ATLANTIC RICHFIELD HANFORD COMPANY

QUARTERLY REPORT

PROCESS TECHNOLOGY AND PROCESS DEVELOPMENT

JULY 1976 THROUGH SEPTEMBER 1976

Research and Engineering Division

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ABSTRACT

This quarterly report is the second in a series intended to provide information on research and engineering activities being performed to improve the processing of irradiated reactor fuels, the production of plutonium, and the management of resultant chemical wastes. The work reported here was performed during the period July through September 1976.

ATLANTIC RICHFIELD HANFORD COMPANY
QUARTERLY REPORT
PROCESS TECHNOLOGY AND PROCESS DEVELOPMENT

INTRODUCTION

This report describes the scientific investigations and engineering application programs being sponsored by the Energy Research and Development Administration (ERDA) under the direction of the Research and Engineering Division of the Atlantic Richfield Hanford Company (ARHCO).

This report presents summaries of technical progress. Brief statements of objective and prior work introduce individual portions of the report and appear in a type style different from that used to describe progress during the report period. The ERDA Division of Environmental Control Technology sponsors the mission entitled "Management of Surplus Facilities and Equipment;" other missions are sponsored by the Division of Nuclear Fuel Cycle and Production.

Previous periodical reports covering segments of this report's subject material were published as ARH-ST-110 A through D, ARH-ST-132 A through C, ARH-ST-128 A and B, ARH-ST-139, ARH-LD-111 A through E, and ARH-LD-149 A.

FUEL CYCLE RESEARCH AND DEVELOPMENT

WASTE MANAGEMENT (COMMERCIAL)

The overall objective of the Commercial Waste Management mission is to develop and demonstrate the necessary technology and capability to safely maintain custody of commercial radioactive wastes so that they are not a threat to man and his environment now or in the future. The Commercial Waste Management program covers a broad spectrum of radioactive wastes generated by facilities such as fuel fabrication plants, fuel reprocessing plants, and nuclear power reactors. It includes such processes as waste treatment, packaging, shipping, and interim and final storage.

TERMINAL STORAGE

Documentation of Geological Studies on Columbia River Basalts at Hanford - R. A. Deju

In 1968 Atlantic Richfield Hanford Company initiated a series of programs to assess the feasibility of storing radioactive wastes in Columbia River basalts. The programs were suspended in 1972. In 1976, as part of the National Waste Terminal Storage Program, the data collected during the period 1968-72 were compiled and will be documented ("Preliminary Feasibility Study on Storage of Radioactive Wastes in Columbia River Basalts," ARH-ST-137).

As a result of the work performed to date, the geology of the Columbia River Physiographic Province is reasonably well understood. The properties of the flood basalts in this area have been studied extensively using petrographic, geophysical, and geochemical techniques. The preliminary stratigraphy of the Pasco Basin has been developed from analyses of samples obtained by drilling deep coreholes on the Hanford Reservation and by sampling and mapping sections exposed on the sides of anticlines and in river gorges. The formations within the Columbia River Basalt Group have been identified.

Hydrologic studies of the Columbia River Basalt Physiographic Province have led to an understanding of the regional hydrologic regime. Some of the basaltic interbeds are water producers isolated from one another by extensive flow units. The chemical and hydrologic properties of these interbeds appear to be distinct. Some of the basalt flow units are as much as 50 meters thick, and are quite impervious since nearly all joints and fractures are filled with secondary minerals such as nontronite and beidellite. These thick basalts may represent hydrologically isolated units.

The engineering feasibility of building an underground cavern into the Columbia River Basalts has not been evaluated; however, studies were made regarding the extent of heat dissipation from radioactive wastes stored in such a cavern. These studies have shown that the maximum cavern temperature decreases with (1) increasing cavern radius, (2) wider cavern spacing, (3) fewer adjacent caverns, (4) higher thermal conductivity of the surrounding medium, (5) shorter half-life of the radioactive waste products, and (6) lower heat generation rates per volume of the wastes.

Geochemical studies were also initiated to identify those factors that need to be considered in order to set

criteria for a waste form that is acceptable for storage in a basalt cavern. These studies attempted to identify the factors needed to evaluate the stability of various waste forms, their solubility, and their compatibility with the basalt.

The Columbia River basalts have also been studied with respect to tectonic deformation and behavior under stress. Preliminary earthquake and tectonic studies have led to stability considerations which can be used for formulating criteria for the construction of a prototype facility.

The work done to date was reviewed by a panel of scientists and engineers. The recommendations of the panel have been incorporated in the plan for additional final storage studies.

SUPPORTING STUDIES - RESEARCH AND DEVELOPMENT

Sealed Storage Cask Demonstration - D. C. Nelson, Program Manager

The Federal Government is required to assume permanent custody of all high-level radioactive waste within ten years of its generation by the commercial nuclear industry. Final waste storage sites and methods are under development by the Energy Research and Development Administration (ERDA). In the event that these final storage facilities are not available when waste deliveries begin, above-ground storage in a Retrievable Surface Storage Facility (RSSF) may be required to provide interim storage until final storage facilities are established. Atlantic Richfield Hanford Company has studied various interim storage concepts and is currently conducting engineering and demonstration programs to verify the feasibility of the Sealed Storage Cask Concept (SSCC) - concrete-shielded steel casks placed outdoors and cooled by natural

air circulation - as an interim storage concept. After completion of design verification in fiscal year 1977, a demonstration unit containing radioactive waste will be put in service in FY 1978.

Conceptual Design Support Studies - J. M. Davis,
J. R. LaRiviere, E. L. Moore, G. W. Wilson

A demonstration unit has been built and activities are being conducted to evaluate the integrity and feasibility of the Sealed Storage Cask Concept (SSCC). Important phases of this program are: (1) verification of heat transfer and radiation shielding calculations through tests with a sealed storage cask (SSC) demonstration unit equipped with an electric heater to simulate decay heat from the waste, (2) evaluation of the structural integrity of the storage cask, (3) evaluation of canister decontamination techniques as a means of establishing acceptable contamination levels for the outer surfaces of waste-filled canisters received by the RSSF, (4) investigation of surveillance methods to assure waste containment during storage, (5) evaluation of canister and cask handling methods, and (6) fabrication of an SSC to be loaded with radioactive waste to demonstrate the feasibility of the concept. Phases 1 through 5 are currently in progress while phase 6 has not yet been initiated.

Design Verification

No progress has been made in continuing the heat transfer design verification testing on the SSC demonstration unit. The striking members of the Hanford Atomic Metal Trades Council returned to work during this report period, but the large backlog of maintenance work which had accumulated during the strike has prevented the repairs from being made on the heater.

Structural Evaluation

The ARHCO report that summarizes all the various studies performed to select a final closure configuration for the SSC was completed and will be issued. Using the results of the studies, four major selection criteria were employed to rank the closure configurations as to desirability. These were: (1) weldability, (2) ease of non-destructive examination, (3) ability to survive a threat to structural integrity, and (4) economics and hot cell operation. By following a procedure described in the report, the corner weld closure was ranked as most desirable. Ranked in decreasing order of desirability were the threaded plug and seal weld closure, the full penetration circumferential butt-weld closure and the multiplate closure.

The corner weld closure and the threaded plug and seal weld closure were selected for further structural analyses. These structural analyses will be quantitative rather than the qualitative evaluations performed on the four closure configurations during the initial studies. This work should be completed during the next report period.

Decontamination Evaluation

Battelle-Northwest is continuing their testing of Waste Solidification Engineering Prototype (WSEP) canisters in the mini water basin equipment. The first run was invalidated by a malfunction of the ion exchange system, but the second run is proceeding smoothly. No results are as yet available.

Battelle-Northwest has submitted a preliminary proposal for continuing the decontamination studies, using empty capsules similar in size to those used by ARHCO to encapsulate

cesium and strontium salts. They propose to contaminate them with real high-level waste calcine and with a calcine-glass making frit, heat them in a furnace to glassmaking temperatures, and then evaluate various decontamination methods. This would more closely approximate the Fuels Reprocessing Plant situation, and should produce decontamination information which will be more directly usable. The proposal is currently being evaluated.

Storage Area Surveillance

Hanford Engineering Development Laboratory (HEDL) has completed work on the design, fabrication, and testing of Geiger-Muller nuclear radiation detectors for surveillance of individual SSC integrity. The goal of this activity is to develop a reliable design for a surveillance radiation detector for the SSC concept. The detectors should function unattended for long periods of time and should provide suitable signals to alert personnel to increases in detected radioactivity caused by a breach in an individual SSC within the facility.

A report on the evaluation of the detector operation has been completed by HEDL, and it will be transmitted to ARHCO early in October. Upon receipt of this report the task will be terminated.

Demonstration of Remote Welding and NDE

Work has begun on a task whose objective is to demonstrate that the storage cask can be remotely welded, using the corner weld closure design, and that the weld can be nondestructively examined using the ultrasonic technique developed by BNW.

A test weld has been made for BNW to use in developing a transducer support system, and plans are underway for setting up a mockup hot cell in which the welding demonstration will be conducted. Procurement action has been started for a cask support and rotating device.

Evaluation of Canister and Cask Handling

A program is being conducted to develop a system capable of handling canisters and casks as they are processed in an SSCC facility.

Program objectives are to design, fabricate, and demonstrate a sealed container handling mechanism during FY 1977.

A draft of Preliminary Functional Design Criteria has been prepared and issued for comment. Conceptual design of the handling system has been initiated.

Design and fabrication of a sealed container handling mechanism are planned for next quarter.

SPECIAL STUDIES

Nuclear Regulatory Commission S-3 Task Force on Waste Management Impact for Reactor Licensing - J. R. LaRiviere

The Nuclear Regulatory Commission formed the S-3 Task Force in August to provide a thorough new staff analysis of the environmental impact of fuel reprocessing and waste management associated with individual nuclear power plants. This action was taken as a direct result of two July 21 decisions of the U. S. Court of Appeals for the District of Columbia circuit. The court held that the present rule, governing how the Commission considers the impact of reprocessing and waste disposal in its reactor licensing process, must be more fully documented and explained.

At the request of Energy Research and Development Administration, ARHCO personnel have been assigned to assist in providing the technical information and environmental analysis for the interim storage of solidified high-level waste at the fuel reprocessing plants; interim storage of solidified high-level waste at a central Federal repository; and treatment of noncombustible transuranic waste.

ARHCO personnel have been requested to be technical witnesses, if needed, at the hearings on this subject which will probably be held in Washington, D. C. in December 1976 or January 1977.

Generic Environmental Impact Statement - R. A. Kennedy

Atlantic Richfield Hanford Company has been asked to participate in the preparation of the "Generic Environmental Impact Statement for Managing Radioactive Wastes From Commercial Reactors and Post-Fission Operations in the LWR Fuel Cycle (GEIS)." The document preparation is being coordinated by Battelle-Northwest with ARHCO preparing sections on the following subjects:

- Failed Equipment and Noncombustible Scrap Treatment
- Waste Solvent Treatment
- Intermediate and Low-Level Liquid Waste Treatments
- Interim Storage of Solidified High-Level Waste at the Fuels Reprocessing Plant
- Contingency Plan of an RSSF for Interim Storage

The first three sections were completed in draft form and transmitted to BNW on October 1, 1976. The other sections were delayed because key personnel were diverted to higher priority work on the Nuclear Regulatory Commission S-3 Task Force.

The GEIS is in an early stage of development and substantial revisions are to be expected as the document develops. ARHCO will continue to be involved in the GEIS preparation during the development and revision period.

SEPARATIONS, PRODUCTION, AND SCRAP RECOVERY

SEPARATIONS - PUREX

The objective of this program is to provide technical support for reprocessing N-Reactor Fuel at Purex to recover uranium, plutonium, and neptunium while adhering to the environmental release requirements. The flowsheet, technical manual, and development of monitor and automatic control systems for the vacuum fractionator and process condensate recycle system are to be completed prior to plant startup (October 1978). Methods for control of NO_x and iodine-129 will be developed for possible installation during plant operation.

Flowsheet Development - D. A. Jeppson

The Purex flowsheet for reprocessing N-Reactor fuel was modified to include process modification since shutdown, changes in fuel to be processed, and control of release of radioactive material to the environment. Modifications to the process condensate recycle system were made and adopted into the updated flowsheet. Comments have been received from the rough draft and the flowsheet ARH-F-103, Purex Flowsheet -Reprocessing N-Reactor Fuels, is being issued.

Technical Manual Revision - D. A. Jeppson, G. L. Raab

The Purex Technical Manual is being revised to include Reprocessing of N-Reactor Fuel and to incorporate plant changes which have been adopted into the plant since initial startup. An outline of the manual has been completed.

Development of Monitor and Automatic Control Systems for the Process Condensate Recycle System - S. S. Koegler

Development of monitor and automatic control systems for the vacuum fractionator and HA Column scrub systems will enable the adoption of the process condensate recycle system to the plant. Nitric acid monitors and automatic controllers are being selected for pilot plant demonstrations of process applications.

Control of Iodine-129 During Fuel Reprocessing - D. M. Strachan

Pathways of ^{129}I to the environment during fuel reprocessing will be identified and methods for control of ^{129}I to acceptable limits will be developed. Recent samples of the Purex silver reactors, analyzed by Battelle-Northwest Laboratories, reveal that about 90 percent of the surface silver has reacted with chlorine and 10 percent with bromine. Less than 0.1 percent of the silver exists as silver iodide.

Further studies are in process to determine how the chlorine is getting to the silver reactor and if it can be eliminated.

PRODUCTION - Z PLANT

The program objective is to improve existing processes for recovering plutonium in order to reduce plutonium losses, waste produced, and cost.

Plutonium Oxide Sinterability Characteristics - A. L. Dressen

The purpose of this activity is to develop the technology to consistently produce sinterable PuO_2 for the Fast Flux Test Facility reactor development program.

Continuance of the Hanford Atomic Metal Trades Council strike and the recent 242-Z incident delayed plant production of PuO_2 during this quarter. Examination of PuO_2 powder characteristics will be conducted as plant material becomes available.

