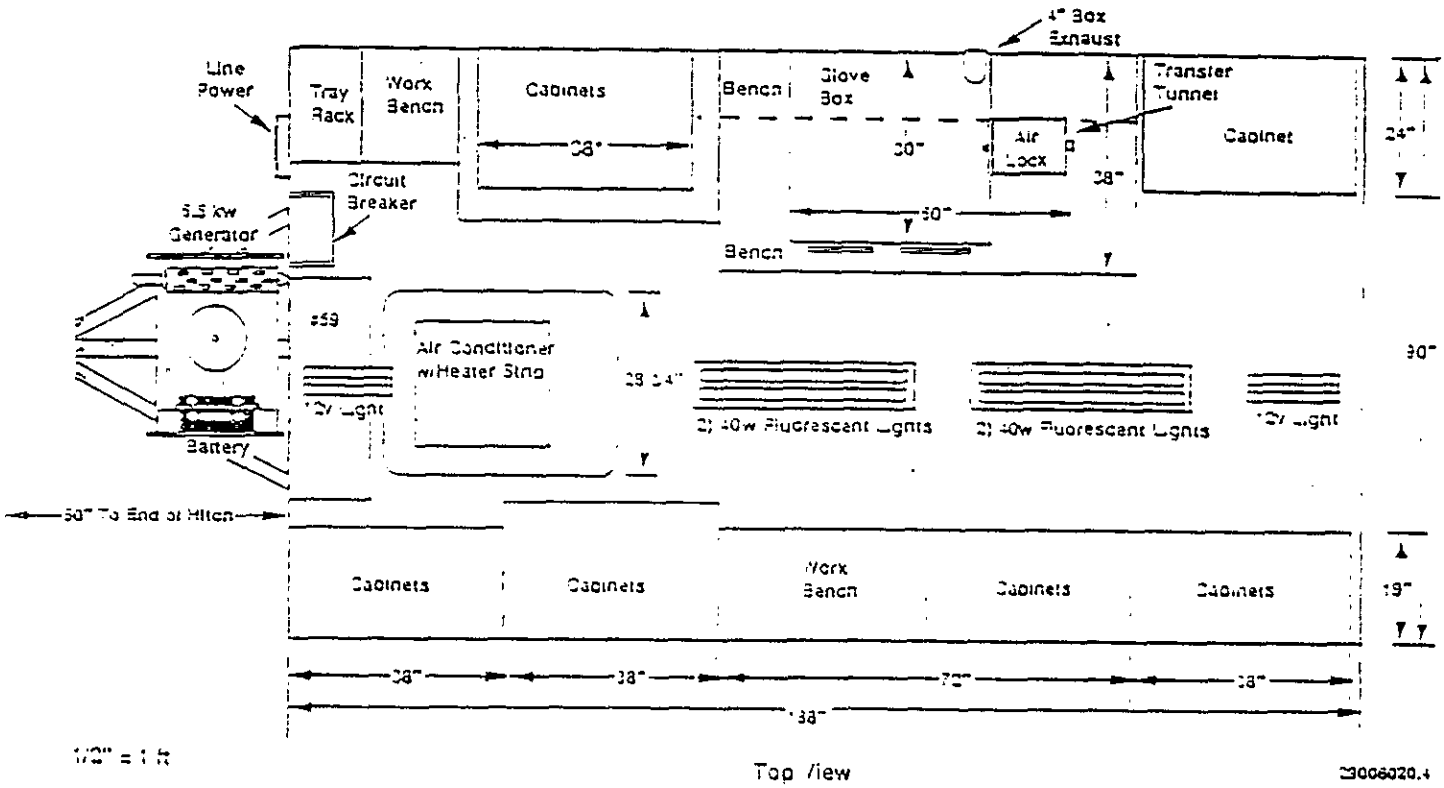


Figure 11. Sample Trailer.

Sample Trailer

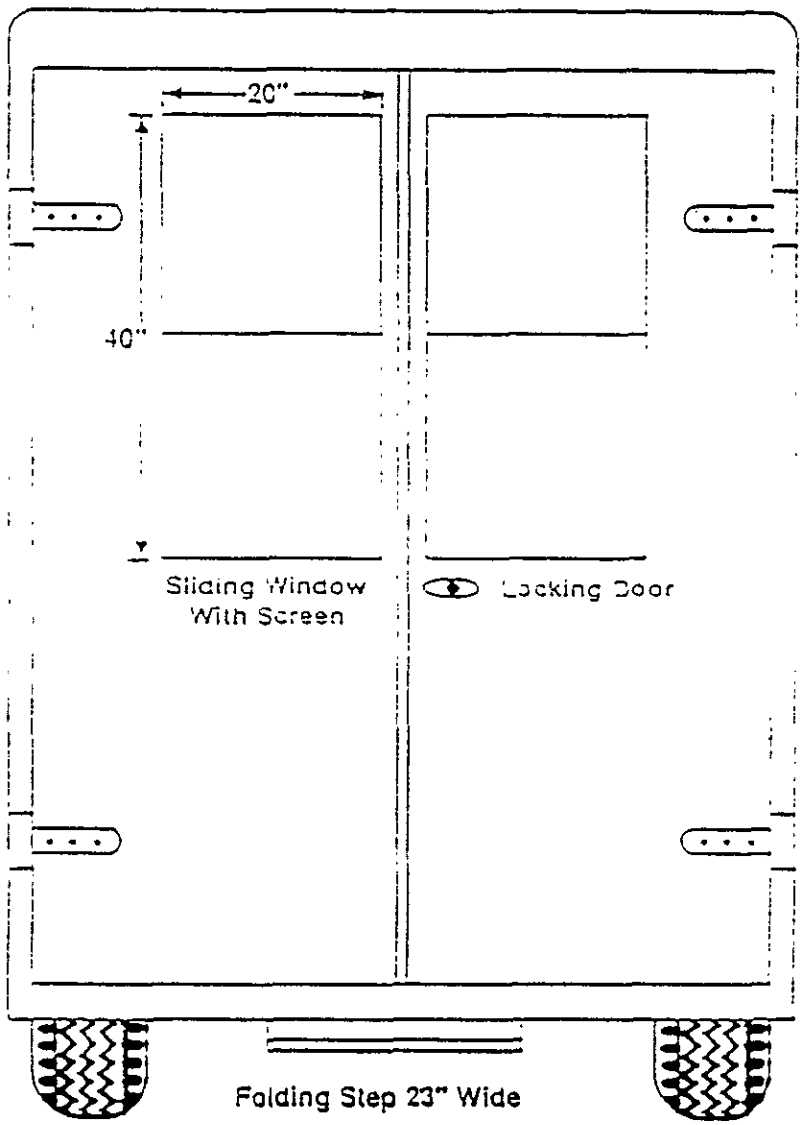


Figure 12. Sample Trailer.

3.0 HAZARDS

The intrinsic hazards for remedial investigation activities of 200-BP-1 are potential exposures and/or releases of contaminants in the soil beneath the cribs. The potential contaminants are chemicals and radioactive substances that have been discharged into the cribs. The activity segments considered are drilling/sampling (relocation), the preparation of the soil samples (packaging), and the interim storage (accumulation) of the drill cuttings. The following is a discussion of the hazards considered in the safety assessment.

3.1 INVENTORY

The subject cribs were used to dispose liquid process wastes. The 216-B-43 and 216-B-49 cribs received wastes from the tributyl phosphate (TBP) process. Crib 216-B-43 was used for a lesser period of time and received a smaller volume of waste, approximately 560,000 gal (2.1E+6 L). Crib 216-B-49 received approximately 1,770,000 gal (6.7E+6 L) and should represent the upper limits of contaminant levels from the TBP liquid wastes in the 216-B cribs. Crib 216-B-57 received a large volume of another type of process condensate from the in-tank solidification (ITS) waste process. The 216-B-61 crib is reported to have received no discharges of liquid wastes. The following is a summary of the worst-case estimate of the hazardous substances discharge to the cribs as provided by DOE/RL 88-32.[2] It should be noted that the inventories are estimated totals for the entire crib and not the inventories for the 200-BP-1 activities. The concentrations will be the same, but the inventories (total quantity) will be substantially less.

Substance	Crib 216-B-43	Crib 216-B-49	Crib 216-B-57
Chemicals			
Sodium	170,000 kg	600,000 kg	--
Nitrate	400,000 kg	1,150,000 kg	--
Sulfate	29,000 kg	80,000 kg	--
Phosphate	21,000 kg	60,000 kg	--
Ferrocyanide	1,100 kg	4,000 kg	--
Ammonia Carbonate	--	--	12,000 kg
Radionuclides			
H-3	170 Ci	536 Ci	--
Co-60	0.0157 Ci	0.09 Ci	0.015 Ci
Sr-90	630 Ci	1,240 Ci	2.01 Ci
Ru-106	--	0.00001 Ci	0.00006 Ci
Cs-137	142 Ci	198 Ci	246 Ci
Pu-239	0.029 Ci	0.86 Ci	0.011 Ci
Pu-240	0.0077 Ci	0.231 Ci	0.00287 Ci
U-238	0.00456 Ci	0.102 Ci	0.00029 Ci
Volume (liters)	2.1E+6	6.7E+6	8.4E+7
Years	1954	1955	1968-73
Duration	1 month	2 months	76 months

Additional information regarding the discharges can be found in DOE/RL 88-32.[2] Attachment 1 provides maximum concentrations of the substances that are used in the assessment and evaluations.

More detailed evaluations of ferrocyanide depositions has subsequently reduced the postulated quantities of ferrocyanide. A summary follows.

3.1.1 Ferrocyanide Fire/Explosion

The potential concentrations and distributions of the contaminants have been reviewed to determine if there is a potential for ferrocyanide to ignite or explode. The evaluation (E. C. Thornton, Attachment 3) has been performed assessing the drilling/sampling activities in the cribs. It is concluded that the chemistry and soil properties are such that a fire or explosion hazard is highly unlikely. Laboratory tests and analyses conducted to date indicate that purely mechanical insult to nickel cesium ferrocyanide with sodium nitrate and sodium nitrite should not cause a chemical reaction that could result in deflagation or detonation. The compounds of ferrocyanide are found to react with evolution of gas at temperatures above 200°C, and the rate of reaction increases with temperature. This indicates a potential for deflagations/detonation if large quantities of the ferrocyanide compound were to reach temperatures above 200°C. The examination of available data (subsequent to DOE/RL 88-32) indicates that relatively small amounts of nickel ferrocyanide solids were diverted to the 216-B-43 and 216-B-49 cribs (13.4 kg and 42.2 kg, respectively). Furthermore, the ferrocyanide compounds have been diluted by the soil to a significant extent. This information, when examined in the context of the range of reactive compositions and general soil characteristics, indicates that no credible hazard exists for generating an ignition or explosive reaction as the result of heat generated during drilling. Laboratory testing shows that the ferrocyanide compounds are insensitive to spark, impact, and frictional stresses at anticipated ambient temperatures; however, the results are not conclusive because the magnitude of laboratory stresses imposed may not be representative of those associated with drilling activities. Drilling stresses can not initiate an ignition or explosive reaction, however, because of the dilution effect of the sand and the inadequate amount of nitrate present in the soils. The detailed evaluation of ferrocyanide deposition is provided in Attachment 3.

3.1.2 Criticality

Potential criticality events do not present a hazard because of the insufficient inventory of fissionable materials in the cribs. The criticality evaluation is found in Attachment 5.

3.2 ACTIVITY HAZARDS

The controlling hazards are those associated with exposures from potential contact and releases of hazardous substances (chemical and radiological). The contact handling work procedures and potential spills of contaminated material may involve events of concern.

3.2.1 Drilling/Sampling Activities

The drilling/sampling activities have a variety of conditions that can lead to individual exposures from hazardous substances or potential releases to the environs. Procedures for drilling and sampling activities, identified as EII, can be found in WHC-CM-7-7. The more significant hazards associated with drilling/sampling is contact and handling of the drilling tools and contaminated materials. Site workers could come into direct contact with contaminated material, inhale loose particulate or volatile gases, or be exposed to the radiant energies of radionuclides bound in the vadose soils. EII 2.1, Preparation of Hazardous Waste Operations Permits, prescribes the Westinghouse Hanford procedure for preparing health and safety plans to address the hazards consistent with the requirements of Occupational Safety and Health Act (OSHA). Guidance for monitoring, tracking, retrieving, and collating personal exposures is given in EII 2.2, Occupational Health Monitoring, compliant with WHC-CM-4-3[9] and WHC-CM-4-10.[4] The tools that provide the largest volumes of soil materials to the surface are summarized in the following.

- Split barrel sampler 265 in^3 (4,343 cm^3)
- Drive barrel 2,827 in^3 (46,326 cm^3)
- Bailer 3,534 in^3 (57,912 cm^3)

Airborne release of contaminated soils is considered a potential hazard in the routine operations. Each time the drill string is removed from the borehole small quantities of borehole material can be attached to the exterior of the tool surfaces. When the drive barrels and bailers are emptied into the storage drums, there is a potential to release fractions of the soil materials into the air. Plastic liners and sleeving are barriers used to prevent releases of contaminated or potentially contaminated particulate. Instruments are used to survey the drilling tools and soils to detect contamination. Personnel are provided respirators to prevent inhalation of contaminated particulate. Pulling and removal of the well casing also presents a potential pathway for airborne release. Procedures similar to those for tool removal are used to control potential airborne releases when pulling the casings during the borehole abandonment.

Handling and decontaminating drilling/sampling tools and equipment creates the potential for workers to receive skin contaminations. Protective clothing, monitoring, and administrative controls are employed to prevent skin contaminations. Water, nonphosphate detergent and abrasives are the decontamination media permitted. This alleviates issues concerning material compatibility. Decontamination procedures are found in EII 5.4, Drilling, Well Development, and Sampling Equipment.

Direct radiation exposures are possible when drilling and sampling in the cribs. The drill string is surveyed as the cable and tools are removed from the borehole to verify if radioactive contamination is present. Procedures for surveying tools, shielding, and administrative controls are found in WHC-CM-4-12, *Health Physics Manual*, procedure IP-0692.[14] The work procedures employed include requirements for shielding and administrative controls to prevent personnel from receiving excessive exposures of direct radiation. Should detectable levels exceed 1,000 mrem/hr of contact, the operations will stop and alternative sampling methods will be employed or operations abandoned (radiation levels this high are not anticipated).

Guidance for obtaining core samples in radiologically contaminated soils can be found in draft Table 12-1, Section 12 (Contamination Control) of WHC-CM-4-10[4] and G. F. Booth memo (Attachment 2). Other guidance for radiological monitoring, surveying, and contamination control can be found in the lower-tier Westinghouse Hanford Health Physics manuals.

The potential for volatile organics requires gas monitoring of the borehole to ensure that no volatile hazards exist during drilling operations.

Requirements for monitoring of potential volatile organics will be found in the site-specific Hazardous Waste Operations Permit (HWOP) and as guided by health and safety plan in DOE/RL 88-32.[2] The air below the capped borehole is monitored before the start of the work day and periodically during the work day. Should concentrations of volatile gas be detected the borehole will be purged. If concentrations are unacceptable after purging, work will either stop or special work procedures will be effected.

Monitoring, respirators, and administrative controls will be employed to ensure personnel safety.

Upset or accidental releases from the drilling activities could occur. The potential consequences are greatest to the site worker. More detailed discussions are included in Section 3.5.3, Drilling/Sampling Segment; and Attachment 6, Hazard Screening Evaluation. An accident during routine operations may involve an instantaneous release of contaminated soil borings from a drive barrel just before or during the transfer of the material to the waste drum. An unlikely but potential borehole fire/explosion could also provide a pathway of contaminated soil to the environment.

Some potential for environmental spread is associated with the drilling activities. Perched water (small pockets) may be present in the vadose zone that could lead to the movement of contamination during the drilling process. The telescoping casing method, the relatively short drilling advancement limited by tool capacity, drilling procedures, and administrative controls limit the opportunity to spread contaminants. The borehole is also capped to prevent intrusion during off-work hours or when the weather presents unfavorable work conditions. EII 5.2, Soil and Sediment Sampling, describes the sampling techniques. The borehole may enter the aquifer by approximately 1 to 3 ft. This does not represent a significant hazard to the ground water because the aquifer intrusion is limited depth and duration. The casing is removed and the borehole is grouted closed once the sampling is completed. EII 6.5, Plugging and Abandoning of Characterization Boreholes, and the requirements for abandonment of WAC-173-160[5], Minimum Standards for Construction and Maintenance of Water Wells, will be followed.

3.2.2 Sample Preparation

The radiological and hazardous substance surveys and monitoring at the borehole help to limit the hazard concerns in the sample truck/trailer. Volatiles and unacceptable radioactivity will be controlled with the drilling procedures. The volume of material is limited to the sample barrel, 265 in^3 (4.343 cm^3). The hazards of skin contamination and direct radiation exposure are similar to those of the drilling activities. Shielding blankets will be used when required to minimize radiation exposures when handling the split

spoon sampler. Personnel monitoring and administrative controls are used to minimize personnel exposures and substance contact. Airborne releases caused from upsets or accidents within the laboratory could potentially cause some degree of hazard to the workers within the confined space of the truck/trailer. It is unlikely that any onsite or public hazard exists because the anticipated contaminant concentrations are limited and the volume of contaminated soil is limited to 265 in^3. The glovebox exhaust HEPA filter(s) would have a very small quantity of accumulated hazardous substances. The filter is not likely to contain sufficient material to pose a hazard to onsite or public sectors. Performance requirements for HEPA filters can be found in WHC-CM-7-5,[1] *Environmental Compliance Manual*, Section D8.B.4.

Potentially, the typical sample handling trailer may contain small quantities of nitric acid, hydrochloric acid, or sodium hydroxide as preservatives for water samples to be prepared for other sites and activities. To prevent unwanted reactions with soil samples from the cribs, the acid preservatives will not be allowed in the trailer or on the 200-BP-1 work site.

3.2.3 Interim Storage Segment

The drill tailings drums, once filled at the drilling site, are closed. Normally, the drums are not opened at the work site during the period of interim storage. The drums will be moved to separate areas segregated by waste types; unknown waste, hazardous wastes, radioactive waste or mixed waste. Requirements for management of the drummed waste are found in EII 4.2, Interim Control of Unknown, Suspected Hazardous, and Mixed Waste; WAC-173-303, *Dangerous Waste Regulations*[12]; and WHC-CM-5-16, *Hazardous Waste Management*.[10] The drums will be set on pallets, banded, and moved by fork lift or A frame. Mixed waste drums will be stored in an interim storage building. The other types of waste will be stored on open pads. The anticipated hazards of interim storage include direct radiation, potential ruptures and spills that could affect the local site and site workers. Although unlikely, consideration is also given to accidents that could result in catastrophic rupture of several drums or potential fires, thereby releasing fractions of the materials.

3.3 NATURAL PHENOMENA

Work activities at the site are performed during hospitable weather conditions. High winds, in excess of approximately 10 to 15 mph, thunder storms or precipitation, or the threat of these conditions, will stop work. Consequently, adverse weather conditions would present a threat to a work site that has been secured. The borehole or material containers are closed during periods of adverse weather. Specific procedures are defined in the HWOP and Radiation Work Permit (RWP) for the site.

High wind speeds up to 112 mph have been determined credible for the Hanford Site, UCRL-15910.[11] Missiles generated by high winds could penetrate the interim storage drums, which could lead to surface spills or airborne releases. High wind could provide the motive force to upset or overturn equipment, which may result in fires involving the hazardous materials.

Potential material hazard conditions caused by seismic events are limited to initiating accident events. A severe earthquake could initiate a fire breach or overturn one or more drums, breach confinement barriers in the sample preparation truck/trailer, or possibly overturn equipment.

Floods are not considered an energy source that would increase the hazard of the activity. The Columbia River represents the worst-case flood potential to the Hanford Site. The 200 East Area Plateau, where the cribs are located, is above the worst-case postulated flood by 250 to 300 ft. No other river or drainage source represents a flood threat to the site.

No other natural phenomena is expected to represent a hazard associated with an exposure event.

3.4 OTHER HAZARDS

Other hazards would be present with the drilling and sampling activities associated with the soil investigation activity. The site workers would be exposed to industrial hazards that are associated with drilling activities (i.e., noise, pinning and crushing, falls and tripping hazards, eye and skin abrasions, etc.). None of the events are associated with the consequences where the contaminated soils would increase hazard except as described previously. Industrial hazards and controls to mitigate potential industrial consequences are addressed in the HWOP compliant with 29 CFR 1910.120. The site-specific work plan, site safety plan, and radiation work permit will address occupational hazards.

3.5 ASSESSMENT SUMMARY

The radiological and toxicological dose consequences determined by the safety assessment were found to be within the criteria for low hazard activities in accordance to the criteria and guidance of WHC-CM-4-46[6] and WHC-SD-GN-ER-301.[7] Attachment 6, Hazard Screening Evaluation, provides a segment evaluation of the intrinsic hazard of the activity segment. Attachment 7, Facility Hazard Classification, provides an overall bounding analysis and hazard classification. Potential radioactive substances, the site worker, and the site environment were found controlling. However, due to the uncertainties of the inorganic and organic constituents discharged and/or complexed, qualitative identification of the compounds is limited.

The supporting analyses presented in Attachment 6 were based on worst-case conditions for radiological release and transport for each of the assumed conditions. Inventory, postulated contaminant concentrations and release fractions commonly contain uncertainties of several orders of magnitude. The analytical results, therefore, should not be construed to be expected air concentrations or radiological dose consequences that would occur during the actual operations. These results represent a worst-case situation under extremely unfavorable conditions.

However, even with the conservatism used in the analysis, the planned activities for 200-BP-1, Task 4 are classified as a low hazard. The following subsections provide a summary of the analysis found in Attachment 2.

3.5.1 Terms and Definitions

The following terms and definitions are used throughout the assessment and the analysis (Attachment 3 and Attachment 4).

Committed Effective Dose Equivalent (CEDE)--The CEDE is the weighted sum of the committed dose equivalents. The committed dose equivalent represents the total effective dose equivalent that an organ or tissue is expected to receive over a period of time (ICRP:50 yr, EPA:70 yr) following exposure. The committed dose varies with the effective half-life of the isotope in the body. The effective half-life is dependent on the radiological half-life (isotope-dependent radioactive decay) and the biological half-life (element-dependent retention in the body).

$$CEDE = \int_0^t EDE = \int_0^t H_E = \int_0^t W_T H_T$$

where t = 50 or 70 years.

Effective Dose Equivalent (EDE)--The EDE represents the overall risk from irradiation of the body under uniform or non-uniform irradiation based on the dose equivalent to specific tissues. For non-uniform radiation, such as partial radiation exposure to an external radiation field, or from internal exposure where the isotope concentrates to different degrees in various organs, weighting factors, which are based on the relative impact to the body as a whole, are used to calculate an effective dose equivalent. The EDE is therefore a weighted sum of organ doses. The EDE, H_E, is given by

$$H_E = \sum W_T H_T$$

where W_T is the weighting factor for tissue T and H_T is the dose equivalent to the tissue.

Immediately Dangerous to Life or Health (IDLH)--A maximum concentration of a substance in air from which, in the event of a failure of a respirator being worn, a worker could escape within 30 minutes without experiencing escape-impairing or irreversible health effects (NIOSH-90).[8] The IDLH is considered a maximum concentration above which only a highly reliable breathing apparatus providing maximum worker protection is permitted. It is noted for clarity that definitions other than as defined by NIOSH are widely accepted and used.

Exempt Quantity (E.Q.)--The unsealed quantities of radioactive substances above which requires activities to be classified low hazard. These quantities represent the values above, which there is regulatory concern and that requires some form of radiation protection program.[7]

Threshold Limiting Value/Time Weighted Average (TLV/TWA)--The time-weighted average concentration for a normal 8-hr work day and a 40-hr work week to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

3.5.2 Hazard Screening Values

Hazard assessment guidelines consider unmitigated radiological exposures to all individuals to determine the relative hazards of activities. The guidelines also suggest using potential toxicological substance exposures to provide the relative degree of hazard to onsite and public individuals. Screening values found in WHC-SD-GN-ER-301[7] are used to determine the relative hazard level of the concentrations derived from the analysis (Attachment 4). The IDLH and TLV/TWA values for TBP, 125 ppm and 0.2 ppm, respectively, cyanide salts, 50 mg/m^3 and 5 mg/m^3 and Ammonia, 500 ppm and 25 ppm, respectively were considered. In any of the conditions assessed, potential cyanides were the toxicological substances that provided an indicator of chemical hazard. The postulated concentrations of TBP are anticipated to be factorially lower than potential cyanide salts. The discharge concentration and subsequent drying of the soils discounted ammonia releases as controlling. The following depicts the IDLH guidance found in reference 6.

	Receptor Groups	
Hazard category	Onsite range	Offsite range
General Use	<0.1 IDLH	<0.01 IDLH
Low Hazard	≥0.1 IDLH <1.0 IDLH	≥0.01 IDLH <0.1 IDLH

The site worker is not specifically identified in the toxicological guidance as a determining factor. But, in the analysis and the assessment the TLV/TWA are also considered.

The hazard screening values for radiological substances are EDE and CEDE values reported in rem. The radiological screening values are shown below.

