Westinghouse
Hanford Company

P.O. Box 1970 Richland, WA 99352

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February 2, 1990

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Mr. R. D. Freeberg, Branch Chief
Environmental Restoration Branch
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Freeberg:

SUBMITTAL OF IMPLEMENTATION PLAN FOR 200-BP-1 RISK ASSESSMENT AND APPROACH FOR ADDRESSING PAST PRACTICE OPERABLE UNITS RISK ASSESSMENTS

Reference: Letter, R. D. Izatt, DOE-RL, to President, WHC, "Implementation Plan For Risk Assessments of Past Practices Operable Units," ERD:JJB, dated January 11, 1990.

This letter has been prepared in response to the referenced letter requesting preparation of a baseline risk assessment implementation plan for past practice operable units with special emphasis on the 200-BP-1 Operable Unit (OU). A dialogue has occurred between the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology, and U.S. Department of Energy (DOE)-Richland Operations Office regarding various aspects of the 200-BP-1 OU risk assessment. Westinghouse Hanford Company (WHC) has responded to each EPA written comment and entertained discussions at the monthly Unit Managers Meetings. However, as indicated in the referenced letter, some level of confusion still remains regarding implementation of the 200-BP-1 OU Baseline Risk Assessment and how the Hanford Site Performance Assessment (HSPA) activities are integrated with 200-BP-1 OU and the other past practice operable units.

Currently, HSPA efforts focus on quantifying recharge in the 200 and 300 Areas using lysimeters, performing geochemistry experiments to quantify retardation and diffusion coefficients, and developing computer simulation models. The one major HSPA activity that will directly support the 200-BP-1 OU Baseline Risk Assessment is the ongoing lysimeter research work to evaluate conditions which affect near-surface water balance and ultimately recharge. Rather than a single value for recharge, the results of lysimeter measurements will identify a range of recharge rates which will largely depend upon soil type; the presence or absence of vegetation and vegetation type; and the duration, frequency, and seasonality of rainfall. All other data needs to support flow and transport modelling will be compiled from existing documentation or from the 200-BP-1 OU specific characterization activities during the Phase I Remedial Investigation (RI).

Several other activities which either directly or indirectly support 200-BP-1 OU performance assessment activities are listed below:

1. Protective Barrier and Warning Marker System Development Program encompasses long-term climate change assessment which has a bearing on potential recharge rates and calibration of the UNSAT-H computer code for near-surface water balance against data being collected from the Field Lysimeter Test Facility.

2. Single-Shell Tank Performance Assessment will calibrate the flow and transport codes (UNSAT-H, PORFLO-3D, VAM2D) against 241-T-106 tank leak data.

3. Hanford Site Performance Assessment Program includes independent benchmark and verification testing of computer codes by Idaho National Engineering Laboratory, estimation of recharge rates using isotopic evaluations for a range of Hanford sediments (Touchet Bed Silts to Pasco Gravels), and determination of retardation and diffusion coefficients for several mobile and immobile constituents (Sr, U, Tc, I, Ru, C, Zr, etc.) for the range of Hanford sediment types.

4. Operational and Site Wide Groundwater Monitoring Programs will determine groundwater contaminants and concentrations, hydraulic gradients, stratigraphic units and contacts, sediment types, moisture contents, hydraulic conductivities, groundwater flow directions, and impacts of artificial mounds on groundwater flow.

The referenced letter identifies a number of items which are to be addressed in an implementation plan that covers the scope of all operable units with specific emphasis on 200-BP-1 OU. To address this request in a timely, yet responsive, manner a specific implementation plan for the 200-BP-1 OU Baseline Risk Assessment has been prepared and is provided as Attachment 1 to this letter. The 200-BP-1 OU Baseline Risk Assessment Implementation Plan is based on information delineated in the 200-BP-1 OU Work Plan and provides details showing how specific Phase I RI tasks are interfaced with each other (including baseline risk assessment specific activities) and applicable HSPA activities, namely recharge data from lysimeter research work. Either a revision to WHC-EP-0072, "Performance Assessment Technology Development for Cleanup and Disposal of Hanford Defense Wastes", or a new companion document will be generated by September 30, 1990, to delineate those activities required in support of Hanford "site wide" performance assessment.

Attachment 2 provides an overview of current fiscal year (FY) HSPA activities including operable unit specific support work, identification of funding sources, funded work, and unfunded proposed work. Attachment 2 is in viewgraph format and was presented at the General Topics session of the January Unit Managers Meeting.

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The following paragraphs are brief discussions addressing each of nine items which were requested in the referenced letter to be incorporated into the "Implementation Plan."

1. Attachment 3 is a package of FY 1989 and FY 1990, 200-BP-1 OU specific budget and schedule information and related correspondence for conductance of the 200-BP-1 OU Baseline Risk Assessment.

2. The 200-BP-1 OU Baseline Risk Assessment will be using the PORFLO-3D code which has the capability of performing 1, 2, and 3 dimensional coupled flow and transport analyses. The nature of the waste entrained within the 200-BP-1 OU confines and availability of existing data prescribes the initial use of either the 2 or 3 dimensional aspects of PORFLO-3D for 200-BP-1 OU. This may not be the case for all operable units. The UNSAT-H code will be utilized to define near surface recharge input to the PORFLO-3D code.

3. The required activities to perform the HSPA which includes barrier development programs, computer code development, experimental lysimeter data, and results of operational and site wide groundwater monitoring program will be included in the rewrite of "Performance Assessment Technology Development for Cleanup and Disposal of Hanford Defense Wastes," WHC-EP-0072 as described earlier.

4. The funding source for 200-BP-1 OU specific baseline risk assessment work is from the Environmental Restoration Program. Specific task packages that were funded in FY 1989 and are currently funded in FY 1990 are provided in Attachment 3. Funding for the lysimeter related research work being conducted through the Protective Barrier Development Program and the HSPA Program is provided through the DOE-Headquarters Office of Technology Development (RDDT&E work scope). Attachment 4 only identifies that portion of the HSPA work being conducted by Pacific Northwest Laboratory (PNL). Westinghouse Hanford Company also has a FY 1990 budget to manage/review the PNL efforts, complete the quality assurance documentation for the primary computer codes, and complete benchmark and verification testing of these computer codes.

5. A logic diagram showing how work will progress for the 200-BP-1 OU Phase I RI and baseline risk assessment is provided in Attachment 1. Budget change impacts are evaluated internally using Timeline scheduling software for individual RI coordinators. The WHC Management Control System is the official budget and schedule control system for implementing budget change impacts.

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6. The Regulators concerns will continue to be addressed during the monthly Unit Managers Meetings as delineated in the Tri-Party Agreement. If additional time is required to address specific issues, special topics meetings with the appropriate personnel should be scheduled.

7. Major issues as they are identified will continue to be raised at the monthly Unit Managers Meetings where they will be discussed and resolved, or elevated in accordance with the process outlined in the Tri-Party Agreement. Westinghouse Hanford Company is currently preparing a presentation regarding Hanford Groundwater Protection and Remediation Strategy Issues which will address the key issues of future land use and point of compliance. These areas are extremely important to resolve in order to proceed with feasibility studies and preparation of baseline risk assessment conclusions.

8. The tasks that need to be completed to perform the baseline risk assessment have been identified. The activities may be performed by WHC personnel or consultants if manpower is unavailable internally.

9. The HSPA and specific operable unit risk assessment activities will continue to be managed under the WHC Environmental Engineering and Technology Function. Results will be provided periodically at the General Topics Unit Managers Meetings.

If there are any questions or need for additional information, please contact me on 376-7000 or Mr. T. M. Wintczak of my staff on 376-0902.

Very truly yours,

T. M. Wintczak for RDW

R. D. Wojtasek, Manager
Environmental Restoration Program
Environmental Division

kmc

Attachments - 4

DOE-RL - A. W. Kellogg (w/o Attachments)
M. W. Tiernan

200-BP-1 BASELINE RISK ASSESSMENT IMPLEMENTATION PLAN

INTRODUCTION

The baseline risk assessment provides an evaluation of the potential threat to human health and the environment in the absence of any remedial action, i.e., evaluation of the no-action alternative. This assessment provides the basis for determining whether or not remedial action is necessary and provides the basic justification for performing remedial actions. Risk assessments are performed in accordance with the guidelines set forth by the U. S. Environmental Protection Agency, Superfund Public Health Evaluation Manual (EPA, 1986).

A discussion of the steps that constitute completion of a risk assessment are outlined in the work plan, Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington (DOE, 1990). These steps include:

- Contaminant identification
- An estimate of exposure point concentration
- An estimate of the chemical or radionuclide consumed
- Toxicity assessment for the contaminants of interest
- Characterization of the risk

A discussion of these steps is provided on pages WP-171 through WP-174 of the work plan. The purpose of this implementation plan is to amplify upon the discussion provided in the work plan. This plan provides more detail for each of the steps by discussing the data base and models that will be used to support the Phase I Remedial Investigation (RI). The evolution of the 200-BP-1 data base and how implementation of the work plan supports preparation of the baseline risk assessment is presented.

Step 1: Contaminant Identification

The objective of the contaminant identification step is to screen the list of contaminants if necessary. Generally speaking, this is a desirable step if the list of contaminants is extensive and if the relative impact associated with each of the contaminants is believed to be considerable. It usually consists of the following four steps:

- A list of candidate contaminants is prepared
- Representative concentrations for each of the contaminants are measured
- Indicator scores are calculated based upon the concentrations that are measured and the route specific toxicity data assigned
- Based upon the indicator scores, indicator chemicals are selected

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In the work plan, a set of 9 radionuclides and 9 chemicals are listed in Table 13 of Chapter 3. This list will be refined and representative concentrations determined in Tasks 2, 3, 4 and 7 in the RI. This data will be evaluated in the baseline risk assessment to determine the indicator scores and select indicator parameters.

Step 2: Estimate Exposure Point Concentrations

Once the list of indicator chemicals and radionuclides has been selected, flow and transport analyses will be performed to estimate the concentration in the mediums of interest. To complete this task, the following three steps will be performed:

- Identify the potential human exposure pathways
- Estimate exposure point concentrations
- Compare projected concentrations to ARAR's

The preliminary exposure pathways model for 200-BP-1 is shown on Figure 26 of the work plan. The operable pathways to be included in the baseline risk assessment will be determined during the Phase 1 RI.