Bench scale equipment for semicontinuous production of PuO_2 has been fabricated and is ready for glovebox installation. The bench scale tests call for evaluating the operating parameters of feed adjustment, precipitation and calcination which have important effects on powder characteristics and sinterability. The oxide characteristics program has been divided into two parts. The evaluation of plant PuO_2 portion is six months behind schedule. The bench scale oxide line is currently on schedule but is expected to fall behind about three to six months because of limited glovebox space and availability of staff. The program milestone date of third quarter fiscal year 1977 for implementing process technology needs revision.

Z Plant Waste Solidification - D. A. Reynolds,

M. J. Schliebe

The purpose of this activity is to develop a concentrating and drying process for conversion of Plutonium Reclamation Facility (PRF) high salt waste to a solid suitable for retrievable transuranic storage.

A thermal concentrator-drum dryer system has been developed for converting PRF liquid waste to solid waste. Work during the previous period determined (1) materials of construction that were resistant to pit corrosion caused by the synthetic Z Plant waste and (2) the neutralized synthetic acid digester waste from the Hanford Engineering Development Laboratory prototype unit was satisfactorily converted to solids by the dryer.

During this quarter the effect of aluminum nitrate non-hydrate on drum dryer operation was evaluated. Aluminum nitrate with nine waters of hydration melts at about 70° C and in high concentrations produces a molten product. Dryer tests showed that a maximum mole ratio of aluminum to sodium of 0.6 could be tolerated and still produce an acceptable product. Higher aluminum ratios (0.8) gave a molten product that caused operating problems.

The drum dryer final report is in preparation with the program milestone date met.

Solvent Extraction Model - L. A. Fort, M. J. Klem

The purpose of this activity is to develop a mathematical model of the PRF solvent extraction system using the SEPHIS computer program.

Previous computer results for evaluating trichlorobenzene (TCB) as a replacement diluent for carbon tetrachloride (CCl_4) showed that under conditions identical to the standard plutonium(IV) flowsheet, extraction column losses would double and stripping column losses would decrease a factor of 10.

During this quarter, the SEPHIS program was again altered for evaluating tetrachloroethylene (TCE) diluent. Both TCB and TCE are more radiation-resistant than CCl_4 . Results show that extraction column losses would decrease a factor of 1,000 while stripping column losses would increase a factor of 200. The computer results for a plutonium(III) flowsheet (no uranium present) and the standard plutonium(IV) flowsheet are listed in Table I for CCl_4 , TCB, and TCE diluents.

TABLE I

EXTRACTION RESULTS ALTERNATE DILUENT FLOWSHEET

Column waste stream	<u>CCl₄</u>		<u>TCB</u>		<u>TCE</u>	
	Pu(III)	Pu(IV)	Pu(III)	Pu(IV)	Pu(III)	Pu(IV)
Extraction, mg Pu/l	0.1	2	0.04	4	0.001	0.002
Stripping, mg Pu/l	0.2	3	0.05	0.3	8	6.00

The results show that trichlorobenzene more closely resembles the CCl₄ system than does tetrachloroethylene at standard conditions.

Future plans call for further evaluation of both diluents at different flowrates and stream compositions. The program milestone date of first quarter FY 1977 of selecting a new diluent based on extraction characteristics is on schedule. Work will be delayed on modeling and documenting the standard plutonium-uranium partitioning flowsheet.

Waste Treatment Columns - M. J. Klem, C. E. White

The purpose of this work is to develop improvements in the continuous Waste Treatment Facility equipment and flowsheet for improved solvent extraction recovery of americium and plutonium.

Analyses of the Waste Treatment Facility extraction column have shown that more americium can be recovered by reducing the aqueous-to-organic flow ratios than by maintaining the same flow ratios and the addition of two extraction stages. The flow ratio change versus a proposed new extraction column system represents a shift in emphasis on improving americium recovery.

During this quarter pilot column waste losses and concentration profiles were determined for different operating conditions. The laboratory problem of analyzing for cerium (III) [substitute for americium(III)] has been reduced, thereby permitting easier evaluation of test data.

Future plans call for improving pilot column efficiencies by varying flowrates, pulsing conditions, types of column packing material, different sieve and nozzle plates and using new process solvents. The program milestone date of first quarter FY 1978 is on schedule.

SCRAP RECOVERY - Z PLANT

Plutonium Scrap Dissolution - C. E. White

The purpose of this work is to develop optimum dissolution and/or leaching conditions compatible with PRF operations for recovery of plutonium from scrap.

Testing of the prototype plutonium scrap dissolver under laboratory conditions was started using inerts to simulate PuO_2 . The dissolver solution flowrate was dependent on the vertical movement of solids in the settling zone of the dissolver.

During this quarter, the splashing action at the top of the dissolver was reduced by use of smaller air sparge jets. A solids cleanout port was installed permitting easy removal of undissolved residue.

Future plans call for completing capacity tests and determining the volume of residual solids for different types of synthetic scrap feed (criticality prevention requirement). The dissolver is then to be relocated in a glovebox for test dissolution of plutonium scrap. The program milestone date of first quarter FY 1977 may need revision due to equipment installation time.

Plutonium Scrap Processing

Bidentate Extraction - W. W. Schulz, D. G. Bouse

Unlike commonly-used monodentate extractants [e.g., tributylphosphonate (TBP) and dibutylbutylphosphonate (DBBP)], bidentate organophosphorus reagents, such as dihexyl-N,N-diethyl-carbamylmethylene phosphonate (DHDECMP), extract both Am^{3+} and Pu^{4+} strongly from concentrated nitric acid solutions. The objective of this activity is to develop a DHDECMP solvent extraction process to recover americium and plutonium directly from the acidic ($\sim 2\text{M}$ HNO_3) waste stream produced in the Hanford Plutonium Reclamation Facility (PRF) operations, thereby avoiding the tedious and difficult pH adjustment step required in the presently-used DBBP waste treatment extraction scheme. An important milestone for this activity is to complete all scheduled laboratory work by the end of Fiscal Year 1977; this milestone is on schedule.

Resin Purification of DHDECMP Extractant

Commercially-available DHDECMP contains an unidentified acidic impurity which seriously interferes with dilute HNO_3 (0.1-0.25M) stripping of americium from DHDECMP-trichlorobenzene (TCB) solutions. Various more or less effective solvent purification procedures - hydrolysis with 6M HCl at 60°C , extensive washing with ethylene glycol, and vacuum distillation - have been previously devised and tested. This quarter a new procedure for purifying 30 percent DHDECMP-TCB solvent was devised and extensively tested with good success. This procedure involves washing the 30 percent DHDECMP solvent once with an equal volume of ethylene glycol

at $\sim 25^{\circ}$ C followed by passage of the washed solvent through a bed of OH-form Amberlyst A-26 resin. (Amberlyst A-26 resin is a macroreticular strong base anion exchanger made by the Rohm and Haas Co.) Capacity runs, with ethylene glycol washed 30 percent DHDECMP solvent from several sources, demonstrate that a bed of the A-26 resin will satisfactorily purify 20-25 column volumes of solvent before breakthrough of the acidic impurity. The loaded resin bed can be regenerated with 1-2M NaOH. Present indications are that the ethylene glycol wash - A-26 resin procedure is a simple, reliable, and efficient purification scheme which can be satisfactorily scaled up for use in the Hanford PRF.

Mixer-Settler Flowsheet Tests

Good progress continues to be made toward a primary goal of this work which is to devise and demonstrate a 30 percent DHDECMP Am-Pu extraction process that can be used in the same equipment as the present DBBP process. Previous mixer-settler runs have been aimed at defining flowsheet conditions for the extraction (E1) and Am partition (S1) columns of the DHDECMP process. Current runs are directed toward testing various flowsheet conditions for stripping of plutonium from the 30 percent DHDECMP solvent with dilute HNO_3 -HF solutions. The most recent stripping column (S2) runs have employed four or six mixer-settler stages, an S2X composition of 0.1M HNO_3 -0.25M HF, and an aqueous:organic flow ratio of 0.4. These conditions suffice to remove 80 to 90 percent of the plutonium from a 30 percent DHDECMP-TCB solvent (purified by ethylene glycol washing) originally containing 0.07M HNO_3 and ~ 0.1 g/liter Pu. This degree of

plutonium removal is judged satisfactory for plant process operation. With the present DBBP process, 20-40 percent of the plutonium is recycled in the S2W (organic) stream back to the E1 column.

Batch and limited mixer-settler tests indicate HNO_3 -HF solutions strip Pu(IV) more effectively from 30 percent DHDECMP-TCB solvent purified by HCl hydrolysis than from ethylene glycol washed extractant. Such tests also indicate that stripping of plutonium from DHDECMP solutions is adversely affected by prior contact of the solvent at 50° C with either water or 0.1M HNO_3 . The reason for this peculiar behavior is not known.

Computer-Assisted Flowsheet Tests

The computer program SOLVEX, recently developed at the Savannah River Laboratory, was successfully modified for operation from a remote terminal in the 222-S Building. Efforts are now underway to further modify the program for simple entry of distribution data.

Future Work

Tests next quarter will emphasize mixer-settler runs with Amberlyst A-26 resin purified 30 percent DHDECMP-TCB. Supplementing these runs, the SOLVEX program will also be used to test various flowsheet conditions.

CURRENT WASTE MANAGEMENT (DEFENSE)

WASTE FRACTIONIZATION

The waste fractionization program is designed to improve strontium recovery, cesium recovery, and purification process performance. Increased process efficiency will reduce strontium and cesium waste losses and cut processing costs at B Plant.

B PLANT EXTRACTION AND PURIFICATION

STRONTIUM RECOVERY - J. H. Gehrke, J. S. Buckingham

Solvent Extraction Computer Model

A solvent extraction model has been developed to provide an accurate and convenient means for B Plant solvent extraction flowsheet modification and an engineer training tool. Work on the solvent extraction computer model is essentially complete. Some modifications were made during the report period to make the computer program easier to use and results more easily understood. The model has been useful in engineer training.

Solvent Extraction of Sulfate Rework

A laboratory and plant test program to reduce solvent extraction strontium losses on sulfate-containing rework to less than five percent is nearly complete. A plant process test was initiated at the end of the report period. First indications are that the test was successful in maintaining acceptable strontium losses while processing sulfate purification rework feed with high sulfate concentrations. If the process test is successful in the final evaluation, no further work is planned.

Current Acid Waste Flowsheet

The effort to document the Current Acid Waste Strontium Recovery flowsheet continues. A review of solvent extraction technology for strontium recovery from Current Acid Waste (CAW) is in progress. The basic form of the flowsheet will depend on the results of the cesium recovery from CAW program. Strontium recovery prior to cesium removal appears most promising.

STRONTIUM PURIFICATION - J. H. Gehrke, J. S. Buckingham

First Sulfate Strike

Efforts to decrease the strontium waste losses from the first strike of the sulfate purification process continue. Previous laboratory tests were unable to reduce strontium losses during the first strike of the purification process itself. A lead carrier precipitation process was developed and laboratory tested, which recovered 90 percent of the strontium from the first strike waste. With the laboratory program completed, the lead carrier precipitation will be process-tested during the next three months.

A second phase of the program is to reduce the strontium waste losses from the metathesis step of the sulfate purification process. Laboratory tests have been conducted to measure the effect of some process variables on the centrifugation efficiency and the resulting losses of strontium solids. An evaluation of the laboratory study is not yet complete and will determine if additional work is necessary.

REMOVAL OF CESIUM BY ION EXCHANGE - J. H. Gehrke, R. F. Carlstrom, J. S. Buckingham

The objective is to provide an accurate description of Cesium Ion Exchange recovery through a flowsheet document, test various ion exchange resins, and develop an ion exchange computer program.

Ion Exchange Flowsheet

A preliminary flowsheet has been submitted for review at this time and after subsequent reviews and revisions, the final flowsheet will be submitted for approval and publication. The Ion Exchange flowsheet will be used for later development of the Current Acid Waste flowsheet.

Ion Exchange Resins for Removal of Cesium from Current Acid Waste

Various ion exchange resins are being tested as to their ability to remove cesium from CAW. The Chemical Technology Laboratory has investigated various zeolite resins and final data results will be available soon. The report document for the investigation is in its final stages of preparation. With evaluation of the Chemical Technology Laboratory report, Development Engineering will set up a pilot plant project to test the recommended resin and use the results for development of the CAW flowsheet. The design of the system to test the resin has been completed and procurement of necessary equipment is in the preliminary stages. Upon completion of the system for testing the resin and evaluation of the report, pilot plant testing will begin.

Ion Exchange Computer Program

A computer model and program for ion exchange cesium recovery and purification process control is being developed. Ion exchange technology is being reviewed for a chemical and mathematical model. The development of the computer program will be aimed at CAW processes as the new CAW flowsheet will include cesium recovery by ion exchange. Review of ion exchange technology will continue next quarter and initial development of the computer model will begin.

ENCAPSULATION

The purpose of this program is to provide the process technology necessary to solve equipment and process problems existing in the Waste Encapsulation and Storage Facility (WESF). New equipment will be developed to replace unreliable plant equipment so encapsulation production goals can be met.

Tilt-Pour and Pan-Dry Cesium Equipment - J. D. Moore

Development of equipment for achieving desired WESF rates for solidification and encapsulation of cesium chloride is in progress. In tests with full-scale equipment, the tilt-pour melt-caster was judged to be more promising for development than the pan dryer. Consequently, emphasis has been placed on tilt-pour equipment development with completion anticipated by December 15, 1976. The pan-dryer development completion date has been postponed until May 15, 1977.

In tilt-pour equipment tests conducted in the last quarter, successful transfer of molten salt to storage capsules was demonstrated in each of the nine tests attempted. Modification of the capsule holder to provide a better capsule-to-melter seal is in progress. Corrosion resistance of the Hastelloy G melter to molten cesium chloride has been excellent during the 12 tests conducted to date.

Progress toward modification of the pan dryer stirrer system has been slowed by lack of drafting services for completion of design drawings.

In the next quarter, development of the tilt-pour equipment will be completed following remote operation in a test station equipped with hot cell manipulators. A new stirring system will be installed in the pan dryer and testing will be started.