	Receptor Groups		
Hazard category	Site worker	onsite	offsite
General Use	<EQ*	<0.1 rem	<0.01 rem
Low Hazard	≥EQ* <25 rem	≥0.1 rem <5.0 rem	≥0.01 rem <0.5 rem

*Exempt Quantity

3.5.3 Drilling/Sampling Segment

Minor direct radiation exposures potentially exists in the drilling operations. Time, distance and shielding, and site survey and monitoring will be employed to manage personnel exposures to ALARA guidance.

No or only negligible airborne release of contaminants is anticipated. Under accident conditions instantaneous releases of contaminated particulate could occur if the containment sleeving of the drive barrel and container is lost or breached. The worst-case accidental release assessed, spilling of the

largest capacity drive barrel is an instantaneous release that would have potential consequences to the site worker. The potential radiological concentrations in moderate dust conditions would be above occupational guidelines. Anticipated consequences to an onsite or public individual are negligible to insignificant.

The potential inventory of radiological contaminants removed with one drive barrel could exceed above Exempt Quantities (EQ). The potential exceedance of the EQ supports the minimum classification of Low Hazard.

The screening evaluation (analysis) is found in Attachment 6.

3.5.4 Sample Preparation Segment

Anticipated effluents from the filtered exhaust of the sample preparation unit are anticipated to be negligible. Separate documentation regarding the regulated discharge will be provided.

Assessment of accident conditions in the sample preparation trailer indicates that a site worker in the confined space is the controlling receptor. Assuming a spill of the maximum quantity of material, 265 in^3 (4,343 cm^3), at the worst-case airborne concentrations generated by vigorous work in the unit (100 mg/m^3), and with an exposure of 2 hr is found to be within the acceptable accident consequence limits of Reference 6. The assessment assumed the air concentrations were released to the environment unfiltered. The derived consequences are summarized below.

Radiological Consequences

Receptor	EDE (rem)	Low-hazard range
Site Worker	3E+0	<25E+0
Onsite	2E-3	≥1E-1 <5E+0

Site boundary consequences would be less than the low hazard threshold. The screening evaluation (analysis) can be found in Attachment 6.

3.5.5 Interim Storage Segment

Normal work and anticipated upset conditions will not have any or only negligible hazardous material releases because contaminated materials or materials suspected to be contaminated will be contained in plastic sleeving and/or other containers. Only accidents or upset conditions would lead to releases that could affect individuals or the environment.

To provide an initial screening of the potential quantities of contaminated materials the bounding worst-case release is assessed. The entire inventory of radiological contaminants, the quantity extracted from all three contaminated cribs, are considered in the release. Using guidance from WHC-SD-GN-ER-301[7] and Appendix D Part 61, Methods for Estimating Radionuclides Emissions[13], a conservative fractional release or 0.001 is

used. The assessment considered the release of the entire fraction over a 2-hr to 8-hr period. The radiological consequences release is summarized below.

Radiological Consequences

Receptor	EDE (rem)	Low hazard range
Onsite	8E-3	≥1E-1 <5E+0

Consequences to an individual at the site boundary would be negligible or insignificant based on hazard screening values.

The screening evaluation can be found in Attachment 6. The conservatively derived assessment finds the potential unmitigated accident consequences acceptable.

3.5.6 Assessment Conclusions

The safety assessment determined that the proposed characterization and investigation segments, drilling/sampling, sample preparation, and interim storage are low hazard activities. The exposures and dose concentrations can be managed within acceptable limits onsite and offsite by providing radiological and hazardous substance survey and monitoring. The large distance between the activities and the nearest point of public access, combined with the low inventories, ensure the public is unaffected by 200-BP-1 characterization activities. Additional prudent actions invoked by EPA, Ecology, DOE, OSHA, and Westinghouse Hanford will further control and manage spills and ensure the appropriate ALARA practices. The required controls and prudent actions are discussed in the following section.

4.0 SAFETY FUNCTIONS AND CONTROLS

The required safety function provided for the characterization and investigation activities for the 200-BP-1, Task 4, is administrative survey and monitoring to control radiological exposures within occupational requirements. Occupational control will ensure onsite and public protection considering the distance between activities and the nearest point of public access, combined with the low inventories anticipated.

The following Operational Safety Limit and prudent actions will ensure that the intrinsic hazards (mechanical relocation of potentially contaminated soils, packaging of soil samples and accumulation of potentially hazardous materials) comply with the intent of DOE orders regarding appropriate and necessary controls of low-hazard activities. Industrial and occupational safety issues will be addressed in the project specific HWOP and RWP.

The following is the Operational Safety Limit established for 200-BP-1, Task 4.

4.1 OPERATIONAL SAFETY LIMIT - LIMIT THE RADIOLOGICAL CONTENT OF SOIL MATERIALS TO LEVELS APPROPRIATE FOR CONTACT HANDLING WORK PROCEDURES

4.1.1 Applicability

This limit applies to the drill cuttings and sample materials extracted from the characterization boreholes (mechanical relocation) from radiologically contaminated or potentially contaminated zones.

4.1.2 Objective

The objective of this limit is to ensure that surface inventories are safe for contact handling conditions that will also ensure onsite and offsite safety.

4.1.3 Requirement

An HPT will be provided at all times during borehole operations in contaminated or potentially contaminated zones. Measured dose rates of extracted cores shall not exceed 240 mR/hr at contact, (window closed CP). Surface measurements of drilling equipment or tools shall not exceed an Alpha reading of 7,000 dpm/100 cm^2.

4.1.4 Surveillance

An auditable survey log of the drilling equipment and tools extracted from the borehole will be maintained.

4.1.5 Recovery

In the event of instrument readings higher than allowed (Section 4.1.3), the drilling equipment or tools containing the source shall be returned to the borehole. The work will stop until a recovery work plan by line management has been approved by Safety and Quality Assurance.

4.1.6 Basis

The limits specified in the requirements are based on the maximum concentrations assessed. Work procedures (G. F. Booth, Attachment 2) would accept higher limits based on occupational safety alone. Onsite and offsite safety consequence assessments are based on the worst-case anticipated inventories. Additional analysis and assessment in accordance with DOE Order 5481.1B, Chapter 1, Basic Requirements, part A,[15] may determine that the limits of Attachment 2 are appropriate operational controls for onsite and offsite safety concerns for 200-BP-1, Task 4.

4.2 OPERATIONAL SAFETY LIMIT - LIMIT THE DRILLING/SAMPLING ACTIVITIES WHEN VOLATILE ORGANICS ARE DETECTED

4.2.1 Applicability

This limit applies to the sampling boreholes (characterization and investigation) through the 216-B-43, -49, -57 and -61 cribs in the 200-BP-1 operable unit as defined in DOE/RL 88-32.[2]

4.2.2 Objective

The objective of this limit is to ensure that drilling/sampling operations are curtailed when volatile organics are detected in the boreholes, as specified in Section 4.2.3.

4.2.3 Requirements

Routine combustible gas analysis and portable gas analysis monitoring will be conducted on an a.m./p.m. basis. If action levels are exceeded ($\geq$10% flammability) monitoring will be taken at increased frequency at the discretion of the site supervision with concurrence of the site safety representative.

Cutting and welding is not allowed if combustible gas levels are 10% or more at the well or borehole head. A 30-minute fire watch is required after hot work. Portable gas analysis monitoring will be conducted to check the borehole prior to any activity that may produce a spark or flame if combustible gas analysis readings indicate the presences of organic vapors.

4.2.4 Surveillance

An auditable site log of the borehole gas monitoring will be maintained at the work site.

Instruments will be checked, tested, and calibrated according to the Site Safety Plan/HWOP and the actions recorded in the site log.

4.2.5 Recovery

In the event of instrument readings higher than allowed (Section 4.2.3), welding, cutting or other spark producing activities will not be permitted. The borehole will be purged compliant with WHC-CM-7-7, E11 6.7, Ground Water Well and Borehole Drilling. If concentrations are still higher than allowed after purging, all drilling and sampling work will cease until a recovery work plan by line management has been approved by Safety and Quality Assurance.

4.2.6 Basis

The volatile concentrations are based on potential gases that may be encountered but can not be qualitatively predicted at this time. The concentration limits are conservatively set to provide a safety margin between detection and potential deflagration/detonation.

4.3 PRUDENT ACTIONS

The prescriptive requirements of EPA, Ecology, DOE, and Westinghouse Hanford governing the work procedures (discussed in Sections 2.0 and 3.0) provide the core of prudent actions that ensure the potential exposures will be managed to ALARA practices. Interactive discussions between safety personnel and project personnel have led the line organization to adopt additional prudent actions to enhance ALARA considerations and to ensure that the operation is maintained within the bound of the analysis. These are noted as follows:

- Restrict acid solution from the 200-BP-1 work site as a precaution to prevent potentially volatilizing substances bound in the soils
- Restrict work area access to only those site personnel that are required to perform the characterization and investigation activities
- Minimize combustible inventories within the drilling/sampling, sample preparation, and interim storage areas.

5.0 REFERENCES

1. *Westinghouse Hanford Company Environmental Compliance Manual*, Westinghouse Hanford Company, Richland, Washington.

2. *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit*, DOE-RL 88-32, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

3. *Environmental Investigations and Site Characterizations Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

4. *Radiation Protection Manual*, WHC-CM-4-10, Westinghouse Hanford Company, Richland, Washington.

5. *Minimum Standards for Construction and Maintenance of Water Wells*, WAC-173-160, Washington State Department of Ecology, Olympia, Washington.

6. *Nonreactor Facility Safety Analysis Manual*, WHC-CM-4-46, Westinghouse Hanford Company, Richland, Washington.

7. *Implementation Guideline for Hazard Documentation*, WHC-SD-GN-ER-301, September, 1990, Westinghouse Hanford Company, Richland, Washington.

8. "Pocket Guide To Chemical Hazards," NIOSH-90, June 1990, U.S. Department of Health and Human Services, Washington D.C.

9. *Industrial Safety Manual*, WHC-CM-4-3, Westinghouse Hanford Company, Richland, Washington.

10. *Hazardous Waste Management*, WHC-CM-5-16, Westinghouse Hanford Company, Richland, Washington.

11. "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards," UCRL-15910, June 1990.

12. *Dangerous Waste Regulations*, WAC-173-303, Washington State Department of Ecology, Olympia, Washington.

13. "Rules and Regulations," 55 FR 240, *Federal Register*, Vol. 54, No. 240, December 15, 1989, Washington, D.C.

14. *Health Physics Manual*, WHC-CM-4-12, Westinghouse Hanford Company, Richland, Washington.

15. *Safety Analysis and Review, System*, Chapter 1, "Basic Requirements," DOE Order 5481.1B, U.S. Department of Energy, Washington, D.C.

ATTACHMENT 1

INVENTORY BASIS

FOR SOURCE TERMS

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ATTACHMENT 1

Crib Inventory

The contamination in the vadose zone is a residual of chemicals and radionuclides bound and filtered from the discharged liquid wastes. The liquids discharged were the residual liquids from a flocculation or settling process that was performed in the BY storage tanks. Chemicals were added to the BY storage tanks to precipitate radioactive contaminants to the tank bottoms. The process was performed using a cascading sequence. Flocculent was added and settling time was given to progressively precipitate the radioactive contaminants. The effectiveness of the process was not well documented leaving questions regarding the specific characteristics of the residue retained in the soil column.

DOE/RL 88-32[2] is a remedial investigation/feasibility study (RI/FS) work plan of the 200-BP-1 operable unit prepared for the EPA. The document includes a conservative reconstruction of postulated liquid discharges to the cribs. The following is a summary of the postulated discharges.

TOTAL DISCHARGES

SUBSTANCE (chemicals in kg)	216-B-43	216-B-49	216-B-57
Sodium	1.70E+5	6.00E+5	--
Nitrate	4.00E+5	1.15E+6	--
Sulfate	2.90E+4	8.00E+4	--
Phosphate	2.10E+4	6.00E+4	--
Ferrocyanide*	1.10E+3*	4.00E+3*	--
Ammonia Carbonate	--	--	1.20E+4
(radionuclide in Ci)			
H-3	1.70E+2	5.36E+2	--
Co-60	1.57E-2	9.00E-2	1.50E-2
Sr-90	6.30E+2	1.24E+3	2.01E+0
Ru-106	--	1.00E-5	6.00E-5
Cs-137	1.42E+2	1.98E+2	2.46E+2
Pu-239	2.90E-2	8.60E-1	1.10E-2
Pu-240	7.70E-3	2.31E-1	2.87E-3
U-238	4.56E-3	1.02E-1	2.90E-4
Volume (liters)	2.10E+6	6.70E+6	8.40E+7
Year(s)	1954	1955	1968-1973
Duration	1 month	2 months	76 months

*The discharges of ferrocyanide were recently evaluated. The recent evaluation (Attachment 3, E. C. Thornton) reduces the estimated ferrocyanide quantity in the 216-B-43 and -49 cribs. The revised quantity is discussed below.

Concentrations

The contaminant inventory in the vadose zones is unknown. The postulated discharged liquids, of such high ionic values, limit our abilities to predict the residual concentrations without extensive laboratory simulation. To address the potential bounding concentration of the substances in the vadose zones; simplified and conservative assumptions were made. Westinghouse Hanford Environmental Technology developed a basis which assumes that the radionuclides are confined in a 4-ft deep cylinderical zone beneath each crib. Significant amounts of tritiated water are not expected to be retained in the soil. Westinghouse Hanford Environmental Engineering, developed a basis that has a fraction of the soluble chemicals residing in the soil. Westinghouse Hanford Geosciences reviewed the basis and concurred that the radionuclide concentration assumption would be a bounding case and that the fraction derivation would reasonably represent the chemical components that would remain in the soil. (See Geoscience letter appended to Attachment 2.) For purposes of conservatism, an assumption that the soils acted as a filter and that ferrocyanide behaved as easily filtered particulate is also made. This was made to derive a worst case concentration of ferrocyanide. The postulated concentrations of the constituents are summarized in the following.

MAXIMUM CONCENTRATIONS

SUBSTANCE (contamination) (volume) (chemicals/ppm)	216-B-43 (142 m^3)	216-B-49 (142 m^3)	216-B-57 (170 m^3)
Sodium	8.00E+3	8.96E+3	--
Nitrate	1.89E+4	2.24E+4	--
Sulfate	1.37E+3	1.19E+3	--
Phosphate	9.91E+2	8.96E+2	--
Ferrocyanide g/cm^2*	1.15E-2	3.62E-2	--
Ammonia Carbonate	--	--	1.40E+1
(radionuclides/uCi/cm^3)			
H-3	--	--	--
Co-60	1.10E-4	6.33E-4	8.65E-5
Sr-90	4.44E+0	8.73E+0	1.18E-2
Ru-106	--	7.04E-8	3.50E-7
Cs-137	1.00E+0	1.39E+0	1.45E+0
Pu-239	2.00E-4	6.03E-3	6.23E-5
Pu-240	5.42E-5	1.63E-3	1.69E-5
U-238	3.21E-5	7.18E-4	1.70E-6

*Sodium nickel ferrocyanide complex has been evaluated to be the controlling ferrocyanide compound (E.C. Thornton, Attachment 3). The concentration of the ferrocyanide compound assumes that a silt lens has filtered and retained the ferrocyanide particulate over a 116.4 m^2 area (the same area used for radioactive isotope concentrations).

Other Characteristics

Chemical constituents were evaluated to identify potential hazards. Three substances were considered; ferrocyanide, ammonium carbonate, and tributyl phosphate.

The postulated inventories of ferrocyanide were evaluated to determine if a fire or explosion hazard exits. The evaluation (Attachment 3) found that the ferrocyanide accumulation presents no fire or explosion hazard.

The potential of volatile gases from the ferrocyanide discharges was also evaluated. It was concluded that only in the presence of acids could free cyanide gases evolve. The native soil characteristics and the liquids discharges are basic. No acids will be present on the site to initiate reactions to generate free cyanide gas.

Ammonium carbonate decomposes on exposure to air with loss of NH_3 and CO_2 and converting to sodium bicarbonate. The alkaline discharges and drying action following the discharges termination is expected to have liberated the free ammonia and carbon dioxide. The ammonium carbonate does not represent a hazard to the activities for 200-BP-1.

The discharges to cribs 216-B-43 and -49 are associated with tributyl phosphate (TBP) process. The document DOE/RL 88-32 found that the TBP concentrations, if any, in the vadose zone to be insignificant.

For purposes of the hazard evaluation, cyanide compounds are the controlling hazardous substances. The evaluation assumes that residual cyanide compounds similar to potassium cyanide or sodium cyanide may have formed from the discharges to the cribs. These substances are identified as hazardous substances[5] with airborne concentrations, Immediately Dangerous to Life and Health (IDLH) at 50 mg/m^3. The airborne concentration Time Weighted Average (TWA) for these substances is 5 mg/m^3.

Other hazardous chemical compounds may exist as a result of the discharges into the cribs. But due to the complexity of the discharged effluents and because of the limited historical data, the actual substances are unknown.

References

Remedial Investigation/Feasibility Study Wrok Plan for the 200-BP-1 Operable Unit, DOE/RL-88-32, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

Minimum Standards for Construction and Maintenance of Water Wells, WAC-173-160, Washington State Department of Ecology, Olympia, Washington.

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ATTACHMENT 2

RADIATION WORK CRITERIA

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From: Lester K Aldrich II at ~WHC145
Date: 1/29/91
To: Larry C Brown at ~WHC37
William A Decker Jr at ~WHC34
Karl R Fecht at ~WHC68
M (Mano) Kaviani at ~WHC80
Robert E Heineman at ~WHC62
Mark E Hevland at ~WHC62
Richard A Hughes
Stephen R Johnson at ~WHC62
Barry L Poorman
Kris A Smith at ~WHC62
Dennis S Takasumi at ~WHC82
Robert J (Bob) Thomas at ~WHC110
Wendy S Thompson at ~WHC142
Richard L Watts at ~WHC118
Gary F Boothe
Subject: Radiological Criteria for Core Sampling - Extension

REF: Letter 33160-90-GFB-047, G.F. Boothe to W.H. Price, "Radiological Criteria for Obtaining Core Samples in Radiologically Contaminated Soils" dated October 8, 1990.

The reference letter provided interim radiological criteria and guidance for core sampling in contaminated soils. The letter stated the interim criteria would expire January 31, 1990. The interim criteria was established to provide guidance until publication of criteria in WHC-CM-4-10. The revised sections of WHC-CM-4-10 are still in the review and approval cycle.

The expiration date for criteria in the reference letter is hereby extended to March 31, 1991.

/s/ L.K. Aldrich, II, for
G.F. Boothe, Manager
Radiological Engineering

Westinghouse
Hanford Company

From: Radiological Engineering 33160-90-GFB-047
Phone: 376-4739 L8-16
Date: October 8, 1990
Subject: RADIOLOGICAL CRITERIA FOR OBTAINING CORE SAMPLES IN RADIOLOGICALLY CONTAMINATED SOILS

To: W. H. Price S0-03

cc:

L. C. Brown	H4-51	W. C. Mallory	S5-51
W. A. Decker	S0-02	D. J. Moak	S0-03
H. D. Downey	S0-04	B. L. Poorman	L8-16
K. R. Fecht	H4-56	K. A. Smith	G4-08
J. M. Garcia	X0-04	D. S. Takasumi	R3-27
R. E. Heineman, Jr.	R3-12	R. J. Thomas	T4-20
M. E. Hevland	R3-12	W. S. Thompson	S0-04
R. A. Hughes	L8-16	R. L. Watts	L6-52
S. R. Johnson	R3-12	GFB File/L8	

Reference: Internal Memo, 33160-90-GFB-030, W. H. Price from G. F. Boothe, same subject, dated July 16, 1990.

This is a revision to the reference letter regarding radiological release criteria for drilling operations. The criteria specified in this letter is interim and shall expire on January 31, 1991.

The intent of the criteria below is to ensure that in conducting drilling operations, all radioactive contamination is contained or confined, that no new contaminated outdoor areas are created, and that personnel doses are ALARA.

Before detailing the specific radiological criteria that applies to coring or drilling, some definitions are appropriate.

"Contaminated soil" or "contamination" means that the radioactivity within soil or within cores is detectable with portable instrumentation normally used by Health Physics Technicians (HPT) at the surface of the soil or core. In those cases where, in the judgement of the Area Health Physics Manager, the soil could exclusively contain radionuclides not normally detectable with portable instrumentation (e.g., tritium, carbon-14, iodine-129, etc.), "contaminated" means that the concentration of those radioactive materials exceeds:

200 pCi/gram total beta/gamma activity, OR

60 pCi/gram total alpha activity

"Surface contamination" means radioactivity on the surface of materials or equipment that is detectable with portable instrumentation. In those cases where, in the judgement of the Area Health Physics Manager, materials or equipment could be contaminated exclusively with radionuclides not normally detectable with portable instrumentation, "surface contamination" means that the total radioactivity on the material or equipment does not exceed an exempt quantity as defined in WHC-CM-4-10, "Radiation Protection".

General Criteria. The following general good practices shall apply to drilling and coring operations:

* Prior to boring into soil containing radioactive contamination, a calculation shall be made with the best available site data to estimate the expected radioactive concentrations within cores and expected dose rates that may be encountered. The Radiation Work Permits (RWP) and ALARA Management Worksheets (AMW) shall use these estimates and the job shall be planned accordingly.

* HPT coverage shall be provided at all times during boring operations into known contamination (e. g., cribs) to ensure compliance with the criteria specified herein.

* For all cores containing radioactive contamination or with surface contamination, the following practices shall be employed:

  - The cores shall be double-wall OR sleeves shall be employed to maintain contamination control at all times.

  - The cores or surface contaminated equipment shall not be placed directly on the ground. Plastic sheets, troughs, or other materials shall be employed to prevent the spread of contamination.

  - If samples are to be taken from the cores outdoors (i.e. exposed to the ambient air), steps shall be taken to prevent any loss or spread of contamination. This can be accomplished with the use of troughs or ground sheets, provided that the wind does not exceed 15 mph. If the wind exceeds 15 mph, no attempt shall be made to sample cores outdoors or expose radioactive contamination to the environment. In some instances, wind velocities exceeding 15 mph may preclude drilling or core pulling altogether (i.e., if detectable radioactivity would be spread by the winds).

- Gloves and other appropriate protective clothing shall be worn by all personnel handling contaminated or potentially contaminated soils or equipment and other provisions of the RWP and AMW shall be adhered to.

High External Radiation Rates. If the initial calculation of dose rates from cores exceeds 10 mrem/hr @ contact OR, if the actual dose rate measured from a core exceeds 10 mrem/hr @ contact, no attempt to sample the core outdoors shall be made. Additionally, provisions shall be devised and employed to limit doses to personnel handling the cores to ALARA. These provisions shall be formulated in pre-job planning and shall be available, even if expected dose rates do not exceed the 10 mrem @ contact criteria. (The latter requirement is due to the uncertainty in predicting the dose rates from cores in some cribs). Special provisions include moving the cores indoors or utilizing a glove box or other greater containment. Doses can be reduced by:

- The use of shielding
- Keeping all nonessential personnel in a low dose rate area
- Limiting time of exposure and numbers of personnel near the core
- The use of shielded transport containers

At all times, containment of the core shall be maintained with a sleeve or with other appropriate methods.

Very High External Radiation Rates. If the initial calculation of dose rates from cores exceeds 1,000 mrem/hr @ contact OR if the measured dose rate from a core exceeds 1,000 mrem/hr @ contact during the job, the job shall not be performed or the job shall be shut down immediately. Alternative methods for sampling the underground radioactivity should be pursued.

High Alpha Contamination. If the initial calculation of alpha concentrations in the core exceeds 10 nCi/gram OR, if alpha contamination levels measured at the external surface of the core, soil, or the surface of any material or equipment exceed 4,000 dpm/cm^2, no attempt shall be made to sample the core outdoors. Special provisions shall be devised

and employed to ensure containment, such as going indoors or utilizing a glove box or other form of greater containment. These provisions shall be formulated in pre-job planning relative to TRU or uranium cribs and shall be available in such cases.

If you have any questions regarding the above interim criteria, please contact L. K. Aldrich, 6-4139, for clarification.

G. F. Boothe, Manager
Radiological Engineering

cab

References

Radiation Protection Manual, WHC-CM-4-10, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT 3

ASSESSMENT OF FERROCYANIDE

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ATTACHMENT 3

EVALUATION OF HAZARDS ASSOCIATED WITH DISPOSAL OF FERROCYANIDE TO 200-BP-1 CRIBS BASED ON CHEMICAL INVENTORIES AND BEHAVIOR

E.C. Thornton
Rev. 4/22/91

Introduction

Several action items were identified in a meeting held on March 15, 1991, which was convened to address "Safety Aspects of Drilling Vadose Zone Characterization Boreholes Through Cribs Potentially Containing Ferrocyanide" (Kaczor 1991). This report is being provided to respond to those issues that are related to information needs associated with chemical inventories of components introduced to the cribs (216-B-43 and 216-B-49) and the conditions necessary for potential ignition or explosive reactions involving these components. The specific information requirements may be stated as follows:

- Define the maximum amount of ferrocyanide that could have been diverted to the cribs.
- Define the maximum amount of nitrate that could have been diverted to the cribs.
- Assess the credibility for potential ignition or explosion of nickel ferrocyanide and nitrate mixtures through application of heat, based on chemical inventories and soil characteristics.
- Document the potential for ignition or explosion of the above mixtures by sparks, impact, or friction.

