U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

0063134

NOV 19 2004

04-ED-092

Mr. Ron Kreizenbeck, Acting Regional Administrator
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Dear Mr. Kreizenbeck:

TRANSMITTAL OF APPLICATION FOR POLYCHLORINATED BIPHENYL (PCB) RISK ASSESSMENT FOR THE MOBILIZATION OF SINGLE-SHELL TANK (SST) SOLID WASTE USING DOUBLE-SHELL TANK (DST) SUPERNATE

The purpose of this letter is to transmit an application to utilize DST PCB remediation waste (supernatant) to mobilize solid waste from twelve SSTs pursuant to Title 40 Code of Federal Regulations 761.61 (c). The twelve SSTs are 241-S-102, 241-C-101, 241-C-102, 241-C-103, 241-C-104, 241-C-105, 241-C-107, 241-C-108, 241-C-109, 241-C-110, 241-C-111, and 241-C-112). Retrieval of the SSTs is required for compliance with the Hanford Federal Facility Agreement and Consent Order (HFFACO) Milestone M-045.

Introduction of DST supernate into Tanks C-101, C-105, C-110, and C-111 could pose a higher risk due to the current tank status. Therefore, raw water will be introduced into these four tanks. The water carrying the mobilized solids will then be pumped to a pump skid above ground, where DST supernatant will be introduced to further carry the mobilized solids to the DST receiver tank. This equipment setup reduces the chance of DST supernatant being introduced into the SST and the risk through a leak scenario.

Use of DST supernatant for mobilization has three advantages over the use of raw water for retrieval without posing unreasonable risk to human health and the environment: waste minimization, maximizing the use of the limited available DST space, and chemistry control in the DST system without the addition of caustic solution. Specific comparisons of use of DST supernatant versus raw water have been documented at the direction of the State of Washington Department of Ecology in the 241-S-102, "Initial Waste Retrieval Functions and Requirements," document and the 241-C-103 and 241-C-109, "Tank Waste Retrieval Work Plan."

The DST supernatant is classified as PCB remediation waste in accordance with the "Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste." Risks associated with transfers of DST supernatant have been assessed as part of the "Double Shell Tank System PCB Risk Assessment." Up to one million gallons of DST supernatant will be utilized to mobilize the solid waste in the set of twelve SSTs enumerated above. The maximum PCB concentration in the SST solids is 37 ppm based on analytical data from six of the twelve SSTs. Trace amounts of PCBs have been found in the DST supernatant (6.50E-02 ppm). Both these values are well below the upper-bound assumed PCB concentrations for the solids (50 ppm) and liquids (2.9 ppm) in the DST system used in the DST PCB Risk Assessment. Therefore, the assessed risk for this activity to all human receptors, evaluated to be 10^{-06} or less, are below what would be considered an unreasonable risk to human health and the environment. The risks and the exposure pathways are considered to be reasonably anticipated. These pathways present no unreasonable risk to the public, worker, or the environment from the mobilization activities.

It is our expectation that the Toxic Substances Control Act of 1976 (TSCA) tank closure requirements will be satisfied through the implementation of the Resource Conservation and Recovery Act (RCRA) closure performance objectives consistent with the framework agreement, hence achieving the desired regulatory integration among the RCRA and TSCA regulations. It is our expectation that elements of a risk-based disposal approval for the proposed activities relating to PCB remediation waste residuals in the SST tank system components associated with retrieval activities will be based on the applicable Tier II and III closure activities to be developed to satisfy SST closure requirements under Washington Administrative Code 173-303-610, 640, and 800.

The U.S. Department of Energy (DOE) is requesting your review and approval of the risk evaluation (attached) for the use of DST PCB remediation waste (supernatant) to mobilize solid waste from twelve SSTs. In order to meet the HFFACO Milestone M-045, without impacting Tank Farm operations, DOE requests a letter approving this approach by December 7, 2004.

If you have any questions, please contact me, or your staff may contact Mary E. Burandt, Environmental Division, (509) 373-9160.

Sincerely,

Roy J. Schepens
Manager

ED:MEB

Attachment

cc w/attach:
T. L. Faust, CH2M HILL
M. N. Jarassi, CH2M HILL
D. B. Bartus, EPA
Administrative Record
CH2M Correspondence Control

Attachment
04-ED-092

RPP-22777, Revision 0, "PCB Risk Assessment for the Mobilization of Single-Shell Tank Solid Waste Using Double-Shell Tank Supernate"

RPP-22777

PCB Risk Assessment for the Mobilization of Single-Shell Tank Solid Waste using Double-Shell Tank Supernate

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

RPP-22777
Revision 0

PCB Risk Assessment for the Mobilization of Single-Shell Tank Solid Waste Using Double-Shell Tank Supernate

T. L. Faust
CH2M HILL Hanford Group, Inc.

Date Published
October 2004

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

P.O. Box 1500
Richland, Washington

Contractor for the U.S. Department of Energy
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TERMS

CFR	*Code of Federal Regulations*
CHG	CH2M HILL Hanford Group, Inc.
CSF	cancer slope factor
CSM	conceptual site model
CY	calendar year
DCRT	double contained receiver tank
DOE	U.S. Department of Energy
DST	double-shell tank
EPA	U.S. Environmental Protection Agency
EPDM	Ethylene-Propylene-Diene-Monomer
ERPC	ecological receptors of potential concern
HEPA	high efficiency particulate air (filter)
HEIS	Hanford Environmental Information System
HFFACO	Hanford Federal Facility Agreement and Consent Order
HIHTL	hose-in-hose transfer line
HLW	high-level waste
HRR	high-resolution resistivity
HQ	hazard quotient
IARC	International Agency for Research on Cancer
LDM	leak detection monitoring
MS	Maximum Stationary (worker)
NOAEL	no observed adverse effects
ORNL	Oak Ridge National Laboratories
ORP	U.S. Department of Energy, Office of River Protection
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PPE	personal protective equipment
PVB	portable valve box
RPP	River Protection Project
RA	risk assessment
RBDA	Risk Based Disposal Approval
RCRA	*Resource Conservation and Recovery Act of 1976*
RfD	reference dose
RH	relative humidity
SCLERA	screening-level ecological risk assessment
SpG	specific gravity
SST	single-shell tank
TEF	toxic equivalency factor
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRV	toxicity reference value
TSCA	*Toxic Substance Control Act of 1976*
WAC	*Washington Administrative Code*

WDOE	Washington State Department of Ecology
WRS	Waste Retrieval System
WTP	Waste Treatment Plant

1.0 INTRODUCTION

This Polychlorinated Biphenyls (PCB) Risk Based Disposal Approval (RBDA) application assesses the use of double-shell tank (DST) supernate to mobilize solid waste from single-shell tanks (SSTs). The DST supernate is classified as PCB remediation waste in accordance with the *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste* (Ecology et al., 2000a). Because the DST supernate is PCB remediation waste the retrieval of 241-S-102, and C farm tanks (241-C-101, 102, 103, 104, 105, 107, 108, 109, 110, 111 and 112) must be managed for PCBs under the *Toxic Substance Control Act of 1976* (TSCA). The U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA), Region 10, have established the process for approving risk-based disposal under Title 40 *Code of Federal Regulations* (CFR) Part 761.61(c). Introduction of DST supernate into tanks C-101, C-105, C-110 and C-111 could pose a higher risk due to the current tank status (assumed leaker). Therefore, raw water will be introduced into these four tanks to mobilize the SST solids. The water carrying the mobilized solids will then be pumped to a pump skid or portable valve box (PVB), where DST supernatant will be introduced to further carry the mobilized solids to the DST receiver tank. This equipment setup reduces the chance of DST supernatant being introduced into the SST and the risk through a leak scenario. This assessment is focused on demonstrating that the PCBs pose no unreasonable risk through the retrieval of a select number of SSTs solids utilizing DST supernate. The risks and the exposure pathways presented in this assessment consider reasonably anticipated or known risk pathways associated with SST retrieval operations. The risks posed by the SST retrieval operation in support of site clean-up are expected to be bounded by the nuclear safety controls. Requirements are described in the *U.S. Department of Energy (DOE) Office of River Protection (ORP) and Washington State Department of Ecology (WDOE)* agreement primary document defined by Section 9.1 of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology, 1996). Details for individual SST are provided in "*S-102 Intial Waste Retrieval Function and Requirements*" (Cogema, 2004), "*241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*," (CHG, 2004e), *"241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan"* (CHG, 2004g), and *"241-C-101, 214-C-105, 241-C-110 and C-111 Tanks Waste Retrieval Work Plan"* (CHG, 2004i).

The single-shell tanks are scheduled for closure under the HHFACO Tri-Party Agreement, milestone M-045. The *Single-Shell Tank System Closure Plan* (CHG, 2004a) describes a 3 tiered approach which will be used in developing closure plans for the SST prior to closure to meet Resource Conservation and Recovery Act of 1976 (RCRA) closure standards in accordance with the HFFACO.

1.1 OBJECTIVE

The objective of this RBDA is to perform an evaluation of the twelve SST tanks identified to be retrieved using DST PCB remediation waste supernate, and associated operational controls to determine if the retrieval activities, do or do not pose an unreasonable risk. This document outlines how the evaluation was performed and provides reasonable assurance of continued safe retrieval operations. The evaluation for the SST retrieval was based on the existing operational controls and existing equipment. The following objectives are addressed:

- Present SST operations under the *Resource Conservation and Recovery Act of 1976* (RCRA) in accordance with the *Hanford Facility Resource Conservation and Recovery Act Permit* (Ecology, 2000b), and the *Clean Air Act*, as implemented through state codes and regulations, and the *Atomic Energy Act of 1954* provide for the key requirements to adequately handle the actual or potential PCB remediation waste with reasonable risk.

- Ensure that potential human-health and environmental risks from onsite and offsite exposure to PCBs released during normal retrieval operations and upset conditions (i.e. valve pit jumper spill, or valve pit spray) of the SST system are within the reasonable risk guidelines for the mobilization activity.

1.2 METHODOLOGY

This risk assessment evaluates the following aspects of PCBs during SST waste retrieval operations:

- Normal SST waste retrieval operations (normal ventilation stack operation);
- Accidents that may release PCBs to the environment using a valve pit jumper spill and valve pit spray scenarios;
- Receptor exposure locations; and
- The effects of PCB releases on the public and the environment.

Figure 1-1 provides an overview of the Hanford site covered in the scope of this assessment.

This RBDA is consistent with principles established in the EPA's *PCB Risk Assessment Review Guidance Document* (EPA, 1989). Conservative exposure assumptions were developed from existing data. Based on system configuration and scenarios, the air pathway was determined to be the dominant pathway.

Emissions to the air were modeled using the EPA meteorological dispersion model, SCREEN3. This model assumes the worst case meteorology for creating adverse impacts from plume dispersion and provides estimated concentrations with distance.

Effects to both onsite and offsite human receptor populations and wildlife were characterized. The activities of these receptors were considered in developing the exposure scenarios. The EPA guidance was used to develop quantitative reasonable maximum exposure factors (e.g., inhalation rate).

The release concentrations and information gained during the exposure assessment were integrated to characterize the current and potential risks to human health and the environment caused by the PCB releases. This risk characterization also identifies any uncertainties associated with contaminants, toxicity, release, and exposure assumptions.

This risk assessment is organized into six chapters. Chapter 1 introduces the risk assessment and includes background information on how the risk assessment was performed. Chapter 2 describes the SST system components which are involved in waste retrieval, PCB inventory involved in the SST retrieval and the release scenarios. Chapter 3 describes the approach used to quantify exposures to PCBs through the retrieval operation and accidental releases from the specified SSTs. Chapter 4 evaluates the potential human health impacts caused by exposure to PCB releases and potential carcinogenic risk to human receptors. Chapter 5 is an environmental evaluation of the potential impacts of PCB releases on wildlife receptors. Chapter 6 presents the overall results of the PCB Risk Assessment.

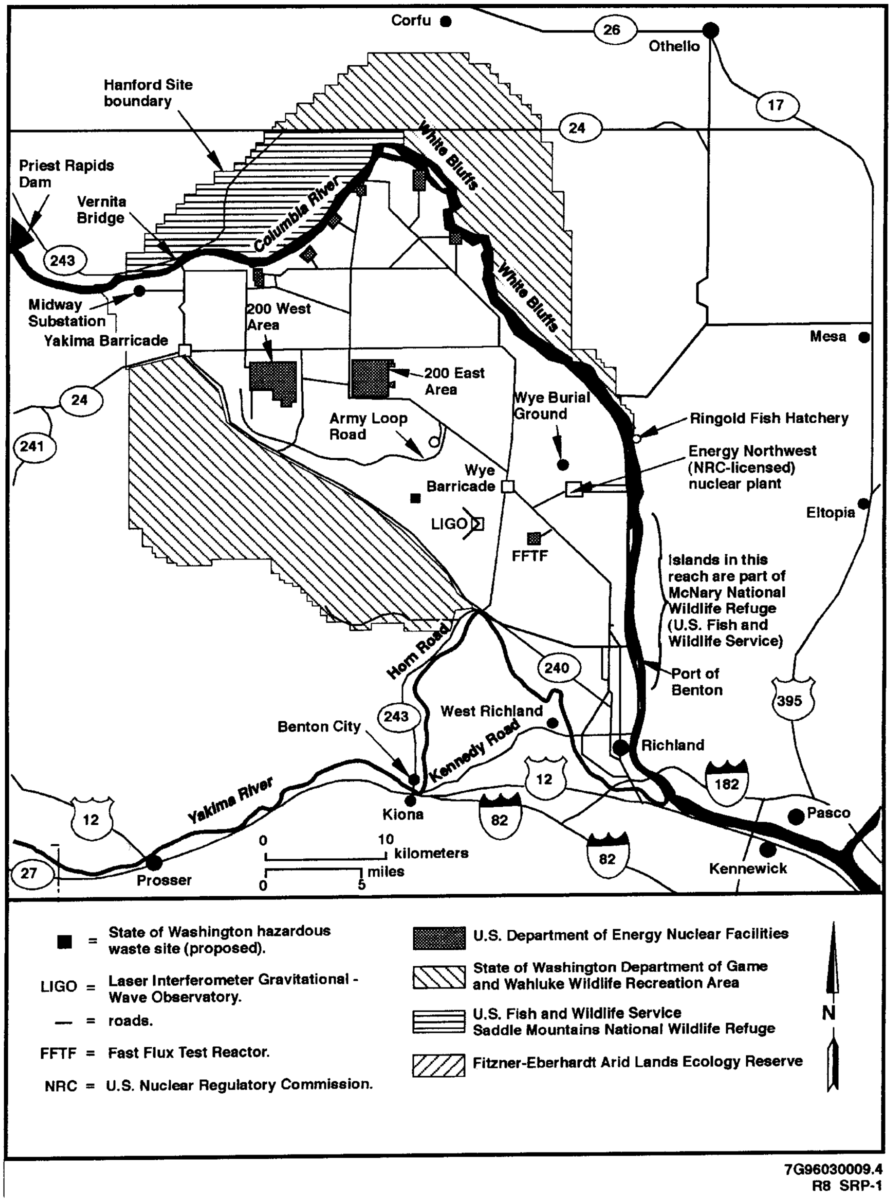

Figure 1-1. Hanford Site Map.