Capsule Decontamination by Electropolishing - D. W. Jeppson

Capsule decontamination by electropolishing has been developed to reduce the in-cell processing time required to decontaminate capsules of strontium fluoride and cesium chloride. The in-cell equipment has been developed and had final cold-testing in the laboratory and cell mockup. The rough draft of the development report has been issued and the final report is being prepared. The rough draft of the safety analysis report has been completed.

Hot Pressing of Strontium Fluoride - D. W. Jeppson

Hot pressing of strontium fluoride is being developed as an alternative process for encapsulating strontium fluoride at WESF. This process will require less in-cell maintenance than the current process and result in increased processing rates. Additional test specimens have been prepared by pressing at 1100° C. Evaluations of these test specimens pressed at lower temperatures will be made.

Alternate Product Forms for Encapsulation - D. M. Strachan

Laboratory studies are in progress to synthesize strontium and cesium compounds which meet criteria for materials suggested for ultimate storage of radioactive wastes. To this end, several preparative routes to strontium orthosilicate (Sr_2SiO_4) were investigated during the last quarter. Attempts to prepare Sr_2SiO_4 were made using sodium metasilicate, Ludox (DuPont Corp., Delaware) and Quram (Philadelphia Quartz, Pennsylvania) as silica sources. Quram is a quaternary ammonium silicate. Ludox is a colloidal silica which is stabilized in a variety of solutions. Of the routes

studied, precipitation of the strontium as the carbonate, followed by mixing with Ludox, drying and firing to 1373° K was the best route to Sr_2SiO_4 . Based on the known solubilities, precipitation of strontium as the carbonate should lower the strontium losses by a factor of 10 relative to precipitation as the fluoride.

Synthesis of strontium orthotitanate (Sr_2TiO_4) using an organic titanate was unsuccessful.

In the next quarter, work will continue with Sr_2SiO_4 synthesis as job priorities permit. The completion date has been extended from January 1 to April 1, 1977, due to interferences from higher priority tasks.

WASTE CONCENTRATION

The objective of this program is to transform liquid high-level waste into less mobile solids, and to safely isolate these solids from the biosphere for an extended time.

Waste Solidification

Interstitial Liquor Removal - W. E. Ogren

The objective of this activity is to develop and demonstrate methods for removing as much interstitial liquid from Hanford waste storage tanks as is technically and economically practicable and to immobilize the residual liquid.

A draft of the test report for the Moyno pump using nonradioactive materials was issued for management review. Additional testing of the Moyno pump is not planned.

Theoretical and experimental studies into the feasibility of the capillary pump concept continued. The theoretical model describes laboratory scale experimental studies and is being used to determine the technical basis for pilot and full-scale application of the concept.

Evaluation of *in-situ* drying of waste in Hanford tanks resumed following the work stoppage. Scheduling of tanks to be tested and equipment movement to the tanks is underway.

The document, "Criteria-Waste Tank Isolation and Stabilization (ARH-CD-784)," was issued in September for implementation.

Residual Liquor Disposition - R. E. Van der Cook

The objectives of this activity are to develop and demonstrate processes for converting residual liquors to acceptable solids for interim storage, preferably in existing underground waste storage tanks.

The Double-shell Slurry Process Test at 242-S Evaporator-Crystallizer is scheduled for late November 1976. However, the double-shell tanks required for the process test may not be ready due to the work stoppage. Further delays in the process test impair ARHCO's capability to influence the number of FY 1977 double-shell tanks to be built.

A pilot plant double-shell slurry test confirmed batch laboratory tests and indicates that double-shell slurry is a workable process. Significant sodium aluminate supersaturation was attained under test conditions, even when some sodium aluminate precipitation occurred. Modest cooling, 10° F, of the slurry below process temperature resulted in nearly 100 percent solids. While this caused slurry line pluggage in the pilot plant, no problem is expected in the plant because the process cell is heated and the slurry lines are heat-traced.

The partial neutralization prototype at 242-S Evaporator-Crystallizer remains 50 percent complete. The work stoppage by pipefitters is impairing ARHCO's capability to reduce the volume of liquid waste stored in single-shell tanks.

A partial neutralization flowsheet problem was identified, prior to plant testing. Laboratory tests in the Chemical Technology Laboratory confirm that a significant portion of the dissolved NO_2 in concentrated nitric acid is converted to NO upon dilution. Based upon anticipated yields, 8 ppm of NO_x in the feed acid would result in about 1000 ppm of NO_x at EC-3 condenser. Currently, the best acid available contains up to 300 ppm of NO_x .

Laboratory tests indicate potassium permanganate added to the dilution water will effectively prevent NO_x evolution. Concentrated nitric acid currently costs about 50 cents per gallon. Permanganate treatment increases this cost by only about one cent per gallon of the nitric acid used. Flow-sheet documentation and equipment selection will proceed after additional laboratory evaluation tests.

Four unclassified documents concerning waste solidification (which are not yet available to the general public) were issued during this period.

Complexant waste disposition is being evaluated. Concentration, segregation and storage in a double-shell tank appears to be the best alternative at this time. Other alternatives appear less promising, although other options, such as oxidation or reaction with calcium hydroxide, may be possible for application at some future date.

Salt Cake and Sludge Characterization - G. K. Allen

The objective of this subtask is to obtain core samples of waste tank solids for the purpose of defining chemical and physical properties of the solids stored in waste tanks as a function of depth or strata.

Radioactive testing of the salt cake core driller resumed. Chemical analyses for the samples taken before the HAMTC strike are about 50 percent complete. Alternative means for speeding up the laboratory analyses are being considered.

Redox Organic Waste Disposal - L. Q. Fong

The objectives of this activity are to characterize the waste, define a disposal concept, install suitable equipment, and dispose of the organic waste stored in Tanks 276-S-141 and 276-S-142.

Funding restrictions do not permit work on this activity during FY 1977.

TANK FARM SURVEILLANCE AND MAINTENANCE - F. S. Strong, E. A. Vickery

The objectives of this program are to develop improved instrumentation and surveillance methods for waste tanks and transfer lines.

A contract was signed in April 1976 with the Boeing Company for the development of a soil conductivity prototype leak detection system. This system was to be installed on five tanks in the "A" Tank Farm complex to demonstrate that

the theory of operation developed under a previous research contract could be put into practice in an operating tank farm environment. Because of onsite labor negotiations, considerable program slippage has occurred. Initial tests of the second generation design conducted on Tank 241-AX-102 have been inconclusive. The development program was modified to investigate the problems encountered and improvements to the system have been made. New sensitivity tests are scheduled for December 6, 1976, using revised electrode spacings. This work is currently only partially funded for FY 1977.

The first demonstration "in-place" gamma monitoring system is now essentially complete. Initial laboratory operating tests have been successful. The system is comprised of remotely monitored sensitive GM type gamma detectors located at intervals within a dry well casing in such a way that use of the dry well for scanning by conventional equipment can continue as required. The in-place detectors are sequentially scanned by a computer-controlled counting system. The computer performs a statistical analysis on the data received and provides an alarm where a problem or a trend exists. The demonstration system can scan 45 detectors located up to two-thirds of a mile away. It was originally scheduled for an initial test installation in nine selected dry wells surrounding Tank 241-SX-108. Due to lack of onsite contractor craftsmen, this installation is now cancelled. A one-to-two hour hand-installed entry to each dry well will be made to verify calibration sensitivity in the well environment. Following this, a permanent test installation of the system will be made in wells around a selected single-shell active tank and the existing computer will be replaced with a microcomputer. This system appears equally suited for transfer line monitoring or any other normally static surveillance activity.

Development work is still in progress on a solid state electronics pressure transducer and readout system that has shown satisfactory resistance to "salt-over" while measuring interstitial salt well liquid levels. The prototype system has operated successfully in simulated salt cake and sludge environments. Tests in the salt well system of Tank 241-S-111 will be conducted as soon as the installation can be made. This system may also be useful for proportional salt well pumping for rate-of-flow measurements.

Development of a neutron soil-moisture monitoring detector for scanning of surveillance dry wells is now about 50 percent complete. The detector is to be used with the dry well surveillance vans. It is hoped that the detector will be sufficiently free of gamma response to also allow its use in the internal dry wells of tanks containing salt cake or sludge. Interstitial liquid levels and dry salt cake moisture content measurements may be possible.

A portable flowmeter using an ultrasonic measuring technique has been successfully tested under a variety of conditions. Tests are in progress to demonstrate its usefulness in transfer line material accountability. The portable system is useful for temporary across-the-ground transfers and for salt well pumping flow measurements. A computer-based version of this system utilizing up-down totalizers is recommended for permanent installation on selected transfer lines should the tests be successfully concluded.

A high/low gamma detector probe has been successfully tested in the surveillance leak detection pit of Tank 241-AZ-102. The probe contains two GM type detectors operating together to scan for very low levels of radiation, but remaining operational if very high levels are encountered. Normally sensitive gamma probes would be overwhelmed imme-

diately and cease to function in the event of significant leakage. This probe can also be used in conjunction with the "in-place" computerized gamma detection system and is especially useful for surveillance of leak detection pits, diversion boxes, pump pits, lift stations, and the like.

Sluicing and A/R Vault - S. S. Koegler, R. F. Carlstrom

High Pressure Sluicing Apparatus

The objective of this activity is to provide technology for removal of final sludge heels from underground storage tanks as a backup to the present sluicing program.

From recent trips to Savannah River Laboratories, it was concluded that a combination of the Savannah River high pressure sluicer and the existing waste recovery pump would provide a system capable of removing residual sludge. Prints and photographs of the Savannah River equipment have been procured. A vendor survey for a high pressure water feed pump has been initiated. Cost estimates and design of necessary equipment are in preliminary stages.

LONG-TERM MANAGEMENT OF DEFENSE WASTE AT HANFORD

The overall objective of this mission is to develop, evaluate, and demonstrate the technology for the long-term management of the Hanford high-level waste which will remain upon completion of the current waste solidification program. This waste will consist of approximately 3,500 capsules of ^{90}Sr and ^{137}Cs stored in water basins and 6,000,000 cubic feet of material in underground tanks. Because the waste will remain hazardous for hundreds to thousands of years, a long-term waste management program is needed to insure its long-term isolation from man's environment. Development and demonstration of the technology required to implement this program is expected to be complete by the mid-1980's.

The alternatives being considered for Hanford high-level defense waste are:

- To retrieve the waste, process it to an improved stabilized form, and store it retrievably in deep natural rock or other formations (geologic storage).
- To retrieve the waste, process it to an improved stabilized form, and store it in new retrievable surface storage facilities for an interim period, with possible eventual transfer to a final storage site.
- To continue storage of the waste in existing tanks and capsules as is, or with improvements to the storage facilities to extend the period of safe storage.

The mission has been divided into four major tasks:

- Storage System Integrity and Engineered Improvements

- Waste Retrieval
- Waste Immobilization and Storage
- Alternatives Studies and Assessments.

Note: Starting with the next reporting period, the Waste Immobilization and Storage tasks will be divided into two tasks: Waste Immobilization and Storage and Disposal Alternatives.

STORAGE SYSTEM INTEGRITY AND ENGINEERED IMPROVEMENTS -
P. F. Mercier

The objectives of this program are:

- To develop a data base to permit the annual assessment of the safety of continued waste storage in the existing underground tanks; to be completed in FY-1980.
- To identify, develop, and test engineered improvements that would extend the safe waste-storage period in the existing tanks; to be completed in FY-1980.
- To analyze the safety and the effect on the biosphere of continued waste storage in the existing tanks; to be completed in FY-1980.

Although the presently solidified waste is immobile compared to the original liquid form, there is concern about the continued reliability of the tanks because of the potential hazard in the event of loss of containment. The first annual assessment of the safety of continued waste storage in the Hanford tanks is planned for publication at the beginning of FY 1979. Testing and selection of engineered improvements to the storage tanks are scheduled for completion in FY 1980.

Storage System Integrity

The following activities are planned to provide a data base to assess the integrity of the single-shell waste storage tanks and to develop methods to periodically evaluate their integrity.

Salt Cake Stability - G. A. Beitel

The nitrates which form the bulk of salt cake are energetically capable of reacting with any organic materials which may be present. Safe storage of high-level wastes such as salt cake requires that violent or uncontrolled exothermic reactions between the salt cake and any organic materials present be kinetically impossible.

Tests have shown no evidence of susceptibility to shock-initiated detonation or to combustion within the moisture - nitrate - organic mixture calculated to be present.

Salt cake nitrates mixed with organic materials have been tested in one-gram samples at atmospheric pressure. Additional testing of larger samples in a closed container has been discussed with Dr. Chester Grelecki of the Hazards Research Corporation and a proposal is in preparation. Additional testing is being considered because the heat transfer characteristics of a combustible mixture depend upon the size and geometry of the system.

Containment Integrity - F. R. Vollert

The objective of this activity is to determine the integrity of the reinforced concrete tanks. The extended use of the waste-storage tanks will depend on how seriously elevated temperature, thermal cycling, and chemical solutions have affected the elastic properties of the concrete and the reinforcing steel.

Two laboratory programs have been developed by the Portland Cement Association Laboratories (PCAL) to investigate the effects of elevated temperatures and simulated waste on specimens of the kind of concrete used in Hanford tank construction. All specimens were manufactured with Hanford aggregate and the original 3000 psi and 4500 psi concrete formulations.

The two-year-long elevated-temperatures activity third-quarter report has shown no change in the concrete elastic properties. Testing is performed at the test temperature but future tests will include specimens cooled to room temperature.

Concrete cores taken from the domes of in-service tanks because of tank modifications are being prepared for test specimens by cutting into 3-inch cubes.

A new specimen for testing the effect of salt cake solutions and temperature on the durability of Hanford concretes has been designed. Manufacture will begin when additional Hanford aggregate can be shipped to PCAL.

Engineered Improvements - P. F. Mercier

The objective of this activity is to identify, develop, and demonstrate methods and techniques that can extend the safe storage period of the solidified waste in the single-shell tanks.