Background

A summary of the operational history associated with the waste fluids diverted to the 216-B-43 and 216-B-49 cribs has been provided by Anderson and Mudd (1979), DOE (1990), and Waite (1990). The original source of this material was waste remaining after extraction of plutonium from irradiated reactor fuels by the bismuth phosphate process. This waste, which has been referred to as bismuth phosphate or metal waste, was subsequently stored in single shell tanks, such as those in the 241-BY Tank Farm.

U Plant was utilized from 1952 to 1958 to recover uranium from the metal wastes by the tributyl phosphate (TBP) process. During this period, the metal waste was transferred from the 241-BY Tank Farm to U Plant, where the sludge was dissolved in nitric acid and the uranium extracted using TBP. The TBP waste was then treated with ferrocyanide and nickel to scavenge cesium by coprecipitation in a mixture of nickel ferrocyanide compounds. The scavenged waste was made alkaline and then transferred back to the 241-BY Tank Farm and the precipitate allowed to settle. The supernatent was cribbed after the activity of Cs-137 dropped below 0.1 µCi/ml (Burns et al. 1954).

Ferrocyanide Inventory

An estimate of the total inventories of ferrocyanide diverted to the 216-B-43 and 216-B-49 cribs can be obtained by considering the chemical flow sheets associated with the scavenging process and historical information related to disposal activities.

Chemical flow sheets pertinent to this report are presented in Smith and Coppinger (1954). The scavenging process involved making the acidified waste 0.005M in $K_4Fe(CN)_6$, adding NaOH to bring the pH up to about 9, and adding $NiSO_4$ to 0.005M. This resulted in the coprecipitation of the cesium in salts of nickel and ferrocyanide. Although the composition of these compounds is not precisely known, they probably consisted primarily of $Na_2NiFe(CN)_6$ and $NaCsNiFe(CN)_6$ with smaller amounts of $Cs_2NiFe(CN)_6$ and $Ni_2Fe(CN)_6$. It is important to note that the nickel ferrocyanide compounds are very insoluble. Thus, essentially all of the nickel added to the waste should have been taken up into the precipitates. Some ferrocyanide could remain in solution, however, if an appreciable portion of the precipitate consisted of nickel ferrocyanide. The concentration of ferrocyanide remaining in solution should theoretically lie in the range from 0 to 0.0025M. To be conservative, it will be assumed in this report that the concentration of dissolved ferrocyanide was 0.0025M (or 0.53 g/l as $Fe(CN)_6^{4-}$) in the waste supernate following completion of the scavenging process. The total inventories of dissolved ferrocyanide diverted to the cribs are as follows:

Crib #	Total Volume of Liquid*	Total Dissolved Ferrocyanide**
216-B-43	2,120,000 liters	1124 kg
216-B-49	6,700,000 liters	3551 kg

*Stenner et al, 1988.
**Calculated as described above and baseline for DOE, 1990.

A primary objective of this report is to assess the amount of nickel ferrocyanide precipitate that might have been diverted to the 216-B-43 and 216-B-49 cribs. This is dependent on the extent of settling of these compounds prior to diversion of the supernate to the cribs. It is not possible to accurately assess this, since the supernatant fluids were not analyzed for ferrocyanide particulates during cribbing. These fluids were monitored for Cs-137 activity, however, which was required to be below 0.1 µCi/ml. An estimate of the amount of precipitate remaining in the supernate may thus be provided by the Cs-137 decontamination factors associated with this requirement. Typical Cs-137 activities of about 20 to 30 µCi/ml before scavenging suggest that decontamination factors of 250 were routinely attained during the scavenging process (see Table I of Sloat 1955). Laboratory evaluation of the scavenging process, furthermore, indicated that decontamination factors of 300 or greater could be anticipated if a week was allowed for settling of the precipitate (Burns et al. 1954 and Table I of Sloat 1955). Based on the knowledge that the total concentration of ferrocyanide added during scavenging was 0.005M and assuming that a decontamination factor of 250 was attained during settling, the inventories of nickel ferrocyanide solid material potentially diverted to the cribs may be

estimated. This information is presented below, where nickel ferrocyanide is expressed as $Na_2NiFe(CN)_6$:

Crib #	Total Volume of Liquid	Total $Na_2NiFe(CN)_6$
216-B-43	2,120,000 liters	13.4 kg
216-B-49	6,700,000 liters	42.2 kg

Nitrate Inventory

Chemical flow sheets indicate that TBP wastes scavenged in the U Plant contained approximately 3.3M nitrate (Smith and Coppinger 1954). This corresponds to 205 g/l NO_3^-, or approximately 16 wt% dissolved nitrate for a brine with a specific gravity of 1.3. This will also be the concentration of dissolved nitrate diverted to the cribs, assuming that no significant dilution or concentration activities occurred. Estimated inventories of dissolved nitrate disposed of in the cribs are presented below:

Crib #	Total Volume of Liquid	Total Dissolved Nitrate
216-B-43	2,120,000 liters	434 kg
216-B-49	6,700,000 liters	1374 kg

Assessment of the Reactivity of Ferrocyanide-Nitrate Mixtures at Elevated Temperatures

Testing activities have been conducted by Pacific Northwest Laboratory (PNL) and Los Alamos National Laboratory (LANL) to document the reaction characteristics of $Cs_2NiFe(CN)_6$ in mixtures of nitrate and nitrite (Burger and Scheele 1991). These tests consisted of thermal and explosive tests intended to identify initial reaction temperatures and explosion temperatures, respectively. The thermal tests indicated that initiation of exothermic reactions with these mixtures may occur at temperatures as low as 230°C. Explosive events are generally not observed until temperatures in excess of 340°C are attained. It was observed, however, that EDTA lowers the explosion temperature to 280°C.

Thermodynamic considerations provide another approach to evaluating the potential for initiation of a reaction between these components. That is, a reaction may generate energy and thus support ignition within specific compositional ranges. This approach requires definition of probable reactions and the utilization of thermodynamic data and relationships to determine which mixtures will react in an exothermic manner. It is also possible to predict the effect of diluent matter on quenching the reaction, since the specific heat capacity of most materials is well known. Water is particularly important with respect to the latter, since the heat of vaporization is large.

Triangular diagrams may be utilized to illustrate the range of endothermic versus exothermic reaction behavior as a function of the relative proportions of fuel, oxidizer, and diluent. A diagram of this type has been constructed by M. D. Crippen and is presented in Figure 1. Note that the vertices of the triangle utilize $Na_2NiFe(CN)_6$ as the fuel, $NaNO_3$ as the oxidizer, and sand as the diluent. An internal boundary is also shown, which

represents the division between the fields of endothermic and exothermic behavior. This boundary has been constructed under the assumption that NO and N_2O are generated during the reaction, which is consistent with available laboratory data. This reaction can be written as

$$Na_2NiFe(CN)_6 + 10NaNO_3 = FeO + NiO + 6Na_2CO_3 + 6N_2O + 4NO$$

which has a heat of reaction of -435 kcal (M.D. Crippen pers comm).

Note that the area of the diagram that is theoretically combustible is relatively large. Much of this area can be disregarded, however, since the soils beneath the cribs represent a significant diluent. It is possible to define the areas within the diagram that pertain to the cribs by considering soil characteristics and chemical inventories.

Let us assume that the porosity of the crib gravel and underlying soils is a conservative 40%. This pore space will contain some combination of nickel ferrocyanide, nitrate, water, and air. Air may be neglected since it will have little effect on the reactions owing to its low heat capacity and insignificant oxidizing capacity relative to nitrate. It will also be assumed in this presentation that the specific retention of the soil for the waste water is 10 volume% immediately following drainage, but eventually decreases to less than 5% as the soil drys out (Bear and Verruijt 1987). This residual water will also be neglected, although it would serve to markedly reduce the potential for reaction because of its large quenching capacity.

Two scenarios have been proposed to represent feasible distributions of ferrocyanide and nitrate in the crib soils (Kaczor 1991). In the first case, consider a homogeneous infiltration of waste water containing dissolved ferrocyanide and nitrate through the soils. Solid nickel ferrocyanide will be ignored in this case, since the inventory is inconsequential (see above). The amount of fluid in the soil will initially be approximately 10 volume% following drainage. The amount of nitrate salts remaining after the soil dries out will be about 1.4 wt% and ferrocyanide salts will be about 40 ppm, based on the inventories presented earlier and assuming densities of 2.3, 2.26, and 1.88 g/cm^3 for sand, sodium nitrate, and ferrocyanide solids, respectively. Thus, a mixture consisting of about 98.6 wt% sand, 1.4 wt% nitrate, and negligible ferrocyanide will result. This mixture is represented in Figure 1 by the point labeled "Case I". Note that this mixture lies in the area that is endothermic and thus would not be ignitable.

In the second case, consider the hypothetical situation where a low permeability soil horizon underlies a more permeable one. It is possible that this may serve as a trap for fine particles of the nickel ferrocyanide that entered the crib. Assume that half of the pore space is packed with this material and that the initial moisture content is again 10 volume%. If this soil dries out, a cubic centimeter of the resulting mixture will consist of about 1.38 grams of sand, 0.02 grams of sodium nitrate, and 0.38 grams of $Na_2NiFe(CN)_6$. This corresponds to 77.5 wt%, 1.1 wt%, and 21.4 wt% of the above components. This mixture is also not ignitable, as can be observed from the location of the point designated "Case II" in Figure 1.

Sensitivity of Ferrocyanide-Nitrate Mixtures to Sparks, Impact, and Friction

In addition to heat tests, LANL evaluated mixtures of $Cs_2NiFe(CN)_6$ and nitrate for sensitivity to sparks, impact, and friction (Burger and Scheele 1991 and unpublished LANL project report). LANL characterized the mixtures as safe to handle from an explosives point of view. That is, these mixtures did not react under the most severe conditions attained in the impact and friction tests. Although reactions were observed in the spark-sensitivity tests, the energy of the electrical discharges required to generate explosive reactions were much higher than that required to ignite all but the most insensitive explosives.

Although the information provided by LANL indicates that ferrocyanide-nitrate mixtures are relatively unreactive to spark, impact, and frictional stresses, it must be recognized that the conditions imposed by the laboratory tests may not be as severe as those associated with drilling activities.

Conclusions

An examination of available data indicates that relatively small amounts of nickel ferrocyanide solids were diverted to the 216-B-43 and 216-B-49 cribs. Furthermore, ferrocyanide and nitrate salts have been diluted by the soil to a significant extent. This information, when examined in the context of the range of reactive compositions and general soil characteristics, indicates that no credible hazard exists for generating an ignition or explosive reaction as the result of heat generated during drilling.

Laboratory testing has also shown that $Cs_2NiFe(CN)_6$ and nitrate mixtures are insensitive to spark, impact, and frictional stresses. These tests should not be taken as conclusive since the magnitude of the stresses imposed may not be representative of those associated with drilling activities. Drilling stresses cannot initiate an ignition or explosive reaction, however, because of the diluting effect of the sand and the inadequate amount of nitrate present in the soils.

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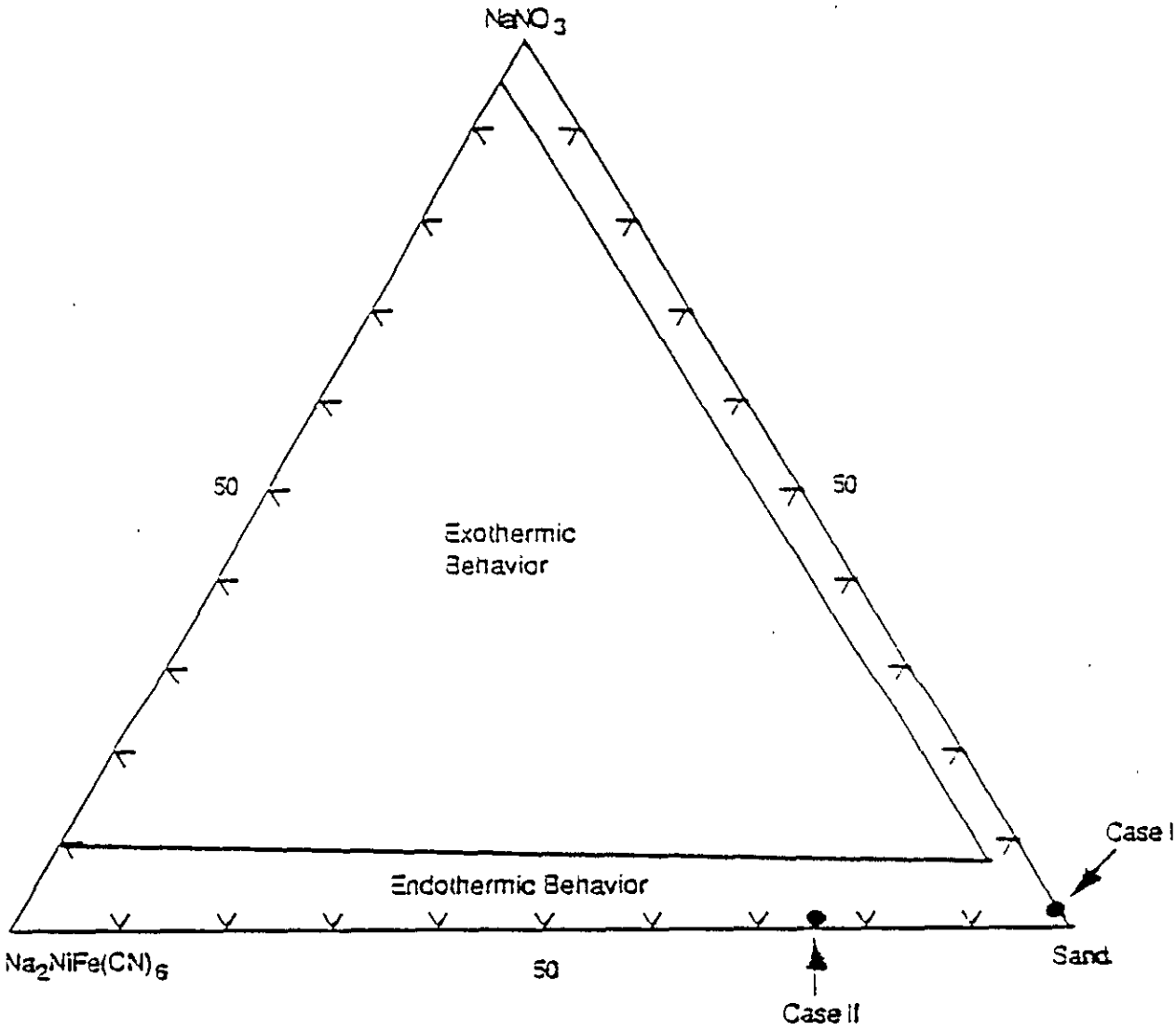


Figure 1. Triangular diagram illustrating compositional ranges of potentially reactive and nonreactive mixtures of $NaNO_3$, $Na_2NiFe(CN)_6$, and sand (constructed by M.D. Crippen). Points labeled "Case I" and "Case II" represent feasible soil mixtures present beneath the 216-B-43 and 216-B-49 cribs as explained in text.

From: Partitioning and Process Integration
Phone: 6-8653 L5-31
Date: April 3, 1991
Subject: GRAPHICAL REPRESENTATION OF FERROCYANIDE CRIB COMPOSITIONS

To: M. R. Adams H4-55

cc:

H. Babad	H4-23	J. J. Holmes	L5-55
G. L. Borsheim	R2-11	J. A. Hunter	L5-31
M. A. Buckmaster	H4-55	B. C. Simpson	R2-12
R. A. Carlson	H4-55	D. D. Stepnewski	N1-31
R. J. Cash	H4-23	E. C. Thornton	H4-55
S. A. Colby	L5-31	MDC/File/LB	
R. C. Hill	H4-23		

Introduction

The purpose of this memo is to illustrate the composition of the ferrocyanide cribs using a three component diagram. The diagrams can show the thermodynamic and physical relationships between reactants and diluents as a function of concentration. It will be especially useful for presentations, safety work, and chemistry issues.

Definitions

Figure 1 is a three component diagram and consists of an equilateral triangle. The north vertex will represent pure oxidizer (such as $NaNO_3$) and movement away from that point will represent decreasing mass fractions of oxidizer. The west vertex will represent pure fuel (such as sodium nickel ferrocyanide) and movement away from that point will represent decreasing mass fractions of the fuel. The east vertex will represent pure diluent (such as sand, gravel or silt) and movement away from that point will represent decreasing mass fractions of diluent. The advantage to this system is that the sum of the normal distances to each side from any point on the diagram is constant so that the mass fraction of all possible material combinations can be represented by a linear scale. These diagrams are usually used to show phase relationships between components but can show other properties that are additive in nature. It should be apparent that this system allows one to represent a huge amount of data with a few lines and therefore provides a powerful tool to understanding the crib composition situation.

Thermodynamics of the Diagram

The maximum energy release for the compound of interest is given by (and the equivalent equation for the nitrite):

$$Na_2NiFe(CN)_6 + 6NaNO_3 \text{ ----> } FeCO_3 + NiCO_3 + 4Na_2CO_3 + 6N_2$$

$$Na_2NiFe(CN)_6 + 10NaNO_2 \text{ ----> } FeO + NiO + 6Na_2CO_3 + 8N_2$$

For our purposes here, we can ignore the second equation as there is little or no nitrite in the cribs. We have also taken the reaction products as carbonates rather than oxides and carbon dioxide; thermodynamic data show the carbonates to be the preferred form at the lower temperatures of interest and it does give a higher energy release so is more conservative.

For a reaction to proceed by itself it has to be exothermic (heat releasing) and it must be able to heat the reactants to the minimum temperature where reaction can occur. Any excess energy can then be used to raise the reaction products to higher temperatures which may result in light emissions and/or mechanical work. If any excess reactant, either fuel or oxidizer, is added then the maximum temperature is less because some reaction energy is required to heat the material up and no energy is released from that material. For our reaction, it is necessary to heat the sodium nickel ferrocyanide and the sodium nitrate from 13°C (the ground temperature of 55°F at depth) to at least 220°C (the minimum reaction temperature). This is very conservative because for the actual compositions the ignition temperature is really higher.

The reaction is also conservative because of a number of other assumptions. First, the reaction heat is based on a reversible reaction which this certainly is not. Second, that the system is isothermal which it is not except under the most rapid reaction conditions. Third, is that the system is adiabatic which is questionable since warm gases can escape the reaction zone before giving up their energy to the immediate area. It will be later seen that all of these together give a very conservative case for reaction propagation purposes.

Point A is the optimum ratio of nitrate and ferrocyanide to give the maximum reaction energy. On the figure, point C is where enough ferrocyanide has been added so that its heat capacity exactly balances the heat given off by the limited nitrate. Similarly, D is the point where enough nitrate has been added so that its heat capacity exactly balances the heat given off by the limited ferrocyanide. If a tie line is made from A toward the sand vertex and the same heat capacity argument is used for the addition of sand, then E is the excess sand that exactly balances the reaction heat.

The area C-A-D-E are compositions that <u>theoretically</u> evolve heat or energy; not all compositions will necessarily sustain an exothermic reaction especially with real gas evolution and heat losses. The area outside are compositions that <u>absolutely never</u> will burn. We refer to the line C-E-D as the "snuff" line for that reason.

One can now see that the figure does not represent the actual cribs fully as there are potentially large quantities of inert salts and water that act as diluents. What is needed is a fourth vertex (for the other diluents) which could be represented by a Lucite tetrahedron with internal lines and colors to show the snuff boundary which is now a surface instead of a line. Such a unit is hard to visualize, even if well made, and definitely does not go through the FAX machine. However, there is a way to refine the triangular diagram by changing the sand component to sand and all other diluents. As long as other diluents are entered at the same equivalent thermal value as the sand, the effect of this analysis is served. Table I shows the thermal equivalent of some other diluents.

Table I

Thermal Equivalent of Diluents

Component	Mass equiv to 1 lb sand
sand	1.
H_2O	17
$NaNO_3$	1.9
$Na_2Ni(CN)_6$	1.2

The loss in making this combination is slight. It only requires that all other salts and water be added on an equivalent thermal basis and not a mass basis. Compared to the other assumptions and unknowns, this will be minor.

Up until now we have assumed the reaction equation to give elemental nitrogen and carbon dioxide as the cyanide combustion products. This is conservative because it does give the maximum energy release but it may not be realistic; in fact, present experimental data indicate a much lower energy release than the maximum. There is obviously a range of nitrogen oxides as products that give varying amounts of energy. The following are possible equations in descending order of energy release from our original one to the one that is the most endothermic:

a) $Na_2NiFe(CN)_6 + 6NaNO_3 \text{ ----> } FeCO_3 + NiCO_3 + 4Na_2CO_3 + 6N_2$
reaction energy is -728 kcal

b) $Na_2NiFe(CN)_6 + 9NaNO_3 \text{ ----> } FeO + NiO + 5.5Na_2CO_3 + 7.5N_2O + .5CO_2$
reaction energy is -514 kcal

c) $Na_2NiFe(CN)_6 + 10NaNO_3 \text{ ----> } FeO + NiO + 6Na_2CO_3 + 6N_2O + 4NO$
reaction energy is -435 kcal

d) $Na_2NiFe(CN)_6 + 14NaNO_3 + 2H_2O$ ----> $FeO + NiO + 6Na_2CO_3 + 20NO + 4NaOH$
reaction energy is -54 kcal

e) $Na_2NiFe(CN)_6 + 54NaNO_3 + 22H_2O$ ----> $FeO + NiO + 6Na_2CO_3 + 60NO_2 + 44NaOH$
reaction energy is +1490 kcal

It should be apparent that the non-reactive area on the diagrams will increase as the reaction energy goes down; equation d) will give a snuff line that is nearly a point around the stoichiometric mix and e) requires large amounts of energy to force the reaction to go. The limited laboratory data to date indicate that reaction c) is the most probable of the ones shown; the actual energy yield would give a reaction combination somewhere between c) and d). Point B on the diagram is the stoichiometric mix for reaction c) and its snuff line is drawn inside the snuff line for equation a).

Crib Compositions

At first sight the diagram looks daunting; there is a very large area that is theoretically combustible. However, much of that is not physically possible in a real crib. The maximum void volume is taken at a conservative 40%. Point F represents 60 vol% sand in which waves of saturated nitrate brine have repeatedly deposited crystals of sodium nitrate until the remaining 40 vol% is filled with the salt at its maximum theoretical density. Point G represents 60 vol% sand in which ferrocyanide particles have been repeatedly deposited until the remaining 40 vol% is filled with the salt is packed in at its maximum packing fraction of 50 vol%. The line between the two points are the various combinations of mixed states of the ferrocyanide and the nitrate based on no water being present. There can be no compositions to the left of this line for any real crib and any lower pore volume will move the line to the right. The second line is a repeat with a minimum of 2% moisture (based on the weight of the sand).

Because water has a high heat capacity plus a significant heat of vaporization it is a much better diluent than sand as can be seen by the large gap between the bone dry and minimum moisture lines. It can be determined that about 19% water (on the basis of the sand) will put the mixture at the vertex of the snuff line. It would be essentially a slurry of ferrocyanide in saturated nitrate brine that nearly fills the available voids. Any more moisture or less ferrocyanide or less nitrate would be in the endothermic region and therefore non-reactive.

Further calculations were done to determine what compositions would be in the non-reactive region. If a liter of sand were bone dry then anything less than 26 gpl ferrocyanide or less that 41 gpl of nitrate would be in the endothermic range. If the sand contained the minimum of 2% water, then

anything less than 35 gpl ferrocyanide or less than 55 gpl of nitrate would be in the endothermic range. Considering the vast volume of the crib and the relatively small amounts of ferrocyanide it would seem highly unlikely to have that high of concentration of reactants.

If it is determined that there is a real risk of reaction during drilling, then the use of an added diluent is a sure way to ensure safety with a minimum of effort. Water is the obvious choice for a number of reasons but would confound sample data for moisture or soluble species. Carbon dioxide could also be used but still has some confounding problems with moisture and carbonate analysis; it is certainly cheap and otherwise benign. Any one of several (but not all) freons would be good choices -- non-flammable, non-poisonous, non-corrosive, non-interactive with sample data, easy to handle, cheap and only modest quantities would be required.