Future land use and institutional controls at the Hanford Site will be critical to determine exposure points. At each of these exposure points, the maximum concentration will be calculated using appropriate flow and transport models. The PORFLO-3 unsaturated/saturated ground water flow and transport model will be used to calculate these concentrations (WHC, 1989). The UNSAT-H model will be used to evaluate recharge and provide this data to the PORFLO-3 model (PNL, 1986). The modelling effort will be initiated and conducted concurrently with the Phase 1 RI to evaluate the adequacy of the data and identify any data needs. The modelling effort will be used to determine the sensitivity of the parameters and whether the optional tasks (Task 10 - Column Leach Test and Task 12 - Sorption Tests) identified in the work plan are required. A summary of information needs and sources of the data for input to the models to determine exposure point concentrations are provided below:

INFORMATION TYPE	SOURCE OF DATA
Source Term	Data from Tasks 2, 3, 4, and Appendix A of the work plan.
Stratigraphy	Soil logs from wells identified in Figures 11-13 of the work plan and data from Tasks 4 and 6.
Physical Properties	Data from Tasks 2, 4, and 6. Also, with existing Hanford Site Wide Performance Assessment data through application of assumption on textural properties.
Hydraulic Properties	Use existing HSWPA data with data from Tasks 4, 6 and 11.

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Recharge	Use range of data based upon work performed in support of Hanford site lysimeters studies conducted by HSWPA.
Transport Properties	Use existing Hanford site baseline data, i.e., HDW-EIS (DOE, 1986) and data from Tasks 10 and 12.

Once the exposure point concentrations are calculated, these concentrations will be either compared with existing applicable or relevant and appropriate requirements (ARAR's) or the concentration data will be used to estimate the intake of chemicals based upon the use of exposure scenarios discussed in Step 3.

Step 3: Estimate Chemical or Radionuclides Consumed

Human exposure is expressed in terms of intake. Intake is defined as the amount of a substance taken into the body based upon a pattern of behavior. Step 3 will be approached by completing the following tasks:

- Define intake factors based upon site specific factors
- Estimate intakes for individual exposure routes
- Sum intakes across exposure routes as appropriate

For Hanford, basic scenarios that define intake factors based upon local considerations exist and will be applied. However, issues such as future land use need to be resolved to adequately define future intake and exposure scenarios. Using these scenarios, subchronic and chronic exposures will be calculated for the chemicals of interest using the formulations proposed by the EPA (EPA, 1986). For radionuclides, the appropriate dose will be calculated using the GENII radiological dose model (PNL, 1988). All of the data needs associated with performing these analyses is either contained within the EPA guidance documentation or the GENII computer code.

Step 4: Toxicity Assessment

The purpose for the toxicity assessment step is to simply define the numerical information that will be used to describe the relative toxicity for the chemicals of interest. In most cases, this is specified through published information and is available in sources such as the Integrated Risk Information System Database (EPA, 1989). The work plan will not provide additional information on this subject, but will rely on toxicity information available in the literature.

Step 5: Risk Characterization

The final step in the baseline risk assessment involves the comparison of the calculated intake of chemicals and radionuclides with established standards. The risk associated with noncarcinogenic effects, carcinogenic effects, and radiological dose will be evaluated and documented.

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An important aspect of this evaluation process has to do with addressing the uncertainties associated with the analyses. It is important to recognize that the work plan should focus on those aspects of the analyses that will reduce these uncertainties.

WORK PLAN/RISK ASSESSMENT INTERFACE

As a result of the discussion contained herein, it is postulated that at a minimum the work plan needs and does address the following areas of uncertainty:

- Implementation of the work plan must result in an adequate characterization of the waste form. Completion of Task 2 described in the work plan will address this need.

- Implementation of the work plan will reduce the uncertainty by providing detailed geologic stratigraphic information, concentration profiles for the constituents of interest, and hydraulic properties for the soils in the vadose zone. Completion of Tasks 2, 4, and 6 will address this need.

- Sufficient testing must be performed to evaluate the assumptions concerning unsaturated zone soil properties and hydraulic characteristics. Completion of Tasks 2, 4 and 6 will satisfy this need.

- The evaluation of existing data during implementation of the baseline risk assessment will provide insight into the need to exercise Tasks 10 and 12. A recommendation on the need to perform column leach tests and sorption tests will be provided.

A logic diagram that depicts the work that will be performed to complete the 200-BP-1 baseline risk assessment is shown in Figure 1. A schedule that relates completion of the baseline risk assessment to other tasks described in the work plan is provided in Figure 2.

It is planned that the data compilation tasks and initial exercising of the models for conducting the baseline risk assessment will be performed by Westinghouse Hanford Company (WHC) and the revisions to and final baseline risk assessment analyses will be performed by WHC consultants.

REFERENCES

EPA, 1986. Superfund Public Health Evaluation Manual, U.S. Environmental Protection Agency, Washington, D. C., 1986, PB87-183125

EPA, 1989. Integrated Risk Information System Database, Dialcom for the U.S. Environmental Protection Agency, Washington, D.C.

DOE, 1990. Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington, U.S. Department of Energy, Richland, Washington, 1990, DOE/RL 88-32

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PNL, 1988. GENII - The Hanford Environmental Radiation Dosimetry Software System -- Volumes 1-3, Pacific Northwest Laboratory, Richland, Washington, 1988, PNL-6584

PNL, 1986. UNSAT-H Version 1.0: Unsaturated Flow Code Documentation and Applications for the Hanford Site, Pacific Northwest Laboratory, Richland Washington, 1986, PNL-5899

WHC, 1989. PORFLO-3: A Mathematical Model for Fluid Flow, Heat and Mass Transport in Variable Saturated Geologic Media, Westinghouse Hanford Company, Richland, Washington, 1989, WHC-EP-0041