Loss of containment of the solidified waste has been postulated to occur by (1) an exothermic reaction in the solidified waste, (2) the collapse of the reinforced concrete dome, and (3) structural failure of the tank wall.

A demonstration of the selected techniques is planned for FY 1977 and FY 1978.

Tank Dome Support Studies - P. F. Mercier

Consultant studies have provided fifteen conceptual plans for the support of a tank dome. The objective of the studies was to determine a feasible method to support a tank dome because of loss of elasticity with time or the impact of an aircraft on the earth cover. The study considered external support and internal support, including methods and materials to completely fill the internal void volume without preventing retrievability of the salt cake at a later date. Three of the concepts have been selected for additional study and cost evaluation and are scheduled for completion during the next quarter.

Tank Dome Elevation Surveillance - R. G. Geier

Model tests and stress analysis involving relationships of time, tank operating temperatures, and earth cover loads indicate a margin of safety of 4 to 5 times the present earth cover load. Changes in the elevation of the tank domes could be indicative of cracking of the concrete or yielding of the reinforcing steel. In order to provide an early indication of possible tank dome collapse, a program for monitoring the change in elevation of dome reference points has been initiated. A demonstration program initiated in August 1975 showed that measurement methods could be established and that measurement criteria provided allowance for changes due to routine tank farm operations.

The plan being implemented will provide measurements on two diameters, 90 degrees apart, on a minimum of two selected tank domes in each tank farm. Protected reference bench marks will be established to assure repetitive accuracy of measurements. The initial frequency will be on a quarterly basis for the first year.

Tank Safety Analysis - P. G. Easley

The purpose of this activity is to determine the effects upon the biosphere of continued storage of the solidified waste in the single-shell tanks. This analysis will determine the radiologic impact upon man resulting from the loss of containment through failure of the storage system.

The base data on radionuclide migration rates through Hanford sediments are obtained through field and laboratory tests and computer models are used to predict radionuclide transport rates, directions, concentrations, and radiation doses.

Preliminary field data from a reassessment of the 241-T-106 Tank leak (work conducted under the Tank Farm Geology Program), show that the radioactive materials associated with this 115,000 gallon leak have not migrated over a foot upward or downward during the past two years. Studies of moisture migration through the ground at the field test site south of the 200 East Area tend to confirm the extremely slow rates of moisture movement at depths below ten to fifteen feet of the ground surface.

Laboratory studies on sediment-waste reactions have been stopped temporarily because of the loss of a qualified geochemist. If a qualified replacement is not identified within three months, milestones under this activity could slip.

A laboratory test was scoped during the report period to investigate the rate of vertical movement of long-lived radionuclides through Hanford sediments under field moisture conditions (2 to 15 percent moisture by volume). Techniques to measure radionuclide movement on the order of one centimeter per year are being assembled. It is expected that the

actual sediment columns will be in operation during the coming quarter.

Sensitivity tests were conducted on two predictive computer models during the past quarter. A nonisothermal moisture flow model was used to simulate the 241-T-106 Tank leak. The initial evaluation of the data shows that the results are sensitive to the hydrological properties of the sediments input into the model and the layering of the sediment types. However, results also indicate that transport to the surface would require the unrealistic assumption of ten or more years of continual dryness in the sediment column above the leak.

A recently developed wind-field model was tested to determine its sensitivity to predict the movement and dilution of gaseous waste as a function of the number of wind-field stations on the Hanford Reservation. The results show that a wind-field pattern (plume) prediction from a single station, versus one developed from five stations, can differ as much as 15 miles in terms of where the plume might cross the boundary of the Hanford Reservation. It is expected that the Hanford reservation will be equipped with a minimum of five permanent wind-field stations during the next quarter. The wind-field model was also used to predict the movement and dilution of a hypothetical unit source of contaminated matter from the tank farm areas. Two wind-field patterns were chosen from the many that have been measured to be input to the model: one typical situation in which contamination reaches the Tri-Cities, and one "worst case" that would simulate the greatest impact to the Tri-Cities. The results for the conditions assumed indicate that ERDA guidelines for exposure to the public would not be exceeded in the Tri-Cities by a release in the 200 Areas of roughly 1000 curies of gaseous material. This represents a worst case release from the tank farms of fine particulate matter of the same quantity.

WASTE RETRIEVAL - I. E. Reep

The objective of this task is to develop and demonstrate the technology necessary for retrieval of the waste material (salts, sludges, liquids, and accumulated debris) from the underground storage tanks. This technology will provide the Hanford High-Level Radioactive Waste Management Program with the option of removing the stored wastes to permit their conversion to a more acceptable product form.

The waste retrieval task consists of the following five activities:

- Concept and equipment development
- Engineering studies and conceptual design
- Engineering design
- Fabrication and construction
- Prototype test operations.

Conceptual design of the proposed waste retrieval system will be completed in FY 1977, and fabrication of this system will begin in early FY 1979. Cold testing of major components of the waste retrieval system could take place as early as FY 1980, with hot testing and demonstration of this equipment beginning in FY 1982.

Concept and Equipment Development - I. E. Reep

The objectives of this activity are:

- Identification of potential retrieval techniques.
- The definition of areas of the waste retrieval program which will require technology development and evaluation.

- Preliminary testing of the identified retrieval techniques to establish feasibility.
- Evaluation and reporting on engineering studies and designs performed in support of this activity.

Concept Development - H. A. Wallskog

This activity is nearing completion. The major components for accomplishing the waste retrieval objective have been identified. They are the (1) prototype waste retrieval system, (2) prototype test facility and, (3) facilities for hot demonstration.

A draft narrative description of the program for the Hanford high-level waste retrieval task was completed during the report period.

Equipment and Tool Development - N. M. Arnold

The objective of this activity is to develop tools and equipment for recovery and removal of wastes from the underground tanks. Work is currently being focused on the development of hydraulic retrieval devices.

Two Scumbuster (Vaughan Company, Inc., Montesano, Washington) agitator pumps are being evaluated for their capability to slurry salt cake in its own interstitial liquor and pump the resulting slurry out of the tank. This technique could also be used for the retrieval of sludge if the moisture content is sufficiently high. A hydraulic retrieval test loop has been installed for use with the larger, 100-horsepower pump, which has successfully slurried and pumped synthetic salt cake containing up to 70 weight percent included solids.

Vaughan Model 150 "Scumbuster" Pump Test

Fabrication of the "Hydraulic Miner" test setup for testing a modified 60-horsepower Scumbuster pump is complete except for installation of flowmeter and hydraulic lines (see Figure 1). The purpose of the test is to determine the ability of a small portable pump to remove synthetic solid radioactive wastes with the addition of very little liquid.

Pump-Bucket Recovery Tool

Conceptual design of a proposed recovery tool consisting of a "Scumbuster" type centrifugal pump mounted onto a backhoe style excavation bucket was completed. This tool is designed for digging through hard, crusty material while a controlled amount of water is added to form a slurry in the back of the bucket aided by a "Scumbuster" type pump which also pumps the slurry to a central distribution point. Detailed design was initiated and "off-the-shelf" components have been ordered. Fabrication is expected to begin in February 1977.

Engineering Studies and Conceptual Design - I. E. Reep

This activity consists of:

- Engineering studies in areas requiring further definition, and
- Conceptual designs for the further development of concepts and equipment identified as feasible in the Concept and Equipment Development activity.

A number of engineering study reports have been received from consultants. These include an engineering study and cost estimate for a waste retrieval system; a design study

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FIGURE 1

277-T "HYDRAULIC MINER" TEST SETUP

of a salt cake retrieval system; a study evaluating the adaptability of standard mechanical, hydraulic, and pneumatic devices to salt cake and sludge retrieval at Hanford; and a study of the high-level waste management technology development program. This information will provide a basis for conceptual designs of a prototype waste retrieval system, a prototype test facility, and facilities for hot demonstration.

Engineering Studies - I. E. Reep, H. A. Wallskog,
J. K. Strickler

The objective of this activity is to evaluate the technical feasibility, cost effectiveness, and safety of retrieval concepts under study and development.

A design study, in support of the Hanford Defense Waste Document (HDWD), was initiated with Kaiser Engineers during the report period (see Alternatives Studies and Assessments - R. Y. Lyon, p. 65). One of the tasks of this study is to conduct engineering design and feasibility studies, cost/benefit analyses, and safety analyses on three alternative concepts for waste retrieval: (1) a sluicing and slurry-pumping system based upon designs already in existence or currently employed in waste management operations, (2) a retrieval system based upon using a mechanical arm as the primary means for positioning specially designed tools and equipment in the waste tank for retrieval of wastes, and (3) a retrieval system based upon a creative approach developed by Kaiser Engineers.

A preliminary report has been received from F. R. Vollert, Development Engineering Department, indicating that it would be allowable, from a structural integrity

standpoint, to construct a 42-inch penetration and riser at the dome center of the oldest 500,000 gallon waste tanks. Further analyses, for constructing an additional off-center 42-inch riser in the dome structure, will be performed by an outside consultant. The contract for these consulting services has been prepared and consulting work is expected to begin during the next report period.

A design study was initiated during the report period on the transportation of retrieved bulk high-level radioactive waste from the Hanford tanks to an on-site waste processing facility. The purpose of the study is to develop technically feasible concepts and cost estimates; and to evaluate potential safety hazards associated with transportation of high-level bulk waste.

Conceptual Design - H. A. Wallskog, N. M. Arnold

The objective of this activity is to provide conceptual designs of the major components and support facilities for accomplishing the waste retrieval objective.

A consultant agreement (CA-190, Supplement No. 1) was initiated on July 1, 1976, with Programmed and Remote Systems Corporation (PaR), St. Paul, Minnesota. The engineering studies being performed under this contract will lead to the conceptual design of a functionally complete Prototype Retrieval System capable of retrieving solidified high-level waste from any of the 75-foot-diameter single-shell waste storage tanks in a safe and effective manner.

To provide a sound basis for this conceptual design effort, a comprehensive survey of all waste storage tanks was initiated for determining dome configurations and in-tank equipment based upon as-built drawings, photographs, and visual checks.

Work on conceptual design and a cost estimate for modifications to the 277-T Building, 200 West Area, for use as a waste retrieval tool development facility was initiated by Vitro Engineering. Modifications will include extension of an existing support structure to provide a 55-foot high-bay tower. Pipe loops of 2-inch and 4-inch diameter carbon steel are to be installed in the tower to simulate lift conditions to be encountered within a Hanford waste tank. The facility will be used to evaluate the performance of tools for the recovery and removal of high-solids content slurries.

WASTE PROCESSING

IMMOBILIZATION AND STORAGE - R. A. Watrous

The objectives of this program are:

- Identification, development, and demonstration of technologies for converting high-level waste to an immobilized form satisfactory for long-term or final storage.
- Evaluation of alternative engineered and final storage methods.

Aqueous Silicate Process

The conversion of fission product wastes to solid, insoluble products suitable for long-term or final storage is currently being investigated through the high temperature alternative of the Aqueous Silicate Process - Clay Calcination. In this process dry waste materials (such as salt cake) or other dehydrated wastes are reacted with clay at 600° to 800° C to form water- and nitrate-free sodium aluminosilicate powders. These powders may then be incorporated with binders or sintered to form clay calcination products.

Fixation of Actual Residual Liquor - M. J. Kupfer

Application of the clay calcination process to fixation of alkaline waste solution from Tank 110-BX was demonstrated. The composition of Tank 110-BX solution is shown in Table II. A mixture of 31 weight percent waste solution: 69 weight percent kaolin clay was reacted at 750° C for 1 hour. The reacted powder was pressed (20,000 pounds) and sintered at 1100° C for 1 hour. Only 0.014 percent of the ^{137}Cs volatilized during the initial 750° C heating step. The extent of Cs volatility was not determined for the sintering step. The leach rate (based on ^{137}Cs) of the sintered pellet after 19 days leaching in deionized water was 4.4×10^{-6} g/cm²-day.

TABLE II
COMPOSITION OF 110-BX WASTE LIQUOR

	<u>M</u>
Al	1.9
Na	NA
NO ₃	3.74
NO ₂	1.47
OH	3.28
CO ₃ ²⁻	0.23
PO ₄ ³⁻	0.13
SO ₄ ²⁻	0.035
CrO ₄ ²⁻	0.035
^{137}Cs - 3.5×10^5 $\mu\text{Ci/liter}$	
^{90}Sr - 74 $\mu\text{Ci/liter}$	

Fixation of Phosphate Bearing Sludge - G. S. Barney

Sludges containing large amounts of phosphate were immobilized by reacting with kaolin in a 1:1 weight ratio at 750° C. Sintered products obtained by firing at 1104-1222° C were dense (2.13 - 2.57 g/cm³) and very resistant to abrasion. Leach rates for these products ranged from 5.6×10^{-4} to 7×10^{-6} g/cm²-day during the first 24 hours of leaching.

These sludge wastes more closely approximate actual sludge waste than previous synthetic sludge formulations since they contain appreciable amounts of phosphate. Three different sludge compositions were mixed with kaolin (Table III).

TABLE III
COMPOSITION OF CLAY - SLUDGE MIXTURES

<u>Batch Number</u>	<u>Percent of Mixture</u>					
	<u>Kaolin</u>	<u>Purex Sludge</u>	<u>Redox Sludge</u>	<u>Na₃PO₄</u>	<u>Sr₃(PO₄)₂</u>	<u>Titanate Resin</u>
1	50	9.2	15.8	25	0	0
2	50	17.8	30.2	2	0	0
3	50	17	29.6	0	2.4	1.0

The mixtures were thoroughly blended and then fired as loose powders at 750° C for two hours. The fired products were blended again, mixed with a small amount of water and pressed at 20,000 pounds into cylindrical shapes. For some samples, a small amount of kaolin was added to the fired powders, along with water, in order to improve the green strength and sintering properties of the pressed samples. The preparation of the pressed samples is summarized in (Table IV).