Conclusions

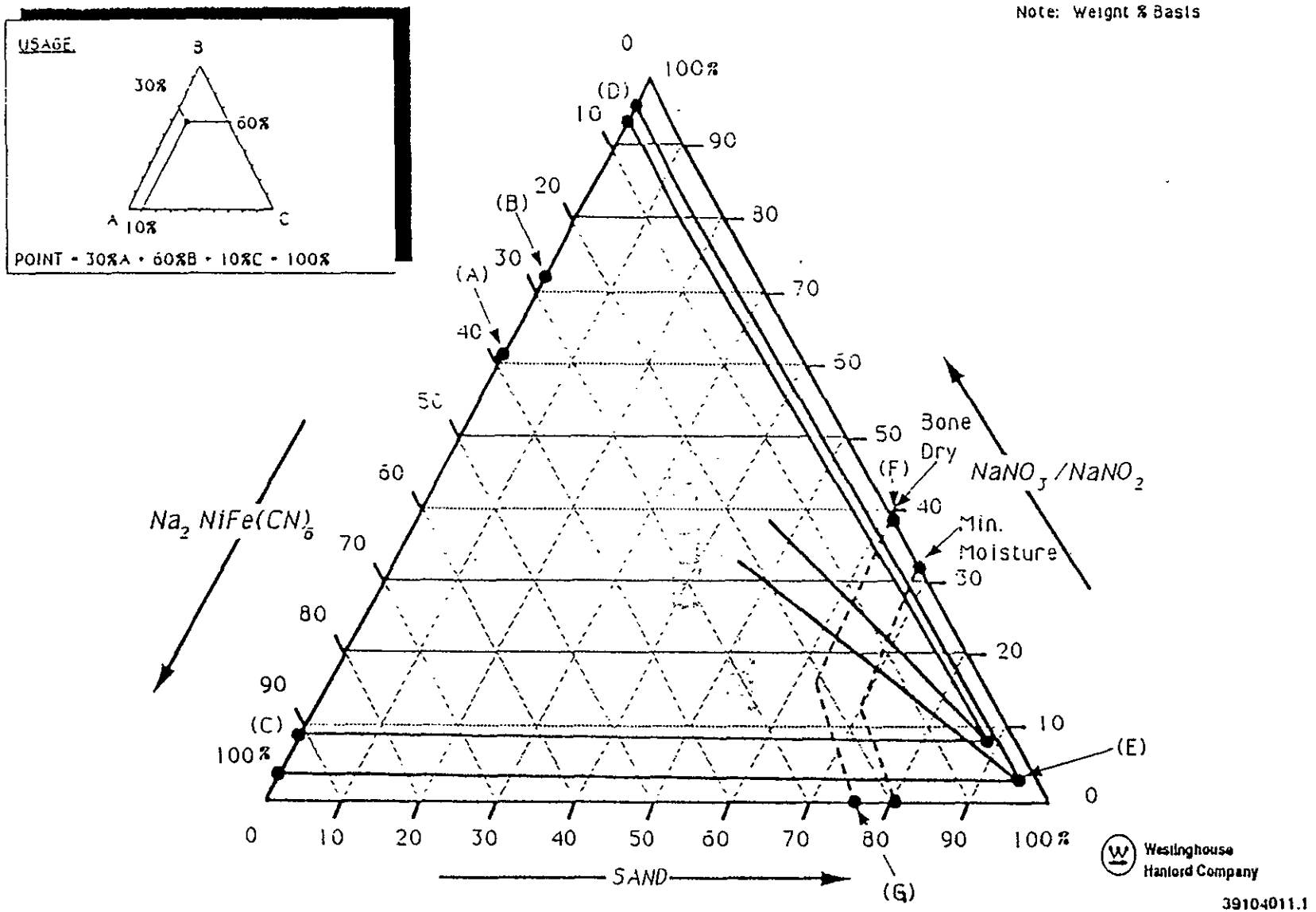
Three component diagrams have been presented as a way to aid in the understanding of possible and probable crib compositions. A basis has been developed to show that a large fraction of possible compositions cannot participate in any exothermic reaction. Most overall crib compositions appear to be non-reactive and show that the fraction of material in the crib that might react is only a small part of the total.

Monte Crippen

M. D. Crippen, P.E.
Partitioning and Process Integration

Attachment

FERROCYANIDE CRIB 3-COMPONENT DIAGRAM



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ATTACHMENT 4

DOSE ASSESSMENT

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Westinghouse Hanford Company

Internal Memo

From: Environmental Technology, Risk and Performance Assessment 25320-91-020
Phone: 6-9956 H4-14
Date: March 1, 1991
Subject: ESTIMATE OF EXTERNAL DOSE RATES FROM TASK 4 CORE SAMPLING NEAR THE 216-B CRIBS

To: W. H. Price S0-03

cc:

J. A. Bultena	S0-04	H. D. Downey	S0-04
M. A. Buckmaster	H4-55	E. J. Rink	H4-55
R. A. Carlson	H4-55	P. D. Rittmann	H4-54
S. K. Demers	T3-02	R. J. Thomas	T3-06
D. A. Dodd	T6-50	W. S. Thompson	S0-04

JCS:PDR File/LB

This memo documents calculations done to estimate possible external dose rates near core samples and waste drums containing soil from the 216-B Crib area, just north of the 241-BY tank farm.

The dose rates are estimated by assuming the soil has a uniform concentration of the radioactivity sent to the crib. For the drilling of monitoring wells in Task 4 of the RI/FS.

The estimated maximum dose rates near a sample core are 240 mR/hr (window closed CP) and 2,000 mrad/hr (window open CP) at a distance of 2 inches (contact). This dose rate is estimated assuming that the radioactivity sent to crib B-49 is spread over a volume of soil 40 feet in diameter, and only 4 feet thick. Larger soil volumes give lower dose rates.

Exposure rate estimates for B-43 and B-57 are not much different. These dose rates also depend on the assumed soil volume contaminated. More refined estimates of radionuclide migration are possible, but not within the time frame needed to begin characterization work.

If you have any questions concerning the attached calculations please call P. D. Rittmann at 6-8715.

J. C. Sonnichsen, Acting Manager
Environmental Technology, Risk
and Performance Assessment

iar

Attachment

Hanford Operations and Engineering Contractor for the US Department of Energy

Attachment 1: Estimate of External Dose Rates From Task 4 Core Sampling Near the 216-B Cribs
by Paul D. Rittmann January 11, 1991

The 216-B cribs are located north of the 241-BY tank farm in 200 East Area. The object of this analysis is to estimate the potential dose rates to be encountered under Task 4 of the 200-BP-1 Operable Unit Remedial Investigation Work Plan (DOE/RL/88-32). Three primary sources of external dose rate are the core sample (1 or 2 feet long, and 4 or 5 inches in diameter), a 250 ml sample bottle, and a 55 gallon drum, which is assumed to collect the majority of the excess soil produced by the drilling.

The method used in this report is to estimate soil concentrations for the three cribs to be drilled, and then calculate dose rates from these estimated soil concentrations for simple geometries such as can be handled by the program ISOSHLD.

The estimate of soil contamination assumes that the activity discharged to the cribs is uniformly distributed over some volume of soil under the cribs. The volume of the contaminated soil was varied to provide a range of possible contamination levels.

The discharges of water and Sr-90 and Cs-137 during the operation of the cribs are summarized in the table below. The Sr-90 and Cs-137 activities have been decayed to 1986. To bring the amounts to 1990 would require an additional 4 years of decay, which would reduce the Sr-90 activity by 9 percent, a difference which is too small to be concerned about when estimating dose rates.

Discharges to the Cribs North of 241-BY Tank Farm

Crib ID	Liquid Liters	Total Curies Sr-90	Total Curies Cs-137	Average µCi/cc Sr-90	Average µCi/cc Cs-137
216-B-43	2.12E+06	630	142	2.97E-01	6.70E-02
216-B-44	5.60E+06	1310	336	2.34E-01	6.00E-02
216-B-45	4.92E+06	1290	727	2.62E-01	1.48E-01
216-B-46	6.70E+06	692	96.9	1.03E-01	1.45E-02
216-B-47	3.71E+06	286	72.7	7.71E-02	1.96E-02
216-B-48	4.09E+06	600	218	1.47E-01	5.33E-02
216-B-49	6.70E+06	1240	198	1.85E-01	2.96E-02
216-B-50	5.48E+07	3.72	55.8	6.79E-05	1.02E-03
Total:	8.86E+07	6052	1846	6.83E-02	2.08E-02
216-B-57	8.44E+07	2.01	246	2.38E-05	2.91E-03

Volumes of contaminated soil under the three cribs of interest are listed below. The first two estimates give high and low values for activity concentrations under individual cribs. The third estimate assumes the activity from all eight (#43 to #50) cribs has uniformly mixed into a single slab.

Assumptions for Contamated Soil Volumes

Cribs B-43 to B-50

(1) Small cylinder, radius 20 feet, thickness 4 feet (a worst case to maximize soil concentrations). Soil volume is 142 cubic meters.
(2) Large cylinder, radius 80 feet, thickness 20 feet. Soil volume is 11,390 cubic meters.
(3) Rectangular slab under all eight cribs, 200 feet wide, 300 feet long, and 10 feet thick. Soil volume is 17,000 cubic meters.

Crib B-57

Rectangular slab 15 feet wide, 100 feet long (half the actual length of the crib, to be conservative), and 4 feet thick. Soil volume is 170 cubic meters. This is (hopefully) the smallest reasonable volume of soil that the radioactivity has spread into.

The activity concentration in the soil is the total activity divided by the assumed soil volume. The concentrations to be used to estimate the Task 4 dose rates are summarized below. Crib B-49 has more radioactivity than Crib B-43, but Crib B-49 also has received three times more liquid than B-43. Therefore, although the B-49 activities are matched with the smaller soil volume, the dose rates which are calculated could also be found at B-43.

Soil Concentrations Within the "Task 4" Cribs

Category	Volume m^3	Total Curies Sr-90	Total Curies Cs-137	µCi/cc Activity Concentration Sr-90	µCi/cc Activity Concentration Cs-137
B-49 (Maximum)	142	1,240	198	8.7E+00	1.4E+00
B-43 (Minimum)	11,387	630	142	5.5E-02	1.2E-02
8 Crib Average	16,990	6,052	1,846	3.6E-01	1.1E-01
B-57 (Maximum)	170	2.01	246	1.2E-02	1.4E+00

The ISOSHLD-PC program, Version 1.6, was used to estimate the external dose rates from a concentration of 1 µCi/cc of either Sr-90 or Cs-137 in the soil. Six geometries are used. Four cases are the core samples themselves, either 2 feet or 1 foot long, and either 5 inches or 4 inches in diameter. The other two cases are the 250 ml sample and the 55 gallon drum. The assumed soil density is 1.6 g/cc in all cases. ISOSHLD-PC results are shown on the next page. The complete input files are listed in attachment 3, for reference.

ISOSHLD-PC Exposure Rates (R/hr) Using a Soil Concentration of 1 µCi/cc

Sr-90	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
2 inches	1.27E-03	1.01E-03	1.09E-03	8.79E-04	2.21E-04	2.46E-03
1 foot	2.33E-04	1.71E-04	1.37E-04	1.00E-04	1.36E-05	9.30E-04
3 feet	3.82E-05	2.72E-05	1.96E-05	1.40E-05	1.66E-06	2.26E-04
10 feet	3.72E-06	2.59E-06	1.84E-06	1.30E-06	1.52E-07	2.76E-05

Cs-137	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
2 inches	9.38E-02	7.18E-02	7.76E-02	6.01E-02	1.40E-02	2.49E-01
1 foot	1.67E-02	1.17E-02	9.59E-03	6.75E-03	8.62E-04	9.08E-02
3 feet	2.74E-03	1.87E-03	1.41E-03	9.57E-04	1.06E-04	2.20E-02
10 feet	2.70E-04	1.80E-04	1.34E-04	9.01E-05	9.82E-06	2.72E-03

Table Headings:
- 2' 5" = 5 inch diameter cylinder, 2 feet long
- 2' 4" = 4 inch diameter cylinder, 2 feet long
- 1' 5" = 5 inch diameter cylinder, 1 foot long
- 1' 4" = 4 inch diameter cylinder, 1 foot long
- 250 ml = 250 ml sample bottle, 2" diameter, 5" tall
- 55 gal = 55 gallon drum filled with soil

Notes:
(1) The assumed soil density is 1.6 g/cc in all cases. Higher densities give rise to lower exposure rates.
(2) The 4" and 5" cylinders are bare, i.e., they are not encased in a pipe.
(3) The 250 ml bottle has a 0.1 cm thick plastic wall.
(4) The 55 gallon drum has a 1/16" thick steel wall.

To calculate the expected dose rates, the above dose rates are adjusted according to the expected soil concentration. These calculated dose rates are shown in the tables below for contact (2 inches) and 3 feet.

Note that ISOSHLD-PC does not compute the direct dose rate from the beta radiation, such as would be measured with a CP. ISOSHLD-PC computes "bremsstrahlung" photon radiation, an indirect effect of the beta rays which can be measured.

ISOSHLD-PC Photon Exposure Rate, mR/hr (does not include beta)

On Contact (2 inches)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	1.4E+02	1.1E+02	1.2E+02	9.1E+01	2.1E+01	3.7E+02
Minimum	1.2E+00	9.5E-01	1.0E+00	8.0E-01	1.9E-01	3.2E+00
All 8 Cribs	1.1E+01	8.2E+00	8.8E+00	6.8E+00	1.6E+00	2.8E+01
216-8-57	1.4E+02	1.0E+02	1.1E+02	8.7E+01	2.0E+01	3.6E+02

At 3 feet (from the outside)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	4.1E+00	2.8E+00	2.1E+00	1.5E+00	1.6E-01	3.3E+01
Minimum	3.6E-02	2.5E-02	1.9E-02	1.3E-02	1.4E-03	2.9E-01
All 8 Cribs	3.1E-01	2.1E-01	1.6E-01	1.1E-01	1.2E-02	2.5E+00
216-8-57	4.0E+00	2.7E+00	2.0E+00	1.4E+00	1.5E-01	3.2E+01

The direct beta dose rate was estimated using the IBM-PC program VARSKIN (reference 5). The radionuclide concentrations were assumed to be 1 $\mu Ci/cm^2$, and a disk radius of 5.642 cm (100 cm^2) was used to calculate peak dose rates. The peak dose rates at various thicknesses of skin are listed for Cs-137 and Sr-90 below. The density of skin is 1.0 g/cc.

VARSKIN Peak Dose Rates for Cs-137, rem/hr

thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr
0.007	6.46	0.036	1.38	0.068	0.322	0.1	0.0675
0.008	5.93	0.038	1.25	0.07	0.293	0.104	0.0557
0.009	5.5	0.04	1.14	0.072	0.267	0.108	0.046
0.01	5.12	0.042	1.05	0.074	0.242	0.112	0.038
0.012	4.49	0.044	0.959	0.076	0.22	0.116	0.0315
0.014	4.01	0.046	0.878	0.078	0.199	0.12	0.0262
0.016	3.55	0.048	0.803	0.08	0.18	0.124	0.0217
0.018	3.19	0.05	0.733	0.082	0.163	0.128	0.0179
0.02	2.88	0.052	0.676	0.084	0.148	0.132	0.0146
0.022	2.6	0.054	0.619	0.086	0.134	0.136	0.0116
0.024	2.36	0.056	0.563	0.088	0.122	0.14	0.00887
0.026	2.15	0.058	0.515	0.09	0.11	0.144	0.00637
0.028	1.96	0.06	0.47	0.092	0.0997	0.148	0.00405
0.03	1.79	0.062	0.427	0.094	0.0904	0.152	0.00193
0.032	1.63	0.064	0.39	0.096	0.0819	0.156	3E-05
0.034	1.51	0.066	0.355	0.098	0.0744	0.16	0

VARSKIN Peak Dose Rates for Sr-90 & Y-90, rem/hr

thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr	thick g/cm^2	dose rem/hr
0.007	16.1	0.088	3.54	0.255	1.15	0.53	0.149
0.008	15.2	0.09	3.48	0.26	1.11	0.54	0.135
0.009	14.5	0.092	3.39	0.265	1.08	0.55	0.123
0.01	13.9	0.094	3.33	0.27	1.04	0.56	0.111
0.012	12.8	0.096	3.27	0.275	1.01	0.57	0.1
0.014	12	0.098	3.22	0.28	0.98	0.58	0.0901
0.016	11.2	0.1	3.16	0.285	0.95	0.59	0.0808
0.018	10.5	0.104	3.06	0.29	0.92	0.6	0.0723
0.02	9.97	0.108	2.96	0.295	0.891	0.61	0.0644
0.022	9.46	0.112	2.87	0.3	0.863	0.62	0.0572
0.024	9.05	0.116	2.79	0.305	0.836	0.63	0.0507
0.026	8.59	0.12	2.71	0.31	0.809	0.64	0.0447
0.028	8.22	0.124	2.63	0.315	0.783	0.65	0.0393
0.03	7.87	0.128	2.56	0.32	0.758	0.66	0.0344
0.032	7.56	0.132	2.49	0.325	0.733	0.67	0.0301
0.034	7.27	0.136	2.43	0.33	0.709	0.68	0.0261
0.036	7.02	0.14	2.36	0.335	0.687	0.69	0.0227
0.038	6.77	0.144	2.3	0.34	0.664	0.7	0.0196
0.04	6.54	0.148	2.25	0.345	0.642	0.71	0.0168
0.042	6.32	0.152	2.19	0.35	0.621	0.72	0.0144
0.044	6.11	0.156	2.13	0.355	0.6	0.73	0.0123
0.046	5.92	0.16	2.08	0.36	0.58	0.74	0.0105
0.048	5.74	0.164	2.03	0.365	0.56	0.75	0.00891
0.05	5.56	0.168	1.98	0.37	0.54	0.76	0.00752
0.052	5.4	0.172	1.95	0.375	0.522	0.77	0.00632
0.054	5.24	0.176	1.9	0.38	0.504	0.78	0.00527
0.056	5.1	0.18	1.85	0.385	0.486	0.79	0.00437
0.058	4.96	0.184	1.81	0.39	0.47	0.8	0.0036
0.06	4.83	0.188	1.76	0.395	0.453	0.81	0.00293
0.062	4.7	0.192	1.72	0.4	0.436	0.82	0.00237
0.064	4.58	0.196	1.66	0.41	0.405	0.83	0.00188
0.066	4.47	0.2	1.62	0.42	0.376	0.84	0.00147
0.068	4.36	0.205	1.57	0.43	0.349	0.85	0.00113
0.07	4.26	0.21	1.52	0.44	0.322	0.86	0.00084
0.072	4.16	0.215	1.47	0.45	0.298	0.87	0.0006
0.074	4.07	0.22	1.43	0.46	0.275	0.88	0.00041
0.076	3.98	0.225	1.38	0.47	0.253	0.89	0.00026
0.078	3.92	0.23	1.34	0.48	0.233	0.9	0.00014
0.08	3.84	0.235	1.3	0.49	0.213	0.91	7E-05
0.082	3.76	0.24	1.26	0.5	0.195	0.92	2E-05
0.084	3.68	0.245	1.22	0.51	0.179	0.93	0
0.086	3.61	0.25	1.18	0.52	0.163		

To estimate the direct beta dose rates from contaminated soil through various shields, the unit concentration (1 µCi/cc) dose rate was computed first. Each of the above dose rate was weighted by the actual activity between it and the layer below it. The weighted dose rates were then summed from the amount of the current shielding to the end of the table.

Beta Dose Rate at 1 µCi/cc = Σ(beta dose rate)*(thickness)/(1.6 g/cc)

This has all been automated in a spreadsheet for reliability. The shield thicknesses which need to be considered are listed in the table below. The estimated beta dose rates are also shown below.

Shield Thicknesses

Shield	Thickness
Open window GP	7 mg/cm^2
250 ml sample bottle	100 mg/cm^2
3 feet of air	110 mg/cm^2
Closed window GP	407 mg/cm^2

Beta Dose Rates from VARSKIN Photon Dose Rates from ISOSHLD

	Sr-90 Bare Soil		Sr-90 250 ml Sample		Cs-137
	W/O	W/C	W/O	W/C	Source
VARSKIN (mrem/hr)	668	31.6	284	11.8	66.1
	262	10.6	133	3.07	0.36
ISOSHLD (mR/hr)	3.95	3.64	3.86	3.57	320

Once the beta dose rates were determined, the ISOSHLD dose rates shown above for a similar large surface were also determined. The ratio of the two is assumed to be fairly geometry independent, i.e., the ratio would hold for each of the various shapes of soil samples, as well as the 250 ml sample bottle. The photon plus beta divided by the photon dose rates are shown on the table below.

Total Dose Rates Divided by Photon Dose Rates

	Sr-90 Bare Soil		Sr-90 250 ml Sample		Cs-137
	W/O	W/C	W/O	W/C	Source
2 in	170	9.7	75	4.3	1.2
3 ft	67	3.9	35	1.9	1.0

The above ratios do not take into account distance effects like inverse square law. They only consider the effects of shielding provided by the added air. The above ratios are thus suitable to be applied to the photon dose rates computed by ISOSHLD to estimate the window open and window closed readings.

Estimated Absorbed Dose Rates, mrad/hr (Window Open CP Reading)

On Contact (2 inches)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	2.0E+03	1.6E+03	1.7E+03	1.4E+03	1.7E+02	3.7E+02
Minimum	1.3E+01	1.1E+01	1.1E+01	9.2E+00	1.1E+00	3.2E+00
All 8 Cribs	8.9E+01	7.1E+01	7.6E+01	6.1E+01	7.5E+00	2.8E+01
216-B-57	1.7E+02	1.3E+02	1.4E+02	1.1E+02	2.0E+01	3.6E+02

At 3 feet (from the outside)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	2.6E+01	1.9E+01	1.3E+01	9.5E+00	6.8E-01	3.3E+01
Minimum	1.8E-01	1.2E-01	9.1E-02	6.1E-02	4.7E-03	2.9E-01
All 8 Cribs	1.2E+00	8.6E-01	6.2E-01	4.4E-01	3.3E-02	2.5E+00
216-B-57	4.0E+00	2.7E+00	2.1E+00	1.4E+00	1.5E-01	3.2E+01

Estimated Absorbed Dose Rates, mR/hr (Window Closed CP Reading)

On Contact (2 inches)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	2.4E+02	1.9E+02	2.0E+02	1.6E+02	2.8E+01	3.7E+02
Minimum	1.8E+00	1.4E+00	1.6E+00	1.2E+00	2.3E-01	3.2E+00
All 8 Cribs	1.5E+01	1.1E+01	1.2E+01	9.6E+00	1.9E+00	2.8E+01
216-B-57	1.4E+02	1.0E+02	1.1E+02	8.7E+01	2.0E+01	3.6E+02

At 3 feet (from the outside)

	2' 5"	2' 4"	1' 5"	1' 4"	250 ml	55 gal
Maximum	5.1E+00	3.5E+00	2.6E+00	1.8E+00	1.7E-01	3.3E+01
Minimum	4.2E-02	2.9E-02	2.2E-02	1.5E-02	1.5E-03	2.9E-01
All 8 Cribs	3.5E-01	2.4E-01	1.8E-01	1.2E-01	1.3E-02	2.5E+00
216-B-57	4.0E+00	2.7E+00	2.0E+00	1.4E+00	1.5E-01	3.2E+01

From the above tables, it can be seen that the exposure rates could be quite high near a core sample, under the assumption that the nuclides are uniformly distributed in a layer of soil only four feet thick. If the activity has spread over a thicker layer, the dose rates will be lower.

For information related to shipping the samples, the total activities in a sample at the concentrations calculated earlier are shown on the table below.

Maximum Total Activity (Curies) in the Samples

Sample Type	Soil Vol, ml	Maximum Curies Sr-90	Cs-137
2' Long, 5" Diameter	7,722	6.7E-02	1.1E-02
2' Long, 4" Diameter	4,942	4.3E-02	6.9E-03
1' Long, 5" Diameter	3,861	3.4E-02	5.4E-03
1' Long, 4" Diameter	2,471	2.2E-02	3.4E-03
Sample Bottle	250	2.2E-03	3.5E-04
55 Gallon Drum	206,893	1.8E+00	2.9E-01

References:

1. DOE/RL 88-32, Revision 1, "Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington", March 1990.

2. J. F. Cline and L. L. Cadwell, "Movement of Radiostrontium in the Soil Profile of an Arid Climate", Health Physics, Volume 46, pages 1136-1138, May 1984.

3. I. O. Lourant, "Validation of ISOSHLD-PC on the IBM PC (PS-2/AT/XT)", WHC-SD-SQA-CSWD-303, 12/20/89, EDT 109878.

4. Internal Memo 81210-90-071, "Estimate of External Dose Rates from Core Sampling in the Vicinity of the 216-B Cribs North of 241-BY", June 15, 1990.

5. R. J. Traub, W. D. Reese, R. I. Scherpelz, and L. A. Sigalla, "Dose Calculation for Contamination of the Skin Using the Computer Code VARSKIN", NUREG/CR-4418 (PNL-5610), August 1987.

Document Reviewed (Complete reference) Estimate of external dose rates from Task 4 One Sampling Year 216-B-(0,1,2)

Author(s) P. K. Fitzner

CHECKLIST FOR CALCULATION REVIEW

Yes	No	N/A	
			General Considerations
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[X]	Hand calculations checked for errors.
[ ]	[ ]	[X]	Code runstreams correct and consistent with analysis documentation.
[X]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[X]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.

C. Glen Mitchell 7/24/96
Technical Reviewer Approval Date

Radiological Calculations

[ ]	[ ]	[ ]	GENII (current version) used for radiological calculations.
[ ]	[ ]	[ ]	Appropriate receptor locations evaluated.
[ ]	[ ]	[ ]	Appropriate models (finite plume vs. semi-infinite cloud, building wake, etc.) used.
[ ]	[ ]	[ ]	Appropriate pathways evaluated for each receptor.
[ ]	[ ]	[ ]	Analysis consistent with HDOC Recommendations.