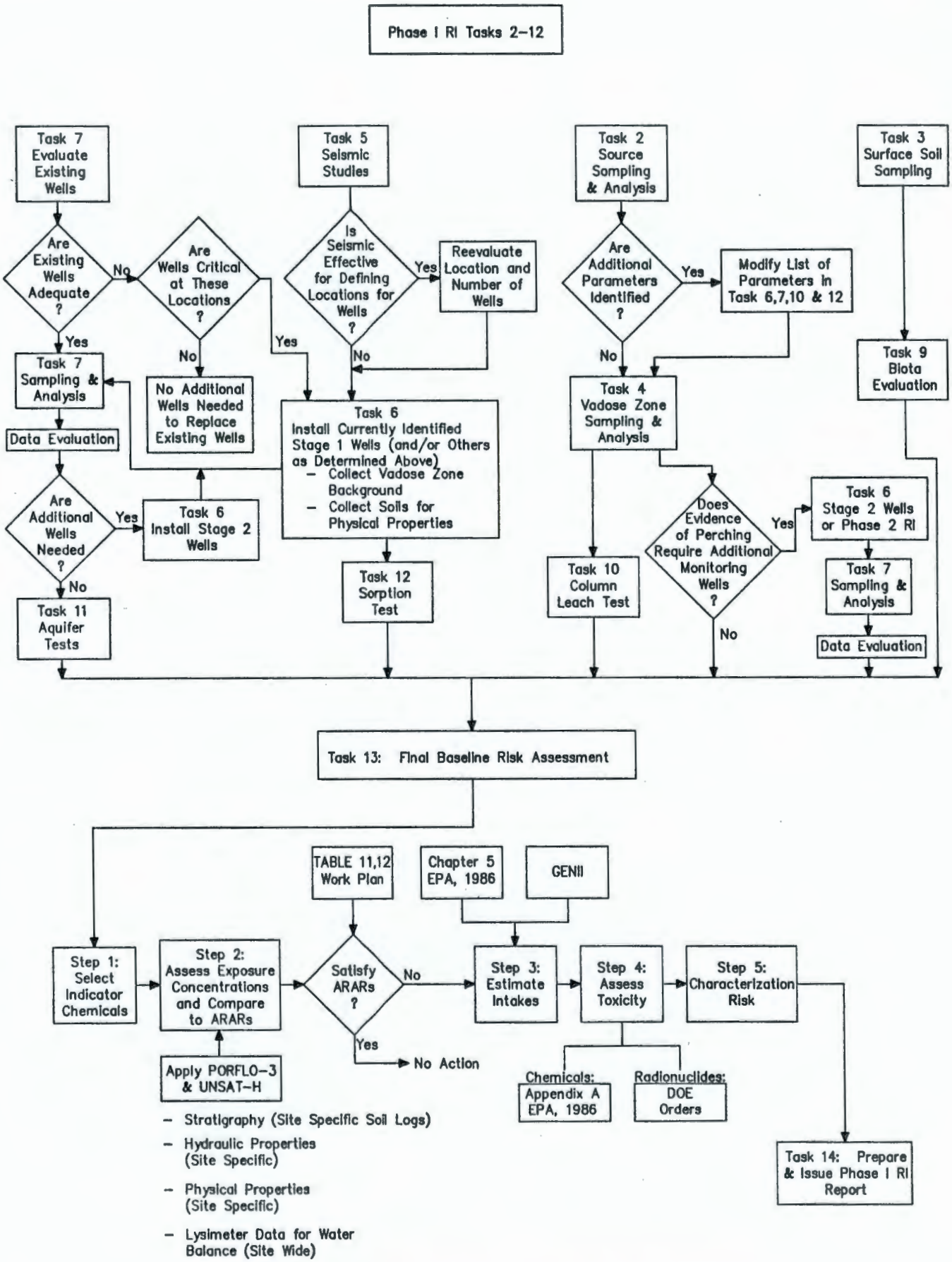

Figure 1. Plan for Completing 200-BP-1 Baseline Risk Assessment

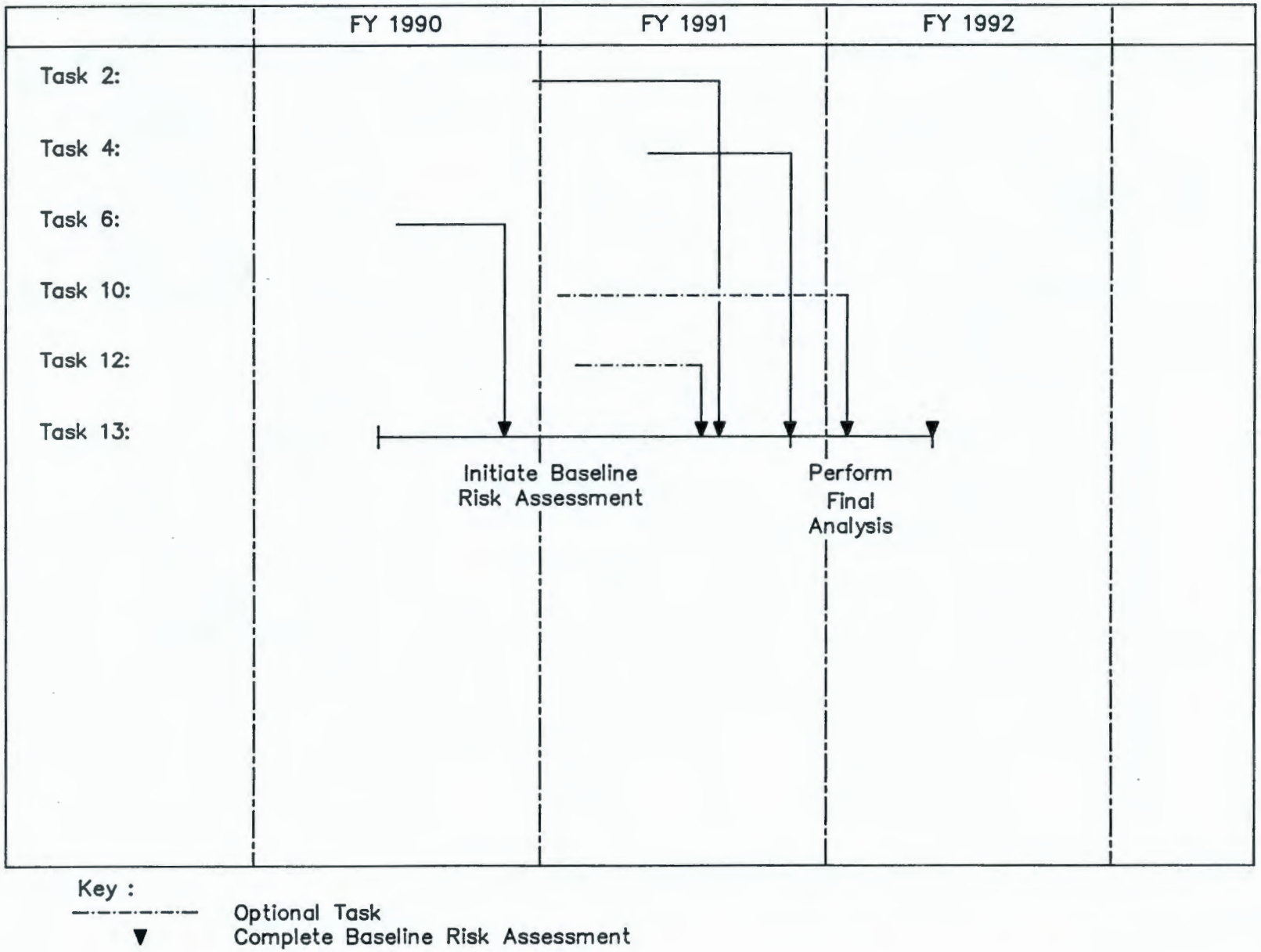

Figure 2: Key Task Duration and Input to Baseline Risk Assessment

FY 1990 PERFORMANCE ASSESSMENT ACTIVITIES

January 24, 1990

Jerry W. Cammann

Westinghouse Hanford Company
Richland, Washington

Outline

- PA Technology Development Program Activities
- PA Applications Program Activities
- Related PA Activities
- General: PA Funding Outlook/Integration
- Suggested Future Special Topic Sessions

PA Technology Development

- **Code Testing/Documentation**
  - PORMC-3
  - PORFLO-3, Version 2.0
  - User's Guide/Technical Manual
  - "Jornada Site" Calibration
- **Evaluation/Documentation of Recharge**
  - Lysimeter Measurements (BWTF, Grass Site, 200E)
  - Isotopic Evaluation (Touchet Bed Silts/Pasco Gravels)
- **Contaminant/Sediment Interactions**
  - Batch-Sorption/Diffusion Half-Cell Tests (Sat/Unsat)
  - Flow-Through Column Tests (Unsat)
  - Retardation/Diffusion Coefficients for Reactive Species
  - Focus on Contaminants of Most Concern (U, Sr, Ru, Tc, I, C, Zr)
  - SST Waste Extracts or Synthetic Solutions with Tracers
  - Touchet Bed Silts/Pasco Gravels

PA Technology Development (cont.)

- Data Archiving/Data Base Maintenance
- RDDT&E Proposals (Performance/Risk Assessment Related)
  - RL5010: Development of Geophysical Well Logging Technique
  - RL5014: Test Facility for Evaluation of Contaminant Transport
  - RL8070: Hanford Site Geohydrologic PA Model
  - RL8101: Cumulative Impacts Assessment - Hanford

PA Applications

- **SST Characterization Well**
  - Address GAO Concern Regarding Water Infiltration
  - Soil Moisture Content/Contamination with Depth
  - Support Code Calibration
- **100 Area Flow/Transport Simulations**
  - Impacts of N-Reactor Shutdown/Reduced Discharges
  - Plume Migration from 1301 LWDF to N-Springs
  - Influence of River Level Fluctuations
  - Moisture Retention (Pressure Plate, Vapor Adsorption, etc.)
  - Hydraulic Conductivity (Unsat Soil Column, Centrifuge, Guelph)
  - Sr Retardation Coefficient (Batch/Flow-Through Column)
  - Support Study for Mitigative Actions, If Required
  - Recommend Changes to Groundwater Monitoring Well Network

PA Applications (cont.)

- **Low-Level Solid Waste Burial Grounds Support**
  - Radiological Performance Assessments (DOE Order 5820.2A)
  - Support Design/Siting of New LLBG's
  - Estimate Remaining Life of Existing LLBG's
  - Determine Cumulative Effects of LLBG Operations
- **RCRA/CERCLA Program Support**
  - 2101M Pond "NOD" Response
  - 1100-EM-1 Baseline Risk Assessment Review
  - 200-BP-1 Implementation Plan (PA Role in Phase I RI)
  - Initiate 200-BP-1 Baseline Risk Assessment ("No Action")

Related PA Activities

- **Physical Property Determination (Nonradioactive Samples)**
  - 1100-EM-1, LLBG's, RCRA Groundwater Wells, 100N Area
  - Hydraulic Conductivity, Particle Size, Moisture Retention
- **Physical Property Laboratory (Radioactive Samples)**
  - 377 Bldg. Being Transferred from PNL to WHC
  - Support Development of Physical Property Test Procedures
  - Current Budgetary Shortfall - Under Program Office Review
- **Long-Term Climate Change Assessment**
  - Protective Barrier Program
  - Identify Bounds on Long-Term Climate Change
  - Independent Peer Review Conducted
  - Study Plan Being Modified
- **Calibration of UNSAT-H Against FLTF Data Base**

General: PA Funding Outlook/Integration

- **Funding Outlook**
  - PA Technology Development Activities Funded Through OTD
  - Funding Provided Through Second Quarter of FY 1990
  - Team Going Back to DOE-HQ to Prioritize Work Nationally
  - Good Chance of Receiving Entire FY 1990 Budget Allocation
  - Out-Year Funding Somewhat Uncertain

  - PA Applications Funded Through Operations Programs
  - Expected to Continue

- **PA Integration Activities**
  - Finalizing Responses to Third-Party Peer Review Comments
  - Enhance Coordination with "MA & PA" Integration Team
  - Form a Hanford Site-Wide PA Overview Committee
  - Revise PA Technology Development Plan to Provide More of an Operational Focus

Suggested Future Special Topic Sessions

- **Site-Wide Groundwater Monitoring/Modeling Efforts**
  - Presented by PNL's Geosciences Department
  - March/April Unit Manager's Meeting
- **Hanford Protective Barrier and Warning Marker System Development Program**

Task: 1881211110 BEIOS PRELIM RISK ASSESS - 200-BP-1 Scope Of Work: Revision No: 1
Performing Org: 8210 ENVIRONMENTAL TECHNOLOGY PERFORM PRELIMINARY BASELINE RISK ASSESSMENT FOR Date: 12/17/88
Method: 4 LEVEL OF EFFORT METHOD 200-BP-1 USING MODELS RECOMMENDED IN WORK PLAN AND Div Num:
Approved By: JW Cammann Date: 3 13 89 EXISTING DATA.

Milestones: Narrative BCWS

19 09/30/89 COMPLETE DRAFT YEAR END LETTER REPORT IDENTIFYING THE STATUS OF FY 89 ACTIVITIES, THE EXISTING DATA AND MODELS USED, & DATA GAPS THAT MUST BE RECON- CILED TO COMPLETE THE PRELIMINARY ASSESSMENT.

Cost Elements:

Fiscal Year: 1989		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
00 NON-EXEMPT	Hrs	0	0	0	0	0	0	10	10	10	10	10	10	60
	$	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	1.0
01 EXEMPT	Hrs	0	0	0	0	0	0	91	73	70	82	71	83	475
	$	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.3	2.2	2.6	2.2	2.9	14.8
19 HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	20.0	-20.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	20.0
6H HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	3.0	-3.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0
7C ORG OVERHEAD		0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	0.5	0.7	0.6	0.8	4.1
Total BCWS	Hrs	0	0	0	0	0	0	101	83	80	92	81	98	535
	$	0.0	23.0	-23.0	0.0	0.0	0.0	3.8	3.1	26.0	3.4	3.0	3.7	42.9

Total TASK		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
00 NON-EXEMPT	Hrs	0	0	0	0	0	0	10	10	10	10	10	10	60
	$	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	1.0
01 EXEMPT	Hrs	0	0	0	0	0	0	91	73	70	82	71	83	475
	$	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.3	2.2	2.6	2.2	2.8	14.8
19 HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	20.0	-20.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	20.0
6H HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	3.0	-3.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0
7C TASK Overhead		0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	0.5	0.7	0.6	0.8	4.1
Total BCWS	Hrs	0	0	0	0	0	0	101	83	80	92	81	98	535
	$	0.0	23.0	-23.0	0.0	0.0	0.0	3.8	3.1	26.0	3.4	3.0	3.7	42.9