TABLE IV
PREPARATION OF SINTERED PRODUCTS

<u>Sample Number</u>	<u>Batch Number of Fired Powder</u>	<u>Weight of Fired Powder, g</u>	<u>Weight of Kaolin,* g</u>	<u>Sintering Temperature, °C**</u>
1	1	50	0	1222
2	2	50	0	1222
3	3	50	0	1222
1-5	1	45	5	1104
2-5	2	45	5	1185
3-5	3	45	5	1185
1-10	1	40	10	1222 (melted)
2-10	2	40	10	1222
3-10	3	40	10	1222

*Added to improve green strength and sintering.

**Each sample was sintered for four hours.

Each of the samples sintered well, except for Sample Number 1-10 which melted, apparently due to the presence of large amounts of Na_3PO_4 .

The density, abrasion resistance, and leach rate were measured for each of the sintered products and the results are summarized in (Table V).

TABLE V
PROPERTIES OF SINTERED PRODUCTS

Sample Number	Density g/cm ³	Abrasion Resistance* mg/min	Leach Rate,** g/cm ² -day, based on	
			Cesium	Strontium
1	2.14	3.2	5.6×10^{-4}	1.1×10^{-5}
2	2.33	6.0	1.3×10^{-4}	4.5×10^{-5}
3	2.13	5.7	2.1×10^{-4}	6×10^{-6}
1-5	2.26	2.8	1.8×10^{-4}	3×10^{-6}
2-5	2.44	3.5	4.5×10^{-5}	3×10^{-6}
3-5	2.57	1.7	1.0×10^{-5}	5×10^{-6}
1-10	2.91	4.0	2.0×10^{-5}	3×10^{-6}
2-10	2.25	5.1	1.4×10^{-5}	6×10^{-6}
3-10	2.24	2.0	7×10^{-6}	9×10^{-6}

*Average of three measurements - amount of sample abraded per minute.

**During the first 24 hours of leaching.

The densities of the products show that they were effectively sintered. Each of these products was more resistant to abrasion than products made previously without phosphate present in the synthetic waste.

Silicate Melt Process - M. J. Kupfer, W. W. Schulz

Fixation of Sludge in Glass

The objectives of this activity are to develop and demonstrate processes for incorporation of Hanford high-level wastes into immobile silicate-based glass forms.

Scouting tests to define glass-making formulas for fixation of synthetic Hanford Purex and Redox sludge continued. Visually acceptable low leaching glasses were made from these sludges using only SiO_2 and sodium tetraborate ($\text{Na}_2\text{B}_4\text{O}_7$) as the glass-forming ingredients. Leach rates in deionized water (25°C , 5 days leaching) ranged from 6×10^{-7} to 1.7×10^{-5} $\text{g/cm}^2\text{-day}$ when based on cesium and from 5×10^{-7} to 1.3×10^{-6} $\text{g/cm}^2\text{-day}$ when based on strontium for glasses in the composition range: 30-40 wt percent Redox or Purex sludge, 25-50 wt percent SiO_2 , 15-35 wt percent $\text{Na}_2\text{B}_4\text{O}_7$. Not surprisingly, highest rates were observed for products containing the largest percentage of flux and lowest percentage of SiO_2 .

The best furnace operating temperatures for production of fluid melts (estimated 200-500 poises) of the compositions containing Redox sludge ranged from 1100 to 1400°C . The corresponding Purex glass melts were much less viscous at a given temperature than the Redox melts. The best furnace operating temperatures were 1000-1200° C for production of the Purex sludge glasses.

The addition of 1-5 wt percent of Li_2O to some of the above glass formulations reduced the melting temperature 50-250° C with little or no sacrifice in product leachability.

Devitrification of Sludge-Glasses

Glasses prepared from synthetic Redox or Purex sludge at 1000-1200° C were stored at 450 and 550° C for one month. Of the eight formulations tested, none devitrified at 450° C and three 1000° C Redox sludge-glasses devitrified at 550° C.

The principal mineral phase identified in the crystalline products was nepheline (NaAlSiO_4). Electron microprobe analyses showed uniform distribution of cesium and strontium before and after devitrification. Heating at 450 and 550° C had no effect on the leachabilities of the products that did not devitrify. The leach rates of devitrified products increased from 10 to 100 times, however.

Fixation of Residual Liquor in Glass

Based on results of earlier scouting tests⁽¹⁾ experiments were performed to define glass formulation ranges for effective fixation of synthetic residual liquor (the composition of the synthetic residual liquor is shown in Table VI). Clear green to yellow-green glasses were prepared by melting 30-40 weight percent residual liquor solids (prepared by evaporating the residual liquor solution at 150° C), 40-60 weight percent SiO_2 , and 10-20 weight percent B_2O_3 . The leach rates based on cesium for these glasses ranged from 7.3×10^{-7} to 3.3×10^{-5} g/cm²-day. The optimum melting temperatures for these formulas were in the range 1000-1200° C.

TABLE VI

COMPOSITION OF SYNTHETIC RESIDUAL LIQUOR SOLUTION

	<u>M</u>
NaAlO_2	2.0
NaNO_2	2.5
NaNO_3	2.0
NaOH	5.0
Na_2CrO_4	0.10
Na_2SO_4	0.05
Na_2CO_3	0.1
Cs_2CO_3	0.06

Small additions (1-3 percent) of lithia (Li_2O) to the above formulas did not increase leachability and reduced the optimum melting temperature by 50-100° C. Addition of TiO_2 to the residual liquor: B_2O_3 : SiO_2 glass formulas resulted in clear, dark green glasses and, in some cases, specimens containing mixed glass and crystalline phases. The TiO_2 additions did not influence leachability and reduced the melting temperatures slightly.

The volatility of cesium from the above melts ranged from 1.1 to 5.7 percent when the reaction mixtures were placed in a hot (650° C) furnace and subsequently raised to the maximum operating temperature. For these runs, the lowest volatilities were obtained for mixtures containing TiO_2 . Based on limited data, the Li_2O additions also appeared to aid in reducing Cs volatility. When the reaction mixtures were heated from ambient temperature instead of 650° C, the Cs volatilities were much lower, ranging from 0.5 to 1.0 percent.

A soluble sulfate phase was not observed to separate during melting of any of the above formulations. Data showed a maximum of 0.5 to 1.5 wt percent sulfate could be accommodated in these glasses (the above glasses contained only about 0.13 to 0.17 wt percent sulfate). Actual residual liquor is not expected to contain more sulfate than that present in the synthetic residual liquor.

In future work, glass formulations will be tested with actual sludges and residual liquors as they become available. Fixation of high phosphate sludge, $\text{Sr}_3(\text{PO}_4)_2$ and titanate ion exchanger will be demonstrated. Further devitrification tests with sludge and residual liquor glasses will be performed.

Other Immobilization Concepts

Fixation of Sludge in Cement - M. J. Kupfer

Fixation of sludge in portland and high aluminum cement was described earlier.⁽²⁾ An alternate process route involving volume reduction of the product by cold-pressing the cement-sludge mixture before curing was also described. During the present report period, compressive strengths of both pressed and regular cement specimens were determined. The results (Table VII) show that product strength is increased about a factor of two by pressing and that both pressed and unpressed specimens containing 30 wt percent sludge are about twice as strong as specimens containing 50 wt percent sludge.

TABLE VII

COMPRESSIVE STRENGTHS OF PRESSED
AND REGULAR CEMENT-SLUDGE SAMPLES

	<u>Compressive Strength, pascals Average</u>
Unpressed - 30% Sludge	2.8×10^7
Unpressed - 50% Sludge	1.4×10^7
Pressed - 30% Sludge	4.9×10^7
Pressed - 50% Sludge	2.9×10^7

Radionuclide Removal Studies

These studies are concerned with devising, developing, and demonstrating processes for removal of all long-lived ($t_{1/2} > 25$ y) radionuclides from Hanford salt cake solutions and residual liquors. The overall objective is to develop technology for partitioning such high-level wastes into a small volume of highly radioactive waste requiring further immobilization for long-term storage and a large volume of chemical or very low-level waste which can be safely stored or disposed of by inexpensive means.

Sludge-Salt Cake Separation - M. J. Kupfer

Tests were conducted to determine the optimum conditions for separation of salt cake and sludge wastes. Mixtures containing two parts (by weight) synthetic salt cake, one part synthetic Redox sludge (formed by precipitation with caustic of a metal nitrate solution) were stirred with water at 80° C using water:waste ratios of 1:1, 5:1 and 10:1. The dried (140° C) sludge after the 1:1, 5:1, and 10:1 contacts still contained, respectively, 70, 45, and 27 weight percent water soluble salts. Other data indicated that one other wash (pH 9.5) of the dried solids using wash:solids ratio (by weight) of 5:1 removed essentially all of the remaining soluble salts.

Sorption of ^{90}Sr on Sodium Titanate - W. W. Schulz

Results obtained previously, both at Hanford and at Sandia Laboratories, Albuquerque, have demonstrated that the inorganic ion exchanger $\text{Na}(\text{Ti}_2\text{O}_5\text{H})$ has a great affinity for uncomplexed ^{90}Sr and other polyvalent cationic radionuclides in alkaline salt cake solutions and residual liquors. Further proof of the good capacity of the sodium titanate

exchanger for sorbing ^{90}Sr was obtained this quarter in an extended column test in which 540 column volumes of actual salt cake solution were passed at 25°C through a 2-ml bed of the 80 to 200 mesh titanate sorbent at the rate of 2 column volumes per hour. The influent salt cake solution, obtained by water dissolution of material from Tanks 102- and 103-SX, contained $\sim 4\text{M Na}^+$, 1.0M OH^- , $2180\text{ }\mu\text{Ci/liter }^{90}\text{Sr}$, $3 \times 10^4\text{ }\mu\text{Ci/liter }^{137}\text{Cs}$, and small ($<1\text{ }\mu\text{Ci/liter}$) amounts of actinides. All 540 column volumes of effluent solution contained a uniformly low ($4\text{--}5\text{ }\mu\text{Ci/liter}$) concentration of ^{90}Sr . (The strontium decontamination factor obtained in the run with actual salt cake solution was approximately the same as that observed in recent column tests at Sandia Laboratories, Albuquerque with synthetic salt cake solution.)

Further tests with the composite effluent from the titanate column will be made to determine if its ^{90}Sr concentration can be reduced from $5\text{ }\mu\text{Ci/liter}$ to $\leq 1\text{ }\mu\text{Ci/liter}$ by passage through a second titanate column or by strontium phosphate scavenging. The actinide content of the titanate column influent and effluent streams will also be determined.

Titanate Exchanger Development - R. W. Lynch

Under ARHCO support, Sandia Laboratories continued developing and testing their sodium titanate (ST) to be used as an exchanger in removing Sr. During the quarter, effort was aimed at improving the physical form of the ST material. Two possibilities that received early attention were extrusion pelletizing and web agglomeration. Extrusion pelletizing involves using water, water-PVA, or water - Cerama-Bind 542 (an inorganic binder) mixed with sodium titanate to form pellets. The pellets made were cylindrical, about $1/8$

inch long and .093 inch diameter. Web agglomeration involves incorporating 1 percent by weight of teflon K additive via compressive shearing. The material can be obtained as a fibrous mat or as a powder. The powder produces fines in water, while the mat retains its form.

Exchange capacity of sodium titanate in the above described forms was determined. Capacity for consolidated forms varied from 2-4 milliequivalents (meq/g) as compared to about 5 meq/g for unconsolidated ST. The pellets with the inorganic binder showed the largest loss of capacity, but this could be because the maximum temperature used in making them was higher than for other forms (200° C compared to 25° C). All the consolidated forms retained sufficient capacity to be candidate materials. From the standpoint of particle integrity, the material with the inorganic binder seems to be superior. Tests will be performed increasing inorganic binder content from present level of 5 - 20 weight percent.

Experiments with ST loaded on molecular sieves and porous glass were also performed. The glass used as an insert support had the following properties:

Pore diameter	1350Å
Particle diameter	177-844 microns
Surface area	34 m ² /gm
Pore volume	1.25 cm ³ /gm

The dry glass particles contained about 35 percent by weight sodium titanate. The overall capacity of the loaded glass for Sr⁺⁺ per gram of ST was found to be the same as that measured for pure ST. The molecular sieves used to load sodium titanate were 8-12 mesh beads with an effective pore size of 4Å. ST loading is estimated to be less than 1 weight percent and ion exchange

capacity is low. However, the optimum physical form (spherical) and applicability to extremely low Sr concentration may be of interest.

There was some question as to whether possible cation impurities in the salt cake would affect Sr removal. Batch equilibrations were set up with a control solution and a solution doped with various cations. Both solutions were spiked with 1 $\mu\text{Ci/ml}$ of ^{85}Sr . Results showed that the added cations have little effect on samples with low concentrations of Sr, which are representative of those to be actually used. It was also shown that a batch equilibration process to achieve decontamination factors greater than 100 would require hundreds of times more ST than a comparable column process.

An experiment was performed to determine breakthrough in a 3 cm^3 column. Breakthrough occurred when the bed contained about 59 percent of the estimated Sr capacity. After this, the concentration of Sr in eluate divided by feed concentration was about 0.1 through the rest of the feed. The total amount of Sr removed was slightly greater than the estimated ST capacity. This discrepancy could be from uncertainty in multiple analyses or because Sr exchange capacity of ST was based on capacity in acidic, low sodium solutions. The capacity in dissolved salt cake solution will be determined in the near future. More breakthrough determinations will be accomplished varying column size and flow rates.

Cerac, Inc. of Milwaukee is to supply Sandia Laboratories with 200 Kg of sodium titanate. A 1/2 pound sample is to be sent to Sandia during the week of October 4, 1976 to see if it meets the material acceptance criteria. It has been found that vibration has a negligible effect on the

physical form of ST, but dropping produces an undesirably large percent of fines. For this reason, the ST containers will be palletized before shipping.

Headend/Tailend Ozonation Procedures - W. W. Schulz

Unidentified organic ligands which complex ^{90}Sr and prevent its adequate removal by scavenging and/or ion exchange techniques are known to be present in some residual liquors (e.g., Tank 110-S solution) and may be present in small amounts in some salt cake solutions. Previously reported scouting studies with diluted Tank 110-S liquor have shown that these organic impurities can be oxidatively destroyed by reaction with ozone. Ozone is preferred over other candidate oxidants because it can be readily generated on site from air or oxygen.