1.3 OVERVIEW OF SST INTERFACES

The Hanford Tank Farms consist of both the DST system and SST system. Transfer lines, valve pits, and related equipment provide the direct connection points between the two systems. For purposes of this assessment only those components within the SST system utilized for the retrieval of the twelve identified tanks were considered.

1.3.1 Nature of Contamination

Twelve SSTs including one tank in S farm (241-S-102), and eleven tanks in C farm (241-C-101, 102, 103, 104, 105, 107, 108, 109, 110, 111, and 112) have been identified for retrieval using DST supernate to mobilize the SST solids. During the retrieval of solid waste in S-102 raw water will be initially introduced into the SST to dissolve saltcake. After the initial retrieval step the liquid will be transferred to the SY-102 tank. Once this liquid enters the DST system at SY-102 it is considered PCB remediation waste. However, the concentration of PCB, in this liquid will have originated in S-102. Therefore for risk calculations, no contribution to the overall PCB inventory for the S-102 retrieval is attributed to the 241-SY-102 supernate. This is not the case for the eleven east area C farm tanks. The supernate used for retrieval of these tanks will come from existing DST solutions. Each DST has a capacity of 1 Mgal. Approximately 300,000 gallons is expected to be utilized to retrieve the solids in each of the SSTs. Three DST receiver tanks have been identified as supernate sources for the C Farm retrievals; 241-AN-101, AN-106, and AY-101. However since this amounts to 900,000 gallons being utilized repeatively over the 2 year life of the retrieval project a conservative value of 1 Mgal of DST supernate was assumed in this document to represents a worst case scenario.

Because of their low aqueous solubility, PCBs contained within the tank waste are expected to be associated mostly with the solids. The PCB concentration in the SST solids is based on the maximum concentration listed in the analytical data from six of the twelve SST. This value is 37µg/g for tank C-111. Trace amounts of PCBs have been found in the DST supernate up to 6.50E-02µg/mL (Nguyen, 2004). Transfer of the DST supernate to the SST to mobilize the solid waste poses a low risk and is outside the scope of this PCB risk assessment. A higher risk is expected while the waste is in the SST and during the retrieval operation. Therefore an airborne release through normal operation of the SST ventilation systems and SST valve pit jumper spill or valve pit spray are used as the scenarios for this risk assessment.

SST Solid Waste Retrieval Inputs

Two supernate sources have been identified for use during this operation:

> For 241-S-102 approximately 1 Mgal of raw water will be used to dissolve the saltcake portion of the specified SST solid waste. This saltcake solution will then be recirculated through a DST (241-SY-102) and back to the SST to mobilize the undissolved SST solids.

For the eleven C farm tanks, up to 1 Mgal of existing DST supernate will be utilized to retrieve the solids from all tanks. This DST supernate will be recirculated through the SST system and associated piping system back to the DST.

During the SST retrieval activities supernate waste will be recirculated between a designated DST and the SST being retrieved.

Once retrieval is completed the supernate utilized during the retrieval will remain in the DST for storage until it is processed through the 200 East Liquid Treatment facilities and/or transferred to the Waste Treatment Plant (WTP). Management of the waste after it has been returned for storage in the DST is outside the scope of this risk assessment and is covered by the Risk Based Disposal Approval Application *Double-Shell Tank System PCB Risk Assessment* (CHG, 2001).

2.0 SST SOLID WASTE RETRIEVAL OPERATIONS

The SST system maintains and manages the mixed waste to both radioactive and hazardous waste requirements. The SST system presently operates under RCRA interim status standards. Interim status was implemented until issues concerning the ability of some equipment to meet RCRA standards are adequately addressed. The interim status provides management controls that meet the intent of RCRA requirements, while providing adequate time within cost constraints to address or upgrade known deficiencies. The SST solid waste was generated prior to April 1987 and therefore not currently regulated under TSCA. The operational controls in place for managing the mixed waste within the SST system are believed to be adequate to address the risk criteria required under TSCA for the purpose of the proposed solid waste retrieval utilizing DST supernate. A primary goal in retrieval of the SST solid waste is to ensure the safety of the public and workers just as it is for TSCA requirements.

2.1 ENGINEERED AND ADMINISTRATIVE CONTROLS AND EQUIPMENT

The SST solid waste retrieval operation relies on many engineered and administrative controls to ensure safety of the workers and the public. These controls ensure that mixed waste will be maintained under control and ensure that the risk that the waste will be released to the environment, where it could pose a threat to the safety of workers and the general public is acceptable. These controls placed on management of the mixed waste also will provide an acceptable risk for controlling PCBs in the waste. The administrative controls are implemented in operating procedures, alarm response procedures, functional test procedures, operator round sheets, transfer procedures, and maintenance procedures used within the tank farms. Personnel who use these procedures are specifically trained to understand the controls identified by the procedures.

Personnel working in a radiological environment also receive required radiation worker training and hazardous material training. Job hazards analyses are performed on work packages to identify hazards the workers can expect to encounter while performing the required tasks. These procedures, training, and controls help reduce the risk of maintaining and managing the mixed waste. Some general administrative controls are as follows.

- In process pits, open nozzles connected to a transfer line are required to be sealed or capped with process blanks or equivalent to prevent misrouting of waste.

- In a process pit, newly installed or repositioned jumpers used to route waste must be leak tested after installation.

- During waste transfers, the material balance must be closely monitored to ensure that waste is going where it is intended. A predefined material balance discrepancy triggers an immediate response to shut down the transfer and investigate the reason for the discrepancy.

- An administrative lock and tag program requires that all transfer pumps be under administrative lock, which removes any motive force from the pump when the pump is not being used in an active transfer. This is done to prevent inadvertent starting of a transfer pump.
- Excavation controls are employed to prevent potential damage to underground piping and to protect excavation workers during transfers.
- Before, periodically, and during waste transfers walk downs of the transfer route are performed to ensure integrity of the route and provide advance warning of abnormal conditions.
- Valving for transfers requires independent verification to ensure that valves are properly positioned.
- Flushing transfer lines with raw water, is required after the completion of transfers to reduce radiation levels and minimize waste that may be trapped inside the piping.
- Administrative controls require Radiological Control and Industrial Health & Safety personnel to review or determine the hazards and prescribe proper personal protective equipment (PPE) for work within radiological areas. This prevents personnel from inadvertently contacting or accessing potentially contaminated equipment, systems, and areas. Radiation monitoring controls ensure personnel do not come into contact with any contamination, and PCBs while working in potentially contaminated areas.
- Alarm response procedures are provided to personnel to ensure that, under abnormal conditions, immediate actions are taken that place the equipment or systems in a safe condition while investigating or correcting the alarm condition.

Retrieval of the SSTs uses transfer line and tank leak detection to minimize leak loss potential during retrieval.

The leak detection, monitoring, and mitigation strategy during waste retrieval from an SST includes both management of free liquid within the tank and the monitoring of in-tank and ex-tank parameters that are potential leak indicators. For an SST with PCB material, it is assumed that a loss of tank waste will also result in a loss of PCB materials. Therefore the methods planned for waste leak detection, monitoring, and mitigation are assumed to be applicable for the PCB materials that are in an SST.

The primary method for leak detection and leak monitoring for SST tanks is external to the tanks and involves periodic logging of the drywells surrounding the tanks. Established drywell logging methods will be used as the primary method of leak detection. Pending completion of high-resolution resistivity (HRR) demonstration testing the HRR leak detection system will be deployed at each of the tanks unless ongoing demonstration deployments show that HRR is unacceptable for use as a means of leak detection.

The HRR method uses geophysical resistivity measurement methods as a means to detect changes in moisture levels. The electrical resistivity of the sediments beneath a waste tank depends on a number of parameters, one of which is moisture content. The leakage of water or tank waste into these sediments lowers the sediment resistivity. The HRR method detects changes in soil moisture content by comparing a current resistivity measurement against a previously obtained baseline measurement, or a ‘pre-leak’ measurement. This delta processing allows the HRR method to discount existing resistivity differences in the soil caused by factors that include conductive structures or prior leaks.

Responses to spills that accidentally release waste to the environment also are addressed through administrative controls and personnel training. These controls and training provide personnel with proper responses and techniques for spill cleanup and shall provide an acceptable risk for handling any PCBs that also could be contained in the waste material. Controls provide for the following:

- Minimizing the exposure of personnel
- Expeditious isolation of the source of the spill
- Minimizing further spread of contamination
- Identification of proper PPE to use and also the proper use of the PPE during cleanup
- Monitoring and sampling requirements during cleanup to ensure personnel protection and adequacy of the cleanup
- Ensuring the expeditious return of the waste to a controlled environment.

This emergency response and clean up of spills to the soil is one of the reasons this assessment focused on the air pathway to evaluate PCB risks. Details of ground water and soil monitoring for leaks from the twelve SSTs are covered in the documents listed in Section 1.

Administrative controls, the emergency response program, and cleanup of soil spills provide a reasonable demonstration that adequate safeguards are in place to protect the mixed waste from release to the environment. The combination of administrative and engineered controls used to manage mixed waste also can be applied to manage PCBs that could be contained in the mixed waste. Mixed waste containing potential PCBs will be detected by the existing instrumentation that monitors for the radioactive content.

If a below grade leak from the tank is indicated during waste retrieval, liquid additions to the tank will be suspended and actions defined in *Tank Leak Assessment Process* (CHG, 2003) will be implemented.

If a visible transfer line leak or release is detected during waste retrieval operations, response actions defined in *Building Emergency Plan for Tank Farms* (CHG, 2004c) would be implemented.

2.1.1 241-S-102

Tank 241-S-102 is classified as a non-leaking combined saltcake/sludge tank, located in the 200 West Area of the Hanford Site. 241-S-102 was constructed in between 1950 and 1951. It is second in a cascade series of three tanks beginning with Tank 241-S-101 and ending with Tank 241-S-103. The tank is constructed with a painted grout layer, an asphalt (waterproof) membrane, and an outer reinforced concrete shell to maintain the structural integrity of the steel liner by protecting it from soil loads. The reinforced concrete shell is cylindrical with a domed roof. The interior of the tank contains a steel liner constructed of mild steel. The steel liner extends up the tank wall to a height of 7.6m (25 feet). It was constructed to support an operating volume of 750,000 gallons. The tank was placed in service in 1953. The tank was labeled inactive in 1980, and had a final transfer from it in 1992. A large surface spill occurred in 1973 that contaminated the soil around Tanks 241-S-102, and 241-S-103. The gamma-ray-emitting radionuclides cobalt-60 (60Co) and cesium-137 (137Cs) were detected in the resulting plume. The majority of the contaminated soil at grade was removed and replaced with an indeterminate depth of clean soil overburden as detailed in *Report on Investigation of the S-Farm Contamination Incident* (ARH, 1973).

2.1.2 C-Farm Tanks

The C farm 100-series tanks are 75 feet in diameter and 32 feet tall. The tanks have a 16-foot operating depth and an operating capacity of 530,000 gallons each. The tanks sit below grade with at least 6 feet of soil cover to provide shielding from radiation exposure to operating personnel.

The tanks were constructed in-place with a carbon steel lining on the bottom and sides, and a reinforced-concrete shell. The welded liners are independent of the reinforced-concrete tanks and were designed to provide leak-tight containment of the liquid radioactive wastes and to protect the reinforced-concrete from waste contact. All other loads (e.g., surface live loads, static and dynamic soil loads, dead loads, hydrostatic loads, and hydrodynamic loads) are carried by the reinforced-concrete tank structure. The tanks have dished bottoms (center of tanks lower than the perimeter) and a curving intersection of the sides and bottom. Inlet and/or outlet lines are located near the top of the liners. These lines are also referred to as ‘cascade’ lines because they allowed transfer of fluids between tanks using gravity flow to support the transfer and storage of waste within a series of three 100-series SSTs.

Tanks C-102, C-103, C-104, C-107, C-108, C-109, and C-112 are classified as ‘sound’ in the waste tank summary report *Waste Tank Summary Report for Month Ending July 30, 2004* (Hanlon B. M., 2004). ‘Sound’ classification is assigned to a tank when surveillance data indicates no loss of liquid attributed to a breach of integrity. Table 2-1 summarizes the description of these tanks. Tanks C-101, C-110 and C-111 are identified as assumed leakers. Currently tank C-105 is status as sound however WDOE has voiced concerns about the status of this tank based on historical data of an unplanned release adjacent to the tank (Ecology, 2004).

Table 2-1. C Farm Tanks

Tank 241-	C-101	C-102	C-103	C-104	C-105	C-107	C-108	C-109	C-110	C-111	C-112
Constructed	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44	1943-44
In service	1946	1946	1946	1946	1946	1946	1947	1946	1946	1946	1946
Declared inactive	1977	1977	1979	1980	1980	1978	1977	1976	1977	1978	1976
Integrity	Assumed Leaker	Sound	Sound	Sound	Sound[1]	Sound	Sound	Sound	Assumed Leaker	Assumed Leaker	Sound
Interim stabilized	11/83	9/95	7/03	9/89	10/95	9/95	3/84	11/83	5/95	3/84	9/90
Solid Waste Volume (gallons)	0.088	0.316	0.072	0.259	0.132	0.247	0.066	0.063	0.178	0.057	0.104

Source: CHG, 2004f, "C-Farm 100 Series tanks, Retrieval Process Flowsheet Description", RPP-21753, Rev. 0, P. G. Haigh, et al., dated August 12, 2004.

1. Ecology, 2004, Use of Double Shell Tank 241-AN-106 Supernate for Waste Retrieval from Single-shell tanks (SST) 241-C-103 and 241-C-105," (letter 0402254 from J. Lyon to R. Schepens, U.S. Department of Energy, Office of River Protection, Richland, Washington, July 22) Washington State Department of Ecology, Richland, Washington. (WDOE believes that data for this tank is indeterminate and does not resolve the nature and source of a past unplanned release. As a result WDOE views the tank leak status as uncertain).