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Total WP		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
11 NON-EXEMPT	Hrs	0	0	0	0	0	0	10	10	10	10	10	10	60
	$	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	1.0
11 EXEMPT	Hrs	0	0	0	0	0	0	91	73	70	82	71	92	479
	$	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.6	2.2	2.3	14.3
19 HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	20.0	-20.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	20.0
2H HANFORD COMPU	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	3.0	-3.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0
7I WP Overhead		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.7	0.3	0.3	4.1
Total BCWS	Hrs	0	0	0	0	0	0	101	83	80	92	81	93	539
	$	0.0	23.0	-23.0	0.0	0.0	0.0	3.8	3.1	26.0	3.4	3.0	3.7	43.9

WORK PACKAGE: 1EE32313 DEV ENG PLANS TO GROUT/CONS
Resp Org: 80220 ENVIRONMENTAL ENGINEERING

Scope Of Work:
DEVELOP ENGINEERING PLANS TO GROUT/CONSOLIDATE APPROPRIATE SITES IN 200-BP-1; DEFINE SITE SPECIAL FORMULATIONS & DEVELOP TREATABILITY STUDY

Revision No:
Date: 11/01/88

Task: 1EE3231300 EE33D DEV ENG PLANS TO GROUT/CONS
Performing Org: 80210 ENVIRONMENTAL TECHNOLOGY
E V Method: 5 MODIFIED MILESTONE METHOD
Approved By: JW Cammann Date: 3 /13/ 87

Scope Of Work:
DEVELOP ENGINEERING PLANS TO GROUT/CONSOLIDATE APPROPRIATE SITES IN 200-BP-1; DEFINE SITE SPECIAL FORMULATIONS AND DEVELOP TREATABILITY STUDY PLANS

Revision No:
Date: 09/20/88
Cim Num:

Milestones:	Narrative	BCWS
01	0 10/28/88 COMPLETE TPP	
02	0 07/31/89 COMPLETE OUT-YEAR PLANNING REPORT	
03	0 09/30/87 COMPLETE STATUS REPORT ON LABORATORY RESULTS.	

Cost Elements:

Fiscal Year: 1989		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
00 NON-EXEMPT	Hrs	10	10	10	10	10	10	10	10	10	10	10	10	120
	$	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.1
01 EXEMPT	Hrs	152	151	151	150	150	149	148	147	147	146	146	146	1733
	$	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	54.8

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RK PACKAGE: 1EE3230C BASELINE RISK ASSESSMENT
sp Org: 80220 ENVIRONMENTAL ENGINEERING
Scope Of Work: CONDUCT PRELIMINARY BASELINE RISK ASSESSMENT
Revision No: 0
Date: 08/11/89

sk: 1EE3230C00 EE3CC BASELINE RISK ASSESSMENT
rforming Org: 80210 ENVIRONMENTAL TECHNOLOGY
V Method: 2 PERCENT COMPLETE METHOD
Scope Of Work: ENVIRONMENTAL TECHNOLOGY
Revision No: 0
Date: 09/16/89
Cin Num:

proved By: JW Cammann Date: 1/22/90

lestones:		Narrative	BCWS
1	0 03/28/90	PLUME MODEL DESCRIPTION REPORT	
2	0 06/28/90	PREPARE BASELINE TRANSPORT CHARACTERISTICS FOR APPLICABLE CONSTITUENTS (LETTER REPORT)	
3	0 09/28/90	ANALYZE HYDROGEOLOGIC DATA AND QUANTIFY & CALIBRATE PLUME MODEL (YEAR-END STATUS REPORT)	

ost Elements:

Fiscal Year: 1990		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1 EXEMPT	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.5	0.2	0.0	2.5	2.5	2.5	5.0	5.0	5.1	5.1	5.1	5.1	38.5
1 PO CONTRACTS	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	140.0
C MATERIAL PROC	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	0.0	1.7	1.7	1.7	1.7	0.8	0.8	0.8	0.8	10.0
C ORG OVERHEAD		0.1	0.1	0.0	0.7	0.7	0.7	1.4	1.4	1.4	1.4	1.4	1.4	10.8
Total BCWS	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.6	0.3	0.0	23.2	24.9	24.9	28.1	28.1	17.3	17.3	17.3	17.3	199.3

otal TASK		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1 EXEMPT	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.5	0.2	0.0	2.5	2.5	2.5	5.0	5.0	5.1	5.1	5.1	5.1	38.5
1 PO CONTRACTS	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	140.0

C MATERIAL PROC	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	0.0	1.7	1.7	1.7	1.7	0.8	0.8	0.8	0.8	10.0
C TASK Overhead		0.1	0.1	0.0	0.7	0.7	0.7	1.4	1.4	1.4	1.4	1.4	1.4	10.8
Total BCWS	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.6	0.3	0.0	23.2	24.9	24.9	28.1	28.1	17.3	17.3	17.3	17.3	199.3

otal WP		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1 EXEMPT	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.5	0.2	0.0	2.5	2.5	2.5	5.0	5.0	5.1	5.1	5.1	5.1	38.5
1 PO CONTRACTS	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	140.0
C MATERIAL PROC	Hrs	0	0	0	0	0	0	0	0	0	0	0	0	0
	$	0.0	0.0	0.0	0.0	1.7	1.7	1.7	1.7	0.8	0.8	0.8	0.8	10.0
C WP Overhead		0.1	0.1	0.0	0.7	0.7	0.7	1.4	1.4	1.4	1.4	1.4	1.4	10.8
Total BCWS	Hrs	15	7	0	80	80	80	160	160	160	160	160	160	1222
	$	0.6	0.3	0.0	23.2	24.9	24.9	28.1	28.1	17.3	17.3	17.3	17.3	199.3

DON'T SAY IT - WRITE IT !

July 14, 1989

To: Wayne Johnson
From: Jack Sonnichsen Jack

SUBJECT: 200-BP-1 PA SUPPORT

Although I haven't had the time to pull together the PA plan for supporting 200-BP-1 closure, I have spent considerable time reviewing Section 5.0 of the closure plan. The closure plan for the 200-BP-1 Operable Unit is by far the best closure plan that I have reviewed. In particular, the framework that was developed for collecting specific type information that supports PA related work (Tasks 4,6,7,10, and 12) is tremendous. I have roughed out a multi-year program that includes several tasks that will support both the preparation of the baseline risk assessment (RI phase) and the analysis that supports the comparison of alternatives (FS phase).

Since there is an existing plume beneath the operable unit, I believe it will be necessary to construct a plume model to resolve the PA/RA issues. I am not sure if this is something that we can field "in-house". However, I believe that it needs to be done. Assuming this level of analysis, I have conceptualized a program consisting of 6 tasks and extending over several years. The tasks include:

1. Define and develop plume model,

2. Baseline transport characteristics for Table 3.8 constituents,

3. Analyze hydrogeologic data for use in plume model,

4. Quantify and calibrate model,

5. Perform baseline risk assessment, and

6. Perform analysis in support of comparing alternatives

With regard to the schedule provided in Section 7.0 of the closure plan, I forecast the following expeditures:

TASKS	1990	1991	1992	1993	1994
1.	75				
2.	75				
3.	50				
4.	35	85			
5.		85			
6.				90	90
TOTAL	235K	170K		90K	90K

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Over the next month or so, I will prepare a write-up for each of these tasks. Each of the PA tasks will be related to the data collection tasks discussed previously (Tasks 4,6,7,10, and 12).

In closing, if you have any questions please don't hesitate to call.

cc: 200-BP-1 File

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DON'T SAY IT - WRITE IT !

Sept. 29, 1989

To: R. A. Carlson
From: J. C. Sonnichsen Jack

SUBJECT: 200-BP-1 PERFORMANCE ASSESSMENT PLAN (1989 MILESTONE)

During FY 1989, an evaluation and selection of the models that will be used to support a decision on the remediation of the 200-BP-1 Operable Unit was completed. A schedule to ready the model for use consistent with the master program schedule outlined in the, " Draft Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington ", (work plan) was prepared.

Due to the apparent nature and extent of contamination in the soil and groundwater, it is proposed that a three-dimensional model of the soil and groundwater system be developed. This simulation model will be calibrated to the onsite conditions using information from the existing Hanford Site database supplemented with the waste site specific information that will be collected as a result of implementing the work plan. Once calibrated, this model will be used to evaluate the "no-action" alternative or the baseline risk assessment and will also be used to assess the effectiveness of the various cleanup options that will be evaluated.

It is proposed that the PORFLO-3 groundwater flow and transport model be used for purposes of simulation. PORFLO-3 can be used to simulate the movement of contaminants under both saturated and unsaturated conditions. The VAM2D flow and transport model will be used for purposes of benchmarking and as a contingency if efforts through the use of PORFLO-3 prove to be unsuccessful.

It is assumed the chemistry that governs the movement of hazardous chemicals and radionuclides within the soil and water of both the saturated and unsaturated zones can be represented through the use of an effective partition coefficient (retardation factor) and that the overall persistence of the contaminant in the environment can be quantified though the use of an effective decay factor (radiogenic or biological decay coefficient). These parameters are contaminant specific and will vary depending upon the ionic nature of the soil and groundwater. It is assumed that these characteristics will be measured for the appropriate hydro-geochemical conditions. There is the possibility that chemical thermodynamic models such as MINTIC and/or EQ3/EQ6 may need to used if the chemistry of the plumes is extremely complex. At the present time, use of these types of models has not been included in the plan.

The plume simulation model will be used to calculate the concentration of contaminants in the soil and groundwater. Once these concentrations have been calculated, the risk to human health and the environment resulting from their presence will be quantified using appropriate dose models. The GENII radiological dose model will be used to assess the radiological consequences

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associated with various pathways and scenarios. To this end, either the PATHRAE-HAZ model or EPA protocol (Spread sheet calculations) analysis will be used to assess the dose resulting from hazardous chemicals.

A plan that consists of six tasks has been prepared and is attached. Work will be initiated during the first quarter of fiscal year 1990. Each task description contains ties to the tasks described in section 5 of the work plan. This is a preliminary cut in terms of relating specific model needs (requirements) to the specific activities identified in the work plan and relating this information to the schedule for collecting this information. A schedule for completing major milestones and deliverables is also provide in the attachment. Generally speaking, it can be concluded that this schedule is consistent with the overall program schedule outlined in the work plan.

cc: W. L. Johnson
J. W. Cammann
J. F. Relyea
200-BP-1 File

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Attachment: Page 1

200-BP-1 PERFORMANCE ASSESSMENT SUPPORT

It is proposed that a three-dimensional numerical groundwater flow and transport simulation model be configured and calibrated to actual site conditions. This model will be used in conjunction with health impact models to evaluate the risks associated with the various waste site remediation alternatives. It is further proposed that the PORFLO-3 model be used for this purpose. The following 6 tasks outline a program to support development of the plume model. Each task is related to the work scope discussed in section 5, "Draft Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington", (work plan).