Definitive experiments performed this quarter with two-fold diluted Tank 110-S liquor clearly demonstrated (Table VIII) the beneficial action of ozonation of complexed ^{90}Sr . The presence of complexed ^{90}Sr in the Tank 110-S liquor is confirmed by the failure to obtain any precipitate of $\text{Sr}_3(\text{PO}_4)_2$ until the solution was made 0.03M Sr instead of the usual 0.0075M; even so, some 10 percent of the ^{90}Sr remained in solution after two strontium phosphate precipitation steps. However, after ozonation for 6 hours at 75° C or 4.5 hr at 90° C, two precipitations of 0.0025M $\text{Sr}_3(\text{PO}_4)_2$ reduced the ^{90}Sr concentration of the diluted Tank 110-S liquor to $< 1\mu\text{Ci/liter}$.

Both brown and white solids precipitated during ozonation of the Tank 110-S solution. The brown solids are thought to be $\text{Fe}(\text{OH})_3$ which precipitated when $\text{Fe}(\text{III})$ was released from its complexed form. The white solids have

TABLE VIII

SCAVENGING OF ^{90}Sr FROM OZONATED TANK 110-S SOLUTION

Conditions: Oxygen containing 1.85 volume percent O_3 bubbled at rate of 2.1 liters/min through two-fold diluted Tank 110-S solution for 2 to 6 hr at either 75 or 90° C. Portions of the waste solution before and after ozonation made 0.025M H_3PO_4 and 0.0075M $\text{Sr}(\text{NO}_3)_2$; resulting precipitate stirred an hour at 25° C. In some cases, five ml of scavenged solution was scavenged a second time under same conditions as first scavenge.

Run No. (a)	Ozonation Time, Hr	°C	Solids Color	(b) Vol	μSr , Ci/l			
					Before Ozone	Before Scav.	After Scav. 1	After Scav. 2
1	Not Ozonated				9320	9320	863(c)	1060
2	2	75	Brown	0.2	9320	6200	82.2	35.1
3	3.5	75	Brown(c)	0.3	9320	1180	224	14.8
4	6.0	75	Brown(c)	0.2	9320	771	0.232	<0.1
5	4.5	90	Brown	0.2	9320	354	3.1	0.244

(a) All with two-fold diluted Tank 110-S Solution: 4.97M Na^+ - 1.23M NO_3^- - 0.69M AlO_2^- - 0.59M NO_2^- - 0.11M CrO_4^{2-} - 0.02M SO_4^{2-} - 0.61M CO_3^{2-}

(b) Solids produced during ozonation of 15 ml portions.

(c) Some white solids also present.

been identified as $\text{Al}(\text{OH})_3$, bayerite; the reaction mechanism whereby Al-bearing solids should form in highly alkaline solutions is not clear. The brown and white solids both scavenge ^{90}Sr and aid in its removal from solution. Radio-nuclide removal flowsheets which incorporate an ozonation step must provide, however, for treatment and disposition of the solids produced in the ozonation treatment. Such solids can likely be combined with sludge and converted to glass.

Another factor to be considered in using ozone to destroy organic complexants in residual liquors (and, possibly, salt cake solutions) is that in alkaline solution ozone readily oxidizes nitrite to nitrate ion. Thus, bubbling ozone for 6 hr at 95°C through Tank 110-S solution (Run 4, Table I) oxidized all the initial 0.59M NO_2^- . The relative rates of reaction of complexants and nitrite ion with ozone are unknown. Ozonation flowsheets should provide for equipment and time cycles to oxidize both the nitrite and complexants. Residual liquors contain considerably more nitrite (e.g., $1\text{--}2\text{M}$) than salt cake solutions ($0.1\text{--}0.2\text{M}$).

Scouting studies were performed to ascertain effects of ozonolysis of 4M NaNO_3 - 1M NaOH - 0.1M organic complexant solutions spiked with approximately $200\text{ }\mu\text{Ci/liter }^{85}\text{Sr}$. Complexants used represented some of those known to have been used in current and past Hanford waste management operations and included sodium citrate, sodium tartrate, hydroxyacetic acid, sodium ethylenediaminetetraacetate (NaEDTA), sodium diethylenetriaminepentaacetate (NaDPTA), and sodium hydroxyethylenediaminetriacetic acid (NaHEDTA). Fifteen ml portions of each solution were ozonated for 6 hr at 75°C by bubbling an oxygen stream containing 1.85 vol percent O_3 at the rate of 2.1 liter/min. All the ozonated solutions contained about 0.3 ml of as yet unidentified

white solids. These solids were removed by centrifugation, and the clarified solution was scavenged once by precipitation of 0.0025M $\text{Sr}_3(\text{PO}_4)_2$. In every case the combined ozonolysis/scavenging treatment reduced the ^{85}Sr concentration to 0.12 to $0.53\text{ }\mu\text{Ci/liter}$. In comparison, $\text{Sr}_3(\text{PO}_4)_2$ would not precipitate from unozonated solutions containing 0.1M EDTA, DTPA, or HEDTA. Precipitates of $\text{Sr}_3(\text{PO}_4)_2$ were obtained with unozonated solutions containing 0.1M sodium citrate, sodium tartrate, or hydroxyacetic acid, but two such precipitations were needed to reduce ^{85}Sr levels to $<1\text{ }\mu\text{Ci/liter}$. These results thus further underscore the general applicability of tailend/headend ozonolysis procedures for destroying complexants in some residual liquors and/or salt cake solutions.

Radionuclide removal studies in the forthcoming quarter will focus primarily on developing and applying techniques for measuring low concentrations of organic carbon in synthetic and actual waste solutions. Such technology will be used in determining kinetics of ozonolysis of complexants to provide data for design and operation of plant-scale ozonation equipment. Additional ozonations will be made with actual waste solutions known to contain large concentrations of chelating agents. Efforts will continue on the assembly and cold testing of equipment for eventual hot cell demonstration (laboratory-scale) of integrated radionuclide removal flowsheets.

Solvent Extraction - G. S. Barney

The separation of sodium salts from radionuclides using liquid-liquid extraction was studied further.

The solubility of t-butylbenzo-15-crown-5 in various aromatic and alkyl halide solvents was measured to evaluate the usefulness of these compounds as diluents. The crown ether was more soluble in alkyl halides ($\sim 1.8\text{M}$) than in aromatic solvents ($\sim 0.9\text{M}$), as evidenced by the data given in (Table IX).

TABLE IX
SOLUBILITY OF t-BUTYLBENZO-15-CROWN-5
IN VARIOUS DILUENTS

<u>Diluent</u>	<u>t-Butylbenzo-15-Crown-5 Solubility, M</u>
0-dichlorobenzene	0.8
1,2,4-trichlorobenzene	0.8
bromobenzene	0.9
nitrobenzene	0.9
chloroform	2.0
1,1,2,2-tetrachloroethane	1.8
1,1,2-trichloroethane	1.7

Extraction coefficients for extractants made from t-butylbenzo-15-crown-5 and either nitrobenzene or bromobenzene (as diluents) were measured for Na, Cs, and Sr. The results are shown in Figures 2 and 3. The nitrobenzene extractant extracted sodium salts much more strongly than the bromobenzene extractant. Cesium separation was poor, however, at low Na concentrations in the synthetic, aqueous salt cake solution.

FIGURE 2

EXTRACTION OF Na, Sr, OR Cs IN CROWN ETHER/DILUENT
SYSTEM (BROMOBENZENE)

(Extraction = 0.93M t-Butylbenzo-15-Crown-5 in Bromobenzene)

FIGURE 3

EXTRACTION OF Na, Sr, OR Cs IN CROWN ETHER/DILUENT
SYSTEM (NITROBENZENE)
(Extraction = 0.93M t-Butylbenzo-15-Crown-5 in Nitrobenzene)

ALTERNATIVES STUDIES AND ASSESSMENTS - R. Y. Lyon

The objectives of this program are:

- To conduct a comprehensive analysis of all reasonable alternatives being considered for safe long-term management of Hanford high-level defense wastes,
- To prepare technical documentation of the analysis for public review and comment (Hanford High-Level Defense Waste Document),
- To prepare documentation on the environmental impact of all alternatives being considered for public review and comment (Generic Environmental Statement),
- To prepare documentation on the environmental impact of the alternative selected for implementation (Project Specific Environmental Statement) at the time construction funds are requested.

Similar documents are being prepared at the Idaho National Engineering Laboratory and the Savannah River Plant as part of an overall ERDA program to keep the public informed of planning for long-term high-level defense waste management at the three sites.

Analysis of Alternatives

The objectives of this activity are to identify all reasonable alternatives for long-term management of the Hanford high-level defense waste; determine the technical feasibility, advantages and disadvantages, and facility and operating costs for each alternative; conduct safety and risk analyses for each alternative; and determine resource requirements. This phase of the work is scheduled for completion by February 15, 1977, to permit integration of results into the Defense Waste Document.

The waste management alternatives and options to be initially considered for analysis were selected during the report period. They consist of 22 options for the salt cake, sludge, and residual liquor; three options for the decontaminated salt product of the radionuclide removal process; and eight options for the ^{90}Sr and ^{137}Cs capsules. These alternatives are shown graphically on Figure 4 and in matrix form on Figure 5. The options are expected to be consolidated and reduced in number during the next reporting period. In an effort to simplify analysis of the various alternatives, the following seven process modules have been selected to be used as building blocks, where applicable, for determining the cost and risk of each alternative:

- Existing waste storage facilities
- Waste retrieval
- Radionuclide removal
- Waste immobilization
- Transportation
- Surface storage
- Geologic storage

For purposes of this study it was originally assumed that long-term waste management technology would be demonstrated by FY 1986 and that the selected alternative would be implemented during the period FY 1990 - FY 2005. Reconsideration of these assumptions was in progress at the end of the report period.

For purposes of this analysis the wastes to be considered will be only those in-tank wastes resulting from the current high-level waste management operations. Wastes resulting from future Purex operations will not be included directly

WASTE FORM		TERMINAL STORAGE MODE			
		DEEP GEOLOGIC STORAGE		SURFACE STORAGE	
		BASALT CAVERN ON-SITE	SALT CAVERN OFF-SITE	VAULT ON-SITE	WASTE TANK ON-SITE
SALT CAKE, SLUDGE, AND TERMINAL LIQUOR	GLASS	1,(17)	2	3	(18)
	CLAY CALCINATION	4	5	6	
	BITUMEN	7	8	9	
	CEMENT	10	11	12	
	GLASS WITHOUT RADIONUCLIDE REMOVAL	13,(19)	14	15	(20)
	UNREPROCESSED WASTE	(21)			[16],22*
CAPSULES	EXISTING CAPSULES WITH OVERPACK	A	B	C	WATER BASIN [D], H*
	CAPSULES CONVERTED TO GLASS	E	F	G	
SALT	DECONTAMINATED SALT	I		SURFACE TRENCH II	III

() Denotes bulk storage options.
 [] Denotes options with engineered improvements to existing facilities and overpacking of capsules.
 * Continued storage as is in existing facilities with no improvements or overpacking of capsules.

FIGURE 5

KEY TO TECHNICAL ALTERNATIVES
 FOR LONG-TERM MANAGEMENT OF HANFORD HIGH-LEVEL DEFENSE WASTE

but will be discussed in relation to effects which could result from their presence. Definition of the waste characteristics and quantities necessary for preparation of process flowsheets was emphasized during the report period. Information sheets on bulk waste quantities and ^{90}Sr and ^{137}Cs inventory projections were prepared. Preliminary flowsheets for Feed Preparation, Radionuclide Removal, and Glass Immobilization were prepared.

Kaiser Engineers (KE), Oakland, California, a prime contractor to ERDA-RL, was retained in early August to provide consulting, technical, and engineering services on facilities and systems for retrieving, processing, transportation and long-term storage of the high-level defense waste. The work will be accomplished in the following six task areas:

1. Engineered Improvements to Existing Storage Systems
2. Waste Retrieval
3. Waste Processing
4. Waste Product Containerization
5. On-Site Storage and Canister Handling
6. Off-Site Transportation and Storage.

Kaiser will provide the level of design necessary to define the facilities required and to give a basis for risk analyses and estimation of capital and operating costs. During the report period KE performed work on Tasks 1, 2, 3, 4, and 5 with most of the effort directed to Tasks 1 and 2. Kaiser Engineers' work schedule is directed toward providing a draft report by February 15, 1977, and a final report by April 1, 1977. Study results will be incorporated into the Defense Waste Document as appropriate. During the next quarter work will be completed on Tasks 1, 2, and 4 and will be started on Task 6. Work will also continue on Tasks 3 and 5 with the main effort being directed at Task 3.

During the report period efforts were in progress to obtain the assistance of an outside consultant firm to perform the risk analyses required as part of the overall analysis of alternatives. Contract approval is expected early next quarter. Accumulation of background information and references is continuing while contract negotiations are in progress. A population density and distribution study for a 90-mile radius centered on the Hanford Meteorological Tower and for the period from 1980 to 2300 being conducted by Battelle-Northwest will be completed during the next quarter. Risk analyses will also be started.

Hanford High-Level Defense Waste Document

The objective of this activity is to document the results of the analysis of reasonable alternatives being considered for safe long-term management of Hanford high-level defense wastes. A draft document is to be prepared for ERDA review by April 1, 1977, with issue of the final document by ERDA scheduled for September 1977.

The Hanford High-Level Defense Waste Document (HDWD) will be one of three similar documents being prepared for the Idaho National Engineering Laboratory, the Savannah River Plant, and Hanford. A draft of the Savannah River (SR) document, which is to be the guide for format and content, was reviewed during July and comments were submitted to ERDA-RL for transmittal to Savannah River. Representatives of the three sites met at ERDA Headquarters in late August to discuss the comments. The HDWD will be less detailed

than the SR report due to less design and risk analyses. Dollar values will not be assigned to risk (\$1000/man-rem) in the HDWD. A suggested outline for the general format of the Defense Waste Documents was submitted to ERDA for inclusion in a Federal Register Notice. A schedule for preparation of the HDWD was prepared.