2.1.3 Ventilation Systems

Currently the SSTs to be retrieved are passively ventilated. Prior to retrieval, a ventilation system will be installed to maintain a negative differential pressure inside the tanks. The design of the ventilation system is such that it prevents or minimizes the escape of radioactive particulate aerosols into the exhaust stack and the environment. This same design helps prevent release of PCB aerosols.

An active ventilation system creates a negative dome space pressure by providing flow through the tank headspace. Outside air is drawn into the tank through inlet filters, pit cover blocks, risers, or a vacuum relief because of the reduced pressure created by the exhaust blowers. Air is drawn from the tank and routed to the air-handling unit. If determined necessary the air then passes through a demister that separates heavy moisture droplets from the air stream. The air passes through a heater to reduce the humidity. The heated air is prefiltered to protect the HEPA filters, then routed through two HEPA filters (or two banks of HEPA filters) mounted in series to remove particulate as small as 0.3 μ with at least 99.95-percent efficiency. The air stream from the air-handling unit is routed to the stack and discharged to the atmosphere. Because of the design of the ventilation system, vapors are the only expected PCB releases from a normal operating stack.

S-102 retrieval will utilize a single 500 cfm exhauster with a nominal operating flow of 450 cfm. C farm retrieval will utilize a combination of up to 3 exhausters. Two types of exhausters will be used: One 1,000 cfm exhauster for the retrieval of C-103, and two 2,000 cfm exhausters for the retrieval of the remaining ten tanks. A nominal flow of 750 cfm will be utilized for each tank during retrieval.

The air pathway is a potential pathway for PCBs to escape from the SSTs during normal operations. This risk assessment addresses this pathway and provides a conservative analysis of potential PCB releases that demonstrates acceptable risks that bound SST retrieval operations.

2.1.4 Waste Retrieval System Transfer structures

The C farm, Waste Retrieval System (WRS) contains two sluicers and a slurry pump in the SST, a portable valve box located in C-Farm and a supernate pump with slurry distributor in the receiver DST. This system is interconnected with Hose-in-hose transfer line (HIHTL) between the SST and the DST.

The DST tanks and SST tanks C-101 through C-106 contain pits located below ground level and are reinforced-concrete structures that contain valves and jumper assemblies to route the liquid waste through the connected pipelines within a tank farm. Most valve pits have 0.3 m (1-ft)-thick walls and heavy, 0.51 m (20-in.) thick grade-level cover blocks. The cover blocks will be removed and replaced with 2 or 3-inch steel cover plates to access the pits for retrieval.

The SST tanks C-107 through C-112 do not contain below ground pits and will have above ground structures built of 2 or 3 inch steel to contain the sluicers. These tanks have a central caisson which will be used for the slurry pump. A 2 or 3 inch steel cover assembly will replace the existing steel coverplate.

When several tanks are pumped to a single receiver tank, the flow is routed to a valve pit. In the valve pit, the transfer lines from the SST tank are connected to the DST receiver tank line by means of a series of HIHTL, PVB and jumper connections. Each valve pit or PVB is equipped with leak detection. The leak detection systems are interlocked to shut down the transfer pumps on detection of a leak. The PVB contains valves to divert the flow in the required direction. The PVB is connected to a raw water skid to provide transfer line flushing and possible sluicing medium. The raw water skid is protected from the tank waste stream by use of a compliant backflow prevention method. The PVB allows for routing by manipulating valves with valve handles and operators that extend through the top of the PVB. This allows for changing flow paths without removing the cover or requiring the moving of jumpers. The PVB are designed to be reused for multiple tank retrievals in Tank Farms.

Because introduction of DST supernate into tanks C-101, C-105, C-110 and C-111 could pose a higher risk due to the current tank status, raw water will be introduced into these four tanks. The water carrying the mobilized solids will then be pumped to a pump skid or PVB, where DST supernatant will be introduced to further carry the mobilized solids to the DST receiver tank. This equipment setup reduces the chance of DST supernatant being introduced into the SST and the risk through a leak scenario. Similarly the WRS for S-102 retrieval utilizes existing buried piping, HIHTL and a raw water source.

2.1.5 Transfer Pipelines and Jumpers

Mixed waste is transferred from a sending facility or tank to a receiving tank through existing underground piping or temporary over-ground piping. This transfer piping provides containment of the mixed waste during the transfer to prevent release to the groundwater and air pathways. The piping (except direct buried piping) contains a secondary encasement that will contain leaks from the primary piping and direct the leakage to pits where it can be detected and routed through drain lines to other tanks. Transfer pipelines are identified and categorized on the basis of the material transferred:

- **Supernate Lines**. Pipelines that transfer liquid waste between tanks or processing facilities.
- **Slurry Lines**. Pipelines that transfer liquid-solid slurries between tanks or processing facilities.

Jumpers are rigid or flexible sections of piping used to connect transfer lines during transfers using non-dedicated routes. Jumpers are removed and installed as needed in diversion boxes or other pits.

The primary pipe used in waste transfer lines is carbon or stainless steel, or Ethylene-Propylene-Diene-Monomer (EPDM) for HIHTLs. Waste transfer lines used at the Hanford Site are of three general types:

- Encased piping
- Direct-buried piping
- Over-ground piping /HIHTL

The term “encased piping” indicates that the primary transfer line is completely enclosed within a secondary confinement barrier. The secondary confinement barrier usually is a larger pipe (newer designs), a concrete jacket (older designs), or a pipe trench. The term “direct-buried piping” indicates that the piping is not encased and is buried directly in the soil. The term “over-ground piping” refers to encased piping that is not buried. In recent years over-ground transfer lines have been utilizing a HIHTL design employing reinforced EPDM hoses.

Once retrieval is complete equipment reusable equipment including the PVB will be flushed, labeled and stored for further use in accordance with 40CFR parts 761.30 and 761.40. The HIHTL and other non-reusable equipment will be managed in accordance with 40CFR 761.60 and other applicable waste regulations. Because of the radiological contamination, equipment will be disposed in an approved radiological disposal facility.

2.2 PCBs IN THE RETRIEVAL SYSTEM

PCBs are a group of 209 semivolatile organic chemicals consisting of from 1 to 10 chlorine atoms attached to a biphenyl. PCBs were not produced as discrete compounds (congeners) but as technical mixtures of congeners in varying proportions. PCB material was produced in the United States from 1930 to 1974. Most of this material was marketed by Monsanto under the trade name Aroclor (National Research Council 1979). Production of PCBs in the United States peaked in 1970 and had essentially stopped by the late 1970s (Patton et al., 1997). The physical properties of PCBs made them adaptable for numerous commercial uses. PCBs were used widely as dielectric fluids for capacitors and coolants for transformers; they also were used as plasticizers, hydraulic and heat transfer fluids, inks, paints, and adhesives (Erickson, 1992). These all are common industrial products that could have been introduced as waste to Hanford Site in the past.

Two sources of PCB are expected during the SST solid waste retrieval, SST solids and DST supernate.

PCBs have been reported in SST solid waste and DST supernate at maximum concentrations of 37 µg/g and <6.5E-02 µg/l, respectively. The Hanford tank waste system was designed to store radioactive liquid waste; PCBs introduced into the tanks would have been incidental waste that had been radiologically contaminated, or relatively small-quantity waste streams that were drained to the tanks from radiologically controlled areas.

Aroclor 1016 was selected as a representative PCB for modeling of releases from SSTs in this risk analysis to be consistent with the *Double Shell Tank System PCB Risk Assessment* (CHG, 2001). Environmental toxicology for PCB is complicated by the large number of congeners in the technical mixtures. The Aroclor mixtures 1016, 1221, 1242, 1248, 1232, 1254, and 1260 are seven PCB compounds that have been identified as possible mixtures used at the Hanford Site (DOE, 2001). In comparison to the other Aroclor compounds, Aroclor 1016 exhibits a large molecular weight, relatively high solubility in dilute aqueous solution at standard temperature and pressure, and a relatively high Henry's Law constant. Calculations using Henry's Law constants for any of the other Aroclor compounds (e.g., 1232) would be expected to result in vapor release rates of one to two orders of magnitude less than that predicted for Aroclor 1016.

PCBs present during the SST retrieval operation could be released to the environment through limited release pathways, but via several mechanisms. Three scenarios were identified for evaluation in this risk assessment based on tank farm operations. These scenarios represented events that were deemed to be realistic and consistent with proposed SST retrieval operation. These pathways are similar to those used in the *Double-Shell Tank System PCB Risk Assessment,* (CHG, 2001).

2.3 RELEASE SCENARIOS

The following sections discuss the release mechanisms and scenarios used in this risk assessment. The release scenarios are: normal ventilation operation, a valve pit jumper spill, and a valve pit spray. The discussion addresses releases from routine operations and accident conditions. Because this was a screening-type analysis, bounding or near bounding parameters were selected to project conservative release amounts. The release calculations are shown in Appendix A. Section 2.4 discusses uncertainty and conservation in each release scenario. These scenarios were used for consistency with the DST RBDA application (CHG, 2001), and represent likely release pathways.

2.3.1 Normal Operating Stack

Several methodologies were considered for the normal operating stack release. Insufficient characterization information was available to develop an adequate mechanistic release scenario. Therefore, a deterministic approach was selected for the normal operating stack release. A conservative total PCB inventory for the waste retrieval system was calculated and 100 percent of this calculated PCB inventory was assumed to be released as a vapor over 2 years. The basis for this release scenario is provided in the remainder of this section.

Although the majority of the PCB expected to be in the retrieval system are expected to come from the SST waste solids and would not be readily available to be released as vapor, this scenario assumes that all PCB is available and will be released as vapor at a steady rate over the retrieval period. Each tank is estimated to have a retrieval time of 2 to 3 months, totaling 2 years for the twelve tanks.

During the retrieval activities the SST waste will consists of supernate (from the DSTs) and SST solids. The solids are made up of both sludge and saltcake. The maximum PCB sample result based on existing data for the SST to be retrieved is 37 ppm. Existing analytical data indicates the concentration of PCB in the supernate are <6.50E-2-µg/l (Nguyen, 2004). This concentration of PCB was chosen to add conservatism to the calculation although actual PCB concentrations are expected to be lower.

Retrieval of S-102 is expected to take less than one year. While the expected duration of the eleven C farm SST is two years. Retrieval times may overlap for the east and west area, therefore a combined risk to the off site receptors has been calculated. Retrieval of each SST's solid waste is expected to last only 2 to 3 months, with some overlap in retrievals.

2.3.2 PCB Release for Valve Pit Jumper Change-Out

This normal release scenario addresses a situation where drainage from a jumper occurs during a valve pit jumper change-out. In this scenario the valve pit cover blocks are not installed. During a jumper change-out operation, a jumper is removed and it is assumed waste is trapped in the jumper. Subsequently the jumper is tipped and the trapped waste is dumped to the valve pit floor, resulting in 7.6 E-3 m^3 (2 gal) of waste draining to the valve pit floor within 10 seconds. An aerosol constituting 0.01 percent of the waste released to the pit is then released to the environs within 1 hour of the drainage.

The slurry is assumed to contain 25 percent entrained solids with the solids containing 37 µg/g PCBs and the liquid containing 6.50E-2 µg/l PCBs. The slurry density is assumed to be 1.2 g/cm^3. The principal PCB constituent is the Aroclor 1016 compound.

The scenario assumes that no solid particulate is lost by deposition during plume migration to the receptor location and that the entire aerosol released is respirable by receptors.

2.3.3 PCB Release for Valve Pit Spray

This accident scenario addresses a SST slurry spray in a valve pit with the cover blocks installed. The scenario assumes that a crack develops in the piping of a length equal to 1 nominal pipe diameter, i.e., 50.8 mm (2 in.). The slurry is sprayed into the valve pit and begins to collect on the pit floor. The pit has a leak detector that is designed to activate at 25.4 mm (1 in.) above the pit floor. However, the scenario assumes that a 50.8 mm (2-in.) accumulation is required to set off the leak detector. An additional 30 minutes response time is assumed before the transfer pump is stopped, resulting in 2.78 m^3 (98.0 ft^3) of slurry on the bottom of the pit.

Release of PCB-contaminated material to the environment is caused by the displacement of air with entrained aerosol through gaps and crevices in and around the cover blocks. The largest release would result from a spray accident at the largest pit within C farm. The internal dimensions of the largest pit within C farm are 5.49 m x 4.42 m x 2.57 m (18 ft x 15.5 ft x 8.42 ft) deep resulting in a surface area of 25.9 m^2 (279 ft^2) and a pit volume of 66.5 m^3 (2,349 ft^3).

The displaced air is assumed to be mixed with a maximum aerosol loading of 100 mg/m^3. An initial expansion of the air in the pit caused by an assumed increase in air temperature and relative humidity from – 1 °C (30°F) at 15-percent relative humidity (RH) to 49 °C (120 °F) at 100 percent RH leads to a release of 35 percent of the total pit volume. The time required to perform the initial heat-up and expansion is assumed to be less than 1 hour.

The release is assumed to result in a spray volume rate of 1.41E-4 m^3/sec, resulting in 5.5 hours elapsing before the release is detected. A total release time of 6.0 hours results with the inclusion of the response time to secure the transfer pump.

The slurry is assumed to contain 25 percent mobilized solids with the solids containing 37 µg/g PCBs and the liquid containing 6.50E-2 µg/l PCBs. The maximum slurry density is assumed to be 1.2 g/cm^3. The principal PCB constituent is the Aroclor 1016 compound.

The scenario assumes that no solid particulate is lost by deposition during plume migration to the receptor location and that the entire aerosol released is respirable by receptors.

2.4 UNCERTAINTY

The PCB rate release models created for this evaluation rely on simplified chemical, physical, and operational concepts. The assumptions chosen provide a conservative and simple calculational basis. As with any model, attempts to simplify a complex process lead to inherent uncertainty. The uncertainty in this model stems from three overall assumptions, namely, that the PCB concentrations in the slurry are known, that the slurry is a homogeneous solution, and that the kinetics and diffusion rates are sufficient to provide a consistent release from the system. The SST solid waste PCB concentration was based on the maximum analytical value for samples from the SST to be retrieved. The DST supernate PCB concentration was based on Nguyen, 2004. No consideration was taken for a potential chemical degradation of the PCBs in the high-pH DST supernate.

The model assumes that all SST solid waste and DST supernate has a homogeneous PCB concentration. No consideration was made concerning the kinetic and diffusion characteristics associated with the transfer of PCBs from the solid to the liquid to the vapor space. The actual kinetic and diffusion characteristics would be expected to be much slower and would not support a consistent high release of PCB.

Table 2-2 provides a compilation of model parameters used in the exposure scenarios and discusses the implications of changes in these values. The results of the emission rates for the various scenarios show that the stack release during normal operations is significantly higher than for the valve pit jumper spill and valve pit spray accident scenarios.