TASK 1: Define and Develop Plume Model

A conceptual model of the 200-BP-1 Operable Unit (unit) will be prepared. This model will be based on our present understanding of the unit as it relates to; the hydrogeology, engineering, and operation conditions, of the facility and site. This existing information provided in sections 2 and 3 of the work plan will provide a basis from which the model will be configured. The conceptual model will focus on those aspects of the waste site and environmental setting that affect the potential migration and fate of the existing contamination. In particular, emphasis will be placed upon defining the stratigraphy and relating this stratigraphy to flow and transport characteristics for each of the contaminants and sources within the unit. This information will be revised as necessary based upon information collected during completion of Task 4, "Vadose Zone Soil Sampling and Analysis", discussed in the work plan. A first cut estimate of soil hydraulic properties and contaminant transport properties will be made based upon information typically used in support of Hanford site performance assessments. A list of suspect information will be prepared and will provide a basis for further analysis as discussed in Task 10, "Column Leach Tests", and Task 12, "Sorption Tests".

Once the conceptual model is defined, this information will be incorporated into the numerical simulation model. A series of test runs will be performed for the purpose of checking out the system. Once these test runs have been completed, the model will be calibrated.

Task 2: Baseline Transport Properties

A preliminary list of hazardous constituents has been provided in Table 3.8 of the work plan. Within the PORFLO-3 model, transport is addressed through the use of two parameters; solubility, and retardation. These transport characteristics will be defined for each of the constituents based upon existing information. Basically, a literature survey will be performed to quantify each of these model parameters. A summary report will be prepared and the results from this assessment will provide a basis for identifying

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Attachment: Page 2

the work that needs to be performed in support of Tasks 10 and 12 in the work plan.

Task 3: Hydrogeologic Data

Existing well logs will be the primary source of information for establishing the stratigraphy used in the model. Once the stratigraghy has been defined, the hydraulic characteristics for each soil type will be established. Laboratory analysis will be performed on those soils types for which insufficient information exists to support hydraulic characterization. Task 4 in the work plan will be used to obtain the additional information on hydraulic characterization to support model use. If after looking at the stratigraphic map it is concluded that additional information is needed to complete the strategraphic representation of the waste site, additional wells will drilled. The location of these wells will be specified. The drilling of these wells will be supported though Task 6 in the work plan.

Task 4: Quantify and Calibrate Model

The model will be calibrated using information collected at the site. The data collected as a result of performing Tasks 4 and 7 discussed in the work plan will provide the primary basis for calibration. As discussed in Task 10 of the work plan, an estimate on the rate of infiltration that has occurred over the years will be calculated using the UNSAT-H water balance model. The existing plume data shown in the work plan will be used for calibration of the model in the unconfined saturated zone.

Task 5: Baseline Risk Assessment

Once the flow and transport model has been calibrated, the model will be used for simulating the behavior of the plume as a function of time. The concentration of hazardous constituents will be calculated. Once these concentrations have been simulated, these concentrations will be used to assess the risk to human health and the environment. For radionuclides, the Hanford dosimetry models will be used to perform these assessments. The appropriate health models are contained in GENII (radiological), and RAPS/MEPAS or PATHRAE-HAZ (hazardous chemicals). All of these models are available and have been documented and peer reviewed over the years. The baseline risk assessment will evaluate the "no-action" alternative and provide a basis for evaluation of various alternatives. This task is outlined as Task 14 in the work plan.

Task 6: Evaluation of Alternatives

In addition to evaluating the "no-action" alternative (Task 5), the calibrated model will be used to investigate the effectiveness of the various alternatives. Various remedial actions such as groundwater pumping

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Attachment: Page 3

can be evaluated using the simulation model. The levels of simulated performance will be provided to the decision makers for consideration. A Record of Decision will be written and the selected alternative will be implemented. For the selected alternative, results from the simulation can be used to provide a basis for preparing the post closure monitoring plan. This work will be performed in support of the Phase II Feasibility Study.

Milestones and Deliverables:

1. Issue Report on Transport Properties (Task 2) ..... March 90
2. Issue Report on Conceptual and Numerical Model (Task 4) June 91
3. Issue Report on Baseline Risk Assessment ..... Oct 91
4. Issue Report on Comparison of Alternatives ..... March 94

DRAFT

STATEMENT OF WORK

for

-- Pacific Northwest Laboratory --

HANFORD SITE PERFORMANCE ASSESSMENT PROJECT

Part of the
Northwest Hazardous Waste Research,
Development, and Demonstration Center

Fiscal Year 1990

Project Definition

Remediation and disposal systems planned for Hanford Site wastes generated by defense-related activities will be comprised of man-made and natural barriers. These systems, functioning collectively, will isolate the wastes from the accessible environment in accordance with Federal and State requirements.

The Hanford Site Waste Management Plan (DOE 1988a) and the Hanford Waste Management Technology Plan (DOE 1987) describe the alternative systems under consideration, and the technology required for their evaluation and implementation. Defensible performance assessment methods that are in accordance with DOE guidance (DOE 1988b; Case and Otis 1988) are required to evaluate compliance of on-site remediation and disposal options with regulatory standards. The program for developing the required performance assessment technology is outlined by Davis (1988).

Performance Assessment (PA) is an analysis that (1) identifies the natural and man-caused events and processes (i.e., scenarios) that might adversely affect a waste remediation or disposal system, (2) predicts the performance of the system in terms of the containment and isolation of radionuclides and hazardous chemicals, and (3) estimates the environmental consequences to determine if the system will comply with governmental regulations. (Note: For a risk analysis, the results of performance assessments must be supplemented by estimates of occurrence probabilities of the scenarios).

A performance assessment usually includes an evaluation of all potentially significant contaminant transport pathways from a specific facility to the accessible environment. Typically, a suite of models (i.e., computer codes, data, and assumptions) is used to predict performance for periods ranging from tens to thousands of years, depending on the class of wastes and applicable regulatory requirements.

Performance assessments are the primary means of evaluating the compliance of a facility with applicable performance criteria. However, performance assessments should also be used to evaluate alternative waste disposal strategies and engineering options for various current and anticipated environmental conditions.

The application of performance assessment technology will help ensure the selection of those engineering and siting options that have minimal current and future risk of contaminating ground water and adversely affecting public health, yet avoid costly, overly conservative options that provide few additional benefits in reducing risk. Consequently, assessments of performance help ensure that the final disposition of wastes generated by defense activities at the Hanford Site will be carried out in an environmentally sound, safe, and cost-effective manner.

Objective

The objective of the Hanford Site Performance Assessment (HSPA) project at Pacific Northwest Laboratory (PNL) is to assist the U. S. Department of Energy through the Environmental Technology Group of Westinghouse Hanford Company (WHC) in developing and maintaining a credible and defensible PA capability. This capability, which includes conceptual models, computer codes, assumptions, and data bases, is necessary to resolve issues of acceptability regarding methods of remediation and disposal of Hanford Site wastes (DOE 1987; Davis 1988). The objectives of the applications of this PA capability will be to 1) help select appropriate disposal sites and methods of site remediation, 2) identify site characterization needs, 3) design waste form, containment and infiltration barrier systems, 4) provide information for cost-benefit studies, 5) define performance goals, and 6) formally document that the system complies with applicable regulations.

Scope

The models and data of the HSPA project will be available to support the performance assessment activities of various waste-specific disposal and remediation programs (e.g., grouted waste, single-shell tank wastes, solid waste burial, and liquid wastes disposed of in cribs and trenches), as well as the Hanford Site as a whole. Definition of the overall scope of the HSPA project has been predicated on the following:

- Loss of institutional control 100 years after Hanford Site operations cease
- Requirements for protection of ground water and surface water
- Consideration of both hazardous chemicals and radionuclides
- Prediction of performance for periods of up to 10,000 years

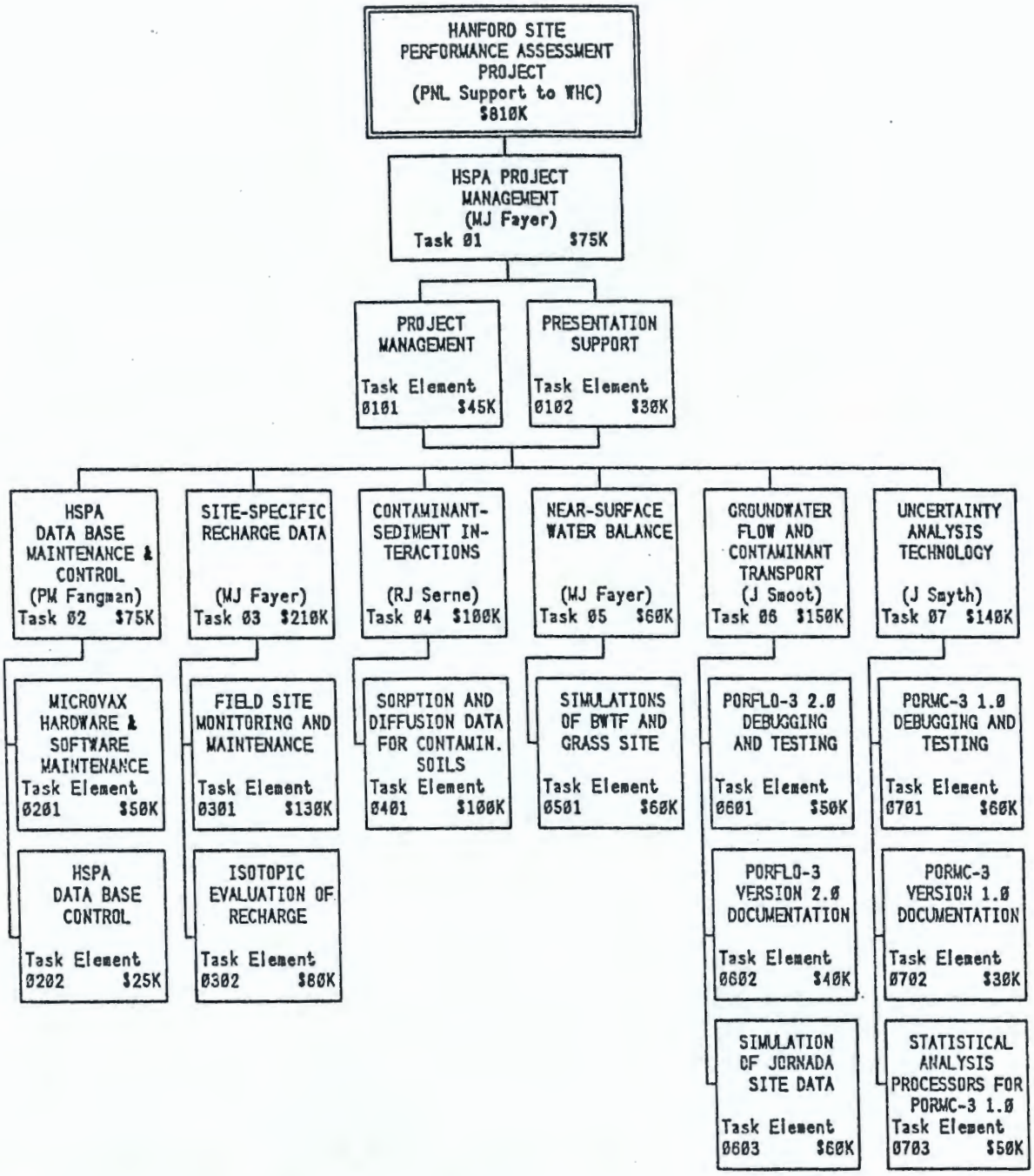
- Contaminant inventories that are not innocuous by default (e.g., because of small inventories)
- Consideration of cumulative effects of multiple contaminant sources
- Evaluation of performance of engineered and natural systems for expected and disruptive scenario conditions
- Significant quality assurance requirements for computer-encoded models and data, and
- Requirements for quantifying the uncertainty levels in performance predictions.