N/A
HDOC Reviewer Approval Date

Note: Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

Attachment 2: ISOSHLD-PC Input Files for the Unit Concentrations

```
1         2   Sr-90 Dose Rates,  1.6 g/cc Soil
Contact (2 inches)                    5" Diameter, 2' Long
 &Input  Next= 1,  IGEOM= 7,  X= 11.43,  T(1)= 6.35,
  SIth= 60.96, Y= 30.48,  NSHLD= 1, JBuf= 1, IConc= 1,
  NTheta= 13, NPsi= 23, Delr= 0.7,
  Weight(82)= 1, Weight(84)= 1  &
1 Soil  16   1.6
Dose Rate at 1 ft
 &Input  Next= 4,  X= 36.83,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 311.15,  NTheta= 7, NPsi= 11  &
Contact (2 inches)                    4" Diameter, 2' Long
 &Input X= 10.16,  NTheta= 13, NPsi= 23,  T(1)= 5.08   &
Dose Rate at 1 ft
 &Input  X= 35.56,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 96.52,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 309.88,  NTheta= 7, NPsi= 11  &
Contact (2 inches)                    5" Diameter, 1' Long
 &Input X= 11.43,  NTheta= 13, NPsi= 17,  T(1)= 6.35,
       SLTH= 30.48, Y= 15.24  &
Dose Rate at 1 ft
 &Input  X= 36.83,  NTheta= 11, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 9, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.15,  NTheta= 7, NPsi= 9  &
Contact (2 inches)                    4" Diameter, 1' Long
 &Input X= 10.16,  NTheta= 13, NPsi= 23,  T(1)= 5.08   &
Dose Rate at 1 ft
 &Input  X= 35.56,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 96.52,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 309.88,  NTheta= 7, NPsi= 11  &
Touching (2 mm)                       250 ml sample bottle
 &Input Next= 3,  X= 2.84, T(1)= 2.54, 0.1,
  SIth= 12.7, Y= 6.35,  NTheta= 19, NPsi= 27, delr= 0.1,
  NSHLD= 2, JBuf= 1  &
  Soil  16   1.6
1 Bottle 2            1.0
Dose Rate at 2 inches (contact)
 &Input  Next= 4,  X= 7.72,  NTheta= 9, NPsi= 17  &
Dose Rate at 1 ft
 &Input  X= 33.12,  NTheta= 9, NPsi= 13  &
```

```
Dose Rate at 3 ft
 &Input  X= 94.08,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 307.44  &
Contact (2 inches)                    55 gallon drum
 &Input Next=3,  X= 33.24, T(1)= 28, 0.16, IConc= 1,
  Slth= 82, Y= 41,  NTheta= 13, NPsi= 23, delr= 2  &
  Soil  16   1.6
1 Iron   9            7.86
Dose Rate at 1 ft
 &Input  Next= 4,  X= 58.64,  NTheta= 11, NPsi= 17  &
Dose Rate at 3 ft
 &Input  X= 119.6,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 332.96  &
This is the End of the Sr-90 Run.
  &Input Next= 6  &
```

```
1         2   For Comparison with Direct Beta Dose Rates
Bare Soil  --  Sr-90 Contamination
 &Input  Next= 1,  IGEOM= 9,  T(1)= 8, 0,  X= 8.2,
 Delr= 0.1,  SLTH= 56.419,  NTheta= 41,  JBuf= 1, NShld= 2,
 IConc= 1,  Weight(82)= 1, Weight(84)= 1  &
 Tissue  2            1.0
1 Soil  16   1.6
Bare Soil with 400 mg/cm2 Shield
 &Input  Next= 4,  T(2)= 0.4,  X= 8.6  &
Bare Soil with 1 mm Plastic Shield
 &Input  T(2)= 0.1,  X= 8.3  &
Bare Soil with 1 mm Plastic with 400 mg/cm2 Shield
 &Input  T(2)= 0.5,  X= 8.7  &
Bare Soil  --  Cs-137 Contamination
 &Input  Next= 1,  T(1)= 8, 0,  X= 8.2,  JBuf= 1, NShld= 2,
 Weight(82)= 0, Weight(84)= 0,  Weight(335)= 1, Weight(336)= 0.946 &
 Tissue  2            1.0
1 Soil  16   1.6
Bare Soil with 400 mg/cm2 Shield
 &Input  Next= 4,  T(2)= 0.4,  X= 8.6  &
Bare Soil with 1 mm Plastic Shield
 &Input  T(2)= 0.1,  X= 8.3  &
Bare Soil with 1 mm Plastic with 400 mg/cm2 Shield
 &Input  T(2)= 0.5,  X= 8.7  &
This is the End of the Flat Disk Run.
  &Input Next= 6  &
```

```
1          3  Cs-137 Dose Rates,  1.6 g/cc Soil
Contact (2 inches)                        5" Diameter, 2' Long
 &Input  Next= 3,  IGEOM= 7,  X= 11.43,  T(1)= 6.35,
  Slth= 60.96, Y= 30.48,  NSHLD= 1, JBuf= 1, IConc= 1,
  NTheta= 13, NPsi= 23, Delr= 0.7,  SFact= 1.0E-06,
  Source(1,1)= 2.61E+09, 0.037, 0.0,
               3.15E+10, 0.66,  0.0   &
1 Soil  16   1.6
Dose Rate at 1 ft
 &Input  Next= 4,  X= 36.83,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 311.15,  NTheta= 7, NPsi= 11  &
Contact (2 inches)                        4" Diameter, 2' Long
 &Input X= 10.16,  NTheta= 13, NPsi= 23,  T(1)= 5.08   &
Dose Rate at 1 ft
 &Input  X= 35.56,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 96.52,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 309.88,  NTheta= 7, NPsi= 11  &
Contact (2 inches)                        5" Diameter, 1' Long
 &Input X= 11.43,  NTheta= 13, NPsi= 17,  T(1)= 6.35,
        SLTH= 30.48, Y= 15.24   &
Dose Rate at 1 ft
 &Input  X= 36.83,  NTheta= 11, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 9, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.15,  NTheta= 7, NPsi= 9  &
Contact (2 inches)                        4" Diameter, 1' Long
 &Input X= 10.16,  NTheta= 13, NPsi= 23,  T(1)= 5.08   &
Dose Rate at 1 ft
 &Input  X= 35.56,  NTheta= 11, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 96.52,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 309.88,  NTheta= 7, NPsi= 11  &
Touching (2 mm)                           250 ml sample bottle
 &Input Next= 3,  X= 2.84, T(1)= 2.54, 0.1,
  Slth= 12.7, Y= 6.35,  NTheta= 19, NPsi= 27, delr= 0.1,
  NSHLD= 2, JBuf= 1  &
  Soil  16   1.6
1 Bottle 2            1.0
Dose Rate at 2 inches (contact)
 &Input  Next= 4,  X= 7.72,  NTheta= 9, NPsi= 17  &
Dose Rate at 1 ft
 &Input  X= 33.12,  NTheta= 9, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 94.08,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 307.44  &
```

```
Contact (2 inches)                          55 gallon drum
 &Input Next=3,  X= 33.24, T(1)= 28, 0.16, IConc= 1,
  Slth= 82, Y= 41,  NTheta= 13, NPsi= 23, delr= 2  &
  Soil  16   1.6
1 Iron   9            7.86
Dose Rate at 1 ft
 &Input  Next= 4,  X= 58.64,  NTheta= 11, NPsi= 17  &
Dose Rate at 3 ft
 &Input  X= 119.6,  NTheta= 9, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 332.96  &
This is the End of the Cs-137 Run.
  &Input Next= 6  &
```

Westinghouse Hanford Company

Internal Memo

From: Environmental Technology Group 81210-90-071
Phone: 6-8506 H4-54
Date: June 15, 1990
Subject: ESTIMATE OF EXTERNAL DOSE RATES FROM CORE SAMPLING IN THE VICINITY OF THE 216-B CRIBS NORTH OF 241-BY

To: W. H. Price S0-03

cc: J. A. Bultena S0-04
R. A. Carlson H4-55
H. D. Downey S0-04
W. L. Johnson H4-55
J. V. Mohatt S0-03
P. D. Rittmann H4-54
R. C. Stupka L8-16
W. S. Thompson S0-04
JWC:PDR File/LB

This memo documents calculations done to estimate possible external dose rates near core samples and waste drums containing soil from the 216-B Crib area, just north of the 241-BY tank farm.

The dose rates are estimated by assuming the soil has a uniform concentration of the radioactivity sent to the crib. For the drilling of monitoring wells 299-E33-38, 39, and 40, the primary contaminant is assumed to be Sr-90. It assumed that most of the Cs-137 has remained near the bottom of the crib.

The estimated maximum dose rates near the 5 inch diameter core are 1 mR/hr (window closed CP) and 200 mrad/hr (window open CP) at a distance of 2 inches (contact). This dose rate is from Sr-90 at a concentration calculated by assuming that all the Sr-90 sent to the eight cribs is spread over a slab of soil 200 feet wide, 300 feet long and 10 feet thick.

If you have any questions concerning the attached calculations please call P. D. Rittmann at 6-8715.

J W Cammann

J. W. Cammann, Manager
Environmental Technology Group

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Attachment

Attachment 1: Estimate of external Dose Rates From Core Sampling in the Vicinity of the 216-B Cribs North of 241-BY
by Paul D. Rittmann June 15, 1990

The 216-B cribs are located north of the 241-BY tank farm in 200 East Area. A plan view of the site is attached. The object of this analysis is to estimate the potential dose rates to be encountered when core drilling takes place to insert two monitoring wells near these cribs. Two primary sources of external dose rate are the core sample (2 feet long and 5 inches in diameter) and a 55 gallon drum, which is assumed to collect the majority of the excess soil produced by the drilling.

The method used is to estimate soil concentrations and then calculate dose rates from these estimated soil concentrations for simple geometries such as can be handled by the program ISOSHLD.

The estimate of soil contamination assumes that the activity discharged to the cribs is uniformly distributed over some volume of soil under the cribs. The volume of the contaminated soil was varied to provide a range of possible contamination levels.

The discharges of water and Sr-90 and Cs-137 during the operation of the cribs are summarized in the table below. The Sr-90 and Cs-137 have been decayed to 1986. An additional 5 years of decay would only reduce the Sr-90 activity by 11 percent, a difference which is too small to be concerned about in the present dose rate estimates.

Discharges to the Cribs North of 241-BY Tank Farm

Crib ID	Liquid Liters	Total Curies Sr-90	Total Curies Cs-137	Average Ci/m3 Sr-90	Average Ci/m3 Cs-137
216-B-43	2.12E+06	630	142	2.97E-01	6.70E-02
216-B-44	5.60E+06	1310	336	2.34E-01	6.00E-02
216-B-45	4.92E+06	1290	727	2.62E-01	1.48E-01
216-B-46	6.70E+06	692	96.9	1.03E-01	1.45E-02
216-B-47	3.71E+06	286	72.7	7.71E-02	1.96E-02
216-B-48	4.09E+06	600	218	1.47E-01	5.33E-02
216-B-49	6.70E+06	1240	198	1.85E-01	2.96E-02
216-B-50	5.48E+07	3.72	55.8	6.79E-05	1.02E-03
Total:	8.86E+07	6052	1846	6.83E-02	2.08E-02
216-B-57	8.44E+07	2.01	246	2.38E-05	2.91E-03
Total:	1.73E+08	6054	2092	3.50E-02	1.21E-02

Three assumptions were made about the volume of soil under the cribs which contains the activity. The first two give estimates of activity concentrations under individual cribs, the third assumes the activity from all eight cribs has uniformly mixed into a single slab. The three assumptions are summarized below:

(1) Cylinder, radius 20 feet, thickness 4 feet (a worst case to maximize soil concentrations). Soil volume is 142 cubic meters.
(2) Cylinder, radius 80 feet, thickness 20 feet. Soil volume is 11,390 cubic meters.
(3) Rectangular slab, 200 feet wide, 300 feet long and 10 feet thick. Soil volume is 17,000 cubic meters.

The activity concentration in the soil is the total activity divided by the soil volume. The bounding cases are listed below. 216-B-44 has slightly more Sr-90, but considerably less Cs-137. Therefore, B-45 was taken to be the crib with the highest concentrations.

Soil Concentrations Under the Cribs

Category	Volume m^3	Total Activity Sr-90	Total Activity Cs-137	uCi/cc Activity Concentration Sr-90	uCi/cc Activity Concentration Cs-137
Crib Maximum (B-45)	142	1,290	727	9.1E+00	5.1E+00
Crib Minimum (B-50)	11,387	3.72	55.8	3.3E-04	4.9E-03
All 8 Cribs	16,990	6,052	1,846	3.6E-01	1.1E-01

The ISOSHLD-PC program, Version 1.6, was used to estimate the external dose rates from a concentration of 1 uCi/cc of either Sr-90 or Cs-137 in the soil. Three geometries are used. The 5 inch diameter, 2 foot long core sample is used with and without a 0.25 inch thick pipe surrounding it to identify the effect of the steel wall in reducing dose rates. The third geometry is a full 55 gallon drum. The assumed soil density is 1.6 g/cc in all cases. This is conservative because if the density were higher, the dose rates would be lower due to self shielding in the source.

From the table below, it can be seen that the effect of the 1/4 inch pipe wall is to reduce the exposure rates from the bare strontium source by a factor of two. The pipe has much less effect on the dose rates from Cs-137.

ISOSHLD-PC Exposure Rates (R/hr) Using a Source Concentration of 1 uCi/cc

	Sr-90			Cs-137		
	1/4 inch	Bare	55 gal	1/4 inch	Bare	55 gal
Contact	6.63E-04	1.27E-03	2.46E-03	7.25E-02	9.36E-02	2.49E-01
1 foot	1.41E-04	2.32E-04	9.22E-04	1.44E-02	1.65E-02	9.03E-02
3 feet	2.45E-05	3.80E-05	2.24E-04	2.45E-03	2.74E-03	2.18E-02
10 feet	2.43E-06	3.72E-06	2.73E-05	2.43E-04	2.70E-04	2.70E-03

1/4 inch = 5 inch diameter cylinder, 2 feet long, 0.25 inch pipe wall
Bare = 5 inch diameter cylinder, 2 feet long, no pipe
55 gal = 55 gallon drum filled with soil

Notes:

(1) The assumed soil density is 1.6 g/cc in all cases. Higher densities give rise to lower exposure rates.
(2) 1 uCi/cc Sr-90 means 1 uCi/cc Sr-90 and 1 uCi/cc Y-90. 1 uCi/cc Cs-137 means 1 uCi/cc Cs-137 and 0.946 uCi/cc Ba-137m.
(3) Contact exposure rates are given at 2 inches to approximate CP window closed readings.

Note that ISOSHLD-PC does not compute the direct dose rate from the beta radiation, such as would be measured in an "open window" CP reading taken by an HPT. ISOSHLD-PC computes "bremsstrahlung" photon radiation, an indirect effect of the beta rays measured in the "closed window" CP readings. The direct beta dose rate can be estimated from the rule of thumb for skin contaminations: 1 uCi/cm^2 of Sr-90 gives about 10 rad/hr to the skin. Assuming the surface contamination is represented by the first millimeter of soil, then a 1 uCi/cc concentration in the soil produces about 1 rad/hr beta radiation at the surface. Using ISOSHLD-PC to calculate the photon dose rate very close to the cylinder gives 2.5 mR/hr. Thus the direct beta dose rate could be expected to be about 400 times the bare Sr-90 exposure rate very close to the source. The beta dose rate will decrease rapidly with distance. A rule of thumb for beta dose rates is that the dose rate decreases by half in one-eight the range. For Y-90 betas (2.2 Mev maximum energy) the range in air is at most 30 feet. For Sr-90 alone (0.546 Mev), the range of the betas is at most 5 feet in air.

Applying the above dose rates for unit concentrations to the projected concentrations under the cribs gives the following exposure rates from the core sample and the 55 gallon drum:

Exposure Rates (mR/hr) for Crib Soil at the Estimated Concentrations

	Bare Sample		55 Gallon Drum	
	Contact	3 feet	Contact	3 feet
Crib Maximum	4.9E+02	1.4E+01	1.3E+03	1.1E+02
Crib Minimum	4.6E-01	1.3E-02	1.2E+00	1.1E-01
All 8 Cribs	1.1E+01	3.1E-01	2.8E+01	2.4E+00

From the above table, it can be seen that the exposure rates could be as high as 490 mR/hr near a 5 inch core sample. Most of this is due to Cs-137. A more average number is 11 mR/hr, again with most of the dose rate due to the Cs-137. These dose rates are for the drilling directly into a crib. For the present problem of drilling to the side of the cribs, the nuclides which have migrated due to water flow into the crib as well as natural water motion in the unsaturated zone are of primary interest.

Experience has shown that strontium is far more mobile in the soil than is cesium. Thus for the present drilling problem, it is expected that the primary contributor to soil contamination will be Sr-90. The table below shows the photon and estimated beta dose rates from the bare core from Sr-90 alone.

Estimated Dose Rates Near a Bare Core from Sr-90 Alone,
at the Concentrations Estimated Above

Assumed Beta to Photon Dose Rate Ratios: 400 at contact,
40 at 3 feet

	Contact (2 in)		at 3 feet	
	mR/hr	mrad/hr	mR/hr	mrad/hr
Crib Maximum	1.1E+01	4.6E+03	3.4E-01	1.4E+01
Crib Minimum	4.1E-04	1.7E-01	1.2E-05	5.0E-04
All 8 Cribs	4.5E-01	1.8E+02	1.4E-02	5.4E-01

mR/hr = the window closed CP reading (bremsstrahlung only)
mrad/hr = the direct beta dose rate (approximated by the window open minus the window closed reading)

The above table has estimates of potential exposure rates for the drilling of monitoring wells 299-E33-38, 39, and 40. The most likely value is the average for all 8 cribs, since there would be some mixing and averaging of Sr-90 concentrations during migration to the drilling sites. Since this is only an estimate, the rounded values to use for planning purposes are 1 mR/hr (window closed) and 200 mrad/hr (window open).

An important consideration during the handling of the core samples is the potential for significant airborne contamination due to suspension of contaminated dusts into the air. The airborne hazard can be estimated using a mass loading assumption. Moderately dusty air supports about 10 mg/m^3. If all 10 mg were soil contaminated to the levels calculated above, then the air concentrations for Sr-90 and Cs-137 are shown on the table below. Air concentrations are also given in terms of Derived Air Concentrations (DAC) for occupational exposure and Derived Concentration Guides (DCG) for environmental releases.

Localized Maximum Air Concentrations

	uCi/cc		DAC units		DCG units	
	Sr-90	Cs-137	Sr-90	Cs-137	Sr-90	Cs-137
Crib Maximum	5.7E-08	3.2E-08	2.8E+01	4.6E-01	6.3E+03	8.0E+01
Crib Minimum	2.0E-12	3.1E-11	1.0E-03	4.4E-04	2.3E-01	7.7E-02
All 8 Cribs	2.2E-09	6.8E-10	1.1E+00	9.7E-03	2.5E+02	1.7E+00

Air Concentration Guidelines, uCi/cc

Limit Type	Sr-90	Cs-137
Occupational (DAC)	2.0E-09	7.0E-08
Environmental (DCG)	9.0E-12	4.0E-10

The air concentrations are potentially high enough during short periods to warrant respiratory protection from the radioactive contamination. Sr-90 is the primary concern here. Since it may be present during the drilling of the monitoring wells, workers should wear particulate respiratory protection. Also, attention should be given to preventing the spread of surface contamination.

For information related to shipping the samples, the total activities in a sample at the concentrations calculated earlier are shown on the table below.

Total Activity (Curies) in a Sample

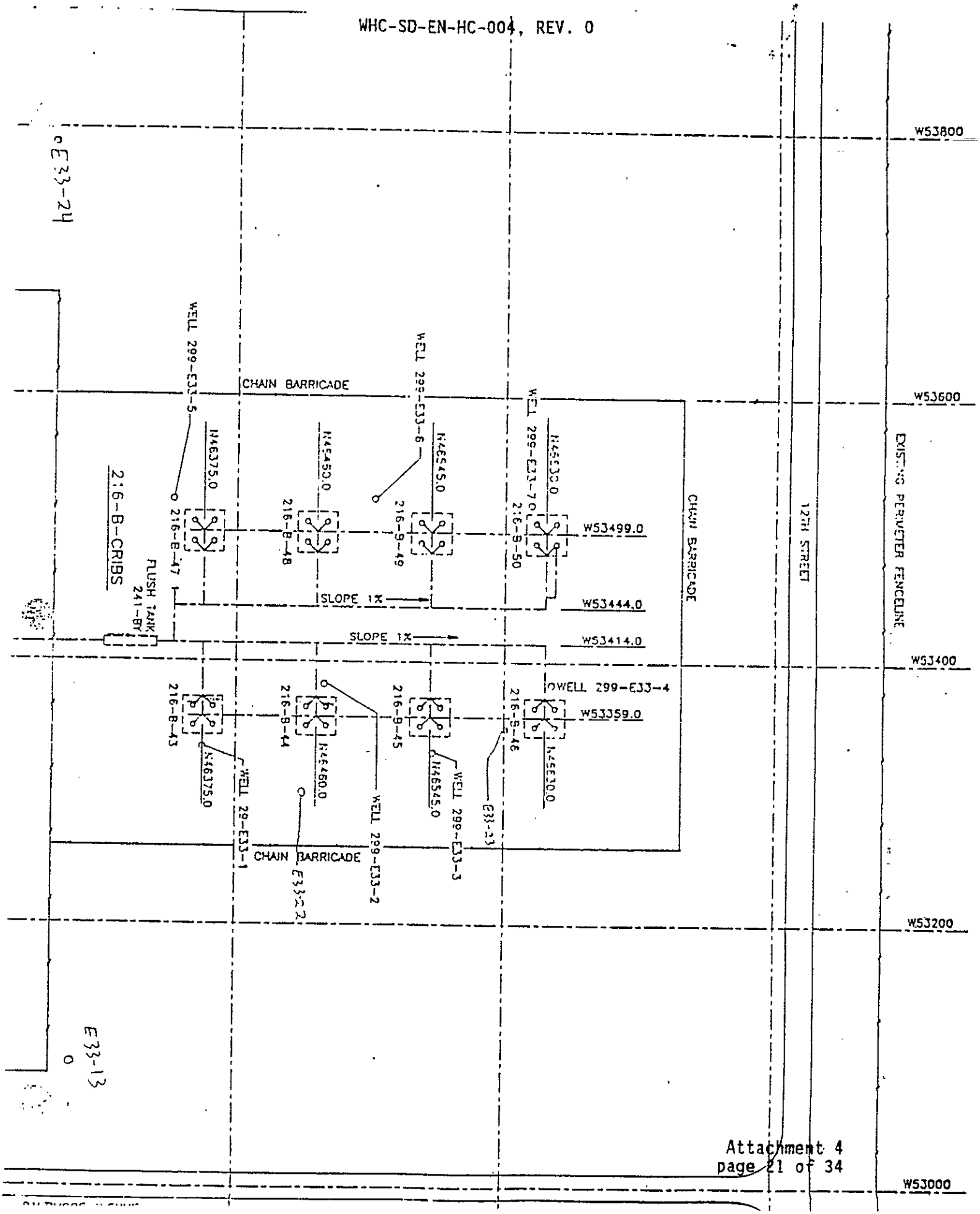
	250 ml Sample Bottle		7,720 ml 5" diameter core		206,900 ml 55 Gallon Drum	
	Sr-90	Cs-137	Sr-90	Cs-137	Sr-90	Cs-137
Crib Maximum	2.3E-03	1.3E-03	7.0E-02	3.9E-02	1.9E+00	1.1E+00
Crib Minimum	8.2E-08	1.2E-06	2.5E-06	3.8E-05	6.8E-05	1.0E-03
All 8 Cribs	8.9E-05	2.7E-05	2.8E-03	8.4E-04	7.4E-02	2.2E-02

References:

1. DOE/RL 88-32, Revision 1, "Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington", March 1990.

2. J. F. Cline and L. L. Cadwell, "Movement of Radiostrontium in the Soil Profile of an Arid Climate", Health Physics, Volume 46, pages 1136-1138, May 1984.

3. I. O. Lourant, "Validation of ISOSHLD-PC on the IBM PC (PS-2/AT/XT)", WHC-SD-SQA-CSWD-303, 12/20/89, EDT 109878.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CHAIN BARRICADE
WELL 299-E33-6
WELL 299-E33-7
W53600
N46375.0
N46450.0
N46545.0
N46530.0
216-B-CRIBS
216-B-47
216-B-48
216-9-49
216-9-50
W53499.0
CHAIN BARRICADE
12TH STREET
EXISTING PERIMETER FENCELINE
FLUSH TANK 241-BY
SLOPE 1%
W53444.0
SLOPE 1%
W53414.0
W53400
WELL 299-E33-4
216-B-43
216-B-44
216-9-45
216-9-46
W53359.0
N46375.0
N46460.0
N46545.0
N46530.0
WELL 299-E33-1
WELL 299-E33-2
WELL 299-E33-3
E33-21
CHAIN BARRICADE
E33-22
W53200
E33-13
W53000

CHECKLIST FOR CALCULATION REVIEW

Document Reviewed (Complete reference) "Estimate of External Dose Rates from Core Sampling in the Vicinity of the 216-b Cribs North of 241-BY" Internal Memo to W. H. Price from J. W. Cammann, 81210-90-071

Author(s) Paul D. Rittmann

Yes	No	N/A	General Considerations
[X]	[ ]	[ ]	Problem completely defined.
* [X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors.
[X]	[ ]	[ ]	Code runstreams correct and consistent with analysis documentation.
[X]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[X]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results, applicable limits, and address all points required in the problem statement.
[X]		[X]	Review calculations, comments, and/or notes are attached.