Table 2-2. Effect of Uncertainty on Model Assumptions.

Parameter	Model Assumptions and Discussion	Effect of Uncertainty
Source term	• Slurry assumed to contain 25 wt% mobilized solids with a PCB concentration in the liquid of 0.065 µg/l and in the solids of 37 µg/g • Normal operation model based on an upper limit of PCB in the waste	Use of actual PCB solubilities or actual concentrations would be expected to lower calculated release rates by several orders of magnitude
Source term	• Model concentrations are based on tank samples.	Maximum concentration of PCB was used. Only six of the twelve tanks have existing data. Actual concentrations would be expected to lower calculated release rates by several orders of magnitude
PCB chemistry	• Effects of pH on PCB volatility and stability are not addressed in model	Degradation of PCBs would be expected to lower calculated release amount
Distribution in matrix	• The maximum expected slurry density was used although lower variations during retrieval are expected • The DST supernate is assumed to be a homogeneous solution • SST solids are not expected to be stratified to the extent that any variation in PCB concentration would affect the over all risk.	Changes in the slurry density during retrieval and changes to the homogeneity between transfers would be expected to lower calculated release rates
Kinetics between solid, liquid and vapor phases	• Model assumes a finite and steady supply of PCBs from solid to liquid to vapor phase until depleted • Diffusion-driven concentration gradients within the waste solution in unmixed SSTs not modeled	• Slower liquid to vapor space kinetic rates would result in decreased calculated release rates

3.0 EXPOSURE ASSESSMENT SCENARIO

This section of the human health risk assessment describes the approach used to quantify human exposures to PCBs posed by potential tank equipment releases from the SSTs retrieval operation for the selected normal and accidental release scenarios. Included within the exposure assessment portion of the risk assessment are the following processes: identification of potentially exposed individuals or populations ("receptors"); identification of potentially complete exposure pathways; and quantification of chemical intakes or potential doses for each receptor-pathway combination.

3.1 CHARACTERIZATION OF RECEPTORS

The selection of receptors to be evaluated in this risk assessment was designed to ensure protection of all potentially exposed members of the worker and public populations (see Figure 1-1 for area map). The identification of potential receptors focused on those individuals most likely to be present and unprotected at the time of normal or accidental releases. Given this objective, the following receptors were examined as part of this risk assessment:

- An adult worker downwind of SST operations as the maximum stationary (MS) worker exposure. For east area the MS worker is approximately 300 m from the source and approximately 110 m for west area based on modeling (Appendix B). The MS worker is a worker who is located at one of these distances from the stack for 8 hours a day, 225 days a year for 2 years. Since workers are not stationary objects the MS worker is a theoretical receptor given a worst case scenario.

- An adult motorist commuting on Highway 240 West of the SST farms. The distance to Highway 240 is 3800 and 9000 m for the West and East SST farms, respectively.

- An adult resident living in Ringold, Washington. The closest distance to Ringold is 17,100 and 25,900 m for the East and West DST farms, respectively. The minimum distance is consistent with that used in the evaluation of the 242-A Evaporator Study (DOE, 2001).

- A less than 12 month old infant of a nursing mother for each one of the three proceeding receptors.

The MS worker is intended to represent a health-protective, exposure for onsite personnel within the SST areas. An adult motorist commuting on Highway 240 is included to represent the potential for less frequent and/or shorter duration exposures by public or worker receptors within the SST vicinity. The adult resident living at Ringold is included to represent the potential long-term risks to populations currently living at a location of offsite exposure. The less than 12 month old infant of a nursing mother is included to represent an early-life exposure.

3.2 DESCRIPTION OF EXPOSURE PATHWAYS

This section identifies the most significant potential pathways through which humans may be exposed to PCBs released during the SST solid waste retrieval activities and presents the basis for elimination of incomplete exposure pathways or insignificant routes of exposure. As described in the *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A* (EPA, 1989), the exposure pathway comprises four characteristics:

- A source and mechanism of constituent release
- A retention or transport medium (e.g., air, soil, water)
- A point of human contact with the affected medium (e.g., workers or resident population)
- An exposure route at the point of contact (e.g., oral, inhalation, or dermal absorption).

This risk assessment utilized the conceptual site model (CSM) evaluation in the *Double-Shell Tank System PCB Risk Assessment* (CHG, 2001). This is a critical component of the risk assessment because only complete pathways have the potential to pose risks to surrounding populations of workers and the public.

The air pathway is based on a review of the operation of active ventilation systems on the SST during the solid waste retrieval activity.

Once in the air, the PCB contamination is uncontained and able to make contact with any human receptors in the path of its transport and migration. Once in contact with humans, the primary route of exposure for air is via inhalation. Thus, a complete exposure pathway exists for inhalation of PCB-contaminated air released from the SSTs.

In addition to the air pathway covered in this risk assessment the risk to the environment through the groundwater pathway has been evaluated for retrieving waste from a select group of SSTs solid waste with DST supernate. Although numerous contaminant fate and transport simulations have been performed to support SST waste retrieval and closure decisions (e.g., CHG, 2004a and CHG, 2004b), to date the analyses have focused on radionuclides and inorganic chemicals and have not explicitly included PCBs or other organic chemicals. Nevertheless, the results of these analyses can be used to evaluate whether PCBs are likely to reach groundwater and be of concern for risk assessment under a retrieval leak scenario.

The argument presented here requires a basic understanding of contaminant mobility in the subsurface. Adsorption is one of the primary mechanisms that control or retard the migration of contaminants in the vadose zone and groundwater (PNNL, 2003). Adsorption refers to the partitioning of the dissolved contaminant from the groundwater to the natural subsurface materials. The most common method used to describe contaminant adsorption, and the method used in all tank farm risk modeling performed to date, is the distribution coefficient or K_d model. The distribution coefficient can be expressed as:

$$K_d = \frac{\text{Mass of contaminant on the solid phase per mass of solid phase}}{\text{Concentration of solute in solution}}$$

The K_d value is typically expressed in units of mL/g. Contaminants with a K_d value of 0 mL/g are non-absorbing and migrate at same rate as water. Tank farm risk modeling has consistently shown that long-term groundwater impacts and associated human health risks are driven by the highly mobile (K_d = 0 mL/g) contaminants. Contaminants with K_d values of 1 mL/g or greater have been consistently shown not to transit the vadose zone (i.e., do not break through to the groundwater table) within the 10,000-year simulation period typically used. Contaminants with K_d values of 0.6 mL/g break through to groundwater but only late in the simulation period and therefore make little or no contribution to risk at the time of peak, which for retrieval leaks is projected to occur approximately 100 years after tank farm closure.

Based on these results, concern over PCB groundwater impacts can be dismissed without an explicit risk calculation if the K_d for PCBs is 1 mL/g or greater. The K_d model is empirical and best applied only to the conditions under which the K_d value was measured. Unfortunately, although there are data on PCB K_ds in the scientific literature, no data exist for Hanford soil and sediments. However, a K_d value can be estimated using the following equation (PNNL, 2003).

$$K_d = f_{oc} \times K_{oc}$$

Where:

f_{oc} = mass fraction of organic carbon in the porous medium (unitless)

K_{oc} = organic carbon distribution coefficient for the contaminant of interest (mL/g)

The fractional organic carbon content of Hanford sediment is typically 0.0003 (PNNL, 2003). The K_{oc} for PCBs is 3.09×10^5 mL/g (EPA, 1996b). Using these values, the estimated K_d for PCBs in Hanford sediment is 92.7 mL/g.

A K_d of 92.7 mL/g is more than 100 times the maximum value of concern ($K_d < 1$) indicated by tank farm risk modeling. Based on this value, PCBs would not be expected to migrate to groundwater within a 10,000-year time frame. The PCB contribution to groundwater risk under a retrieval leak scenario is therefore expected to be zero. Even allowing for some inaccuracy in the calculated K_d estimate, it is unlikely that a measured Hanford value would be two orders of magnitude lower than the calculated value.

A K_d of 420 mL/g was reported for PCBs (PCB-1248) at a remediation site in Tennessee where the soil organic carbon content is somewhat higher (f_{oc} = 0.0012) than at Hanford (EPA, 1999b). A study published by the University of Waterloo, Ontario, Canada entitled *Polychlorinated Biphenyls (PCB's) In The Environment*, reported PCB K_d values ranging from 22 mL/g for silica sand to over 1,000 mL/g for coal char.

A search of the Hanford Environmental Information System (HEIS) database revealed that PCBs have been detected in only one groundwater well on the Central Plateau (well 299-E34-5, sample date April 2004, result shown as flagged for further analysis). PCBs have been detected in a limited number of wells in the 100 Area (mainly 100 N), with most of the reported results being at the detection limit.

Based on the information presented above it can be concluded with reasonable confidence that PCBs would not be expected to migrate to groundwater under a retrieval leak scenario involving recycled DST supernate. PCBs are therefore not of concern for assessment of groundwater risk.

3.3 DETERMINATION OF EXPOSURE POINT CONCENTRATIONS

For the MS Worker, Highway 240 commuter and Ringold resident the exposure point concentrations were estimated using a fate and transport model that simulates transport of the PCB release in air and its resulting concentration at specified points of potential exposure some distance from the point of release. The nursing infant's PCB concentration was calculated by multiplying the PCB concentration of the three adult receptors using a published 1.7 multiplier (Smith, A.H., 1987), to account for the contribution of PCB to an infant's body concentration during 12 months of breast feeding.

SCREEN3 (version 96013) is a single-source, steady-state Gaussian-plume air dispersion model used to estimate maximum 1-hour air pollutant concentrations from point and area sources. The model is based on equations and calculations that are detailed in *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised*, EPA-454/R-92-019 (EPA, 1992). SCREEN3 is EPA approved (40 CFR 51, Appendix W) and is designed to be a conservative screening model for use as a first step in evaluating potential impacts from chemical emission sources. Hence, its code was developed so that it is unlikely to underestimate chemical concentrations in air. A brief summary of the input assumptions and results obtained using SCREEN3 for the previously discussed exposure scenarios are provided in Section 3.3.1.

3.3.1 Model Inputs

For each source type (e.g., point or area), SCREEN3 requires a set of input assumptions. Some of these input assumptions remain constant over the various exposure scenarios evaluated for this risk assessment, while others change depending on receptor or release types. The input values that remained constant across the scenarios, and the rationale for their selection, are provided in Table 3-1. Those values that were variable across scenarios and their rationale are provided in Table 3-2.

Table 3-1. Parameters Constant Across All Exposure Scenarios. (2 sheets)

Parameter	Value	Rationale
Ambient air temperature	285.3 K	Five-year annual average temperature Richland, Washington, meteorological data.
Stack gas exit temperature	285.3 K	See Section 2.3 and App B (SCREEN3 Calculations)
Receptor height above ground	1.75 m	Standard height for an adult.
Urban/Rural Option	Rural	Terrains largely open country.

Table 3-1. Parameters Constant Across All Exposure Scenarios. (2 sheets)

Parameter	Value	Rationale
Building Downwash Option	No	No buildings are located next to SST stacks or pits.
Complex Terrain Option	No	Terrain surrounding tank farms generally is flat and does not rise above the top of the stack.
Simple Elevated or Flat Terrain Option	Flat Terrain	Terrain surrounding tank farms is almost completely flat and does not rise significantly above the bottom of the stack.
Choice of Meteorology	Full Meteorology	SCREEN3 default and most conservative option.
Fumigation Option	No	Parameters for use of fumigation (near large body of water and/or stack higher than 10 m) do not apply at the site.

Table 3-2. Parameters That Vary Across Exposure Scenarios

Parameter	Scenario	Value
Source Type	Stack, Normal Operations	point
	Valve Pit Spill	area
Emission Rate*	Stack, Normal Operations	West Area (S-Farm): 0.00242g/sec East Area (C-Farm): 0.000544g/sec
	Valve Pit Spill	1.81E-10g/sec-m^2
	Valve Pit Spray	4.37E-11g/sec-m^2
Stack Height	Valve Pit Spill or Spray	Ground level
	Stack, Normal Operations	9 m
Stack Inside diameter	Stack, Normal Operations	0.254 m diameter (representing a 10 inch diameter stack)
Size of Release Area	Valve Pit Spill or Spray	25.9 m^2 (using pit dimensions 5.49 m $\times$ 4.72 m)
Stack Exit Velocity	Stack, Normal Operations	West Area (S-Farm) 450 ft^3/min (0.21 m^3/sec) East Area (C-Farm) 750 ft^3/min (0.35 m^3/sec)
	Valve Pit Spill or Spray	NA

* Based on Maximum PCB calculations (Appendix A)

SCREEN3 is designed for single-stack releases. Since the three exhausters supporting C farm tank solid waste retrieval are all located in close proximity to each other (i.e. with in the farm), a single point source (i.e. exhauster/stack) was used for the retrieval of the C Farm SSTs in the calculations.

Both the spray and spill scenarios occur in a SST tank farm valve pit. The aerosols were modeled as vapors with SCREEN3. The PCB emissions from the pit are around the cover in the spray scenario and over the area of the pit for the spill. Thus the releases were developed as area sources.

3.3.2 Model Outputs

SCREEN3 calculates maximum 1-hour pollutant concentrations at distances selected by the user. EPA (1992) provides time adjustment factors for calculating average concentrations for different time periods using this maximum concentration. These factors take into account the variability of wind direction and speed and atmospheric conditions over the time periods. For example, the EPA guidance recommends multiplying the 1-hour concentrations by a factor of 0.7 to calculate 8-hour concentrations. For the public receptor risk estimate, an annual concentration is more appropriate, and the recommended multiplier is 0.08. For the spray and spill release scenarios, which varied in release time from 1 hour to 6 hours, the modeled concentration were not adjusted. This was considered appropriate because these are short-term accident scenarios, and 1-hour maximum concentrations are conservative for these types of exposures. Table 3-3 provides the results of the model calculations for each release scenario, as well as the final adjusted concentrations obtained after using the adjustment factors for the human exposure scenarios. Section 5 applies the air concentrations to the environmental assessment.

Table 3-3. Model Output and Adjusted Concentrations for the Human Exposures.