Environmental impacts will be expressed as a function of time in terms of contaminant concentrations and potential human exposures at a point of compliance. Ground water is generally considered to be the most critical pathway for migration from the Hanford Site of contaminants that pose a risk to human health. Consequently, the transport of contaminants by ground water is the current focus of the HSPA project.

The data, models, and computer codes resulting from this work will be used to (1) identify the key contaminants and performance parameters, thereby providing guidance for data collection and design engineering, and (2) determine the levels of conservatism in design and siting considerations that are adequate to compensate for uncertainty in the performance predictions.

Work for Fiscal Year 1990

In fiscal year 1990, PNL is to 1) continue to expand and maintain the data base of HSPA-generated data and codes, 2) collect site-specific information to better establish the rate of recharge to the unconfined aquifer, 3) evaluate the mechanisms and potential for contaminant-sediment interactions, and 4) further test and document the capabilities of the PORFLO-3 Versions 1.0 and 2.0, PORMC-3 Version 1.0, and UNSAT-H Version 2.0 computer codes. The identity, organization, and funding levels of this work are shown in Figure 1. The work will be done in accordance with the project quality assurance plan EES-7, Rev. 2.



Notes:
1) Not shown are labor costs for technical support of Task Elements 0302 and 0401 by WHC. Estimated cost of this support is $20K and $60K, respectively.
2) Not shown is $60K of WHC support for time on the Cray computer for Task Elements 0501, 0601, 0603, 0701, and 0703.
3) Not shown is $80K of WHC support for MC Connelly for Task Elements 0601, 0603, 0701, and 0703.

FIGURE 4.1. HSPA Project Organization for FY 1990

HANFORD SITE PERFORMANCE ASSESSMENT PROJECT
WORK BREAKDOWN STRUCTURE (WBS) - TASKS AND TASK ELEMENT DEFINITION, OBJECTIVES, AND MAJOR CONTRIBUTORS

WBS 01 HSPA PROJECT MANAGEMENT ($75K)

The HSPA project consists of collecting data and developing technology that can be applied to the conduct of waste-specific and Hanford Site-wide performance assessments. The objective of this task is to coordinate the efforts of the various HSPA personnel to ensure coherent products that comply with the requirements of this Statement of Work.

WBS 0101 Project Management ($45K)

The objective of this task is to coordinate the implementation and ensure the satisfactory completion of tasks 2 through 7 of this Statement of Work. The project manager is responsible for 1) maintaining a broad, multi-year perspective on the objectives and priorities of the technical work, 2) negotiating and controlling PNL program scopes, budgets, schedules, deliverables and change orders, and 3) controlling quality in accordance with the current quality assurance procedures of the HSPA project.

A brief (2-3 page) status report, organized by task, is to be submitted to Westinghouse on the last working day of each month. The report is to describe and present in a tabular format 1) progress toward completion of each task element in terms of percentage completion, 2) cumulative expenditures to the end of the current month, 3) status of deliverables, 4) problems and work-around plans, and 5) work planned for the succeeding month.

Interim Deliverable:

- Submit monthly progress reports to Westinghouse by the last working day of each month (Milestone 0101)

WBS 0102 Presentation Support ($30K)

The objective of this task is to provide an interface between the HSPA project within PNL and the Environmental Technology Group at Westinghouse. The project manager is responsible for 1) maintaining liaison with the Westinghouse cognizant engineer and with performance assessment applications projects at PNL, 2) providing reviews, as requested by Westinghouse, of performance-assessment-related reports, 3) responding to Westinghouse and third-party reviews of performance-assessment-related reports written by PNL authors, and 4) participating, as requested by Westinghouse, in presentations, workshops, and meetings.

WES 02 HSPA DATA BASE MAINTENANCE AND CONTROL ($75K)

Performance assessment applications at the Hanford Site require data and computer codes that are accessible and have the required level of quality

assurance. The objective of this task is to provide the means to house a data base, control its contents, and allow accessibility by HSPA personnel. The HSPA data base contains data and computer codes generated and/or used by HSPA personnel.

WBS 0201 MicroVAX Hardware & Software Maintenance ($50K)

The objective of this task is to ensure that the HSPA MicroVAX is functioning efficiently and is conveniently available to PNL and Westinghouse staff for storage of data and archiving of computer codes. A regular schedule for backups of the MicroVAX storage disks is to be maintained.

WBS 0202 HSPA Data Base Control ($25K)

The objective of this task is to ensure the quality of the data and computer codes in the HSPA data base. The task leader will 1) ensure that updates of the Hanford Site Performance Assessment data base comply with HSPA quality assurance requirements, technical criteria and verification protocol, and 2) notify Westinghouse of the current contents of the data base and the procedures for access to it. As part of this task, HSPA software is to be maintained on the HSPA MicroVAX according to the software control procedures of the current quality assurance plan of the HSPA project.

Milestone:

- Notify Westinghouse by 29 December 1989 of the current contents of the HSPA data base (Milestone 0202)

WBS 03 SITE-SPECIFIC RECHARGE DATA ($210K)

The question of whether natural recharge to the unconfined aquifer at the Hanford Site occurs has not been resolved. One objective of this task is to obtain data at various locations and for various surface conditions to resolve the recharge issue. A second objective is to obtain field data for use in testing flow and transport models. In FY 1990, this task will focus on water balance monitoring of three field sites and characterization of site-specific recharge rates using isotopic analysis.

WBS 0301 Field Site Monitoring and Maintenance ($130K)

The objective of this task is to provide additional site-specific field data for validation of the UNSAT-H and PORFLO-3 computer-encoded models, for different surface conditions and sediment facies, and to estimate the rates of net infiltration of meteoric water into the vadose zone of the Hanford Site. The task will focus on continued monitoring of the water balance at the Grass Site and Buried Waste Test Facility in the 300 Area, and the 200 East Area Lysimeter.

Interim Deliverable:

- Submit draft report on field site monitoring to Westinghouse by 15 August 1990 for review and comment

Milestone:

- Submit revised report on field site monitoring to Westinghouse by 28 September 1990 for approval (Milestone 0301)

WBS 0302 Isotopic Evaluation of Recharge ($80K)

The objective of this task is to initiate application of ground water dating techniques to the vadose zone, to estimate recharge rates at various locations at the Hanford Site. PNL is to 1) review current techniques for dating ground water that are applicable to the Hanford Site vadose zone, 2) draft a test plan recommending techniques for field sampling and laboratory analysis, 3) obtain an external (i.e., independent of PNL) peer review of the test plan, 4) submit the revised test plan to Westinghouse for concurrence, 5) analyze an initial suite of samples using off-site laboratories with the required capabilities, and 6) interpret the results and issue a report for public release. Responsibilities for completion of the work are to be shared among Westinghouse (sample collection), PNL (test plan and interpretation of analyses), and off-site subcontractors (isotopic analyses).

The final test plan is to discuss the expected results in terms of the precision and accuracy of the analytic techniques. As a minimum, samples for isotopic analysis are to be collected from two sediment types of the Hanford Formation: the Touchet Bed silts (McGee Ranch-type soil) and the Pasco Gravels (graded-bedding sands and gravels). The administrative responsibilities and costs of the external peer review are part of this task. A list of the proposed peer reviewers is to be transmitted to Westinghouse for approval prior to placement of any contracts with the reviewers. A copy of the peer review comments are to be transmitted to Westinghouse. The test plan is to be revised in accordance with the peer review comments.

Samples received from Westinghouse are to be submitted to off-site laboratories under contract to PNL for isotopic analysis. Results of the isotopic analyses are to be interpreted in terms of vadose zone ground water ages. This information is to be used to infer recharge rates to the unconfined aquifer. The results are to be compared with those obtained from lysimeter measurements. The results are also to be evaluated in terms of their precision and accuracy.

Interim Deliverables:

- Submit a draft test plan for isotopic analysis of recharge rates to Westinghouse by 30 March 1990 for review, comment, and approval
- Submit a draft letter report describing progress as of 30 July 1990 to Westinghouse by 30 August 1990 for review and comment
- Submit revised letter report describing progress to Westinghouse by 28 September 1990

Milestone:

- Submit a revised test plan for isotopic analysis of recharge rates to Westinghouse by 15 May 1990 for approval (Milestone 0302)

WBS 04 CONTAMINANT-SEDIMENT INTERACTIONS ($100K)

Suprabasalt sediments of the Hanford Site have been contaminated by the disposal of waste solutions from processing facilities and service operations. Contaminants within these sediments exist as sorbed or precipitated radionuclides, and/or hazardous metals or chemicals. The objective of this work is to obtain data on the retardation and diffusion of some of the contaminants known to be present in these Hanford Site sediments.