Michelle Johnson 6/14/90
Technical Reviewer Approval Date

Note: Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

* assumes reference for strontium migration is added to analysis.

Attachment 2: ISOSHLD-PC Printed Output for the Unit Concentrations

Start run at 14:04:34 06/15/90

ISOSHLD-PC (R18D removed)
Version 1.6, December 1989
for IBM & Compatible Personal Computers
Nuclear Safety & Radiological Analysis
Westinghouse Hanford Company
Richland, WA 99352

Sr-90 Dose Rates, 1.6 g/cc Soil

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final uCi/cc
SR- 90	1.00E+00	1.000E+00
Y - 90	1.00E+00	1.000E+00

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
ORDCONC	1.600E+00	0.000E+00			
IRON	0.000E+00	7.860E+00			

Group	Linear Attenuation Coefficients (last region is air)					
1	3.445E+01	3.471E+02	4.424E-03	0.000E+00	0.000E+00	0.000E+00
2	5.610E+00	9.650E+01	6.542E-04	0.000E+00	0.000E+00	0.000E+00
3	1.559E+00	4.468E+01	3.504E-04	0.000E+00	0.000E+00	0.000E+00
4	1.080E+00	2.071E+01	2.715E-04	0.000E+00	0.000E+00	0.000E+00
5	6.952E-01	1.144E+01	2.405E-04	0.000E+00	0.000E+00	0.000E+00
6	5.304E-01	7.632E+00	2.247E-04	0.000E+00	0.000E+00	0.000E+00
7	4.325E-01	5.447E+00	2.137E-04	0.000E+00	0.000E+00	0.000E+00
8	3.648E-01	3.948E+00	2.049E-04	0.000E+00	0.000E+00	0.000E+00
9	3.274E-01	3.135E+00	1.985E-04	0.000E+00	0.000E+00	0.000E+00
10	2.848E-01	1.603E+00	1.725E-04	0.000E+00	0.000E+00	0.000E+00
11	2.048E-01	1.077E+00	1.474E-04	0.000E+00	0.000E+00	0.000E+00
12	1.584E-01	7.844E-01	1.312E-04	0.000E+00	0.000E+00	0.000E+00
13	1.424E-01	6.877E-01	1.183E-04	0.000E+00	0.000E+00	0.000E+00
14	1.376E-01	5.659E-01	1.118E-04	0.000E+00	0.000E+00	0.000E+00
15	1.200E-01	5.007E-01	8.986E-05	0.000E+00	0.000E+00	0.000E+00
16	1.019E-01	4.622E-01	8.210E-05	0.000E+00	0.000E+00	0.000E+00
17	9.760E-02	4.032E-01	7.408E-05	0.000E+00	0.000E+00	0.000E+00
18	8.800E-02	3.694E-01	6.658E-05	0.000E+00	0.000E+00	0.000E+00
19	8.320E-02	3.506E-01	6.180E-05	0.000E+00	0.000E+00	0.000E+00
20	7.360E-02	3.262E-01	5.818E-05	0.000E+00	0.000E+00	0.000E+00
21	7.040E-02	3.160E-01	5.495E-05	0.000E+00	0.000E+00	0.000E+00
22	6.880E-02	2.995E-01	5.262E-05	0.000E+00	0.000E+00	0.000E+00
23	6.560E-02	2.971E-01	5.004E-05	0.000E+00	0.000E+00	0.000E+00
24	6.320E-02	2.877E-01	4.784E-05	0.000E+00	0.000E+00	0.000E+00
25	5.808E-02	2.790E-01	4.383E-05	0.000E+00	0.000E+00	0.000E+00

Contact (2 inches) 5" Diameter Sample, 1/4" Pipe Wall

Source Shields Distance to Detector, X = 1.206E+01 cm
Cylindrical Cylindrical Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 11 NPSI = 21 DELR = 7.056E-01 cm
Total Intervals: 2.079E+03

Shield Thickness, cm 6.350E+00 6.350E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Group	Average Energy, Mev	Bremsstr. photons/sec	Source Total photons/sec	Energy Flux Mev/sq.cm/sec	Dose Rate R/hr
1	1.500E-02	8.462E+06	8.484E+06	0.000E+00	0.000E+00
2	2.500E-02	4.668E+06	4.668E+06	3.933E-26	6.805E-31
3	3.500E-02	2.847E+06	2.847E+06	5.995E-11	3.807E-16
4	4.500E-02	1.969E+06	1.969E+06	3.489E-04	1.144E-09
5	5.500E-02	1.411E+06	1.411E+06	6.803E-02	1.558E-07
6	6.500E-02	1.219E+06	1.219E+06	5.553E-01	1.050E-06
7	7.500E-02	1.109E+06	1.109E+06	2.099E+00	3.598E-06
8	8.500E-02	1.009E+06	1.009E-06	5.323E+00	8.607E-06
9	9.500E-02	9.090E+05	9.090E+05	8.921E+00	1.430E-05
10	1.500E-01	4.174E+06	4.174E+06	6.223E+01	1.075E-04
11	2.500E-01	1.389E+06	1.389E+06	5.693E+01	1.116E-04
12	3.500E-01	6.852E+05	6.852E+05	5.171E+01	1.065E-04
13	4.750E-01	5.154E+05	5.154E+05	5.761E+01	1.175E-04
14	6.500E-01	3.072E+05	3.072E+05	4.361E+01	9.071E-05
15	8.250E-01	1.139E+05	1.139E+05	1.897E+01	3.794E-05
16	1.000E+00	7.685E+04	7.685E+04	1.595E+01	3.079E-05
17	1.225E+00	3.912E+04	3.912E+04	9.750E+00	1.794E-05
18	1.475E+00	1.281E-04	1.281E+04	3.818E+00	6.719E-06
19	1.700E+00	2.925E+03	1.264E+04	4.414E+00	7.548E-06
20	1.900E+00	6.122E+02	6.122E+02	2.435E-01	4.042E-07
21	2.100E+00	3.561E+01	4.356E+02	1.897E-01	3.036E-07
22	2.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
23	2.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
24	2.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
25	3.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TOTALS		3.092E+07	3.095E+07	3.424E+02	6.632E-04

Note that 6.632E-04 R/hr = 4.753E-11 amp/kg

Dose Rate at 1 ft

Source Shields Distance to Detector, X = 3.747E+01 cm
Cylindrical Cylindrical Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 9 NPSI = 13 DELR = 7.056E-01 cm
Total Intervals: 1.053E+03

Shield Thickness, cm 6.350E+00 6.350E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 1.411E-04 R/hr
= 1.011E-11 amp/kg

Dose Rate at 3 ft

Source Cylindrical — Shields Cylindrical — Distance to Detector, X = 9.843E+01 cm
Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm — Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 7 NPSI = 11 DELR = 7.056E-01 cm
Total Intervals: 6.930E+02

Shield Thickness, cm 6.350E+00 6.350E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 2.448E-05 R/hr
= 1.754E-12 amp/kg

Dose Rate at 10 ft

Source Cylindrical — Shields Cylindrical — Distance to Detector, X = 3.118E+02 cm
Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm — Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 7 NPSI = 11 DELR = 7.056E-01 cm
Total Intervals: 6.930E+02

Shield Thickness, cm 6.350E+00 6.350E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 2.426E-06 R/hr
= 1.738E-13 amp/kg

Contact (2 inches) 55 gallon drum

Source Cylindrical — Shields Cylindrical — Distance to Detector, X = 3.324E+01 cm
Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm — Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 13 NPSI = 23 DELR = 3.111E+00 cm
Total Intervals: 2.691E+03

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 2.459E-03 R/hr
= 1.762E-10 amp/kg

Dose Rate at 1 ft

Source Cylindrical — Shields Cylindrical — Distance to Detector, X = 5.864E+01 cm
Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm — Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 9 NPSI = 15 DELR = 3.111E+00 cm
Total Intervals: 1.215E+03

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 9.224E-04 R/hr
= 6.611E-11 amp/kg

Dose Rate at 3 ft

Source Shields Distance to Detector, X = 1.196E+02 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 7 NPSI = 13 DELR = 3.111E+00 cm
Total Intervals: 8.190E+02

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 2.236E-04 R/hr
= 1.603E-11 amp/kg

Dose Rate at 10 ft

Source Shields Distance to Detector, X = 3.330E+02 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 7 NPSI = 13 DELR = 3.111E+00 cm
Total Intervals: 8.190E+02

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 2.728E-05 R/hr
= 1.955E-12 amp/kg

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
ORDCONC	1.600E+00				

Contact (2 inches) 5" Diameter Sample, No Pipe

Source Shields Distance to Detector, X = 1.143E+01 cm
Cylindrical Cylindrical Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 11 NPSI = 21 DELR = 7.056E-01 cm
Total Intervals: 2.079E+03

Shield Thickness, cm 6.350E+00
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source activity is interpreted as uCi/cc

Exposure Rate at Detection Point = 1.266E-03 R/hr
= 9.072E-11 amp/kg

Dose Rate at 1 ft

```
Source            Shields        Distance to Detector, X = 3.683E+01 cm
 Cylindrical        Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  9    NPSI = 13    DELR = 7.056E-01 cm
   Total Intervals:  1.053E+03

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source activity is interpreted as uCi/cc

 Exposure Rate at Detection Point = 2.316E-04 R/hr
                                  = 1.660E-11 amp/kg
```

Dose Rate at 3 ft

```
Source            Shields        Distance to Detector, X = 9.779E+01 cm
 Cylindrical        Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source activity is interpreted as uCi/cc

 Exposure Rate at Detection Point = 3.800E-05 R/hr
                                  = 2.723E-12 amp/kg
```

Dose Rate at 10 ft

```
Source            Shields        Distance to Detector, X = 3.111E+02 cm
 Cylindrical        Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source activity is interpreted as uCi/cc

 Exposure Rate at Detection Point = 3.719E-06 R/hr
                                  = 2.665E-13 amp/kg
```

Dose Rate at 0.2 cm

```
Source            Shields        Distance to Detector, X = 6.550E+00 cm
 Cylindrical        Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA = 17    NPSI = 31    DELR = 2.048E-01 cm
   Total Intervals:  1.634E+04

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source activity is interpreted as uCi/cc

 Exposure Rate at Detection Point = 2.721E-03 R/hr
                                  = 1.950E-10 amp/kg
```

```
***>  This is the End of the Sr-90 Run.


 Finish run at  15:12:41  06/15/90

 Contents of Input file, ISO.IN

0         2   Sr-90 Dose Rates,  1.6 g/cc Soil
Contact (2 inches)      5" Diameter Sample, 1/4" Pipe Wall
 &Input Next=1, IGeom= 7,  X= 12.065, T(1)= 6.35, 0.635,  IConc= 1,
  Slth= 60.96, Y= 30.48,  NTheta= 11, NPsi= 21, delr= 0.7,
  NSHLD= 2, JBuf= 1,  Weight(082)= 1,  Weight(084)= 1  &
  Soil  16   1.6
1 Iron   9   0.0       7.86
Dose Rate at 1 ft
 &Input  Next= 4, Iprnt= 1,  X= 37.465, NTheta= 9, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 98.425,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.785  &
Contact (2 inches)      55 gallon drum
 &Input  Slth= 82, Y= 41,  T(1)= 28, 0.16,  X= 33.24,
  NTheta= 13, NPsi= 23, Delr= 3.0  &
Dose Rate at 1 ft
 &Input  X= 58.64, NTheta= 9, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 119.6,  NTheta= 7, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 332.96  &
Contact (2 inches)      5" Diameter Sample, No Pipe
 &Input  Next= 3,  IGEOM= 7, X= 11.43,  NSHLD= 1, JBuf= 1, T(1)= 6.35,
  Slth= 60.96, Y= 30.48,  NTheta= 11, NPsi= 21, delr= 0.7  &
1 Soil  16   1.6
Dose Rate at 1 ft
 &Input  Next= 4,  X= 36.83, NTheta= 9, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.15  &
Dose Rate at 0.2 cm
 &Input  X= 6.55,  NTheta= 17, NPsi= 31, Delr= 0.2  &
This is the End of the Sr-90 Run.
  &Input Next= 6  &
```

Start run at 13:50:56 06/15/90

ISOSHLD-PC (RIBD removed)
Version 1.6, December 1989
for IBM & Compatible Personal Computers
Nuclear Safety & Radiological Analysis
Westinghouse Hanford Company
Richland, WA 99352

Cs-137 Dose Rates, 1.6 g/cc Soil

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
ORDCONC	1.600E+00	0.000E+00			
IRON	0.000E+00	7.860E+00			

Group	Linear Attenuation Coefficients (last region is air)					
1	1.463E+00	3.989E+01	3.346E-04	0.000E+00	0.000E+00	0.000E+00
2	1.366E-01	5.622E-01	1.106E-04	0.000E+00	0.000E+00	0.000E+00

Contact (2 inches) 5" Diameter Sample, 1/4" Pipe Wall

Source Shields Distance to Detector, X = 1.206E+01 cm
Cylindrical Cylindrical Volume = 7.728E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 11 NPSI = 21 DELR = 7.056E-01 cm
Total Intervals: 2.079E+03

Shield Thickness, cm 6.350E+00 6.350E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Group	Average Energy, Mev	Source photons/sec	Energy Flux Mev/sq.cm/sec	Dose Rate Roentgens/hr
1	3.700E-02	2.015E+07	1.209E-08	6.935E-14
2	6.600E-01	2.432E+08	3.491E+04	7.245E-02
TOTALS		2.634E+08	3.491E+04	7.245E-02

Note that 7.245E-02 R/hr = 5.192E-09 amp/kg

Dose Rate at 1 ft

```
Source            Shields        Distance to Detector, X = 3.747E+01 cm
 Cylindrical       Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  9    NPSI = 13    DELR = 7.056E-01 cm
   Total Intervals:  1.053E+03

 Shield Thickness, cm   6.350E+00  6.350E-01
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 1.442E-02 R/hr
                                  = 1.033E-09 amp/kg
```

Dose Rate at 3 ft

```
Source            Shields        Distance to Detector, X = 9.843E+01 cm
 Cylindrical       Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00  6.350E-01
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 2.452E-03 R/hr
                                  = 1.757E-10 amp/kg
```

Dose Rate at 10 ft

```
Source            Shields        Distance to Detector, X = 3.118E+02 cm
 Cylindrical       Cylindrical     Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm      Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00  6.350E-01
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 2.431E-04 R/hr
                                  = 1.742E-11 amp/kg
```

Contact (2 inches) 55 gallon drum

Source Shields Distance to Detector, X = 3.324E+01 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 13 NPSI = 23 DELR = 3.111E+00 cm
Total Intervals: 2.691E+03

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 2.487E-01 R/hr
= 1.782E-08 amp/kg

Dose Rate at 1 ft

Source Shields Distance to Detector, X = 5.864E+01 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 9 NPSI = 15 DELR = 3.111E+00 cm
Total Intervals: 1.215E+03

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 9.027E-02 R/hr
= 6.470E-09 amp/kg

Dose Rate at 3 ft

Source Shields Distance to Detector, X = 1.196E+02 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 7 NPSI = 13 DELR = 3.111E+00 cm
Total Intervals: 8.190E+02

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 2.181E-02 R/hr
= 1.563E-09 amp/kg

Dose Rate at 10 ft

Source Shields Distance to Detector, X = 3.330E+02 cm
Cylindrical Cylindrical Volume = 2.020E+05 cc
Source Length = 8.200E+01 cm Distance Along Cylinder, Y = 4.100E+01 cm
Integration Specs: NTHETA = 7 NPSI = 13 DELR = 3.111E+00 cm
Total Intervals: 8.190E+02

Shield Thickness, cm 2.800E+01 1.600E-01
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 2.697E-03 R/hr
= 1.933E-10 amp/kg

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
OROCONC	1.600E+00				

Contact (2 inches) 5" Diameter Sample, No Pipe

Source Shields Distance to Detector, X = 1.143E+01 cm
Cylindrical Cylindrical Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 11 NPSI = 21 DELR = 7.056E-01 cm
Total Intervals: 2.079E+03

Shield Thickness, cm 6.350E+00
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 9.365E-02 R/hr
= 6.712E-09 amp/kg

Dose Rate at 1 ft

Source Shields Distance to Detector, X = 3.683E+01 cm
Cylindrical Cylindrical Volume = 7.722E+03 cc
Source Length = 6.096E+01 cm Distance Along Cylinder, Y = 3.048E+01 cm
Integration Specs: NTHETA = 9 NPSI = 13 DELR = 7.056E-01 cm
Total Intervals: 1.053E+03

Shield Thickness, cm 6.350E+00
Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

Source strength is interpreted as photons/sec/cc
Source Scale Factor was 1.000E-06

Gamma Only -- No Bremsstrahlung !

Exposure Rate at Detection Point = 1.655E-02 R/hr
= 1.186E-09 amp/kg

Dose Rate at 3 ft

```
Source            Shields        Distance to Detector, X = 9.779E+01 cm
 Cylindrical        Cylindrical      Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm       Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 2.738E-03 R/hr
                                  = 1.962E-10 amp/kg
```

Dose Rate at 10 ft

```
Source            Shields        Distance to Detector, X = 3.111E+02 cm
 Cylindrical        Cylindrical      Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm       Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA =  7    NPSI = 11    DELR = 7.056E-01 cm
   Total Intervals:  6.930E+02

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 2.698E-04 R/hr
                                  = 1.933E-11 amp/kg
```

Dose Rate at 0.2 cm

```
Source            Shields        Distance to Detector, X = 6.550E+00 cm
 Cylindrical        Cylindrical      Volume = 7.722E+03 cc
 Source Length = 6.096E+01 cm       Distance Along Cylinder, Y = 3.048E+01 cm
 Integration Specs:   NTHETA = 17    NPSI = 31    DELR = 2.048E-01 cm
   Total Intervals:  1.634E+04

 Shield Thickness, cm   6.350E+00
 Taylor Buildup Data for Shield 1 with Effective Atomic Number 10.0

 Source strength is interpreted as photons/sec/cc
 Source Scale Factor was 1.000E-06

          Gamma Only -- No Bremsstrahlung !

 Exposure Rate at Detection Point = 2.084E-01 R/hr
                                  = 1.494E-08 amp/kg
```

```
***>  This is the End of the Cs-137 Run.


 Finish run at  13:56:56  06/15/90

 Contents of Input file, ISO.IN

0         3  Cs-137 Dose Rates,  1.6 g/cc Soil
Contact (2 inches)      5" Diameter Sample, 1/4" Pipe Wall
 &Input Next= 3, IGeom= 7,  X= 12.065, T(1)= 6.35, 0.635,
  Slth= 60.96, Y= 30.48,  NTheta= 11, NPsi= 21, delr= 0 7,
  NSHLD= 2, JBuf= 1,    IConc= 1,    SFact= 1.0E-06,
  Source(1,1)= 2.61E+09, 0.037, 0.0,
               3.15E+10, 0.66,  0.0   &
  Soil  16   1 6
1 Iron   9   0.0       7.86
Dose Rate at 1 ft
 &Input  Next= 4, Iprnt= 1,  X= 37.465, NTheta= 9, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 98.425,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.785  &
Contact (2 inches)       55 gallon drum
 &Input  Slth= 82, Y= 41,  T(1)= 28, 0.16,  X= 33.21,
  NTheta= 13, NPsi= 23, Delr= 3 0  &
Dose Rate at 1 ft
 &Input  X= 58.64, NTheta= 9, NPsi= 15  &
Dose Rate at 3 ft
 &Input  X= 119.6,  NTheta= 7, NPsi= 13  &
Dose Rate at 10 ft
 &Input  X= 332.96  &
Contact (2 inches)       5" Diameter Sample, No Pipe
 &Input  Next= 3,  IGEOM= 7, X= 11.43,  NSHLD= 1, JBuf= 1, T(1)= 6.35,
  Slth= 60.96, Y= 30.48,  NTheta= 11, NPsi= 21, delr= 0 7  &
1 Soil  16   1.6
Dose Rate at 1 ft
 &Input  Next= 4,  X= 36.83, NTheta= 9, NPsi= 13  &
Dose Rate at 3 ft
 &Input  X= 97.79,  NTheta= 7, NPsi= 11  &
Dose Rate at 10 ft
 &Input  X= 311.15  &
Dose Rate at 0.2 cm
 &Input  X= 6.55,  NTheta= 17, NPsi= 31, Delr= 0.2  &
This is the End of the Cs-137 Run.
 &Input Next= 6  &
```

ATTACHMENT 5

CRITICALITY EVALUATION

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Westinghouse Hanford Company

Internal Memo

From: Criticality Engineering Analysis 29210-91-0010
Phone: 3-2246 R3-01
Date: March 14, 1991
Subject: CRITICALITY CONSIDERATIONS 200-BP-1 CRIB SOIL SAMPLING

To: E. E. Leitz NI-37

cc: PCD/lb

References: Memo, E. E. Leitz to P. C. Doto "Criticality Considerations 200-BP-1 Crib Soil Sampling" Dated March 13, 1991

WHC-CM-4-29, "Nuclear Criticality Safety Manual"

The reference 1 letter requested an assessment of the criticality considerations for 200-BP-1 crib soil sampling. Based on the inventory data provided for the three cribs involved in this sampling program, the only fissile isotope present is ^{239}Pu and that is present only in amounts that are below criticality safety concern.

Crib	^{239}Pu (curies)	^{239}Pu (grams)
216-B-43	0.02850	5.16
216-B-49	0.85600	155.2
216-B-57	0.01061	1.92

Facilities that are limited to no more that 3% of a minimum critical mass (15 grams of ^{239}Pu or equivalent) are exempt from criticality safety control (reference 2). Therefore, there are no criticality safety requirements associated with this activity.

P. C. Doto
Manager

db

Westinghouse Hanford Company

Internal Memo

From: Safety Hazards Analysis EEL-29240-91-018
Phone: 6-8079 NI-37
Date: March 13, 1991
Subject: CRITICALITY CONSIDERATIONS 200-BP-1 CRIB SOIL SAMPLING

To: P. C. Doto R3-01

cc: EEL File/LB

Please assess the potential for a criticality event during soils sampling (by well drilling) of the following three cribs:

216-B-43
216-B-49
216-B-57

This total radionuclide inventory in each of these cribs are attached as Tables 5, 6, and 7. If you need more information than the total inventory given in the attached tables, I will be glad to obtain the data you need.

Please provide your analysis by March 19, 1991.

Emil E. Leitz

E. E. Leitz
Manager

siw

References

Criticality Considerations 200-BP-1 Crib Soil Sampling, memorandum from E. E. Leitz to P. C. Doto, March 13, 1991.

Nuclear Criticality Safety Manual, WHC-CM-4-29, Westinghouse Hanford Company, Richland, Washington.

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ATTACHMENT 6

HAZARD SCREENING EVALUATION

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ATTACHMENT 6

N. R. KERR/D. L. HARROLD

200-BP-1, TASK 4 HAZARD SCREENING EVALUATION

Introduction

This screening evaluation of intrinsic hazards of Task 4 consists of three activity segments, drilling and sampling, sample preparation and interim storage. Task 4 is a soil characterization of inactive cribs 216-B-43,-49,-57 and -61. The cribs, with the exception of 216-B-61 were used to dispose liquid wastes associated with the BY Tank Farm. Crib 216-B-61 is believed to have received no liquid discharges. The purpose of the drilling and sampling activities is to determine the nature and extent of the contamination in the vadose zone. The investigation data obtained will be use to determine the required remediation for the 200-BP-1 Operable Unit.

The drilling and sampling activity is the mechanical relocation of soil samples from vadose zone. The primary equipment used will be a cable tool drill advancing the borehole with the dry drilling method utilizing a drive barrel.

Samples will be taken using a split spoon sample barrel. Contaminated samples or samples suspected to be contaminated will be extracted from the split barrel sampler using a field glove box which will be inside a specially prepared truck or trailer sample unit. The glove box will be connected to an independently high-efficiency particulate air (HEPA) filtered confinement system.

The drill cuttings from the borehole advancement will be deposited in 55-gal containers which meet DOT shipping requirements. The containerized cuttings will be segregated by waste type; unknown waste, hazardous waste, radioactive waste and mixed waste. Mixed waste will be interim stored in specially designed metal buildings.

Purpose

The objective of this evaluation is to provide focus, associating the hazards and the adequacy of the selected controls of the Environmental Protection Agency (EPA), Washington State Department of Ecology and Westinghouse Hanford Company (WHC) for the U. S. Department of Energy (DOE).

Findings

The screening exercise, based on radiological inventory, finds the overall classification low hazard. Predominantly the hazards were found to be to the site worker rather than the uninvolved employee or public. Each segment (drilling, sample preparation and interim storage) was assessed for hazards.

Inventory

The contamination in the vadose zone is a residual of chemicals and radionuclides bound and filtered from the discharged liquid wastes. The liquids discharged were the residual liquids from a flocculation or settling process that was performed in the BY storage tanks. Chemicals were added to the BY storage tanks to precipitate radioactive contaminants to the tank bottoms. The process was performed using a cascading sequence. Flocculent was added and settling time was given to progressively precipitate the radioactive contaminants. The effectiveness of the process was not well documented leaving questions regarding the specific characteristics of the residue currently in the soil column.

DOE/RL 88-32 is a remediation investigation/feasibility study (RI/FS) work plan of the 200-BP-1 operable unit prepared for the EPA. The document includes a conservative reconstruction of postulated liquid discharges to the cribs. The inventory involved with each activity segment is addressed in the evaluation of each segment.