Scenario	Receptor*	Distance (m)	Modeled One-Hour PCB Concentration (μg/m^3)	Time factor based on exposure **	Period Adjusted PCB Concentration*** (mg/m^3)
Stack, Normal Operations	East-100 m worker	100	3.46E-01	0.7	2.42E-04
	West-100 m worker	100	2.29E+00	0.7	1.60E-03
	East-MS worker	300	3.58E-01	0.7	2.50E-04
	West-MS Worker	110	2.33E+00	0.7	2.51E-04
	East-Highway 240	9,000	1.51E-02	0.08	1.21E-06
	West-Highway 240	3,800	2.07E-01	0.08	1.66E-05
	East-Ringold	17,100	6.74E-03	0.08	5.39E-07
	West-Ringold	25,900	1.84E-02	0.08	1.47E-06
Valve Pit Spill	East-MS Worker	300	2.24E-05	1.0	2.24E-08
	West-MS Worker	110	1.00E-04	1.0	1.00E-07
	East-Highway 240	9,000	1.36E-07	1.0	1.36E-10
	West-Highway 240	3,800	4.34E-07	1.0	4.34E-10
	East-Ringold	17,100	5.96E-08	1.0	5.96E-11
	West-Ringold	25,900	3.61E-08	1.0	3.61E-11
Valve Pit Spray	East-MS Worker	300	5.40E-06	1.0	5.40E-09
	West-MS Worker	110	2.42E-05	1.0	2.42E-08
	East-Highway 240	9,000	3.28E-08	1.0	3.28E-11
	West-Highway 240	3,800	1.05E-07	1.0	1.05E-10
	East-Ringold	17,100	1.44E-08	1.0	1.44E-11
	West-Ringold	25,900	8.72E-09	1.0	8.72E-12

*East" and "West" in this column refer to the area of the source.
**Averaging time Factor: 3hr=0.9, 8hr=0.7, 24hr=0.4, annual =0.08
***The adjusted concentration is obtained by multiplying the modeled concentration by the time adjustment factor.

3.4 ESTIMATION OF HUMAN DOSES

For this risk assessment, exposure by an individual to PCB may occur only via direct inhalation of air containing PCBs. Each of the receptors was evaluated for all three release scenarios using exposure assumptions and parameters that tend to produce upper-bound exposures. These receptors were chosen to represent health-protective individual exposure scenarios potentially occurring in the DST vicinity. If the risks associated with these individual receptor exposures are found to be within acceptable EPA guideline values, the potential risk to the remaining population is expected to be much lower. Table 3-4 lists all the exposure assumptions and inputs relied on for each public receptor-release scenario. The onsite MS worker scenario assumed a regular 8 hour workday schedule.

Table 3-4. Exposure Assumptions for Receptors.

Parameter	**Highway 240 Commuter**		**Ringold Resident**		**MS Worker**	
	Stack, Normal Operations	**Valve Pit Spill/Spray**	**Stack, Normal Operations**	**Valve Pit Spill/Spray**	**Stack, Normal Operations**	**Valve Pit Spill/Spray**
Inhalation rate (a) (m^3/day)	20	20	20	20	20	20
Exposure (hrs/day)	0.25	8	24	1	8	1
Exposure frequency (days/yr)	250	1	350	1	225	10
Exposure duration (c)(years)	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Body weight (d) (kg)	72	72	72	72	72	72
Lifetime (d) (years)	75	75	75	75	75	75

Notes/References
a. Definition of scenario (Section 2.3 and Appendix A)
b. EPA, 1991a, *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors*," OSWER Directive 9285.6-03, U.S. Environmental Protection Agency, Washington, D.C.

c. Total duration of SST retrieval expected to be 2 years, (1 year West area and 2 years East area were used in calculation in risk, Retrieval schedules for East and West overlap).
d. Versar, Inc., 2000, *PCB Risk Assessment Review Guidance Document. Prepared for Office of Pollution Prevention and Toxics*, for the U.S. Environmental Protection Agency, Washington, D.C.

The potential lifetime average daily doses for the MS Worker, Ringold resident and Highway 240 commuter receptor scenarios were calculated using the following equation (EPA 1989):

$$LADD_{pot} = [C \times IR \times ED \times EF] / [BW \times LT]$$

where:

$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day);
C = contaminant concentration in air (mg/m^3);
IR = inhalation rate (m^3/day);
ED = exposure duration (years);
EF = frequency of exposure events (days/year);
BW = body weight (kg); and
LT = lifetime (days).

Because the Highway 240 commuter and Ringold resident receptors are exposed to continuous emission from stacks in both areas, their total exposure was the sum of the exposures to each stack. The exposure concentration for each receptor was that associated with the distance from each stack to the receptor. The MS worker exposure was calculated separately for east and west areas based on the 300m and 110m distance from the source, respectively.

The human dose for a nursing infant of each of the three receptors was also evaluated. Because the main route of entry for this receptor is through the mother’s milk, calculations were made based on the initial human does to each of the three receptors. Details of the nursing infant exposure are given in Section 4.2.

3.5 UNCERTAINTY

The following sections discuss the uncertainty associated in the models and human exposure parameters used in this risk assessment.

3.5.1 SCREEN3 Air Modeling

The SCREEN3 model is a steady-state Gaussian plume model that relies on predefined sets of weather conditions and dispersion parameters along with user inputs to estimate ambient air concentrations at downwind locations. As with any computational model, SCREEN3 attempts to simplify natural processes to answer a complex question; hence, the model contains inherent uncertainty. For this discussion, model uncertainty will be divided into two components: uncertainty inherent in the SCREEN3 model calculations and uncertainty in the model input assumptions.

SCREEN3 uses a generic set of dispersion parameters and weather conditions (e.g., atmospheric stability and wind speeds) to calculate maximum air concentrations. The range of weather conditions included in a SCREEN3 model run is indeed extreme. This assumption and the fundamental parametric choices embedded in SCREEN3 are why it is a conservative screening model. The worst case weather conditions that lead to a maximum concentration for a particular model run seldom occur. Similarly, the time adjustment factors used to create concentration estimates for periods longer than 1 hour are chosen to be conservative estimates of wind variability over the time period. The weather conditions that produced the maximum air concentrations for the commuter and Ringold resident can be expected at the Hanford Site, but their frequency in the direction of these two receptors is uncertain.

The uncertainty in the SCREEN3 input assumptions also are propagated through the model calculations. Table 3-5 provides the various SCREEN3 input parameters used for the exposure scenarios, and discusses the implications of changes in these values.

Table 3-5. The Effect of Uncertainty on Model Parameters. (2 sheets)

Parameter	**Value**	**Effect of Uncertainty**
Ambient Temperature	285.3 K	If the ambient temperature is lower than the emissions temperature, more plume rise is expected; this pushes the maximum concentration farther from the source, but also disperses the plume more, leading to lower maximum concentrations. The opposite occurs when the ambient temperature is higher than the emission temperature.
Effluent Temperature	285.3 K	
Receptor Height Above Ground	1.75 m	Increasing and decreasing the receptor height by less than 1 or 2 m is unlikely to have a significant effect on modeled air concentrations.
Urban/Rural Option	Rural	The use of the urban option causes the plume to disperse more quickly, which can cause higher concentrations at nearby receptors and lower concentrations at distant receptors.
Building Downwash Option	No	The use of building downwash calculations can affect air concentrations near the stack if buildings are present; generally, higher concentrations are found closer to the stack than if building downwash is not considered.

Table 3-5. The Effect of Uncertainty on Model Parameters. (2 sheets)

Parameter	Value	Effect of Uncertainty
Complex Terrain Option	No	The complex terrain option allows for the calculation of air concentrations assuming the plume touches ground that is at a higher elevation than the stack. If such terrain exists near a stack, the concentrations at impact will be higher than if higher ground is not assumed to exist.
Simple Elevated or Flat Terrain Option	Flat Terrain	The simple terrain option assumes that terrain is higher than the stack base, but lower than the stack top. Hence, the modeled plume will touch the ground sooner, and higher concentrations will result if this option is used.
Choice of Meteorology	Full Meteorology	Use of limited meteorological states can lead to lower calculated concentrations if the condition that produces the maximum concentration is omitted.
Fumigation Option	No	Use of the fumigation option will result in higher air concentrations under certain conditions.
Emission Rate	Variable	Decreasing modeled emission rates linearly decreases modeled air concentrations and vice versa.
Stack Height	Variable	Increasing the modeled stack height will push the location of the maximum concentration further from the stack and decrease that concentration. The opposite also applies.
Stack Inside Diameter	Variable	Decreasing the modeled stack diameter will push the location of the maximum concentration further from the stack (because of the subsequent increase in stack exit velocity), especially under high-wind conditions, and decrease that concentration, if the maximum is close to the stack. The opposite also applies.
Stack Gas Flow Rate	Variable	Increasing the modeled stack gas flow rate will push the location of the maximum concentration farther from the stack and decrease that concentration if the maximum is close to the stack. The opposite also applies.

Table 3-5. The Effect of Uncertainty on Model Parameters. (2 sheets)

Parameter	Value	Effect of Uncertainty
Form (vapor or aerosol) of PCB releases	Variable	The normal stack scenario releases vapor, but PCB may absorb to air particulates. Spray and spill scenarios generate aerosols. The SCREEN3 model runs assumed only vapor emissions. As the proportion of vapor declines, the results of SCREEN3 model runs will tend to underestimate concentrations close to the valve pit, and overestimate concentrations at a distance.

3.5.2 Human Exposure Parameters

The exposure parameter values were designed to be health-protective. Table 3-6 discusses the key exposure assumptions and the effects of uncertainty.

Table 3-6. Effect of Uncertainty on Exposure Assumptions

Parameter	Highway 240 Commuter		Ringold Resident		Worker	
	Stack, Normal Operations	Valve Pit Jumper Leak/ Spray	Stack, Normal Operations	Valve Pit Jumper Leak/ Spray	Stack, Normal Operations	Valve Pit Jumper Leak/ Spray
Inhalation rate	Study assumed $20m^3$/day. Risk is proportional to inhalation rate. Risk will increase if the person is involved in major exercise.					
Exposure	Study assumed 0.25 hr/day for commuting twice per day through a plume from each SST area. Risk is proportional to exposure.	Study assumed the exposure to be the length of the release. Risk is proportional to exposure.	Study assumed 24 hr/day, which cannot be increased. Risk is proportional to exposure.	Study assumed the exposure to be the length of the release. Risk is proportional to exposure.	Study assumed normal 8 hr/day work schedule. Risk is proportional to exposure.	Study assumed the exposure to be the length of the release. Risk is proportional to exposure.

Exposure frequency	Study assumed 250 days for a typical work year. Risk is proportional to exposure frequency.	Study assumed 1 time per year. Accident is anticipated with a frequency of 1 per year.	Study assumed 350 days per year. Risk is proportional to exposure frequency.	Study assumed 1 time per year. Accident is anticipated with a frequency of 1 per year.	Study assumed 225 days for a typical work year. Risk is proportional to exposure frequency.	Study assumed 1 time per year. Accident is anticipated with a frequency of 1 per year.
Exposure duration	Study assumed 1 to 2 years.		Study assumed 1 to 2 years.		Study assumed 1 to 2 years.	
Body weight	Study assumed 72 kg. EPA (1991) recommends 70 kg. Risk is inversely proportional to body weight.					
Lifetime	Study assumed 75 years. Risk is inversely proportional to lifetime					

References

EPA, 1991, *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors,"* OSWER Directive 9285.6-03, U.S. Environmental Protection Agency, Washington, D.C.

Definitions

Inversely proportional. Risk will decrease with an increase in the parameter value, and increase with a decrease in the parameter value.

Proportional. Risk will decrease with a decrease in the parameter value and increase with an increase in the parameter value.

4.0 RISK CHARACTERIZATION

4.1 METHODOLOGY FOR QUANTIFYING RISK

The objective of the characterization portion of the risk assessment is to evaluate the potential health impacts of exposure to the PCB releases in air, in conjunction with toxicity data for PCBs to quantitatively estimate the potential carcinogenic risk posed to the receptors. The equation used to calculate PCB cancer risk to an individual receptor is:

$$R_i = LADD_{pot} \times CSF$$

where

R_i = excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day); and
CSF = cancer slope factor (kg-day/mg)

Excess lifetime cancer risk refers to an individual's increased probability of developing cancer during his or her lifetime because of the scenario exposure conditions. The EPA assumes that no threshold dose exists for cancer risk (i.e., any dose of a carcinogen is assumed to be associated with some risk, however small). The EPA (1991b) has used a target risk range of 10^{-6} to 10^{-4} as generally considered to be acceptable. In this document, each PCB cancer risk presented is an upper-bound estimate based on an upper-bound cancer slope factor. Actual cancer risks are unlikely to be higher than risks calculated using upper-bound cancer slope factors.

4.2 TOXICITY ASSESSMENT

The most common effects seen in humans from exposure to PCBs are skin rashes and acne, although workplace exposures have resulted in lung and nose irritation. Some evidence has been found that exposure of women to PCBs during pregnancy via ingestion of fish may lead to developmental toxicity such as decreased birth weights and head circumference in infants (PHS, 1997). Animals exposed to PCBs via ingestion and dermal routes showed similar effects as humans, but also showed signs of kidney and liver toxicity. Rats that ate food containing various PCB mixtures throughout their lifetimes showed an increase in liver cancer; however, this result has not been confirmed in human occupational studies. Hence, it is uncertain whether these compounds cause cancer in humans (PHS, 1997).

Based on the animal carcinogenesis studies, however, the U.S. Department of Health and Human Services has declared that PCBs can be "reasonably anticipated to be a human carcinogen," (PHS, 1997). EPA has labeled PCBs as "probable human carcinogens," (EPA, 2001), and the International Agency for Research on Cancer (IARC) has listed

PCBs as “probably carcinogenic to humans” (IARC, 2001). Co-planar PCBs have been described as having dioxin-like effects, and have been given toxic equivalency factors (TEF) from 0.00001 to 0.1 times that for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (Van den Berg, et al., 1998).

EPA believes it is important to assess the exposure through the human milk pathway (EPA, 1996a) and recommends estimates can be derived from material exposures (Smith, 1987). Smith (1987) recommends using a 1.7 bio concentration conversion factor from the mother to nursing infant.

To assess the potential for adverse effects in humans exposed to chemical compounds, the EPA has developed reference doses (RfD) for non-carcinogenic effects and cancer slope factors (CSF) for carcinogenic effects. Although PCBs are not a known carcinogen in humans, the EPA decided to develop CSFs for PCBs based on the animal toxicity data. In general, CSFs are assigned on an exposure route basis; for example, there might be one CSF for oral exposure to a compound, and a different one for inhalation exposure. However, the literature for PCBs suggests that they are unlikely to have different CSFs for oral versus inhalation exposure based on the similar bioavailability from these two routes (EPA, 1996a). According to the EPA (1996), the literature also suggests that the toxicity of environmental PCBs can be very different from the commercial mixtures used in toxicity evaluations (and generally responsible for environmental contamination). Two important and related characteristics have been found to be related to the toxicity of environmental PCBs: persistence and bioaccumulation. In the case of nursing infants bioaccumulation through the mother’s milk is the predominant characteristic. Those PCB congeners that are highly persistent tend to be higher in toxicity, and those that bioaccumulate in the food chain tend to have the highest toxicity (EPA, 1996a). These concepts have led the EPA to propose different CSFs for different types of PCB exposures: exposures to PCBs through the food chain or absorbed to particles (i.e., bioaccumulated or more persistent) are evaluated using a higher CSF than exposures to PCBs in vapor or solution (i.e., lower persistence). In addition, the EPA has developed both upper-bound (i.e., upper 95-percent confidence limit on the maximum likelihood estimate of the slope), and central-estimate (i.e., estimate for a typical individual’s risk) CSFs for PCBs (Table 4-1).