Tests are to be designed to evaluate contaminant-sediment interactions for 1) environments that have been altered as a result of the waste disposal actions (e.g., by acidification of the sediments and pore water and/or by increased concentrations of organic matter, especially complexants), and 2) environments that have not been altered by the waste disposal actions.

The work to be performed during FY 1990 is the initial work of a multi-year effort. Laboratory analyses are to include batch-sorption and diffusion half-cell tests (saturated and unsaturated environments, respectively) and flow-through column tests of selected batch-sorption test matrices (unsaturated environment).

WBS 0401 Sorption and Diffusion Data for Contaminated Soils ($100K)

The principal investigators are to contact P. Salter (PNL) and J. Kessner (WHC) to determine if water extracts of core samples of single-shell tank wastes can be obtained and to obtain cost estimates for preparing water extracts and analyzing their chemical and radiologic content. If samples of single-shell tank-waste water extracts are made available in a timely and cost-effective manner for testing, they are to be used as waste-source materials for some of the laboratory tests. If not, synthetic solutions are to be prepared for all of the tests and spiked with tracers that mimic the behavior of the contaminants of most concern (e.g., U, Sr, Ru, Tc, I, C, and Zr) in ground water of the disturbed and undisturbed geochemical environments.

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The experimental parameters to be varied are 1) soil type, 2) contaminants and their concentrations, 3) relative soil-water content and composition, and 4) the presence or absence of organic complexants or other alterations to the unaffected environment (e.g., acidic pH). The objective of the laboratory testing is to empirically derive coefficients of contaminant retardation (R_d) and diffusion (D_R) for reactive species. A parametric approach is to be employed to define R_d and D_R as functions of the experimental parameters.

Sediment samples to be used in the tests are to be collected by Westinghouse. The samples are to be from the two end-member facies of the Hanford Formation: the fine-grained, silty Touchet Bed (McGee Ranch-type soil) and the coarser, graded-bedding sands and gravels of the Pasco Gravels.

The principal investigators are to draft a test plan that describes the batch and diffusion half-cell test methods and protocol that will be used (e.g., test durations, matrices of variables, calculations, etc.). By 30 December 1989, Westinghouse is to provide the principal investigators with samples of the soils to be used in the testing.

By 1 May 1990, the battery of batch and diffusion half-cell tests are to be completed. Based on evaluation of the results, the principal investigators are to prepare a test plan that describes the flow-through column test methods, protocol, and test matrices.

Interim Deliverables:

- Submit draft test plan on batch and diffusion half-cell tests to Westinghouse by 15 November 1989 for review and comment
- Submit revised test plan on batch and diffusion half-cell tests to Westinghouse by 30 January 1990 for concurrence
- Submit draft test plan on flow-through column tests to Westinghouse by 15 May 1990 for review and comment
- Submit revised test plan on flow-through column tests to Westinghouse by 30 June 1990 for concurrence
- Submit draft report on contaminant-sediment interaction tests to Westinghouse by 15 August 1990 for review and comment

Milestone:

- Submit revised report on contaminant-sediment interaction tests to Westinghouse by 28 September 1990 for approval (Milestone 0401)

WBS 05 NEAR-SURFACE WATER BALANCE ($60K)

Predictions of contaminant migration in groundwater beneath the Hanford Site rely heavily on estimates of site-specific recharge rates. To complement Task 03, which is dedicated to collecting site- and time-specific recharge data, the objective of this task is to develop, test, and demonstrate the capability to adequately simulate the near-surface water balance around and within waste disposal areas at the Hanford Site. That capability is vested in UNSAT-H Version 2.0, which accounts for precipitation, evaporation, plant transpiration, runoff, soil-water redistribution, and drainage (i.e., recharge) to the deeper vadose zone. The recharge rates predicted by UNSAT-H will serve as upper boundary conditions for computer codes such as PORFLO-3 that simulate groundwater movement and contaminant transport in the deeper parts of the vadose zone. The UNSAT-H code has been used extensively by the Protective Barrier Program to refine barrier design and assess barrier performance. In FY 1990, this task will focus on simulations of field data and installation of UNSAT-H Version 2.0 on the Hanford Site Cray computer.

WBS 0501 Simulations of the BWTF and Grass Site ($60K)

The objective of this task is to compare UNSAT-H simulation results with actual site-specific measurements to determine how closely the simulation approximates the field data. Using the UNSAT-H Version 2.0 computer code developed and documented during FY 1988-89, PNL is to simulate the 12 years of water balance measurements at the Buried Waste Test Facility, and the 6 years of water balance measurements at the Grass Site. In addition, PNL is to install UNSAT-H Version 2.0 on the Hanford Site Cray XMP computer.

Interim Deliverable:

- Submit draft report on simulations of the BWTF and Grass Site to Westinghouse by 1 April 1990 for review and comment

Milestones:

- Provide documentation to Westinghouse by 1 February 1990 that UNSAT-H Version 2.0 has been successfully installed on the Hanford Site Cray XMP computer (Milestone 0501-A)

- Submit revised report on simulations of the BWTF and Grass Site to Westinghouse by 15 May 1990 for approval (Milestone (0501-B)

WBS 06 GROUNDWATER FLOW AND CONTAMINANT TRANSPORT ($150K)

Predictions of contaminant migration in the unsaturated and saturated zones at the Hanford Site require a capability to simulate both groundwater flow and contaminant transport. The objective of this task is to develop, test, and demonstrate the capability to adequately simulate groundwater flow and contaminant transport in the sediments of the Hanford Site. That

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capability is vested in PORFLO-3 Version 2.0, which simulates fluid flow, heat transfer, and mass transport for three-dimensional problems in variably saturated geologic media. The geologic media may be heterogenous and anisotropic, and may contain linear and planar features such as boreholes and fractures. The PORFLO-3 code was used in FY 1989 to simulate the 1973 leak from the 241-T-106 single-shell waste tank. In FY 1990, this task will focus on code testing and documentation, and on simulations of field data.

WBS 0601 PORFLO-3 Version 2.0 Debugging and Testing ($50K)

During FY 1989, Westinghouse contracted with Analytic & Computational Research, Inc. to add to the PORFLO-3 Version 1.0 computer code the capability to simulate the transport of contaminants by two liquids or by a gas and a liquid. The objective of this task is to debug and test the new version of the code, i.e., PORFLO-3 Version 2.0. PORFLO-3 Version 2.0 differs from Version 1.0 principally in that equations were added that govern 1) the response to pressure or hydraulic head of a second fluid phase that is immiscible with water and that has a capillary pressure different from that of water, and 2) the behavior of a compressible gas.

PNL is to use a series of site-specific test problems to check the capability of PORFLO-3 Version 2.0 to simulate multi-phase, multi-fluid flow and contaminant transport. The test problems that are to be developed by PNL are to use data on the distribution of immiscible organic chemicals in both the vadose zone and unconfined aquifer. Site-specific data from the 1100 Area and the Solid Waste and Non-Radioactive Dangerous Waste Landfill facilities in the 600 Area of the Hanford Site are to be considered first. PNL is to draft a journal article that describes the capabilities of the PORFLO-3 Version 2.0 computer code, the site-specific problems used to test the code, and the results of the simulations.

Interim Deliverable:

- Submit draft journal article on the PORFLO-3 Version 2.0 testing to Westinghouse by 1 June 1990 for review and comment

Milestone:

- Submit revised journal article on the PORFLO-3 Version 2.0 testing to Westinghouse by 16 July 1990 for approval (Milestone 0601)

WBS 0602 PORFLO-3 Version 2.0 Documentation ($40K)

The objective of this task is to document PORFLO-3 Version 2.0. The existing User's Guide and Theory Manual for PORFLO-3 Version 1.0 are to be revised to reflect recent additions to, and modifications of, the capabilities of the code. The additions and modifications include 1) multi-fluid, multi-phase flow and contaminant transport, 2) chain decay of radionuclides or degradation of chemicals, 3) improvements relating to the treatment of the fluid density function, 4) a periodic boundary condition for grids expressed by cylindrical coordinates, 5) changes in the manner in which 1, 2, and 3-dimensional problems are processed, and 6) changes in the solvers of the

governing equations. Initiation of work on the User's Manual is to begin when the code is received from Westinghouse. Initiation of work on the Theory Manual is to begin following successful testing of Version 2.0 (WBS 0601).

Interim Deliverables:

- Submit draft of User's Guide for PORFLO-3 Version 2.0 to Westinghouse by 1 June 1990 for review and comment
- Submit draft of Theory Manual for PORFLO-3 Version 2.0 to Westinghouse by 2 July 1990 for review and comment

Milestones:

- Submit revised User's Guide for PORFLO-3 Version 2.0 to Westinghouse by 2 July 1990 for approval for publication (Milestone 0602-A)
- Submit revised Theory Manual for PORFLO-3 Version 2.0 to Westinghouse by 1 August 1990 for approval for publication (Milestone 0602-B)

WBS 0603 Simulation of Jornada Site Data ($60K)

The U. S. Nuclear Regulatory Commission funded a multi-year field experiment for the collection of data to validate computer models of ground water movement in the vadose zone of sites with arid climates. The NRC site consists of an instrumented trench 4.8-m wide, 26.5-m long, and 6.0-m deep. More than 650 cores and soil samples have been analyzed for bulk density, saturated hydraulic conductivity, and water retention. In situ measurements of unsaturated hydraulic conductivity have been made at the site using Guelph permeameters.

Infiltration tests have been conducted in the walls of the trench using a tritium tracer. The wetting front was mapped on the trench walls. Neutron probe measurements of water contents and tensiometric measurements of soil water potential were recorded throughout the duration of the experiment at 20 locations dispersed through the wetted volume. The advance of the tritium front was monitored within the wetted volume by extracting ground water samples from the soil column using 25 suction candles.

PNL is to proceed as follows:

1) Analyze the Jornada Site data set (available from G. W. Gee at PNL) and assign values to the input parameters of PORFLO-3 Version 1.0.

2) Use the values of input parameters from the above step to simulate the movement of the wetting and/or drying front, and the distribution of the tritium tracer.