Work during the next quarter will include preparation of a detailed document outline, the introduction section, and other selected document sections. The preparation schedule will be revised to reflect the current status.

Generic Environmental Statement (GES)

The objective of this activity is to prepare documentation on the environmental impact of all alternatives being considered for long-term management of the Hanford high-level defense wastes. Issue of the document for public review and comment is presently scheduled for September 1978.

No work has been started on this activity although it is expected that many of the results of the analysis of alternatives now in progress will be applicable to the GES. The main effort will be started when the HDWD has been essentially completed.

LONG-TERM MANAGEMENT OF CONTAMINATED SOILS AND SEDIMENTS

The objective of this mission is to establish the definitive data base and demonstrate the technology required for the selection, establishment, and implementation of a program(s) that provides efficient, effective and socially acceptable management of the radionuclides stored in or on the 200 Areas' soils and sediments.

CONTAMINATED SEDIMENTS CONTROL

Site Characterization - K. R. Fecht

The activity objectives are:

- To characterize various intermediate and low-level fission product waste disposal facilities with respect to the fission product distribution and site stratigraphy.
- To determine the physical stability of the fission products in the sediments at waste disposal facilities.

The U.S. Testing Company analyzed 900 sediment samples for size and calcium carbonate analysis. The sediment sample data provide input used in developing geologic maps of the stratigraphy beneath liquid waste disposal facilities.

The geophysical logging of 240 existing crib wells is 80 percent complete (gamma radiation logging, 100 percent; neutron logging, 60 percent; and density logging, 80 percent). The logging profiles will be used in conjunction with geologic maps and cross sections to define the location of lithologic units in which the radionuclides are found.

Trench Characterization - S. M. Price, M. M. Kiilsgaard

The objectives for Actinide Trench Characterization are:

- **Reactivity Assessment:** Locate probable zones of greatest actinide concentration within trenches and assess the nuclear reactivities of these zones.
- **Actinide Distribution:** Delineate the distribution of actinides stored within trenches as a function of the structure, stratigraphy, and mineralogy of the underlying sediments.
- **Actinide Stability Assessment:** Assess the migration potential of actinides stored within trenches in order to determine the immediacy for implementing waste storage alternatives.
- **Drilling and Sampling Technology:** Design, develop, and test containment facilities and operational techniques for the retrieval of actinide-bearing sediments and wastes.

Reactivity Assessment

Two dual-walled core barrels were emplaced within the Z-Trench Complex to provide access holes for neutron pulsing instrumentation. Pulsing of the two holes, located at the initial points of waste distribution within the 216-Z-1A(c) and 216-Z-12 Trenches (Figure 6), was subsequently carried out by S. R. Bierman of Battelle Northwest. A report discussing the K_{eff} of the pulsed sediments at the two sites is to be completed by the end of the next quarter.

FIGURE 6

Z-TRENCH COMPLEX WELLS

Actinide Distribution

Four wells were completed to the top of the Ringold Formation (30 to 40 meters in depth) within the Z-Trench Complex, three wells adjacent to the 216-Z-12 Trench and one well adjacent to the 216-Z-1A(a) Trench (Figure 6). These wells were drilled to determine the extent of the lateral spread of actinide-bearing wastes beyond the central distributor pipe at each site. No contamination was detectable using either a poppy or geiger-mueller counter in samples obtained from wells 299-W18-152, 299-W18-153, and 299-W18-157 located adjacent to the 216-A-12 Trench (Figure 6). Contamination was detected by these instruments in samples from the 15-meter depth in well 299-W18-158 located adjacent to the 216-Z-1A(a) Trench (Figure 6). Samples from the 15-meter depth have been submitted to ARHCO's Chemical Technology Laboratory for analysis. Samples which surveyed "clean" have been submitted from all four wells to an offsite laboratory to determine if trace quantities of actinides are present. During the next quarter, the actinide distribution will be determined in five additional wells drilled in the vicinity of the 216-Z-1A(a) Trench.

Work conducted by Battelle Northwest indicated that neutron-enhanced autoradiography can be used to produce meaningful autoradiographs of sediments containing relatively low concentrations of plutonium. This technique will be applied during the next quarter to examine the microdistribution of plutonium in samples from the lower portion of the 216-Z-1A Trench sediment profile.

Actinide Stability Assessment

Initial work to develop a sequential leaching technique which could be used to assess actinide-sediment "bonding strength" in trench samples has been completed. The results

of the study, carried out by Battelle Northwest, will be subject to review during the next quarter.

Large-volume water samples have been collected from three wells in the vicinity of the 216-B-5 Reverse Well. The samples will be analyzed to determine if actinide forms are present. Analysis of the water samples is expected to be completed during the next quarter.

Drilling And Sampling Technology

A suction-type tool was developed to sample the actinide-bearing sludge stored in the 361-Z settling tank. The tool was successful in obtaining a representative sample of the uppermost 1.5 meters of the tank contents. During the next quarter, additional samples will be taken from Tank 361-Z using the developed suction-type tool.

Sediment Stabilization

The work performed under this title during the quarter was carried out in two separate activities titled Decontamination/Immobilization and Sediment Stabilization. The combined objective of these activities is to establish the technologies that provide the capability to stabilize surface and subsurface contamination and to establish criteria for the stabilization of contaminated sediments.

In Fiscal Year 1975 experimental bio-barriers were constructed in the 200 West Area to study the prevention of plant root and animal penetration into waste sites. The ground surfaces above the barriers were seeded with Russian Thistle which has one of the longest tap roots of the plants growing in the 200 Areas.

A leaking 102-AX vent line Dresser Coupling was immobilized with a cationic asphalt emulsion in 1975. Measurement of radioactivity movement in this area was started prior to affixation and completed in June of 1976.

The Redox S-16 Pond was backfilled with clean soil in FY 1975. The main channel into the pond contained the highest plutonium readings. This area (~ 0.3 acre) was disced, a root toxin was added, the soil was affixed with asphalt and then the area was covered with 30 inches of contamination free soil. Four separate measurements for movement of radioactivity were completed by June of 1976. No significant changes were noted in the activity.

A field test on grouting a well with five different matrices was started in late June of 1976. Laboratory tests on well grouts by Battelle Northwest showed that asphalt, or cement and asphalt, would be good barriers to prevent movement of activity to the groundwater.

Subsurface Stabilization - P. J. Wiater

Subsurface Bio-barriers

Sampling of the Russian Thistle plants growing in the experimental bio-barrier culverts were checked for uptake of lithium and cobalt tracers during this period. Roots penetrated the control culverts, as expected. Some roots also penetrated below asphalt layers at 3 and 6 foot depths. These studies will continue into Fiscal Year 1977. The mechanism that allowed root penetration below the asphalt layers will be determined.

Subsurface Grouting

The 102-AX Dresser Coupling immobilization test was discontinued. The results to date have been inclusive. Additional cold tests are required to establish the subsurface grouting technique for contamination control in situations represented by the 102-AX Dresser Coupling.

Asphalt-cement grouting of a cold well was completed during this period. Five grout mixtures consisting of water, cement, and asphalt were used in the test. The data collected indicate that injection technique development must be improved before a satisfactory seal can be established using asphalt-cement grout.

The Pressure Grout Company of San Francisco was contracted to grout a moisture-barrier in a configuration that could be used to contain a tank. The grout, consisting of water, sodium silicate, formamide and calcium chloride, was mixed in two separate feed tanks (grout and activator) with final mixing taking place on the way to the injection nozzle. Injection of the grout was started on August 26, 1976. Excavation of the sediment from inside the container has been started. The barrier will be water leak tested by the end of October 1976.

Surface Stabilization and Cleanup - G. M. Holter

Surface Stabilization

Several field tests have been performed to determine the effectiveness of various revegetative techniques in stabilizing surface areas. Stabilization of the S-16 Redox Pond using a latex emulsion and straw mulch has been successful, preventing soil erosion and resulting in a good cover crop of cheatgrass.

A one-acre burned area seeded to cheatgrass is now covered with cheatgrass. The success of this test will be measured by the cheatgrass cover that is produced by self propagation during the 1976-77 season. Cheatgrass is a shallow rooted plant that depletes surface soil moisture early in the growing season.

Vacuum Cleanup Systems

Components for a mini-vacuum system are being received. Performance tests are being carried out as equipment becomes available. The mini-vacuum systems employ a 55-gallon drum as the receiver for vacuumed material. The drum also serves as the storage container for contaminated material, eliminating the need to unload.

Additional field tests on the large truck mounted mobile vacuum system have identified design and operational problems that cause its use in contaminated environments to be questionable. A decision on continued development effort will be made next quarter.

Liquid Laundry Effluent Control - G. M. Holter

A study was initiated to characterize liquid laundry effluents and evaluate treatment options for the effluents. Battelle-Northwest is conducting the study under ARHCO direction.

The liquid laundry effluent characterization study is on schedule. A report will be issued October 15, 1976. Preparatory work for the laboratory evaluation of the study results has begun. Liquid laundry effluents will be collected and run through a treatment test facility to verify the conclusions of the study, and to provide more extensive design data for a full-scale facility.

Chemical Technology Laboratory is investigating the possible use of titanate resin for decontamination of liquid laundry waste, as well as other liquid effluents.

ENVIRONMENTAL IMPACT TECHNOLOGY

HYDROLOGYGroundwater Hydrology - R. A. Deju

This activity is aimed at obtaining the hydrologic data needed to characterize the Hanford groundwater flow regime, developing predictive models of groundwater flow, and developing management and control strategies to avoid groundwater contamination.

Water table measurements were taken in July 1976 in 300 wells throughout the Hanford Reservation. No significant changes were detected from the preceding measurements (December 1975). A study was made to determine the zone adjacent to the Columbia River where water levels are affected by seasonal river fluctuations. Information obtained from these studies has been filed in our computer data bank.

Plans for drilling additional wells to test the hydrologic properties of the unconfined aquifer were laid out during the quarter for implementation in Fiscal Year 1977. One pumping test was conducted at well 699-62-43 just north of Gable Mountain.

Geophysical logs were taken at 12 new wells throughout the Reservation. These wells penetrate glaciofluvial deposits and the Ringold Formation. These geophysical logs will be used as controls for the interpretation of all logs taken within the Hanford Reservation. Five of the 12 holes have core samples available and in these the lithology of the samples will be compared to the log responses. Logs obtained from each well included the Gamma-Gamma log, the Neutron-Gamma log, the Neutron-Epithermal Neutron log, the Natural-Gamma log, and the Caliper log. Radiation logs were conducted in a decentralized mode to improve resolution and facilitate quantitative description.

In the mathematical modeling area, work continued in modifying the Variable Thickness Transient Model (VTT) to calculate accurate travel times through the groundwater pathway from cribs, trenches, and ponds down to points of uptake such as the Columbia River. Work was also initiated in evaluating the need for three-dimensional computer models of the groundwater flow regime. All work, to date, is on schedule and all milestones during the quarter were met.

Offsite Migration - R. A. Deju

This activity is aimed at determining the concentration and ultimate fate of any radionuclides that may be present or could potentially contaminate the confined aquifers underlying the Hanford Reservation. This information is needed to assure isolation of Hanford radioactive wastes from any users of water from the confined aquifer outside of and adjacent to the Hanford Reservation.

Extensive chemical sampling was conducted to assess the potential contamination of the confined aquifer as a result of waste disposal to Gable Mountain Pond. The results of this study will be available in October 1976. The studies show that although a potential interconnection between the confined aquifer and the unconfined aquifer exists to the northwest of Gable Mountain Pond, the levels of contamination of the confined aquifer appear to be extremely small. A plan for additional chemical sampling to assess contamination of the confined aquifer throughout the Hanford Reservation will be implemented in Fiscal Year 1977. Studies were also made during the quarter to further assess the hydrologic properties of the confined aquifer.

Radionuclide Migration in Groundwater - R. A. Deju

This activity is dedicated to definition of the main channels of radionuclide migration through the groundwater pathway and to reduction of radionuclide transport throughout these channels. Such objectives are obtained by conducting geological, geophysical, and geochemical studies.

The gravity program to determine the shape and location of the ancestral channels of the Columbia River continued. All gravity data collected during the summer of 1976 are being compiled as part of the three-dimensional modeling effort to plot the shape of the uppermost basalt surface and thus determine depth to bedrock. The preliminary results indicate the existence of many basalt lows throughout the Reservation. These lows are believed to be either buried ancestral stream channels or scour channels on the basalt surface. During subsequent months gravity modeling of all data collected will be completed. No additional data collection is anticipated. The program is scheduled for completion during Fiscal Year 1977. Upon completion of the modeling effort it is felt that the depth to basalt and the character of the overlying sediments will be established relatively accurately along with the location of paleochannels and the structural and erosional characteristics of the basalt surface.

The analysis of geologic and hydrologic data from wells throughout the Hanford Reservation was continued. Three reports were received from W. K. Summers and Associates summarizing the description of samples from these wells. These reports are being reviewed and will be issued during Fiscal Year 1977. For many of the samples obtained while drilling these wells, determinations of particle density, bulk density, porosity, and saturated hydraulic conductivity have been completed. Such information will extend the understanding of these properties throughout the groundwater flow system.

A literature review of radionuclide sorption is nearly complete. The work done the past quarter was concentrated on identifying the kinds of sorption data needed for computer modeling and on classifying sediments for use in sorption experiments. Almost any model of radionuclide transport through the groundwater pathway requires equations which relate sorption and solubility constants for a specific radionuclide to dependent variables such as concentration of waste components, sediment depth, etc. These variables can be obtained by regression analysis of data obtained from factorial design experiments. It appears that sediments will be classified by mineralogy rather than size mode to obtain meaningful sorption and solubility correlations. Schedules for accomplishing such correlations are being examined. The many variables which can affect the equilibrium distribution have been compiled and statistical means of dealing with important variables are being evaluated.

All milestones under this program have been met.