Table 4-1. PCB Slope Factors (kg-day/mg).

Exposure Condition	Central CSF	Upper-Bound CSF
• Food Chain • Early Life (all pathways and mixtures) • Dust or aerosol inhalation	1	2
Vapor inhalation	0.3	0.4

Reference

EPA, 1996a, *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures*, EPA/600/P-96/001F, National Center for Exposure Assessment, Washington, D.C.

The CSF used for each exposure scenario in this study was based on information about the types of PCB releases and the release pathway. When the release occurs as a vapor (i.e., normal stack operations scenario), the vapor-phase CSF was used. When the release occurs as an aerosol (i.e., spray and spill scenarios), the aerosol value was used. For the nursing infant the food chain exposure condition was used. In each case, however, this study has used the upper-bound CSFs as a health-protective assumption.

The derivation of CSFs requires considerable professional judgment, but they are designed to be upper-bound estimates, reducing the likelihood that the risks are underestimated. The mix of congeners in the release is unknown, however, and thus there is increased uncertainty in determining the appropriate CSFs to use for the releases in this study.

4.3 SUMMARY OF RESULTS

The potential health impacts to human receptors from exposures to PCBs from normal stack emissions and transfer line release (valve pit jumper spill and valve pit spray) have been evaluated.

The estimated cancer risks for the Ringold resident and Highway 240 commuter for the normal stack, valve pit jumper spill and valve pit spray scenarios are below the $1E^{-04}$ to $1E^{-06}$ range. Because these receptors are exposed to the continuous emissions from the stacks in the 200 East and West Areas simultaneously, the calculated risks for the normal stack scenarios were combined. The Ringold resident and Highway 240 commuter have estimated cancer risks of $3.6E^{-09}$ and $1.9E^{-08}$, respectively for normal stack operations. The less than 12 month old nursing infant of the Ringold resident and Highway 240 commuter have estimated cancer risks of $3.1E^{-08}$ and $1.6E^{-07}$, respectively.

The MS worker risk is higher than off site receptors, with cancer risk of $4.6E^{-07}$ and $2.3E^{-07}$ for the east area and west area work, respectively. Both areas MS worker's cancer risk is below the $1E^{-06}$ EPA lower acceptable risk. The nursing infant of an east area MS worker is $3.9E^{-06}$, is at the $1E^{-06}$ EPA lower acceptable risk. The nursing infant of a west area MS worker is slightly lower at $2.0E^{-06}$. This risk assessment is based on a MS worker who is located at the maximum exposure distance from the stack for eight hours a day, 225 days a year for two years for the east area and one year for west area. This person simply does not exist due to the nature of the work being performed. Therefore the cancer risk calculated for the MS worker and the nursing infant of this worker are theoretical worst case scenarios. As discussed in previous sections, this assessment has chosen health-protective assumptions, with the objective of not underestimating the human health risks. Thus it is unlikely that the actual risks exceed the values shown, and the actual risks are likely to be considerably below the estimated values. The specific assumptions and their implications for the actual risks have been discussed in previous sections.

Table 4-2. Estimated Cancer Risks

Scenario	Receptor					
	Ringold		Hwy 240 Commuter		MS Worker	
	Resident	Nursing Infant	Resident	Nursing Infant	Worker	Nursing Infant
Stack, Normal Operations East area releases	1.5E-09	1.3E-08	2.5E-09	2.1E-08	4.6E-07	3.9E-06
Stack, Normal Operations West area releases	2.1E-09	1.8E-08	1.7E-08	1.4E-07	2.3E-07	2.0E-06
Stack, Normal Operations (combined east and west area releases)	3.6E-09	3.1E-08	1.9E-08	1.6E-07	NC	NC
Valve pit jumper spill, east area release	4.8E-16	4.1E-15	1.1E-15	9.4E-15	1.8E-12	1.6E-11
Valve pit jumper spill, west area release	1.5E-16	1.3E-15	1.8E-15	1.5E-14	4.1E-12	3.5E-11
Valve pit jumper spill (combined east and west area release)	6.3E-16	5.3E-15	2.9E-15	2.4E-14	NC	NC
Valve pit spray, east area release	1.2E-16	9.9E-16	2.7E-16	2.3E-15	4.4E-13	3.7E-12
Valve pit spray, west area release	3.5E-17	3.0E-16	4.3E-16	3.6E-15	3.6E-13	3.0E-12
Valve pit spray (combined east and west area release)	1.5E-16	1.3E-15	7.1E-16	6.0E-15	NC	NC

Note:

See Sections 3.3 and 3.4 for discussions of exposure point concentrations, and exposure conditions, respectively. Uncertainty is discussed in Section 3.5.

NC = not calculated: No combined risks were calculated for the MS Worker because the East and West tank Farms are greater than the 343m distance used in the calculation.

5.0 ENVIRONMENTAL ASSESSMENT

The "*Double-Shell Tank System PCB Risk Assessment*" (CHG, 2001), contains a detailed description including a list of ecological receptors (invertebrates, fish, birds, animals, amphibians/reptiles, and plants) of potential concern for exposure to airborne PCB contamination from the Hanford site, and toxicity reference values (TRV). A species-specific TRV and an EPA TRV are used in this risk evaluation. The EPA TRV is consistently more conservative than the species-specific TRV. Retrieval of SST solid waste would potentially affect the same ecological receptors.

Impacts to ecological receptors are indicated in terms of the species-specific hazard quotient (HQ) and the EPA HQ for each species. Generally, an HQ greater than 1.0 indicates that there is a potential for adverse impact to that species. The HQ is a function of the TRV for each species and the dose or exposure concentration.

Using the dose calculations or exposure concentrations, hazard quotients (HQ) were calculated to screen for potential effects to ERPCs. The general equation for calculating a HQ is

HQ = (Dose or Exposure Concentration) / TRV.

The SST retrieval anticipated total dose used is the sum of the MS worker for east and west areas at distance of highest exposure ($1.14E^{-06}$ and $5.7E^{-07}$mg/kg-day respectively). This dose is the most conservative and accounts for species at the tank farm fence lines. The results of the calculations are shown in Table 5-1. The results of this ecological risk assessment indicate that there will be no adverse impact to the ecological receptors. The HQs for all species listed in Table 5-1 are less than 1.0 when the species specific TRVs are used.

Table 5-1. Ecological Receptor Hazard Quotients

Common Name	SST Retrieval Anticipated Total Dose (mg/kg-day)	Species Specific TRV[1] (mg/kg-day)	EPA General TRV[2] (mg/kg-day)	Species Specific HQ	EPA HQ
FISH					
Rainbow Trout/Steelhead	NA	2.1µg/L[4]	0.14 µg/L[3]	NA	NA
BIRDS					
Red-tailed Hawk	1.7E-06	1.73E-01[6]	7.2E-02[10]	9.88E-06	2.38E-05
Great Blue Heron	1.7E-06	1.35E-01[5]	7.2E-02[10]	1.27E-05	2.38E-05
American Robin	1.7E-06	4.2E-01[5]	7.2E-02[10]	4.07E-06	2.38E-05
MAMMALS					
White-tailed Deer	1.7E-06	4.0E-03[8]	2.06E-03[11]	4.28E-04	8.30E-04
Mink	1.7E-06	6.85E-02[6]	2.06E-03[11]	2.50E-05	8.30E-04
Meadow Vole	1.7E-06	4.8E-02[8]	2.06E-03[11]	3.56E-05	8.30E-04
PLANTS					
Pigweed	NA	40.0[7]	10.0	NA	NA

Notes:
[1] Species-specific Toxicity Reference Value.
[2] Recommended TRV from BNFL, 2000.
[3] Suter II G. W. and Tsao C. L. 1996.
[4] No-observed-adverse-effect level (NOAEL) exposed chronically to Aroclor 1254 for 90 days measuring survival.
[5] Oak Ridge National Laboratory Environmental Sciences and Health Sciences Research Division for U.S. Department of Energy, 1997. Value is PCB 1254 NOAEL.
[6] Oak Ridge National Laboratory Environmental Sciences and Health Sciences Research Division for U.S. Department of Energy, 1997. Value is PCB 1254 NOAEL.
[7] 40 mg/kg is noted by Efroymson, R. A. et al., 1997 for NOEC Pigweed in sand.
[8] Oak Ridge National Laboratory Environmental Sciences and Health Sciences Research Division for U.S. Department of Energy, 1997. Value is PCB 1248 NOAEL.
[9] Toxicity for Aroclor 1254 to ring dove used as representative of PCB mixtures,(EPA 1999).
[10] Based on toxicity of 3,4,5-hexachlorobiphenyl to mink (EPA 1999).

References

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6.0 RISK EVALUATION FINDINGS AND CONCLUSIONS

Reasonable assurance has been provided to show that potential human-health and environmental risks from onsite and offsite exposure to PCBs released during normal operations and upset conditions of the SST retrieval operation are within acceptable risk guidelines using the controls already in place to meet nuclear safety and RCRA requirements. These controls address how the waste is received, stored, and transferred, while providing acceptable risks in preventing release of the mixed waste to the environment and subsequently affecting onsite workers and the public. Under abnormal conditions where the waste could be released to the environment accidentally (e.g., spills, spray releases), the present controls demonstrate that PCBs also would be controlled adequately within acceptable risk guidelines. The final conclusion is that, although these controls are meant to specifically address the radioactivity and RCRA concerns, PCBs that would be contained in the waste also would be controlled adequately.

Release scenarios were determined using conservative estimates for PCBs concentrations that could be contained within the SST retrieval system waste stream. Concentrations of 6.5E-02 µg/l in the supernate liquid and 37 µg/g in the solid were used for conservatism. It should be understood that no PCB measurements above specified detection limits have been obtained.

6.1 HUMAN HEALTH ASSESSMENT

The risk assessment evaluated the risk associated with the retrieval of twelve SST tanks (241-S-102, and C farm tanks 241-C-101, 102, 103, 104, 105, 107, 108, 109, 110, 111 and 112) using DST PCB remediation waste supernate, to six human receptors. The risk for six of the receptors ranges between 10^{-06} and 10^{-17} are at the lower EPA acceptance limit of 10^{-06} and lower.

For the onsite worker a theoretical maximum stationary worker was developed to represent a person working at the maximum exposure distance downwind (south east) of the SST stack for the total retrieval duration. Although the east tank farm has a higher volume of DST supernate the risk from the C farm retrieval the risk is lower to the east area worker than the west area worker. The C farm, MS worker and nursing infant of the worker have estimated cancer risk of $3.9E^{-06}$ and $2.0E^{-06}$ respectively. Thus the estimated cancer for all receptors, are equal to or less than 10^{-06}, target cancer risk used by the EPA.

This assessment identified six human receptors as most likely to be present and unprotected during normal or accidental PCB releases from the DSTs:

- An adult worker downwind of SST operations as the maximum stationary (MS) worker exposure. For east area the WS worker is approximately 300 m from the source and approximately 110 m for west area. The MS worker is a worker who is located at one of these distances from the stack for eight hours a day, 225 days a year for two years in east area and one year in west area. Since workers are not stationary objects the MS worker is a theoretical receptor given a worst case scenario.

- An adult motorist commuting on Highway 240 west of the DST farms.

- An adult resident living in Ringold, Washington.
- Less than 12 month old infant of a nursing mother for each of the above receptors

For each of the first three receptors, PCB air concentrations were estimated using SCREEN3, a conservative, EPA-approved air dispersion model. For the motorist and resident, exposures were estimated using default exposure parameters, and the cancer risks were estimated using EPA upper-bound CSFs for PCBs.

For the normal stack operations, the estimated excess lifetime cancer risks for the Ringold resident and the Highway 240 commuter were $3.6E^{-09}$ and $1.9E^{-08}$, respectively. For the less than 12 month old nursing infant of the Ringold resident and the Highway 240 commuter the estimated cancer risks were $3.1E^{-08}$ and $1.6E^{-07}$, respectively.

The estimated cancer risks from the spill and spray accidents, assuming one accident per year for 2 years, were all below 10^{-11}, which is well below the lower value of 10^{-06} in the EPA's target risk range. Based on the information provided in this risk assessment, the retrieval of the twelve identified SSTs, does not pose an unreasonable risk.

As with all risk assessments, the results of this study are subject to uncertainty. The objective of this study was to produce a conservative bounding perspective, providing results that are unlikely to underestimate the health risks. Thus, models and specific parameter values were chosen to be health protective. The air dispersion model, SCREEN3, is health protective. The use of an air dispersion model that used more Site-specific information (e.g., observed wind and stability classes) might reduce the estimated risks.

6.2 ENVIRONMENTAL ASSESSMENT

A screening-level ecological risk assessment (SCLERA) was performed using a simplistic exposure model to be conservative. Each ecological receptor identified in the *Double-Shell Tank System PCB Risk Assessment* (CHG, 2001) was assumed to inhale (or otherwise take up) the combined PCB concentration calculated by SCREEN3 for the MS worker ($1.7E^{-06}$ mg/kg-day).

The SCLERA indicated that ecological receptors would not be exposed to PCB levels above their TRVs during either the spill or spray release scenarios. Although plants, birds, and fish at the Hanford Site would not be affected by PCB emissions during normal DST stack operating conditions, mammals might be exposed to PCB doses above their EPA TRVs. However, the species-specific HQs for these mammals are all below the guideline value of 1. The use of upper-bound emission rates coupled with conservative deposition models and toxicity data indicate that the HQs calculated in the assessment most likely are overestimated by at least an order of magnitude use of less conservative release rates and toxicity values alone could decrease HQs by three orders of magnitude.

7.0 REFERENCES

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APPENDIX A

Details of PCB Release Calculations

Calculation of Maximum PCB contents and Corresponding Release Rates

For West Area, 241-S-102

Reference:
Tank Waste Information Network System "TWINS", http://twins.pnl.gov/twins3/twins.htm, August 2004.