3) Compare the results of the simulations with the measured locations of the moisture and tritium fronts at various times during the field

experiment, to evaluate whether the predicted locations are in good agreement with the measured locations.

Interim Deliverable:

- Submit draft report on Jornada Site simulations to Westinghouse by 15 June 1990 for review and comment

Milestone:

- Submit revised report on Jornada Site simulations to Westinghouse by 31 August 1990 for approval (Milestone 0603)

WBS 07 UNCERTAINTY ANALYSIS TECHNOLOGY ($140K)

The results from deterministic simulation of fluid flow and contaminant transport in natural and engineered systems do not readily convey the uncertainty in model input parameters. The relative values of such output variables as water contents and concentrations would be much more useful to regulators if accompanied by an estimate of the uncertainty; e.g., the standard deviation of the model output. With deterministic models, one way to gauge the uncertainty is to make repeated simulations using a realistic range of values of the input parameters, then summarizing the results and generating statistics on the output. The objective of this task is to develop techniques to estimate the uncertainty of model output variables.

During FY 1989, PNL developed a modularized computer subroutine for Monte Carlo sampling of the ranges of input parameter values for the PORFLO-3 Version 1.0 computer code. This stochastic analysis version of the PORFLO-3 code is termed PORMC-3 Version 1.0. In FY 1990, this task will focus on PORMC-3 code testing and documentation, and on development of software for statistical processing of PORMC-3 input and output.

WBS 0701 PORMC-3 Version 1.0 Debugging and Testing ($60K)

The objective of this task is to debug and test PORMC-3 Version 1.0 using a problem published in the December 1988 edition of Water Resources Research. PNL is to draft a journal article that describes the capabilities of the PORMC-3 Version 1.0 computer code, the test problem(s) for which simulations were made, and the results of the simulations.

Interim Deliverable:

- Submit draft journal article on PORMC-3 Version 1.0 testing to Westinghouse by 30 March 1990 for review and comment

Milestone:

- Submit revised journal article on PORMC-3 Version 1.0 testing to Westinghouse by 15 May 1990 for approval (Milestone 0701)

WBS 0702 PORMC-3 Version 1.0 Documentation ($30K)

The objective of this task is to document PORMC-3 Version 1.0. PNL is to revise the existing User's Guide and Theory Manual for PORFLO-3 Version 1.0 to reflect the changes engendered by addition of the stochastic analysis capabilities.

Interim Deliverables:

- Submit draft User's Guide for PORMC-3 Version 1.0 to Westinghouse by 1 August 1990 for review and comment
- Submit draft Theory Manual for PORMC-3 Version 1.0 to Westinghouse by 1 September 1990 for review and comment

Milestones:

- Submit revised User's Guide for PORMC-3 Version 1.0 to Westinghouse by 30 August 1990 for approval for publication (Milestone 0702-A)
- Submit revised Theory Manual for PORMC-3 Version 1.0 to Westinghouse by 28 September 1990 for approval for publication (Milestone 0702-B)

WBS 0703 Statistical Analysis Processors for PORMC-3 Version 1.0 ($50K)

Because of the large amount of information produced by PORMC-3 Version 1.0 (or, for that matter, any stochastic code), a post-processor software package is needed for statistical analysis of the output data. Similarly, a pre-processor software package is needed to assign probability distributions to the input data. The objective of this task is to provide the support codes necessary to use PORMC-3 efficiently.

In FY 1990, PNL is to evaluate the suitability of existing pre- and post-processor statistical packages and determine their availability for acquisition. The appropriate software is to be developed, and/or acquired and modified, for interfacing with PORMC-3 Version 1.0. PNL is to draft a User's Guide to the statistical analysis software for PORMC-3 Version.

Interim Deliverable:

- Submit draft User's Guide for statistical analysis software for PORMC-3 Version 1.0 to Westinghouse by 30 June 1990 for review and comment

Milestones:

- Submit revised User's Guide for statistical analysis software for PORMC-3 Version 1.0 to Westinghouse by 30 July 1990 for approval for publication (Milestone 0703-A)
- Transmit copies of statistical analysis software by 31 July 1990 to Westinghouse and the computer code archive for the HSPA project (Milestone 0703-B)

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HANFORD SITE PERFORMANCE ASSESSMENT PROJECT
WORK BREAKDOWN STRUCTURE - FY 1990
COST AND PERSONNEL

WBS	Cost[a]	Title	Personnel[a]
01	$75K	HSPA PROJECT MANAGEMENT	MJ Fayer
0101	$45K	Project Management	MJ Fayer, TL Kogan
0102	$30K	Presentation Support	MJ Fayer, CT Kincaid, GW Gee, TL Kogan
02	$75K	HSPA DATA BASE MAINTENANCE AND CONTROL	PM Fangman
0201	$50K	MicroVAX Hardware & Software Maintenance	PM Fangman
0202	$25K	HSPA Data Base Control	PM Fangman, MJ Kanyid, D Felmy
03	$210K	SITE-SPECIFIC RECHARGE DATA	MJ Fayer
0301	$130K	Field Site Monitoring and Maintenance	MJ Fayer, MJ Kanyid, D Felmy, ML Rockhold, OB Abbey
0302	$80K	Isotopic Evaluation of Recharge	EM Murphy, J Szecody, GW Gee
04	$100K	CONTAMINANT-SEDIMENT INTERACTIONS	RJ Serne
0401	$100K	Sorption and Diffusion Data For Contaminated Soils	RJ Serne, VL LeGore, CW Lindenmeier, EA Fairweather
05	$60K	NEAR-SURFACE WATER BALANCE	MJ Fayer
0501	$60K	Simulations of the BWTF and Grass Site	MJ Fayer, ML Rockhold, SO Link
06	$150K	GROUNDWATER FLOW AND CONTAMINANT TRANSPORT	JL Smoot
0601	$50K	PORFLO-3 Version 2.0 Debugging & Testing	JL Smoot, M Connelly
0602	$40K	PORFLO-3 Version 2.0 Documentation	B Sagar
0603	$60K	Simulation of Jornada Site Data	ML Rockhold

(a) Concurrence from Westinghouse is to be obtained on the replacement for any Task manager

HANFORD SITE PERFORMANCE ASSESSMENT PROJECT
WORK BREAKDOWN STRUCTURE - FY 1990
COST AND PERSONNEL
(continued)

WBS	Cost[a]	Title	Personnel[a]
07	$140K	UNCERTAINTY ANALYSIS TECHNOLOGY	JD Smyth
0701	$60K	PORMC-3 Version 1.0 Debugging & Testing	JD Smyth, CS Simmons, P Eslinger
0702	$30K	PORMC-3 Version 1.0 Documentation	B Sagar
0703	$50K	Statistical Analysis Processors for PORMC-3 Version 1.0	P Eslinger, B Sagar
	$810K	Total Expenditures for FY 1990	

(a) Concurrence from Westinghouse is to be obtained on the replacement for any Task manager

HANFORD SITE PERFORMANCE ASSESSMENT PROJECT
CONTROL SCHEDULE AND MILESTONE DESCRIPTION - FY 1990

Task Element	Milestone ID	Due Date	Milestone Description[a]
WBS 0202	0202	29 Dec 1989	Notify WHC of the current contents of the HSPA data base
WBS 0301	0301	28 Sep 1990	Submit report on status of field site monitoring to WHC for approval
WBS 0302	0302	15 May 1990	Submit test plan for isotopic analysis of recharge to WHC for approval
WBS 0401	0401	28 Sep 1990	Submit report on contaminant-sediment interaction tests to WHC for approval
WBS 0501	0501-A	1 Feb 1990	Provide documentation to WHC that UNSAT-H Version 2.0 has been successfully installed on the Hanford Site Cray XMP computer
	0501-B	15 May 1990	Submit report on simulations of the BWTF and Grass Site to WHC for approval
WBS 0601	0601	16 Jul 1990	Submit journal article on PORFLO-3 Version 2.0 testing to WHC for approval
WBS 0602	0602-A	2 Jul 1990	Submit User's Guide for PORFLO-3 Version 2.0 to WHC for approval
	0602-B	1 Aug 1990	Submit Theory Manual for PORFLO-3 Version 2.0 to WHC for approval
WBS 0603	0603	31 Aug 1990	Submit report on Jornada Site simulations to WHC for approval
WBS 0701	0701	15 May 1990	Submit journal article on PORMC-3 Version 1.0 testing to WHC for approval
WBS 0702	0702-A	30 Aug 1990	Submit User's Guide for PORMC-3 Version 1.0 to WHC for approval
	0702-B	28 Sep 1990	Submit Theory Manual for PORFLO-3 Version 1.0 to WHC for approval

(a) Westinghouse approval entails signature by the cognizant engineer of the Environmental Technology Group on the PNL clearance form.

HANFORD SITE PERFORMANCE ASSESSMENT PROJECT
CONTROL SCHEDULE AND MILESTONE DESCRIPTION - FY 1990
(continued)

Task Element	Milestone ID	Due Date	Milestone Description[a]
WBS 0703	0703-A	30 Jul 1990	Submit User's Guide for statistical analysis software for PORMC-3 Version 1.0 to WHC for approval
	0703-B	31 Jul 1990	Transmit a copy of the statistical analysis software for PORMC-3 Version 1.0 to WHC and the HSPA data base

(a) Westinghouse approval entails signature by the cognizant engineer of the Environmental Technology Group on the PNL clearance form.

REFERENCES

Case, J. J. and M. D. Otis. 1988. Guidelines for Radiological Performance Assessment of DOE Low-Level Radioactive Waste Treatment, Storage or Disposal Sites. DOE/LLW-62T, EG&G Idaho, Inc., Idaho Falls, Idaho.

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U. S. Department of Energy-Richland Operations Office (DOE/RL). 1988. Hanford Waste Management Plan. DOE/RL 88-33, DOE/RL, Richland, Washington.

U. S. Department of Energy-Richland Operations Office (DOE/RL). 1987. Hanford Waste Management Technology Plan. DOE/RL 87-14, DOE/RL, Richland, Washington.

U. S. Department of Energy-Headquarters (DOE/HQ). 1988. Guidance for the Conduct of Waste Management Systems Performance Assessment. DOE/LLW/63T, EG&G Idaho, Inc., Idaho Falls, Idaho.

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Author	Addressee	Correspondence No.
R. A. Carlson, WHC	R. D. Freeberg, DOE-RL	9000286B R1

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