The crib inventory concentrations used are discussed in Attachment 1, INVENTORY BASIS FOR SOURCE TERMS.

Drilling/Sampling

The unmitigated hazard associated with the activity segment, drilling and sampling having potential to harm site workers, onsite personnel or offsite personnel is contaminated dust. More specifically, the most significant dust potential from the drilling is the emptying or dumping of the drive barrel. The largest drive barrel has a volume of 2,827 in^3 (46,490 cm^3). Although a plastic sleeve or bag will be used to confine the dust when released from the drive barrel, this control feature is not considered in the assessment of hazard. This is a "mitigating" (control) factor.

The worst case soil concentrations are those postulated for crib 216-B-49, Attachment 1. The maximum volume of the worst case inventory would be the boring of the four foot thick soils containing the controlling substances. This could be contained in two drive barrels. The worst case drive barrel inventory would be one filled with the worst concentration of ferrocyanide and radionuclide activity. The worst condition would be to dump the contents of the drive barrel while suspended in air allowing spillage to become airborne. The dumping of the drive barrel is evaluated as a single event because the time period between dumps is relatively long, greater than 1 h. Consequently, dumping the contents of a drive barrel is a potential instantaneous release.

The first step in the hazard screening is consideration given to the site worker. The worst case meteorology for the site worker is stagnant or stable air. This condition would provide the greatest concentration of breathable dust to the site worker. Assuming that soil and contaminant fractions are such that the dust will be suspended for at least a short time, the instantaneous release can be assessed. Moderately dusty conditions support approximately 10 mg/m^3 of dust in air.

The quantity of soil material found in the cribs are assumed to be compressed by the pounding action of the drill string (1.6 g/cm^3 x 1.3). The inventory in the largest drive barrel (46,490 cm^3) is summarized in the following.

The radiological inventory of the drive barrel was screening against the Exempt Quantities (EQ). The potential volume of radionuclides is greater than listed as EQ[6].

The inventory of ferrocyanide compound is based on surface area as described in Attachment 1. The inventory quantity is determined by the following:

Surface Contamination (g/cm^2) X Area of Drive Barrel bore (cm^2) = Inventory (g)

Substance	Substance Concentration 216-B-49	Quantity in Drive Barrel(12" dia.)	Exempt Quantity
Ferrocyanide	3.62E-2 g/cm^2	2.64E+1 g	-NA-
Co-60	6.33E-4 uCi/cm^3	3.82E+1 uCi	1E+0 uCi
Sr-90	8.73E+0 uCi/cm^3	5.28E+5 uCi	1E-1 uCi
Ru-106	7.04E-8 uCi/cm^3	4.25E-3 uCi	1E+0 uCi
Cs-137	1.39E+0 uCi/cm^3	8.35E+4 uCi	1E+1 uCi
Pu-239	6.03E-3 uCi/cm^3	3.64E+2 uCi	1E-2 uCi
Pu-240	1.63E-3 uCi/cm^3	9.85E+1 uCi	1E-2 uCi
U-238	7.18E-5 uCi/cm^3	4.34E+0 uCi	1E-2 uCi

To evaluate the instantaneous release of radionuclides, moderate dust loading concentrations (10 mg/m^3) were assessed against the DACs. The results are summarized below.

Substance	Concentration in air (uCi/cm^3)	DAC (uCi/ml)
Co-60	3.96E-12	1.00E-8
Sr-90	5.45E-8	2.00E-9
Ru-106	4.40E-16	5.00E-9
Cs-137	8.69E-9	7.00E-8
Pu-239	3.77E-11	2.00E-12
Pu-240	1.02E-11	2.00E-12
U-238	4.49E-13	2.00E-11

The derived concentrations indicate that an instantaneous release could have the potential to generate contaminant concentrations that require respiratory protection for the site worker. The controlling radionuclides are Sr-90, Cs-137, Pu-239 and Pu-240.

Because of the potential contaminant concentrations at the site, the potential consequences to onsite and public receptors are given further consideration. The potential source which could become airborne in this scenario is that portion of contaminated dust released when the drive barrel

is dumped. The fraction of material which could become airborne is dependent upon the wind speeds when the dumping occurs and on the particle sizes of the dumped material. The particle sizes of the vadose zone would include small aggregate, various sizes of sand and likely some clays and silts. The larger particulate settles rapidly and has a filtering effect to the dispersable particulate thereby reducing, in a short distance, the airborne concentration. Dispersion to distances of 100 meters further reduces the airborne concentrations that could be inhaled by other individuals. The consequences to individuals at 100 meters or at the site boundary would be below the ceiling values for low hazard activities.

Sample Preparation

The intrinsic hazard associated with the sample preparation truck/trailer is again, potential airborne release of contaminated soil. The source would also be that derived for crib 216-B-49 but the volume of material is limited by the split tube sample barrel. The maximum volume of soil in the sampler is 265 in^3 (4,343 cm^3). An airborne release of material in the split tube sampler in the confines of the trailer will present a hazard to a site worker in the trailer.

To derive the worst case airborne concentration in the confined airspace of the truck/trailer a hypothetical accident was evaluated. The entire content of the sample barrel is assumed to be spilled in the truck/trailer unit. The interior space of the trailer is 8 ft wide by 16 ft long by 7 ft high or 856 ft^3 (25 m^3). The unit exhauster is assumed to clear the air space at a rate of 8 airspaces per hour to maximize the release to the environs. To postulate a resulting concentration of particulate it is assumed that the resulting dust is allowed to disperse inside the unit during uncontrolled clean up activities, vigorous sweeping.

To evaluate the release of radionuclides the maximum dust loading of respirable particulates (100mg/m^3) was assessed against the DACs. The results are summarized below.

Substance	Concentration in air (uCi/cm^3)	DAC (uCi/cm^3)
Co-60	3.96E-11	1.00E-8
Sr-90	5.45E-7	2.00E-9
Ru-106	4.40E-15	5.00E-9
Cs-137	8.69E-8	7.00E-8
Pu-239	3.77E-10	2.00E-12
Pu-240	1.02E-10	2.00E-12
U-238	4.49E-12	2.00E-11

Maximum dust loading shows the controlling radionuclides to be Sr-90, Cs-137, Pu-239, Pu-240, and possibly U-238 since these are greater than or near the DAC.

A 2-h exposure time was proposed as a conservative value for analysis purposes. Breathing an air concentration of one DAC for 2,000 h would produce a committed dose equivalent exposure of 5 rem. Breathing one DAC for 2 h would produce a committed dose equivalent exposure of .005 rem. Calculating

the air concentrations inside the trailer in terms of a DAC, the associated committed dose exposures for the worker are listed below.

Substance	Release Rate (uCi/s)	Concentration in air (DAC)	EDE (rem)
Sr-90	3.03E-2	2.72E2	1.36E0
Cs-137	4.83E-3	1.24E0	6.20E-3
Pu-239	2.09E-5	1.89E2	9.45E-1
Pu-240	5.67E-6	5.10E1	2.55E-1
U-238	2.49E-7	2.24E-1	1.12E-3
		Approximately	3E+1

The hypothetical radiological airborne concentrations are above the occupational threshold. The potential consequences to a worker breathing the air without a respirator for two hours would be approximately 3 rem based on ratios of the sum of the DAC's. This potential dose is categorized a low hazard activity based on the unmitigated accident consequence to the site worker.

If the trailer exhaust discharged unfiltered air at the rate of eight air spaces per hour for 2 h, (16 x 25 m^3) or 400 m^3 of air would be discharged to the atmosphere. The amount of particulate that would be released is 400 m^3 x .1g/m^3 or 40 grams. The rate of particulate discharge is 40g/7200s or .0055 grams per second. An atmospheric dispersion factor (X/Q) of 1.20E-2 was used to determine exposures to an onsite individual at 100 meters assuming a wind speed of 2m/sec. The results are listed below.

Substance	Concentration in air (DAC)	EDE (rem)
Co-60	2.64E-6	1.36E+0
Sr-90	1.82E-1	9.10E-4
Cs-137	8.29E-4	4.14E-6
Pu-239	1.25E-1	6.25E-4
Pu-240	3.40E-2	1.70E-4
U-238	1.48E-3	7.40E-6
Total	approximately	3E-3

The total committed dose to an individual at 100 meters is approximately 2 E-3 rem. or 2 mrem. The accident assessed is classified as a low hazard activity.

Ferrocyanide compound consequences would be negligible. The fraction of the compound in the sample barrel would be 1E-3 g/g. The concentration of the compound for the maximum respirable particulate would be 1E-4 mg/m^3, significantly below the TWA of 5 mg/m^3 or the IDLH of 50 mg/m^3.

Interim Storage

The intrinsic hazard of the interim storage is potential release to the atmosphere that can cause spread of contamination to the environment and or present a health hazard to individuals. In order to bound the hazard, a maximum release scenario was proposed where a fraction of the total inventory was released into the atmosphere.

The quantity of soil extracted from the maximum radiological contaminated soil. The content of six drive barrels, two from each crib; 216-B-43, -49 and -57. The volume of two drive barrels is 5,654 in^3 (92,635 cm^3). The worst postulated concentrations of material from the three cribs are those discussed under Inventory. The total inventory extracted from the three contaminated cribs is summarized below.

SUBSTANCE	AVERAGE CONCENTRATION 3 CRIBS	QUANTITY OF MATERIALS AT SURFACE
Ferrocyanide	2.50E-4 g/cm^3	6.96E+0 g
Co-60	2.77E-4 uCi/cm^3	7.70E+1 uCi
Sr-90	4.39E+0 uCi/cm^3	1.22E+6 uCi
Ru-106	2.30E-8 uCi/cm^3	6.39E-3 uCi
Cs-137	1.28E+0 uCi/cm^3	3.56E+5 uCi
Pu-239	2.10E-3 uCi/cm^3	5.84E+2 uCi
Pu-240	5.67E-4 uCi/cm^3	1.58E+2 uCi
U-238	3.50E-5 uCi/cm^3	9.73E+0 uCi

To provide the initial screening of the relative hazard presented by the worst case concentrations of contaminated soil the hazard classification method found in PNL-MA-44, Section 2.0, HAZARD CLASSIFICATION, is used. This method looks at different groupings of radionuclides relative to their energy characteristics and the dispersion characteristics of the material. Based upon these categories the overall hazard classification is based on the total quantity available without regard to mitigating features. The inventory consists of Group 1, Long lived alpha emitters (Pu-239, -240 and U-238) and Group 2 Beta emitters, fission products and activation products. The dispersible characteristics are, Dispersible, "Operations with radioactive liquids, powders, or particulate solids" and "Operations that can result in fractional releases of radioactive materials. Using this method the overall hazard classification of 200-BP-1 is found to be a low hazard activity. A summary of the screening follows.

	INVENTORY AT SURFACE	LOW HAZARD CEILING
Group 1	7.52E-4 Ci	< E+01 Ci
Group 2	1.58E+0 Ci	< E+03 Ci

The hazards associated with the ferrocyanide discharges are discussed earlier. The area of concern lies with the potential substances complexed in the tanks or in the soils when discharged. There is a unknown potential for

cyanide salts to be present in the vadose zone. The potential concentrations are expected to represent a potential hazard to site workers if acids are introduced to the soils. As a precautionary control, acids will be restricted from the 200-BP-1 site until the soil samples have been characterized and determined not to generate free cyanide gas in the presence of acids.

Additional assessment was performed to evaluate the potential exposure to other individuals.

Assumptions

* The total inventory at worst case concentrations is the contents removed from six drive barrels (2 drive barrels each crib).
* The inventory is in a single pile.
* Worst case radionuclide concentrations of all 3 cribs are averaged.
* A fraction of the total inventory is released.
* Wind speed is 2 m/s.
* Fractional release factor = .001 (PNL-MA-44 Section 2.6)
* Atmospheric dispersion factor (X/Q) for 100 meters = 1.2E-2 (WHC-SD-GN-ER-301, Attachment C)

Results

Total inventory of soil removed: 277905 cm^3 or 444648 grams
Fraction released: 277.905 cm^3 or approximately 450 grams

For a 2-h release the release rate is approximately 6E-2 g/sec.

2 hour release

Substance	Release Rate (uCi/sec)	100 m (DAC)	100 m (EDE rem)
Co-60	1.07E-5	1.28E-5	6.40E-8
Sr-90	1.69E-1	1.01E-0	5.08E-3
Cs-137	4.94E-2	8.47E-3	4.24E-5
Pu-239	8.09E-5	4.86E-1	2.43E-3
Pu-240	2.19E-5	1.31E-1	6.58E-4
U-238	1.35E-6	8.10E-3	4.05E-5
Total			approximately 8E-3

For a 2-h release the EDE an for an onsite individual at 100 meters is approximately 8E-3 rem. or 8 mrem. This is equal to the EDE for an 8-h release since the same quantity of material is being released. The consequences of this hypothetical accident to an individual at the site boundary would be below the acceptable low hazard thresholds for public individuals.

The conditions, based on the total inventory removed from the cribs, assessed is classified as low hazard.

References

Remedial Investigation/Feasibility study Wrok Plan for the 200-BP-1 Operable Unit, DOE-RL 88-32, U.S. Department of Energy-Richland, Operations Office, Richland, Washington.

Implementation Guideline for Hazard Documentation, WHC-SD-GN-ER-301, September, 1990, Westinghouse Hanford Company, Richland, Washington.

Safety Review Systems, PNL-MA-44, 1990, D. Lucas.

ATTACHMENT 7

FACILITY HAZARD CLASSIFICATION

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NOTE TO READER:

The approaches and methods used in the safety assessment, the evaluations and analyses attached are equivalent. However, the radiological classification values used in Attachment 7 differ from the other parts. The values used in Attachment 7 are as stated in WHC-CM-4-46, *Non-Reactor Safety Manual*. The classification values used elsewhere in the safety assessment and attachments reflect classification values found in WHC-SD-GN-ER-301, *Implementation Guideline for Hazard Documentation*. The classification values of WHC-SD-GN-ER-301 have been submitted to DOE-RL in response to comments concerning WHC-CM-4-46. The classification values of WHC-SD-GN-ER-301 are more conservative and restrictive than are the classification values of WHC-CM-4-46. Both classification values are retained in the appropriate parts of the assessment. The classification of Attachment 7 is supported by verified analysis which is summarized in radiological dose or hazardous material concentrations. The dose and concentration derivations of Attachment 7 provide support for the low hazard classification of the 200-BP-1, Task 4 activities to the more restrictive classification values of WHC-SD-GN-ER-301.

Westinghouse Hanford Company

Internal Memo

From: Radiological Safety Analysis 29250-BEH-91.012
Phone: 6-2921 N1-19
Date: May 14, 1991
Subject: RADIOLOGICAL ANALYSIS OF ACCIDENTAL RELEASE FROM 200 EAST AREA BP-1 OPERABLE UNIT - REV. 1

To: L. A. Morton N1-37

cc: J. S. Davis N1-19 E. E. Leitz N1-37
D. S. Himes N1-19 J. C. Van Keuren N1-19
N. R. Kerr B1-35 BEH LB/File

Reference: Internal Memo from L. A. Morton to J. C. Van Keuren, "Dose Calculations for Postulated Accident Release From 200 Area BP-1 Operable Unit," April 8, 1991.

As requested, radiological dose consequences were evaluated for the source term provided in the referenced memorandum. The conclusion is that the 200 East Area BP-1 Operable Unit does meet the radiological criterion for a low hazard classification. This memorandum supersedes 29250-BEH-91009.

If there are any questions please call me at 6-2921.

Brit E. Hey
Senior Engineer

raw

Concurrence: J. C. Van Keuren
John C. Van Keuren - Manager
Radiological Safety Analysis

Attachment

Hanford Consultant and Engineering Contractor for the US Department of E

Westinghouse Hanford Company

Internal Memo

From: Safety Hazards Analysis LAM-39240-91-005
Phone: 6-8075 N1-37
Date: April 8, 1991
Subject: DOSE CALCULATIONS FOR POSTULATED ACCIDENT RELEASE FROM 200 AREA BP-1 OPERABLE UNIT

To: J. V. Van Keuren N1-19

cc: E. E. Leitz EEL N1-37
LAM File/LB

Please provide dose consequence estimates for a postulated accident at the Remedial Cleanup Operable Unit, designated 200 Area BP-1 Crib Soil Sampling, located adjacent to the 241-BY Tank Farm.

A drill rig will be used to extract soil samples from contaminated cribs and the drill tailings (contaminated soil) will be interim-stored at the Operable Unit Site.

In a postulated accident scenario, the contaminated soil is exposed and a combustible liquid spilled on it and ignited. An estimate of the stored inventory amounts of radionuclides were provided to me and release factors were taken from NUREG 1320. I used this date to calculate the released amounts listed in Table 1. Dose estimates are required for an onsite maximum individual at 100 meters and for an offsite maximum individual.

Results will be used to determine the hazard classification for the 200 Area BP-1 Operable Unit Worksite.

L. A. Morton,
Principle Engineer

siw

Attachment - Table

TABLE 1 200 AREA BP-1 POSTULATED ACCIDENT RELEASED AMOUNTS

Radionuclide	a Inventory Amount (Ci)	b Release Fraction	Released Amount (Ci)
^{60}Co	7.7E-05	0.0077	5.9E-07
^{90}Sr	1.2E+00	0.0077	9.2E-03
^{90}Y	1.2E+00	0.0077	9.2E-03
^{106}Ru	6.4E-09	0.0077	4.9E-11
^{137}Cs	3.6E-01	0.0077	2.8E-03
^{238}U	9.7E-06	0.013	1.3E-07
^{239}Pu	5.8E-04	0.013	7.5E-06
^{240}Pu	1.6E-04	0.013	2.1E-06

a. This is the total inventory to be extracted from the three contaminated cribs, as estimated elsewhere in this report, but with Yttrium added to the list.

b. Release fractions are from NUREG - 1320, Nuclear Fuel Cycle Facility Analysis Handbook, MaY 1988, U S Nuclear Regulatory Commission, Washington, D.C. see Table 4.2.

ATTACHMENT

Radiological Analysis of Accidental Release from 200 East Area BP-1 Operable Unit - Rev. 1

by Brit E. Hey

PURPOSE

The purpose of this analysis is to determine the dose consequences for a postulated accident at the site of 200-BP-1, Task 4. These results will be used to determine the hazard classification of the 200 East Area BP-1 Operable Unit. Results are compared to the criteria contained in Section 2.0 of the Westinghouse Hanford Company Nonreactor Facility Safety Analysis Manual (Ref. 1).

SOURCE TERM

The source term inventory is provided in Reference 2 (attached). Default PNL solubilities are assumed. The dominant inhalation pathway contributor to the effective dose equivalent (^{239}Pu), is assumed to be released as an oxide.

DOSE CONSEQUENCE ANALYSIS

Atmospheric dispersion and radiological consequences for the releases given in Reference 2 are computed using the GENII dose calculation program (Version 1.485 3-Dec-90). The data files used by GENII are:

GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Master Library (11/15/90 PDR)
Food Transfer Factor Library - (RAP 29-Aug-88)
External Dose Factors for GENII in person Sv/yr per Bq/m (8-May-90 RAP)
Internal Dose Increments, PNL Solubility Choices Rerun 12/3/90 PDR
EXTGAM - Gamma Energies by Group for Finite Plume (13-May-90 RAP)
200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)

Receptors at 100 meters and the site boundary are compared to determine the worst case location. The atmospheric dispersion factors (X/Q) are listed in Table 1 for the wind directions tested. The worst case onsite location is 100 meters north of the 200 East Area BP-1 Operable Unit. The worst case offsite location (distance measured from nearest 200 East Area perimeter to site boundary) is 14.8 km southwest. These are shown on Table 1 with asterisks. The plume meander correction factors are calculated using the methodology presented in NRC Regulatory Guide 1.145 (Ref. 3). The resulting correction factors are 0.25 for the onsite receptor and 0.82 for the offsite receptor. GENII input decks utilized in these analyses are included in Appendix A.

The maximum onsite dispersion coefficient (X/Q) along with the release quantities of Reference 2 are input into the GENII dose calculation program to calculate the maximum onsite individual doses. The exposure pathways include both inhalation and submersion. The inhalation doses use standard 50 year

dose commitment conversion factors. These results are compared to the onsite radiological criteria of Table 2-1 of Reference 1 to determine hazard classification.

The maximum offsite (site boundary) dispersion coefficient along with the release quantities of Reference 2 are input into the GENII dose calculation program to calculate the maximum offsite individual doses. The exposure pathways include both inhalation, submersion, external exposure due to deposition of radionuclides on the ground, terrestrial foods ingestion, and animal products ingestion. The sum of the inhalation and submersion pathways are compared to the offsite radiological criteria and the ingestion dose from the soil pathway is compared to the offsite environmental impact criteria of Table 2-1 of Reference 1 to determine hazard classification. Ingestion doses are reported for the autumn scenario (the most conservative of the season scenarios).

CONCLUSIONS

Table 3 provides a comparison between the calculated results and the low hazard radiological classification criteria. It should be noted that calculated 100 meter onsite doses are also below the offsite low hazard radiological criteria used to limit risk to the public. Thus, the dose at the nearest point of uncontrolled public access, which is further than 100 meters, is also below the offsite low hazard radiological criteria. The conclusion is that a low hazard classification for the 200 East Area BP-1 Operable Unit is permissible for the radionuclide inventory given in Reference 2.

REFERENCES

1) J. W. Hagan, Nonreactor Facility Safety Analysis Manual, WHC-CM-4-46, Richland, WA, September 1988.

2) Internal Memo from L. A. Morton to J. C. Van Keuren, "Dose Calculations for Postulated Accident Release From 200 Area BP-1 Operable Unit," April 8, 1991.

3) NRC Regulatory Guide 1.145, Rev. 1, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, United States Nuclear Regulatory Commission, Washington, D.C. 20555, November 1982.

Table 1: Acute 100m and Site Boundary Ground Level 200 East Area X/Q Values

Transport Direction	Onsite X/Q @ 100m (s/m^3)	Site Boundary Distance (km)	Offsite X/Q (s/m^3)
S	2.9E-02	19.4	9.3E-06
SSW	2.6E-02	14.8	1.2E-05
SW	2.9E-02	14.8	1.3E-05 *
WSW	3.1E-02	19.4	1.0E-05
W	3.1E-02	18.5	1.1E-05
WNW	3.3E-02	19.4	1.1E-05
NW	3.0E-02	19.4	9.9E-06
NNW	3.1E-02	19.4	1.0E-05
N	3.3E-02 *	22.2	9.4E-06
NNE	3.2E-02	24.0	8.1E-06
NE	2.9E-02	18.5	9.9E-06
ENE	2.3E-02	15.7	9.7E-06
E	2.3E-02	15.7	9.6E-06
ESE	1.5E-02	19.4	4.5E-06
SE	1.5E-02	23.0	3.5E-06
SSE	2.8E-02	19.4	9.0E-06

TABLE 2: Dose Consequences From the 200 East Area BP-1

ONSITE 100m, North	Sv	Rem
Effective Dose Equivalent		
Inhalation	1.4E-04	1.4E-02
Submersion	2.1E-09	2.1E-07
TOTAL	1.4E-04	1.4E-02
Bone Surface (Pu239)		
Inhalation	1.4E-03	1.4E-01
Submersion	2.1E-09	2.1E-07
TOTAL	1.4E-03	1.4E-01

OFFSITE 14.8km, SW	Sv	Rem
Effective Dose Equivalent		
Inhalation	1.8E-07	1.8E-05
Submersion	2.0E-11	2.0E-09
Ingestion	9.8E-06	9.8E-04
Ground Deposition	6.3E-08	6.3E-06
TOTAL	1.0E-05	1.0E-03
Bone Surface		
Inhalation (Pu239)	1.9E-06	1.9E-04
Submersion	2.0E-11	2.0E-09
Ingestion (Sr90)	8.2E-05	8.2E-03
Ground Deposition	6.3E-08	6.3E-06
TOTAL	8.4E-05	8.4E-03

Table 3: Comparison of Results to Low Hazard Classification Criteria

	EDE (rem)		Limiting Organ (rem)	
Receptor	Results	Criteria	Results	Criteria
Onsite	0.014	5	0.14	50
Offsite Radiological	0.00002	0.5	0.0002	5
Offsite Environmental	0.001*	0.5	0.008*	5

* Includes ingestion pathway only, as allowed by Reference 1.