Assumptions:
1. Maximum PCB concentration in the SST solids/sludge is 7 µg/g.
2. Raw water will be initially used for retrieval the saltcake in S-102. The resulting supernate will be transferred to the SY-102 DST prior to reuse as the DST supernate.
3. Specific gravity (SpG) for solids/sludge is 1.69
4. The total mass of PCBs would be released at a linear rate over a 1 year time span.
5. Volumes of solids for 241-S-102 based on TWINS date August 2004.

Calculations:

1.

Total of 241-SY-102 supernate used	=0	gals.
Total raw water added	=1.0E+06	gals.
Total Combined supernate/water	=1.0E+06	gals.
Total 241-S-102 sludge retrieved	= 1.6E+04	gals.
Total 241-S-102 saltcake retrieved	= 3.07E+05	gals.
Total 241-S-102 combined solid retrieved	= 3.23E+05	gals.

2. Calculate the total PCBs in grams, for the retrieval of the waste in the 241-S-102 (including estimated addition):

   241-S-102 Solids (Total quantity in grams of PCBs involved in 241-S-102 retrieval:

   $3.23E^{+05}$ *gal* x 3.785 *l/gal* x 1000 *gms/l* x 1.69 *SpG* x (37.0 *gms PCB*/1.0E^{+06} *gms waste)* = $7.64E^{+04}$ *gms PCB*

3. Calculate number of seconds in a year:

   60 *sec/Min* x 60 *Min/Hr* x 24 *Hr/Day* x 365 *Day/year* = 3.15E+07 *Seconds/Year*

4. Calculate the release rate for 1 year time span (assuming the entire PCB content is released at a constant rate).

   $7.64E^{+04}$ *total gms PCB in Retrieval*/ (3.153E^{+07} *sec/Yr* x 1 *Yrs*) = 2.42E-03 *gms/sec*

Calculation of Maximum PCB contents and Corresponding Release Rates

For East Area, C Tank Farm

Reference:
Tank Waste Information Network System "TWINS", http://twins.pnl.gov/twins3/twins.htm, August 2004.

Assumptions:
1. Maximum PCB concentration in the SST solids/sludge is 37 µg/g.
2. Maximum PCB concentration in the DST supernate is 0.065 µg/ml.
3. Specific gravity (SpG) for supernate is 1.22 (average based on 2000 through 2004 sample data for AN-101, AN-106 and AY-101)
4. Specific gravity (SpG) for solids/sludge is 1.69
5. The total mass of PCBs would be released at a linear rate over a 2 year time span.
6. The average volume of solids for C farm is the average of the combined volumes based on TWINS date August 2004, for tanks, 241-C-# (101, 102, 103, 104, 105, 107, 108, 109, 110, 111 and 112) best represents the retrieval.

Calculations:

1.

Total of supernate used from DSTs	= 1.0E+06	gals.
Total sludge retrieved from a SST	= 1.44E+05	gals.
Total saltcake retrieved from a SST	= 0	gals.
Total SST combined solid retrieved	= 1.44E+05	gals.

2. Calculate the total PCBs in grams, for the retrieval of the waste in the C Tank Farm (including estimated addition):

   DST Supernate:

   $1.0E^{+06}$ *gal* x 3.785 *l/gal* x 1000 *gms/l* x 1.22 *SpG* x (0.065 *gms PCB*/$1.0E^{+06}$ *gms waste)* = $3.0E^{+02}$ *gms PCB*

   241C Farm Solids (Sludge/Salt cake):

   $1.44E^{+05}$ *gal* x 3.785 *l/gal* x 1000 *gms/l* x 1.69 *SpG* x (37.0 *gms PCB*/$1.0E^{+06}$ *gms waste)* = $3.40E^{+04}$ *gms PCB*

   Total quantity in grams of PCBs involved in 241-S-102 retrieval:

   $3.0E^{+02}$ *gms* + $3.40E^{+04}$ *gms* = $3.43E^{+04}$ *gms PCB*

5. Calculate number of seconds in a year:

   60 *sec/Min* x 60 *Min/Hr* x 24 *Hr/Day* x 365 *Day/year* = 3.15E^{+07} S*econds/Year*

6. Calculate the release rates for 2 year time span (assuming the entire PCB content is released at a constant rate).

   3.43E^{+04} *total gms PCB in Retrieval*/ (3.153E^{+07} *sec/Yr* x 2 *Yrs*) = 5.44E^{-04} *gms/sec*

Calculation of PCB release for a Valve Pit Spill Scenario

Reference:
Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in Tank Farm Waste Transfer Pits, HNF-SD-WM-CN-096, Rev 0-A (Himes, 1997)

Assumptions:
1. Supernate has been added to the tank at the time valve pit jumper spill.
2. Spill assumed to drain 2 gallons of waste to the pit floor or directly to the ground.
3. Assumptions from reference 1 are as follows:
   a) Slurry is assumed to contain 25 wt% entrained solids.
   b) Slurry density is 1.2 g / cm^3.
   c) Jumper drains in 10 seconds.
4. Assumptions for the scenario are as follows:
   a) The aerosol available for release is 0.01 wt% of the waste spilled to the pit.
   b) All aerosol released is respirable by receptors.
   c) The waste quantity is not dependent on time, temperature or relative humidity.
   d) PCB concentration in the liquid is 0.065µg/g. PCB concentration in the solids is 37µg/g.
   e) Aerosol released from pit over 30 minutes.

1. Calculate the volume of waste drained (m^3) = 2 gal x 0.00378 m^3 / gal = <u>7.56 E^{-03} m^3</u>

2. Calculate the quantity of waste drained (g waste)

   $7.6E^{-03}$ m^3 x 1.2 g / cm^3 x $1.0E^{+06}$ cm^3 /m^3 = <u>$9.07E^{+03}$ g waste</u>

3. Calculate the quantity of waste available for respiration (g waste) =

   = 0.0001 x $9.07E^{+03}$ g waste = <u>$9.07E^{-01}$ g waste</u>

4. Calculate quantity of PCB contributed by solids in waste that is 25wt% solids with a PCB concentration of 37 ppm. A gram of material contains 1.0 E^6 parts; therefore the material contains 5.0 E^{-5} g PCB per gram material quantity of PCB in solids (g PCB)

   = $9.07E^{-01}$ g waste x 0.25 x 37.0 E^{-06} g PCB / g waste = <u>$8.39E^{-06}$ g PCB</u>

5. Calculate quantity of PCB contributed by liquid in waste that is 75 wt% liquid with a PCB concentration of 0.065 ppm

A gram of material contains 1.0 E^{6} parts; therefore the material contains 6.5E^{-08} g PCB per gram material

quantity of PCB in (g PCB) = 9.07E^{-01} g waste x 0.75 x 6.5E^{-08} g PCB/g waste

= 4.42E^{-08} g PCB

6. Calculate total quantity of PCB in air displaced:

Total quantity of PCB (g PCB) =8.39E^{-06} g PCB + 4.42E^{-08} g PCB = 8.43E^{-06} g PCB

7. Calculate PCB release rate (g PCB/s):

8.43E^{-06} g PCB / (30 min x 60sec/min) = 4.69E^{-9} g PCB / s

8. Calculate PCB Emission rate (g PCB/s-m^2):

4.69E^{-09} g PCB/s x 1/25.9m^2 = 1.81E^{-10} g PCB/s-m^2

Calculation of PCB release for a Valve Pit Spray Scenario

Reference:

Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in Tank Farm Waste Transfer Pits, HNF-SD-WM-CN-096, Rev 0-A (Himes, 1997)

Assumptions:

1. Spray model for the determination of radiological and toxicological consequences described in reference 1, provides the basis for determining the quantity of PCB released in the spray.
2. Assumptions from reference 1 are as follows:
   - f) Displaced air is assumed to be mixed with a maximum aerosol loading of 100 mg/m^3.
   - g) Valve pit internal dimensions are 42 ft x 14 ft x 4.5 ft deep. Total pit volume is 2349 ft^3 or 66.5 m^3.
   - h) All aerosol released is respirable by receptors.
   - i) Initial expansion of air in the pit due to assumed increase in air temperature and relative humidity from 30°F at 15% R.H. to 120°F at 100% R.H. leading to a release of 35% of the total pit volume.
   - j) Time required to perform initial heat-up and expansion is assumed to be less than 1 hour.
   - k) Time to stop transfer is 6 hours and includes an additional 30 minutes beyond release detection to secure the farm transfer pump
   - l) Slurry is assumed to contain 25 wt.% entrained solids.
   - m) Total spray volume rate is 1.41E-4 m^3/s.
   - n) There is no loss of solid particulate by deposition during plume migration to receptor location.
3. Assumptions for the scenario are as follows:
   - a) PCB concentration in the liquid is 0.065 µg/ml. PCB concentration in the solids is 37 µg/g.

Calculations:

1. Calculate air displacement of initial expansion of the air in the pit due to an assumed increase in air temperature and relative humidity from 30°F at 15% R.H. to 120°F at 100% R.H that results in a release of 35% of the total pit volume:

   Expansion air released (m^3) = (66.5 m^3)(0.35) = <u>23.3 m^3</u>

2. Calculate the air volume displaced from the pit by in-leaking liquid in 6.0 hours: Displaced air from in-leaking liquid (m^3)

$(6.0\ h)\ (1.41E^{-04}\ m^3/s)\ (3600\ s / h) =$ $\underline{3.05\ m^3}$

3. Calculate total air displaced (m^3)

   $(23.3\ m^3) + (3.05\ m^3) =$ $\underline{26.3\ m^3}$

4. Calculate quantity of waste release accompanying the air release (g waste):

   $(26.3\ m^3)\ (100\ mg / m^3)\ (.001\ g / mg) =$ $\underline{2.63\ g\ waste}$

5. Calculate quantity of PCB contributed by solids in waste that is 25 wt.% solids with a PCB concentration of 7 ppm

   A gram of material contains $1.0\ E^6$ parts; therefore the material contains $37.0E^{-6}$ g PCB per gram material

   Quantity of PCB in solids (g PCB)

   $(2.63\ g\ waste)\ (.25)\ (37.0E^{-06}\ g\ PCB / g\ waste) =$ $\underline{2.43E^{-05}\ g\ PCB}$

6. Calculate quantity of PCB contributed by liquid in waste that is 75 wt.% liquid with a PCB concentration of 0.065 ppm

   A gram of material contains $1.0\ E^6$ parts; therefore the material contains $6.5E^{-8}$ g PCB per gram material. Quantity of PCB in (g PCB)

   $(2.63\ g\ waste)\ (.75)\ (6.5E^{-08}\ g\ PCB / g\ waste) =$ $\underline{1.28E^{-07}\ g\ PCB}$

7. Calculate total quantity of PCB in air displaced (g PCB):

   $(2.43E^{-05}\ g\ PCB) + (1.28E^{-07}\ g\ PCB) =$ $\underline{2.45E^{-05}\ g\ PCB}$

8. Calculate PCB release rate (g PCB/sec):

   $(2.45E^{-05}\ g\ PCB)\ (1 / 6\ h)\ (h / 3600\ s) =$ $\underline{1.13E^{-09}\ g\ PCB / s}$

9. Calculate PCB Emission rate (g PCB/s-m^2):

   $1.13E^{-09}\ g\ PCB/s \times 1/25.9m^2 =$ $\underline{4.37E^{-11}\ g\ PCB/s\text{-}m^2}$

APPENDIX B

Air Modeling Details

This appendix contains the SCREEN3 model runs that produced the exposure point concentrations used in this report. Five model runs were required for the conditions described in Section 2. Each model run provides the exposure point concentration for each receptor at the appropriate distance from the source to the receptor.

- **One stack, normal operating conditions, ambient conditions**. This model output addresses the single stack in the 200 West Area.

- **One stack, normal operating conditions, ambient conditions**. This model output addresses the single stack in the 200 East Area.

- **Valve pit jumper Spill release**. This model output addresses the valve pit jumper spill of PCB-contaminated material in both SST areas.

- **Valve pit Spray release**. This model output addresses the valve pit spill of PCB-contaminated material in both SST areas.

APPENDIX C

$LADD_{pot}$ and Risk Calculations

Calculation of Risk From East Area, C Tank Farm Retrieval

Normal Stack Operation

Input Data:

1. Source: Table 3-4: Exposure Assumptions for Public Receptors.
2. Source: Table 3-3. Model Output and Adjusted Concentrations for the Human Exposures.

Equation:

Potential Lifetime Average Daily Dose:

$LADD_{pot}$ = [C x IR x ED x EF] / [BW x LT]

where:

$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day);
C = contaminant concentration in air (mg/m^3);
IR = inhalation rate (m^3/day);
ED = exposure duration (years);
EF = frequency of exposure events (days/year);
BW = body weight (kg); and
LT = lifetime (days).

PCB cancer risk to an individual receptor:

$$R_i = LADD_{pot} \times CSF$$

where

R_i = excess individual lifetime e cancer risk level (unitless);
$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day); and
CSF = cancer slope factor (kg-day/mg)

Calculations:

MS Worker

$LADD_{pot}$: ($2.50E^{-04}$mg/m^3 x 20m^3/day x 2yr x 225days/yr)/(72kg x 75yr x 365 days/yr) = $1.14E^{-06}$ mg/kg-day

Risk: $1.14E^{-06}$mg/kg-day x 0.4kg-day/mg = **$4.6E^{-07}$**

Highway 240:

LADD$_{pot}$: (1.21E^{-06}mg/m^3 x 20m^3/day x 2yr x 250days/yr)/(72kg x 75yr x 365 days/yr) = 6.13E^{-09} mg/kg-day

Risk: 6.13E^{-09}mg/kg-day x 0.4kg-day/mg = **2.5E^{-09}**

Ringold:

LADD$_{pot}$: (5.39E^{-07}mg/m^3 x 20m^3/day x 2yr x 350days/yr)/(72kg x 75yr x 365 days/yr) = 3.83E^{-09} mg/kg-day

Risk: 3.83E^{-09}mg/kg-day x 0.4kg-day/mg = **1.5E^{-09}**

Calculation of Risk From West Area, S Tank Farm Retrieval

Normal Stack Operation

Input Data:

1. Source: Table 3-4: Exposure Assumptions for Public Receptors.
2. Source: Table 3-3. Model Output and Adjusted Concentrations for the Human Exposures.

Equation:

Potential Lifetime Average Daily Dose:

$LADD_{pot}$ = [C x IR x ED x EF] / [BW x LT]

where:

$LADD_{pot}$	= potential lifetime average daily dose (mg/kg-day);
C	= contaminant concentration in air (mg/m^3);
IR	= inhalation rate (m^3/day);
ED	= exposure duration (years);
EF	= frequency of exposure events (days/year);
BW	= body weight (kg); and
LT	= lifetime (days).

PCB cancer risk to an individual receptor:

$R_i = LADD_{pot} \times CSF$

where

R_i	= excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$	= potential lifetime average daily dose (mg/kg-day); and
CSF	= cancer slope factor (kg-day/mg)

Calculations:

MS Worker

$LADD_{pot}$: ($2.51E^{-04}$ mg/m^3 x $20m^3$/day x 1yr x 225days/yr)/(72kg x 75yr x 365 days/yr) = $5.7E^{-07}$mg/kg-day

Risk: $5.7E^{-07}$mg/kg-day x 0.4kg-day/mg = **$2.3E^{-07}$**

Highway 240:

LADD$_{pot}$: (1.66E^{-05}mg/m^3 x 20m^3/day x 1yr x 250days/yr)/(72kg x 75yr x 365 days/yr) = 4.2E^{-08} mg/kg-day

Risk: 4.2E^{-08}mg/kg-day x 0.4kg-day/mg) = **1.7E^{-08}**

Ringold:

LADD$_{pot}$: (1.47E^{-06}mg/m^3 x 20m^3/day x 1yr x 350days/yr)/(72kg x 75yr x 365 days/yr) = 5.2E^{-09}mg/kg-day

Risk: 5.2E^{-09}mg/kg-day x 0.4kg-day/mg = **2.1E^{-09}**

Calculation of Combined Risk From Normal Stack Operation

Input Data:

1. Source: LADDpot value calculated on pages A-2 through A-10 this Appendix..
2. Source: Table 4-1. PCB Slope Factors (kg-day/mg).

Equation:

PCB cancer risk to an individual receptor:

$$R_i = \text{Total } LADD_{pot} \times CSF$$

where

R_i = excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day); and
CSF = cancer slope factor (kg-day/mg)

Calculations:

Highway 240:

Risk: $(6.13E^{-09} + 4.2E^{-08}$mg/kg-day) x 0.4kg-day/mg = **$1.9E^{-08}$**

Ringold:

Risk: $(3.83E^{-09} + 5.2E^{-09}$mg/kg-day) x 0.4kg-day/mg = **$3.6E^{-09}$**

Calculation of Risk From Valve Pit Spill

Input Data:

1. Source: Table 3-4: Exposure Assumptions for Public Receptors.
2. Source: Table 3-3. Model Output and Adjusted Concentrations for the Human Exposures.
3. Because the distance between S-Farm (west area) and C-Farm (east area) is greater than 343m (maximum work exposure distance) no combined risk is calculated for the worker.
4. Because the offsite receptors are exposed to both east and west area activities a combined risk is calculated for the receptors.

Equation:

Potential Lifetime Average Daily Dose:

$$LADD_{pot} = [C \times IR \times ED \times EF] / [BW \times LT]$$

where:

$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day);
C = contaminant concentration in air (mg/m^3);
IR = inhalation rate (m^3/day);
ED = exposure duration (years);
EF = frequency of exposure events (days/year);
BW = body weight (kg); and
LT = lifetime (days).

PCB cancer risk to an individual receptor:

$$R_i = LADD_{pot} \times CSF$$

where

R_i = excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day); and
CSF = cancer slope factor (kg-day/mg)

Calculations:

Maximum Stationary Worker

C Farm MS Worker (East Area)

LADD$_{pot}$: (2.24E^{-08}mg/m^3 x 20m^3/day x 2yr x 10days/yr)/(72kg x 75yr x 365 days/yr) = 4.5E^{-12} mg/kg-day

Risk: 4.5E^{-12}mg/kg-day x 0.4kg-day/mg = **1.8E^{-12}**

S Farm MS Worker (West Area)

LADD$_{pot}$: (1.0E^{-07}mg/m^3 x 20m^3/day x 1yr x 10days/yr)/(72kg x 75yr x 365 days/yr)= 1.0E^{-11} mg/kg-day

Risk: 1.0E^{-11}mg/kg-day x 0.4kg-day/mg = **4.1E^{-12}**

Highway 240 Commuter

(C Farm, East Area contribution):

LADD$_{pot}$: (1.36E^{-10}mg/m^3 x 20m^3/day x 2yr x 1days/yr)/(72kg x 75yr x 365 days/yr) = 2.8E^{-15} mg/kg-day

Risk: 2.8E^{-15}mg/kg-day x 0.4kg-day/mg = **1.1E^{-15}**

(S Farm, West Area contribution):

LADD$_{pot}$: (4.34E^{-10}mg/m^3 x 20m^3/day x 1yr x 1days/yr)/(72kg x 75yr x 365 days/yr) = 4.4E^{-15} mg/kg-day

Risk: 4.4E^{-15}mg/kg-day x 0.4kg-day/mg = **1.8E^{-15}**

Combined (East and West)

Risk: (2.8E^{-15} + 4.4E^{-15}mg/kg-day) x 0.4kg-day/mg = **2.9E^{-15}**

Ringold Resident

(C Farm, East Area contribution):

LADD$_{pot}$: (5.96E^{-11}mg/m^3 x 20m^3/day x 2yr x 1days/yr)/(72kg x 75yr x 365 days/yr) =

$1.2E^{-15}$ mg/kg-day

Risk: $1.2E^{-15}$mg/kg-day x 0.4kg-day/mg = **$4.8E^{-16}$**

(S Farm, West Area contribution):

$LADD_{pot}$: ($3.614E^{-11}$mg/m^3 x 20m^3/day x 1yr x 1days/yr)/(72kg x 75yr x 365 days/yr) = $3.7E^{-16}$ mg/kg-day

Risk: $3.7E^{-16}$mg/kg-day x 0.4kg-day/mg = **$1.5E^{-16}$**

Combined (East and West)

Risk: ($1.2E^{-15}$ + $3.7E^{-16}$mg/kg-day) x 0.4kg-day/mg = **$6.3E^{-16}$**

Calculation of Risk From Valve Pit Spray

Input Data:

1. Source: Table 3-4: Exposure Assumptions for Public Receptors.
2. Source: Table 3-3. Model Output and Adjusted Concentrations for the Human Exposures.
3. Because the distance between S-Farm (west area) and C-Farm (east area) is greater than 343m (maximum work exposure distance) no combined risk is calculated for the worker.
4. Because the offsite receptors are exposed to both east and west area activities a combined risk is calculated for the receptors.

Equation:

Potential Lifetime Average Daily Dose:

$LADD_{pot}$ = [C x IR x ED x EF] / [BW x LT]

where:

$LADD_{pot}$	= potential lifetime average daily dose (mg/kg-day);
C	= contaminant concentration in air (mg/m^3);
IR	= inhalation rate (m^3/day);
ED	= exposure duration (years);
EF	= frequency of exposure events (days/year);
BW	= body weight (kg); and
LT	= lifetime (days).

PCB cancer risk to an individual receptor:

$$R_i = LADD_{pot} \times CSF$$

where

R_i	= excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$	= potential lifetime average daily dose (mg/kg-day); and
CSF	= cancer slope factor (kg-day/mg)

Calculations:

Maximum Stationary Worker

C Farm MS Worker (East Area)

$LADD_{pot}$: ($5.40E^{-09}$mg/m^3 x 20m^3/day x 2yr x 10days/yr)/(72kg x 75yr days/yr) =

$1.1E^{-12}$ mg/kg-day

Risk: $1.1E^{-12}$mg/kg-day x 0.4kg-day/mg = **$4.4E^{-13}$**

S Farm MS Worker (West Area)

$LADD_{pot}$: ($2.42E^{-08}$mg/m^3 x 20m^3/day x 1yr x 10days/yr)/(72kg x 75yr days/yr) = $8.9E^{-13}$ mg/kg-day

Risk: $8.9E^{-13}$mg/kg-day x 0.4kg-day/mg = **$3.6E^{-13}$**

Highway 240 Commuter

(C Farm East Area contribution):

$LADD_{pot}$: ($3.286E^{-11}$mg/m^3 x 20m^3/day x 2yr x 1days/yr)/(72kg x 75yr days/yr) = $6.7E^{-16}$ mg/kg-day

Risk: $6.7E^{-16}$mg/kg-day x 0.4kg-day/mg = **$2.7E^{-16}$**

(S Farm West Area contribution):

$LADD_{pot}$: ($1.05E^{-10}$mg/m^3 x 20m^3/day x 1yr x 1days/yr)/(72kg x 75yr days/yr) = $1.1E^{-15}$ mg/kg-day

Risk: 1.1E ^{15}mg/kg-day x 0.4kg-day/mg = **$4.3E^{-16}$**

Combined (East and West)

Risk: ($6.7E^{-16}$ + $1.1E^{-15}$mg/kg-day) x 0.4kg-day/mg = **$7.1E^{-16}$**

Ringold Resident

(C Farm East Area contribution):

$LADD_{pot}$: ($1.44E^{-11}$mg/m^3 x 20m^3/day x 2yr x 1days/yr)/(72kg x 75yr days/yr) = $2.9E^{-16}$ mg/kg-day

Risk: $2.9E^{-16}$mg/kg-day x 0.4kg-day/mg = **$1.2E^{-16}$**

(S Farm West Area contribution):

$LADD_{pot}$: ($8.72E^{-12}$mg/m^3 x 20m^3/day x 1yr x 1days/yr)/(72kg x 75yr days/yr) = $8.8E^{-17}$ mg/kg-day

Risk: $8.8E^{-17}$mg/kg-day x 0.4kg-day/mg = **$3.5E^{-17}$**

Combined (East and West)

Risk: ($2.9E^{-16}$ + $8.8E^{-17}$mg/kg-day) x 0.4kg-day/mg = **$1.5E^{-16}$**

Calculation of Risk From East Area, (C Tank Farm) and West Area (S Tank Farm) Retrieval to the Infant of a Nursing Mother

Input Data:

3. Source: LADDpot value calculated on pages A-2 through A-10 this Appendix.
4. Source: Table 4-1. PCB Slope Factors (kg-day/mg).
5. Smith, A.H., (1987) *Infant exposure Assessment for Breast Milk Dioxins and Furans derived from Waste Incineration Emissions*, Risk Analysis 7(3):347-353.

Assumptions:

1. PCB Slope Factors of 2 kg-day/mg (reference 2)
2. Infant's body concentration during 12 months of breast feeding would amount to 1.7 times the concentration in the mother (reference 3).
3. Because the distance between S-Farm (west area) and C-Farm (east area) is greater than 343m (maximum work exposure distance) no combined risk is calculated for the worker.
4. Because the offsite receptors are exposed to both east and west area activities a combined risk is calculated for the receptors.

Equations:

<u>PCB cancer risk to an infant receptor:</u>

$$R_i = \text{Total } LADD_{pot} \times BCF \times CSF$$

where

R_i	= excess individual lifetime cancer risk level (unitless);
$LADD_{pot}$	= potential lifetime average daily dose (mg/kg-day);
BCF	= mother to infant body concentration factor (unitless); and
CSF	= cancer (PCB) slope factor (kg-day/mg)

Calculations:

<u>Normal Stack Operation</u>

<u>Infant of MS Worker</u>

<u>*Infant of an East Area (C Farm) MS Worker*</u>

$(1.14E^{-06}$ mg/kg-day) x 1.7 x 2 kg-day/mg = $\mathbf{3.9E^{-06}}$

Infant of a West Area (S Farm) MS Worker

(5.7E^{-07}mg/kg-day) x 1.7 x 2 kg-day/mg = **2.0E^{-06}**

Infant of Highway 240 Commuter

Infant of an East Area contribution (C Farm)

(6.13E^{-09}mg/kg-day) x 1.7 x 2 kg-day/mg = **2.1E^{-08}**

Infant of a West Area contribution (S Farm)

(4.2E^{-08}mg/kg-day) x 1.7 x 2 kg-day/mg = **1.4E^{-07}**

Combined Infant of a Highway 240 Commuter:
(6.13E^{-09} + 4.2E-^{08}mg/kg-day) x 1.7 x 2 kg-day/mg = **1.6E^{-07}**

Infant of Ringold Resident

Infant of an East Area contribution (C Farm)

(3.83E^{-09} mg/kg-day) x 1.7 x 2 kg-day/mg = **1.3E^{-08}**

Infant of a West Area contribution (S Farm)

(5.2E^{-09}mg/kg-day) x 1.7 x 2 kg-day/mg = **1.8E^{-08}**

Combined Infant of a Ringold Resident:

(3.83E^{-09} + 5.2E^{-09}mg/kg-day) x 1.7 x 2 kg-day/mg = **3.1E^{-08}**

Deleted:

Valve Pit Spill Operation

Infant of MS Worker

Infant of an East Area MS Worker

(4.5E^{-12}mg/kg-day) x 1.7 x 2 kg-day/mg = **1.6E^{-11}**

Infant of a West Area MS Worker

(1.0E^{-11}mg/kg-day) x 1.7 x 2 kg-day/mg = **3.5E^{-11}**

Infant of Highway 240 Commuter

Infant of an East Area contribution (C Farm)

($2.8E^{-15}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$9.4E^{-15}$**

Infant of a West Area contribution (S Farm)

($4.4E^{-15}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$1.5E^{-14}$**

Combined Infant of an East-Highway 240 Commuter:
($2.8E^{-15}$ + $4.4E^{-15}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$2.4E^{-14}$**

Infant of Ringold Resident

Infant of an East Area contribution (C Farm)

($1.2E^{-15}$ mg/kg-day) x 1.7 x 2 kg-day/mg = **$4.1E^{-15}$**

Infant of a West Area contribution (S Farm)

($3.7E^{-16}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$1.3E^{-15}$**

Combined Infant of a Ringold Resident:

($1.2E^{-15}$ + $3.7E^{-16}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$5.3E^{-15}$**

Valve Pit Spray Operation

Infant of MS Worker

Infant of an East Area MS Worker

($1.1E^{-12}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$3.7E^{-12}$**

Infant of a West Area MS Worker

($8.9E^{-13}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$3.0E^{-12}$**

Infant of Highway 240 Commuter

Infant of an East Area contribution (C Farm)

($6.7E^{-16}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$2.3E^{-15}$**

Infant of a West Area contribution (S Farm)

($1.1E^{-15}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$3.6E^{-15}$**

Combined Infant of an East-Highway 240 Commuter:
($6.7E^{-16}$ + $1.1E^{-15}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$6.0E^{-15}$**

Infant of Ringold Resident

Infant of an East Area contribution (C Farm)

($2.9E^{-16}$ mg/kg-day) x 1.7 x 2 kg-day/mg = **$9.9E^{-16}$**

Infant of a West Area contribution (S Farm)

($8.8E^{-17}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$3.0E^{-16}$**

Combined Infant of a Ringold Resident:
($2.9E^{-16}$ + $8.8E^{-17}$mg/kg-day) x 1.7 x 2 kg-day/mg = **$1.3E^{-15}$**

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