APPENDIX A

GENII Input Files

```
########################## Program GENII Input File ############  8 Jul 88 ####
Title: Onsite, Inhalation & Submersion, Acute, Ground Level Release
       \SAMPL\G-AIR.AC                          Created on 01-22-1990 at 07:30
OPTIONS======================== Default ==================================
F    Near-field scenario?       (Far-field)    NEAR-FIELD: narrowly-focused
F    Population dose?         (Individual)                 release, single site
T    Acute release?             (Chronic)    FAR-FIELD:  wide-scale release,
     Maximum Individual data set used                      multiple sites
                                Complete                                Complete
TRANSPORT OPTIONS============ Section   EXPOSURE PATHWAY OPTIONS===== Section
T  Air Transport                   1     T  Finite plume, external        5
F  Surface Water Transport         2     F  Infinite plume, external      5
F  Biotic Transport (near-field)  3,4    F  Ground, external              5
F  Waste Form Degradation (near)  3,4    F  Recreation, external          5
                                         T  Inhalation uptake             5,6
REPORT OPTIONS======================     F  Drinking water ingestion      7,8
T  Report AEDE only                      F  Aquatic foods ingestion       7,8
F  Report by radionuclide                F  Terrestrial foods ingestion   7,9
F  Report by exposure pathway            F  Animal product ingestion      7,10
F  Debug report on screen                F  Inadvertent soil ingestion

INVENTORY ##############################################################

  1   Inventory input activity units: (1-pCi  2-uCi  3-mCi  4-Ci  5-Bq)
  0   Surface soil source units (1- m2  2- m3  3- kg)
      Equilibrium question goes here

      --------|----Release Terms------|----------Basic Concentrations---------|
      Use when|  transport selected   |  near-field scenario, optionally      |
      --------|-----------------------|---------------------------------------|
      Release |         Surface Buried|         Surface Deep    Ground  Surface|
      Radio-  |Air      Water   Waste |Air      Soil    Soil    Water   Water |
      nuclide |/yr      /yr     /m3   |/m3      /unit   /m3     /L      /L    |
      --------|------- ------- -------|------- ------- ------- ------- -------|
      C060    5.9E-07
      SR90    9.2E-03
      Y 90    9.2E-03
      RU106   4.9E-11
      CS137   2.8E-03
      U 238   1.3E-07
      PU239   7.5E-06
      PU240   2.1E-06

      --------|----Derived Concentrations-----|
      Use when|   measured values are known   |
      --------|-------------------------------|
      Release |Terres.  Animal  Drink   Aquatic|
      Radio-  |Plant    Product Water   Food   |
      nuclide |/kg      /kg     /L      /kg    |
      --------|------- ------- ------- -------|

TIME ###################################################################

1     Intake ends after (yr)
```

```
50   Dose calc. ends after (yr)
1    Release ends after (yr)
0    No. of years of air deposition prior to the intake period
0    No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) ####################################

0          Definition option: 1-Use population grid in file POP.IN
0                             2-Use total entered on this line

NEAR-FIELD SCENARIOS ########################################################

           Prior to the beginning of the intake period: (yr)
0            When was the inventory disposed?  (Package degradation starts)
0            When was LOIC?  (Biotic transport starts)
0          Fraction of roots in upper soil (top 15 cm)
0          Fraction of roots in deep soil
0          Manual redistribution: deep soil/surface soil dilution factor
0          Source area for external dose modification factor (m2)
TRANSPORT ###################################################################
           ====AIR TRANSPORT=================================SECTION 1=====
                  0-Calculate PM                |0        Release type (0-3)
1          Option: 1-Use chi/Q or PM value      |F        Stack release (T/F)
                  2-Select MI dist & dir        |0        Stack height (m)
                  3-Specify MI dist & dir       |0        Stack flow (m3/sec)
0          Chi/Q or PM value                     |0        Stack radius (m)
3          MI sector index (1=S)                 |0        Effluent temp. (C)
100.0      MI distance from release point (m)    |0        Building x-section (m2)
T          Use jf data, (T/F) else chi/Q grid    |0        Building height (m)

           ====SURFACE WATER TRANSPORT=======================SECTION 2=====
0          Mixing ratio model: 0-use value, 1-river, 2-lake
0          Mixing ratio, dimensionless
0          Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
0          Transit time to irrigation withdrawl location (hr)
           If mixing ratio model > 0:
0            Rate of effluent discharge to receiving water body (m3/s)
0            Longshore distance from release point to usage location (m)
0            Offshore distance to the water intake (m)
0            Average water depth in surface water body (m)
0            Average river width (m), MIXFLG=1 only
0            Depth of effluent discharge point to surface water (m), lake only

           ====WASTE FORM AVAILABILITY=======================SECTION 3=====
0          Waste form/package half life, (yr)
0          Waste thickness, (m)
0          Depth of soil overburden, m

           ====BIOTIC TRANSPORT OF BURIED SOURCE=============SECTION 4=====
T          Consider during inventory decay/buildup period (T/F)?
T          Consider during intake period (T/F)?   | 1-Arid non agricultural
0          Pre-Intake site condition.....         | 2-Humid non agricultural
                                                  | 3-Agricultural
```

EXPOSURE ##

====EXTERNAL EXPOSURE==========SECTION 5=====

Exposure time:		Residential irrigation:	
0	Plume (hr)	T	Consider: (T/F)
0	Soil contamination (hr)	0	Source: 1-ground water
0	Swimming (hr)		2-surface water
0	Boating (hr)	0	Application rate (in/yr)
0	Shoreline activities (hr)	0	Duration (mo/yr)

0 Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0 Transit time for release to reach aquatic recreation (hr)
1.0 Average fraction of time submersed in acute cloud (hr/person hr)

====INHALATION==========SECTION 6=====

3766.0 Hours of exposure to contamination per year
0 0-No resus- 1-Use Mass Loading 2-Use Anspaugh model
0 pension Mass loading factor (g/m3) Top soil available (cm)

====INGESTION POPULATION==========SECTION 7=====

0 Atmospheric production definition (select option):
0 0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
1-Use population-weighted chi/Q
2-Use uniform production
3-Use chi/Q and production grids (PRODUCTION will be overridden)
0 Population ingesting aquatic foods, 0 defaults to total (person)
0 Population ingesting drinking water, 0 defaults to total (person)
F Consider dose from food exported out of region (default=F)

Note below: S* or Source: 0-none, 1-ground water, 2-surface water
3-Derived concentration entered above

==== AQUATIC FOODS / DRINKING WATER INGESTION=========SECTION 8====

F Salt water? (default is fresh)

USE ? T/F	FOOD TYPE	TRANSIT hr	PRODUCTION kg/yr	CONSUMPTION HOLDUP da	CONSUMPTION RATE kg/yr	DRINKING WATER
F	FISH	0.00	0.0E+00	0.00	0.0	0 Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0 Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0 Consumption (L/yr)

====TERRESTRIAL FOOD INGESTION==========SECTION 9=====

USE ? T/F	FOOD TYPE	GROW TIME da	IRRIGATION S *	IRRIGATION RATE in/yr	IRRIGATION TIME mo/yr	YIELD kg/m2	PRODUCTION kg/yr	CONSUMPTION HOLDUP da	CONSUMPTION RATE kg/yr
F	LEAF V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	ROOT V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	FRUIT	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	GRAIN	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0

====ANIMAL PRODUCTION CONSUMPTION==========SECTION 10====

USE ? T/F	FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP da	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	DIET FRAC-TION	GROW TIME da	S *	-IRRIGATION-- RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE da
						----STORED FEED----						
F	BEEF	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	POULTR	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	MILK	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	EGG	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
						----FRESH FORAGE----						
	BEEF					0.00	0.0	0	0.0	0.00	0.00	0.0
	MILK					0.00	0.0	0	0.0	0.00	0.00	0.0

##########

```
########################## Program GENII Input File ############  8 Jul 88 ####
Title: Offsite, Inhalation & Submersion, Acute, Ground Level Release
       \SAMPL\G-AIR.AC                              Created on 01-22-1990 at 07:30
OPTIONS======================== Default ==================================
F    Near-field scenario?      (Far-Field)    NEAR-FIELD: narrowly-focused
F    Population dose?          (Individual)                release, single site
T    Acute release?              (Chronic)    FAR-FIELD:  wide-scale release,
     Maximum Individual data set used                     multiple sites
                                Complete                                Complete
TRANSPORT OPTIONS============ Section   EXPOSURE PATHWAY OPTIONS===== Section
T  Air Transport                  1      T  Finite plume, external       5
F  Surface Water Transport        2      F  Infinite plume, external     5
F  Biotic Transport (near-Field)  3,4    F  Ground, external              5
F  Waste Form Degradation (near)  3,4    F  Recreation, external          5
                                         T  Inhalation uptake             5,6
REPORT OPTIONS======================     F  Drinking water ingestion      7,8
T  Report AEDE only                      F  Aquatic foods ingestion       7,8
F  Report by radionuclide                F  Terrestrial foods ingestion   7,9
F  Report by exposure pathway            F  Animal product ingestion      7,10
F  Debug report on screen                F  Inadvertent soil ingestion

INVENTORY ##############################################################################

 4   Inventory input activity units: (1-pCi  2-uCi  3-mCi  4-Ci  5-Bq)
 0   Surface soil source units (1- m2  2- m3  3- kg)
     Equilibrium question goes here

--------|----Release Terms------|----------Basic Concentrations---------|
Use when|  transport selected   |  near-field scenario, optionally      |
--------|-----------------------|---------------------------------------|
Release |         Surface Buried|         Surface Deep    Ground  Surface|
Radio-  |Air      Water   Waste |Air      Soil    Soil    Water   Water |
nuclide |/yr      /yr     /m3   |/m3      /unit   /m3     /L      /L    |
--------|------- ------- -------|------- ------- ------- ------- -------|
C060    5.9E-07
SR90    9.2E-03
Y 90    9.2E-03
RU106   4.9E-11
CS137   2.8E-03
U 238   1.3E-07
PU239   7.5E-06
PU240   2.1E-06

--------|----Derived Concentrations-----|
Use when|   measured values are known   |
--------|-------------------------------|
Release |Terres.  Animal  Drink   Aquatic|
Radio-  |Plant    Product Water   Food   |
nuclide |/kg      /kg     /L      /kg    |
--------|------- ------- ------- -------|

TIME ###################################################################################

1    Intake ends after (yr)
```

```
50    Dose calc. ends after (yr)
1     Release ends after (yr)
0     No. of years of air deposition prior to the intake period
0     No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) ####################################

0           Definition option: 1-Use population grid in file POP.IN
0                              2-Use total entered on this line

NEAR-FIELD SCENARIOS ########################################################

            Prior to the beginning of the intake period: (yr)
0             When was the inventory disposed?  (Package degradation starts)
0             When was LOIC?  (Biotic transport starts)
0           Fraction of roots in upper soil (top 15 cm)
0           Fraction of roots in deep soil
0           Manual redistribution: deep soil/surface soil dilution factor
0           Source area for external dose modification factor (m2)
TRANSPORT ###################################################################
            ====AIR TRANSPORT=================================SECTION 1=====
                    0-Calculate PM              |0        Release type (0-3)
3           Option: 1-Use chi/Q or PM value     |F        Stack release (T/F)
                    2-Select MI dist & dir      |0        Stack height (m)
                    3-Specify MI dist & dir     |0        Stack flow (m3/sec)
0           Chi/Q or PM value                   |0        Stack radius (m)
3           MI sector index (1=S)               |0        Effluent temp. (C)
14800.      MI distance from release point (m)  |0        Building x-section (m2)
T           Use jf data, (T/F) else chi/Q grid  |0        Building height (m)

            ====SURFACE WATER TRANSPORT=======================SECTION 2=====
0           Mixing ratio model: 0-use value, 1-river, 2-lake
0           Mixing ratio, dimensionless
0           Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s);
0           Transit time to irrigation withdrawl location (hr)
            If mixing ratio model > 0:
0             Rate of effluent discharge to receiving water body (m3/s)
0             Longshore distance from release point to usage location (m)
0             Offshore distance to the water intake (m)
0             Average water depth in surface water body (m)
0             Average river width (m), MIXFLG=1 only
0             Depth of effluent discharge point to surface water (m), lake only

            ====WASTE FORM AVAILABILITY=======================SECTION 3=====
0           Waste form/package half life, (yr)
0           Waste thickness, (m)
0           Depth of soil overburden, m

            ====BIOTIC TRANSPORT OF BURIED SOURCE=============SECTION 4=====
T           Consider during inventory decay/buildup period (T/F)?
T           Consider during intake period (T/F)?    | 1-Arid non agricultural
0           Pre-Intake site condition.....          | 2-Humid non agricultural
                                                    | 3-Agricultural
```

EXPOSURE ##

====EXTERNAL EXPOSURE==========SECTION 5=====

	Exposure time:		Residential irrigation:
0	Plume (hr)	T	Consider: (T/F)
0	Soil contamination (hr)	0	Source: 1-ground water
0	Swimming (hr)		2-surface water
0	Boating (hr)	0	Application rate (in/yr)
0	Shoreline activities (hr)	0	Duration (mo/yr)

0 Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)

0 Transit time for release to reach aquatic recreation (hr)

1.0 Average fraction of time submersed in acute cloud (hr/person hr)

====INHALATION==========SECTION 6=====

3766.0 Hours of exposure to contamination per year

0 0-No resus- 1-Use Mass Loading 2-Use Anspaugh model

0 pension Mass loading factor (g/m3) Top soil available (cm)

====INGESTION POPULATION==========SECTION 7=====

0 Atmospheric production definition (select option):

0 0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
1-Use population-weighted chi/Q
2-Use uniform production
3-Use chi/Q and production grids (PRODUCTION will be overridden)

0 Population ingesting aquatic foods, 0 defaults to total (person)

0 Population ingesting drinking water, 0 defaults to total (person)

F Consider dose from food exported out of region (default=F)

Note below: S* or Source: 0-none, 1-ground water, 2-surface water
3-Derived concentration entered above

==== AQUATIC FOODS / DRINKING WATER INGESTION==========SECTION 8====

F Salt water? (default is fresh)

USE ? T/F	FOOD TYPE	TRANSIT hr	PRODUCTION kg/yr	CONSUMPTION HOLDUP da	CONSUMPTION RATE kg/yr	DRINKING WATER
F	FISH	0.00	0.0E+00	0.00	0.0	0 Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0 Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0 Consumption (L/yr)

====TERRESTRIAL FOOD INGESTION==========SECTION 9=====

USE ? T/F	FOOD TYPE	GROW TIME da	S*	IRRIGATION RATE in/yr	IRRIGATION TIME mo/yr	YIELD kg/m2	PRODUCTION kg/yr	CONSUMPTION HOLDUP da	CONSUMPTION RATE kg/yr
F	LEAF V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	ROOT V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	FRUIT	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	GRAIN	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0

====ANIMAL PRODUCTION CONSUMPTION==========SECTION 10====

USE ? T/F	FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP da	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	DIET FRAC-TION	GROW TIME da	S *	-IRRIGATION-- RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE da
						----STORED FEED----						
F	BEEF	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	POULTR	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	MILK	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	EGG	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
						----FRESH FORAGE----						
	BEEF					0.00	0.0	0	0.0	0.00	0.00	0.0
	MILK					0.00	0.0	0	0.0	0.00	0.00	0.0

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```
########################## Program GENII Input File ############ ,8 Jul 88 ####
Title: Offsite, Ingestion & Soil Contamination, Acute, Ground Level Release
       \SAMPL\G-FOOD.AC                          Created on 01-22-1990 at 07:30
OPTIONS======================== Default ===================================
F    Near-field scenario?      (Far-field)    NEAR-FIELD: narrowly-focused
F    Population dose?         (Individual)                release, single site
T    Acute release?            (Chronic)     FAR-FIELD:  wide-scale release,
     Maximum Individual data set used                     multiple sites
                                  Complete                                Complete
TRANSPORT OPTIONS============ Section   EXPOSURE PATHWAY OPTIONS===== Section
T  Air Transport                    1     T  Finite plume, external        5
F  Surface Water Transport          2     F  Infinite plume, external      5
F  Biotic Transport (near-field)  3,4     T  Ground, external              5
F  Waste Form Degradation (near)  3,4     F  Recreation, external          5
                                          F  Inhalation uptake           5,6
REPORT OPTIONS=======================     F  Drinking water ingestion    7,8
F  Report AEDE only                       F  Aquatic foods ingestion     7,8
F  Report by radionuclide                 T  Terrestrial foods ingestion 7,9
T  Report by exposure pathway             T  Animal product ingestion    7,10
F  Debug report on screen                 T  Inadvertent soil ingestion

INVENTORY ##############################################################################

 4   Inventory input activity units: (1-pCi  2-uCi  3-mCi  4-Ci  5-Bq)
 0   Surface soil source units (1- m2  2- m3  3- kg)
     Equilibrium question goes here

     --------|----Release Terms------|----------Basic Concentrations---------|
     Use when|  transport selected   |  near-field scenario, optionally       |
     --------|-----------------------|----------------------------------------|
     Release |         Surface Buried|         Surface Deep     Ground  Surface|
     Radio-  |Air      Water   Waste |Air      Soil    Soil     Water   Water  |
     nuclide |/yr      /yr     /m3   |/m3      /unit   /m3      /L      /L     |
     --------|------- ------- -------|------- ------- ------- ------- -------|
     C060    5.9E-07
     SR90    9.2E-03
     Y 90    9.2E-03
     RU106   4.9E-11
     CS137   2.8E-03
     U 238   1.3E-07
     PU239   7.5E-06
     PU240   2.1E-06

     --------|----Derived Concentrations-----|
     Use when|   measured values are known   |
     --------|-------------------------------|
     Release |Terres.  Animal  Drink   Aquatic|
     Radio-  |Plant    Product Water   Food   |
     nuclide |/kg      /kg     /L      /kg    |
     --------|------- ------- ------- -------|

TIME ###################################################################################

50   Intake ends after (yr)
```

```
50    Dose calc. ends after (yr)
1     Release ends after (yr)
0     No. of years of air deposition prior to the intake period
0     No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) ####################################

0           Definition option: 1-Use population grid in file POP.IN
0                              2-Use total entered on this line

NEAR-FIELD SCENARIOS ########################################################

            Prior to the beginning of the intake period: (yr)
0             When was the inventory disposed? (Package degradation starts)
0             When was LOIC? (Biotic transport starts)
0           Fraction of roots in upper soil (top 15 cm)
0           Fraction of roots in deep soil
0           Manual redistribution: deep soil/surface soil dilution factor
0           Source area for external dose modification factor (m2)
TRANSPORT ###################################################################
            ====AIR TRANSPORT==================================SECTION 1=====
                   0-Calculate PM                |0        Release type (0-3)
3           Option: 1-Use chi/Q or PM value      |F        Stack release (T/F)
                   2-Select MI dist & dir        |0        Stack height (m)
                   3-Specify MI dist & dir       |0        Stack flow (m3/sec)
0           Chi/Q or PM value                    |0        Stack radius (m)
3           MI sector index (1=S)                |0        Effluent temp. (C)
14800.      MI distance from release point (m)   |0        Building x-section (m2)
T           Use jf data, (T/F) else chi/Q grid   |0        Building height (m)

            ====SURFACE WATER TRANSPORT=======================SECTION 2=====
0           Mixing ratio model: 0-use value, 1-river, 2-lake
0           Mixing ratio, dimensionless
0           Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
0           Transit time to irrigation withdrawl location (hr)
            If mixing ratio model > 0:
0             Rate of effluent discharge to receiving water body (m3/s)
0             Longshore distance from release point to usage location (m)
0             Offshore distance to the water intake (m)
0             Average water depth in surface water body (m)
0             Average river width (m), MIXFLG=1 only
0             Depth of effluent discharge point to surface water (m), lake only

            ====WASTE FORM AVAILABILITY=======================SECTION 3=====
0           Waste form/package half life, (yr)
0           Waste thickness, (m)
0           Depth of soil overburden, m

            ====BIOTIC TRANSPORT OF BURIED SOURCE=============SECTION 4=====
T           Consider during inventory decay/buildup period (T/F)?
T           Consider during intake period (T/F)?    | 1-Arid non agricultural
0           Pre-Intake site condition.....          | 2-Humid non agricultural
                                                    | 3-Agricultural
```

EXPOSURE ##

====EXTERNAL EXPOSURE==========SECTION 5=====

Exposure time:		Residential irrigation:	
0	Plume (hr)	T	Consider: (T/F)
4380.0	Soil contamination (hr)	0	Source: 1-ground water
0	Swimming (hr)		2-surface water
0	Boating (hr)	0	Application rate (in/yr)
0	Shoreline activities (hr)	0	Duration (mo/yr)

0 Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0 Transit time for release to reach aquatic recreation (hr)
1.0 Average fraction of time submersed in acute cloud (hr/person hr)

====INHALATION==========SECTION 6=====

8766.0 Hours of exposure to contamination per year
0 0-No resus- 1-Use Mass Loading 2-Use Anspaugh model
0 pension Mass loading factor (g/m3). Top soil available (cm)

====INGESTION POPULATION==========SECTION 7=====

1 Atmospheric production definition (select option):
0 0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
1-Use population-weighted chi/Q
2-Use uniform production
3-Use chi/Q and production grids (PRODUCTION will be overridden)
0 Population ingesting aquatic foods, 0 defaults to total (person)
0 Population ingesting drinking water, 0 defaults to total (person)
F Consider dose from food exported out of region (default=F)

Note below: S* or Source: 0-none, 1-ground water, 2-surface water
3-Derived concentration entered above
==== AQUATIC FOODS / DRINKING WATER INGESTION==========SECTION 8====

F Salt water? (default is fresh)

USE ? T/F	FOOD TYPE	TRANSIT hr	PRODUCTION kg/yr	-CONSUMPTION- HOLDUP da	RATE kg/yr	DRINKING WATER	
F	FISH	0.00	0.0E+00	0.00	0.0	0	Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T	Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0	Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0	Consumption (L/yr)

====TERRESTRIAL FOOD INGESTION==========SECTION 9=====

USE ? T/F	FOOD TYPE	GROW TIME da	S *	--IRRIGATION-- RATE in/yr	TIME mo/yr	YIELD kg/m2	PRODUCTION kg/yr	--CONSUMPTION-- HOLDUP da	RATE kg/yr
T	LEAF V	90.00	0	0.0	0.0	1.5	0.0E+00	1.0	30.0
T	ROOT V	90.00	0	0.0	0.0	4.0	0.0E+00	5.0	220.0
T	FRUIT	90.00	0	0.0	0.0	2.0	0.0E+00	5.0	330.0
T	GRAIN	90.00	0	0.0	0.0	0.8	0.0E+00	180.0	80.0

====ANIMAL PRODUCTION CONSUMPTION==========SECTION 10====

USE ? T/F	FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP da	TOTAL PROD- UCTION kg/yr	DRINK WATER CONTAM FRACT.	STORED FEED DIET FRAC- TION	GROW TIME da	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR- AGE da
T	BEEF	80.0	15.0	0.00	0.00	0.25	90.0	0	0.0	0.00	0.80	0.0
T	POULTR	18.0	1.0	0.00	0.00	1.00	90.0	0	0.0	0.00	0.80	0.0
T	MILK	270.0	1.0	0.00	0.00	0.25	45.0	0	0.0	0.00	2.00	0.0
T	EGG	30.0	1.0	0.00	0.00	1.00	90.0	0	0.0	0.00	0.80	0.0
						FRESH FORAGE						
	BEEF					0.75	45.0	0	0.0	0.00	2.00	100.0
	MILK					0.75	30.0	0	0.0	0.00	1.50	0.0

##########

TABLE 1 200 AREA BP-1 POSTULATED ACCIDENT RELEASED AMOUNTS

Radionuclide	a Inventory Amount (Ci)	b Release Fraction	Released Amount (Ci)
^{60}Co	7.7E-05	0.0077	5.9E-07
^{90}Sr	1.2E+00	0.0077	9.2E-03
^{90}Y	1.2E+00	0.0077	9.2E-03
^{106}Ru	6.4E-09	0.0077	4.9E-11
^{137}Cs	3.6E-01	0.0077	2.8E-03
^{238}U	9.7E-06	0.013	1.3E-07
^{239}Pu	5.8E-04	0.013	7.5E-06
^{240}Pu	1.6E-04	0.013	2.1E-06

a. This is the total inventory to be extracted from the three contaminated cribs, as estimated elsewhere in this report, but with Yttrium added to the list.

b. Release fractions are from NUREG - 1320, Nuclear Fuel Cycle Facility Analysis Handbook, MaY 1988, U S Nuclear Regulatory Commission, Washington, D.C. see Table 4.2.

CHECKLIST FOR PEER REVIEWS

Document Reviewed: Radiological Analysis of Accidental Release from 200 East Area BP-1 Operable Unit

Scope of Review: Entire Document

Yes	No	N/A	
[ ]	[ ]	[X] *	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[ ]	[ ]	[X]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[X]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[ ]	[ ]	Code runstreams correct and consistent with analysis documentation.
[X]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[X]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[X]	[ ]	[ ]	Document presentation quality meet SA&R standards
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[X] *	Review calculations, comments, and/or notes are attached.

D.A. Himes 5/14/91
Reviewer Approval (Printed Name and Signature) Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

[X] [ ] [ ] Analysis entered into analysis database

J. E. Hey 5/14/91
Analyst (Printed Name and Signature) Date

CHECKLIST FOR HEDOP REVIEW

Document Reviewed: Radiological Analysis of Accidental Release from 200 East Area BP-1 Operable Unit

Scope of Review: Entire Document

Yes	No	N/A	
[X]	[ ]	[ ]	HEDOP-accepted code(s)/version(s) or other appropriate calculation methodology used.
[X]	[ ]	[ ]	Appropriate receptor locations evaluated.
[X]	[ ]	[ ]	Appropriate models (finite plume vs. semi-infinite cloud, building wake, etc.) used.
[X]	[ ]	[ ]	Appropriate pathways evaluated for each receptor.
[X]	[ ]	[ ]	Analysis consistent with HEDOP recommendations.
[ ]	[ ]	[X] *	Review calculations, comments, and/or notes are attached.

D.A. Himes [signature] 5/14/91
HEDOP Reviewer Approval (Printed Name and Signature) Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

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