Long-Term Groundwater Management - R. A. Deju

This activity is aimed at identifying potential ways in which high-level wastes can come in contact with groundwater, and examining the potential impact to the groundwater regime of past and projected activities in the high-level waste storage areas.

Plans for the establishment of piezometers throughout the Hanford Reservation were completed during the quarter. These piezometers furnish the means of detecting vertical as well as horizontal contamination from the 200 Areas. Piezometers will be installed during Fiscal Year 1977 and Fiscal Year 1978 following these plans. Studies were continued in evaluating the extent of aquifer contamination from Gable Mountain Pond and U Pond. Mathematical models are

being used to assess the environmental impact of these facilities.

One well was completed to a depth of 430 feet in the Cold Creek Valley. This well will be tested and monitored to determine the amount of recharge into the Hanford Reservation through the unconfined aquifer that enters through the Cold Creek area. Tests will be conducted in Fiscal Year 1977.

All milestones for this project were met during the past quarter.

TRANSPORT

Moisture Transport Studies - P. G. Easley, G. L. Last

The objectives of this activity are: (1) to characterize moisture movement in partially saturated sediments within the 200 Areas Control Zone; (2) to formulate mathematical equations accurately describing the nonisothermal flow of liquid, vapor, and gas through porous media, together with an algorithm for solving the equations; and (3) to relate moisture movement rates and direction of movement to radionuclide transport.

Field Studies of Moisture Movement

Measurements of moisture distribution in the ground have continued at the lysimeter site, located south of the 200 East Area for the past five years. During the 1976 summer, the moisture envelope from the winter's rainfall penetrated to less than two meters, as opposed to three or four meters in a typical summer. This was due to a fairly dry winter and spring. Also, the 1975-1976 moisture envelope at the two-meter depth did not dry out the moisture content (6 percent by volume) normally found in the deeper sediments

by mid-September as is typical. This is probably due to the cool summer and the higher than average humidity. It appears that abnormally low evaporation rates during some summers will cause rainfall to accumulate in the sediments from one rainy year to the next and several subsequent years may be required to remove this moisture from the ground.

The U. S. Geological Survey recently issued an open file report entitled "Geology and Hydrology of Radioactive Solid-Waste Burial Grounds at the Hanford Reservation, Washington." One of the statements in this document reads as follows, "In general, infiltration (to the groundwater) at the Hanford Reservation is small in amount, but probably is a large percentage of precipitation . . ." This is certainly not true at the 200 Area lysimeter site, and is doubtful on the 200 Areas plateau. Field data for the past five years attest to the fact that all precipitation falling on the ground surface is eventually lost back into the atmosphere. To determine the depth to which precipitation percolates into the ground at other locations in the 200 Areas, six more lysimeters, three each in the 200 West and 200 East Areas will be constructed. Plans call for installation of two lysimeters per year in 1977, 1978, and 1979. A milestone has been established for the completion of the new prototype lysimeter by August 29, 1977.

Development of readout equipment and control devices for the sensors in the open-bottom lysimeter is proceeding, but installation of the equipment is being held up by the steamfitters' strike.

Mathematical Modeling

In the U. S. Geological Survey's open file report it mentions a need to develop "theoretical approaches to the analysis of the soil moisture data." A computer model has been developed and continues to be refined that describes

water, vapor and air flow through sediments in one dimension. Work on this model, called MPHASE, progressed during the quarter, and it will be nearly complete by December 1976. A paper describing the mathematical formulation of the model and some results using the model will be presented at the American Geophysical Union Conference in San Francisco, California, December 1976. A critical review by the leading professionals in this field is expected. A report describing the finished version, sensitivity analyses performed, and comparisons with experimental data will be completed in February 1977.

Two mathematical models, now available in private industry for solving two- and three-dimensional oil reservoir flow problems were evaluated for their capability to solve moisture flow problems, typical at Hanford. Although initial results were encouraging, it appears that these models have definite limitations to their applicability. Further development of MPHASE appears justified, because MPHASE is more suitable for solving some moisture transport problems in the extremely dry sediments at Hanford. All models will require more extensive input data on the hydrological properties of the sediments.

Properties of Sediments

During the report period a controlled environment chamber was finished for measuring hydrologic properties under nonisothermal conditions. This facility will be used to measure the moisture transport characteristics of Hanford sediments in a range of temperatures similar to those found in the upper few meters of the ground surface. These data will be used to evaluate temperature effects on the annual moisture movement cycle, which is different from that which is predicted assuming a uniform temperature with time and

depth. During the next quarter, laboratory experiments will be designed to measure transport of radionuclides through partially saturated sediments. Also, techniques for the determination of hydrological properties of fairly dry sediments will begin.

Biotic Transport - V. A. Uresk

Identification of biological mechanisms acting as vectors for transporting radionuclides to man is necessary to ensure that control of waste radionuclides is maintained within environmentally acceptable limits.

Radioecological Characterization of Waste Disposal Sites

These studies are designed to provide baseline radioecological information about the plants and animals inhabiting the 200 Areas so that their actual and/or potential role in the release, concentration or transport of radioactive wastes can be assessed.

A letter report describing the initial results of a study assessing the potential for root penetration of buried wastes was received. The deepest-rooted plants were bitterbrush (10 ft) and sagebrush (7 ft), but eight of the fourteen species examined had roots extending to more than 5 ft in depth. Bitterbrush and sagebrush are important in undisturbed areas and most likely will become the predominant shrubs in disturbed areas such as burial grounds in the next several decades.

An additional six burial grounds have been sampled to determine the pattern of plant succession with respect to soil characteristics and burial ground age, and the radio-

nuclide concentrations in the vegetation. The burial grounds sampled included 216-S-4, 216-A-6, 216-A-9, 218-E-8, 218-E-2, and 216-B-36. Analytical results will be available the next reporting period.

A draft of the document describing the two-year study of the small mammal populations inhabiting a study area near the B-C Crib Control Zone has been completed. The report describes the species composition, abundance, sex and age class, weight, home range, and population size estimates for the small mammal population on the 200 Area plateau.

As part of a study determining radionuclide concentrations and dose rates to small mammals near U-Pond, thermoluminescent dosimeters (TLDs) were placed at various soil depths along each trapping transect. After 35 days the TLDs were read for gamma exposure. The area which showed the highest readings was between the Z-19 and U-14 ditches with exposures of 207 rads/year at the surface, decreasing to 3 rads/year at the 50 cm depth. Radiochemical analysis of 29 tissue samples of the mammals for plutonium and americium showed levels of <1 pCi/g dry wt, which may be accounted for by fallout.

A study investigating 200 Area deer diets and radionuclide concentrations in fecal pellets has been partially completed. Pellets gathered from near B-Pond, Gable Mountain Pond, and the B-C Crib area have been analyzed for cesium content and prepared for dietary analysis. These values will be related to the radionuclide levels in vegetation identified as important in the deer diet to explore the possibility of using the pellets as biological indicators of environmental contamination.

Compilation of analytical results from a two-year study of radionuclide levels in coots inhabiting 200 Area waste ponds showed average total body burden levels of ^{137}Cs in adult coots to be: B-Pond, 4.21 μCi ; U-Pond, 49.6 μCi ; Gable Mountain Pond, 113 μCi ; and control samples from Columbia Wildlife Refuge, 0.12 μCi . The average concentration of ^{137}Cs in adult coot muscle over the two-year period (from Gable Mountain Pond) was 722 pCi/g. An individual consuming the muscle from one coot per day would after about six months reach an equilibrium level of 1.46 μCi total body burden or 50 percent of the maximum permissible body burden for ^{137}Cs in nonradiation workers. Analysis of coot muscle from U-Pond revealed only fallout levels of plutonium and americium.

An outline for a status report on the radioecology of the 200 Areas has been received from Battelle Northwest. The document is scheduled for completion by April 1977. The report will be a synthesis of information derived from studies conducted in the 200 Areas, the Arid Land Ecology (ALE) Site, other nuclear sites and the pertinent literature which has application toward understanding and solving problems related to biological interactions with radioactive waste management.

Laboratory Studies of Factors Affecting Biotic Uptake

These studies are designed to provide quantitative information concerning the effects of variables such as soil properties, waste chemical form, microbial action, weathering effects, plant structure and nutrient requirements on plant and animal uptake of radionuclides. The information will be used in the formulation and maintenance of environmentally sound waste management practices.

A growth chamber study of the effects of soil properties and waste composition on plant uptake of strontium and

cesium from five Hanford soils was completed. In addition, analysis of the soils for total nonradioactive analogues of cesium and strontium (rubidium, potassium, barium, magnesium, calcium, as well as strontium and cesium) was completed. The harvested plant tissue is also being analyzed for these same stable analogues. This information will provide a basis for selecting stable elements which, when used as soil amendments, would be effective in reducing the availability of strontium and cesium to plants. Analytical results will be available the next reporting period.

Completion of the final document describing plant uptake of technetium, strontium, cesium, plutonium, americium, and neptunium has been postponed to Fiscal Year 1978 due to budgetary limitations.

Resuspension Studies - R. D. Fox

The Resuspension study activity will provide a wind field model to predict site movement of radionuclides through the air. Source terms will be established for the model through actual measurement, data from other programs, and models where appropriate.

Three reports were received from Battelle Northwest: one a formal document BNWL-2047 by T. W. Horst on the "Estimation of Air Concentrations Due to the Suspension of Surface Contamination by the Wind;" a draft report on the status of the resuspension work; and an informal report on the "Implementation of a Variable Trajectory Atmospheric Dispersion Model for the Hanford Reservation," L. L. Wendell, T. D. Fox. An interim report on the "Nature and Significance of Convective Vortices in the Hanford Project," by M. M. Orgill and L. C. Schwendiman has not been reviewed on schedule. The delay is not anticipated to affect the subsequent milestones.

SEISMOLOGY AND GEOLOGY

Tank Farm Geology - W. H. Price

The objectives of this activity are to:

- Document the structure and stratigraphy of sediments underlying the 200 Area Control Zone for use in contaminated soil and sediment management.
- Identify significant hydrological properties of each stratigraphic unit for evaluating the impact of tank leaks on the environment.
- Identify significant mineralogical properties of each stratigraphic unit for use in determining the mineral-waste reactions that affect the stability of radionuclides in the sediment column.
- Assist Tank Farm Surveillance in determining the status of tanks and determining on an as-needed basis the spatial distribution of radionuclides leaked to the environment.

Two core wells were drilled to determine the feasibility of collecting undisturbed sediment samples for use in defining the geology, hydrology and mineralogy of the 200 Area Control Zone. The coring technique recovered 90 percent of all sediments. This was the first successful attempt to continuously core unconsolidated and semiconsolidated sediments of the Hanford Reservation.

Thirteen internal reports containing 140 detailed geology maps and cross sections were issued to provide basic geologic information for utilization in evaluating the movement of suspected and confirmed tank and pipeline leaks.

Modification of tank farm water wells is continuing. The work includes clean out, installation of cement plugs, perforating, and grouting. These modifications in construction will upgrade the wells to meet the State of Washington's Minimum Water Well Standards. At present 200 West Area is completed.

Three 30-meter deep starter wells have been completed in preparation for the coring of 8 additional wells to basalt. The wells will be located in 200 East and 200 West Areas. Coring of these wells will start in October.

Data from these wells, when combined with cable tool well data, will provide sufficient geological information to determine the geology, hydrology and mineralogy of the 200 Area Control Zone.

Seismic Studies - K. R. Fecht

The objectives of this activity are:

- To implement a system for detection of local earthquakes and a plan for evaluation of their impact on major waste containment systems.
- To establish an inspection system for verifying the integrity of critical waste management structures.
- To assess the regional tectonic stability with respect to current and long-term waste management plans.

The immediate response seismic monitoring array, to minimize releases of radionuclides to the environment due to earthquakes, has two operational stations. Two stations to be added to the array are awaiting replacement components.

These additional stations are needed to determine hypocenters and magnitudes with a high degree of precision. At present the array has limited capability.

The field mapping of the basalt units, the geologic structure, and the facets on the north flank of the Horse Heaven Hills from Wallula Gap eastward to Van Sycle Canyon was completed. Compilation of the geologic base map was initiated. Basalt samples collected from the field area were prepared for bulk chemistry analyses and petrographic thin sections. The chemistry and petrography of the basalts are needed to develop the basalt stratigraphy and confirm the geologic structure. In the next reporting period a progress report will be issued on the geological investigations in the Wallula Gap area.

RISK ASSESSMENT

Hazards Available - L. E. Bruns

The objective of this activity is to devise mathematical relationships that equate the toxic substances in waste sites with the "hazards available to man." Such relationships can be used to provide direction as well as to develop criteria for control of contamination sources.

An equation was devised as follows:

$$\text{HA (Hazards Available)} = \text{TF (Transport Factors)} + \text{HI (Hazard Index)}$$

The main thrust of the work for the quarter concentrated on continuing work on a Hazard Index document and writing a paper, "Hazards Available from Toxic Substances", for presentation at the Waste Management '76 Symposium in Tucson, Arizona, October 3-6, 1976.

SPECIAL STUDIES

Gaseous Waste Monitoring Study - Battelle-Northwest

The objective of the BNW study is to determine the particle collection efficiency of selected ARHCO gaseous effluent monitoring systems.

Experimental results for total beta emissions at the 291-B-1 stack (B-Plant stack) showed that the routinely-collected ARHCO sample was within a factor of two of the specially-collected BNW sample 89 percent of the time. Particle sizing experiments at the 296-Z-3 stack (241-Z sump) have shown that the geometric mean aerodynamic diameter of the plutonium bearing aerosol is in the 2.7 to 3.7 micron range. Based on earlier calculations, it is estimated that the 296-Z-3 gaseous effluent monitoring system would deliver approximately 75 percent of the particles sampled to the filter holder. Particle sizing experiments at the 291-Z-1 stack (Z-Plant stack) will be completed in the first quarter of FY 1977. The final report covering all experimental results at the 291-B-1 stack will also be issued in the first quarter of FY 1977. Continued development of a viable tracer technique for economical evaluation of stack sampling system performance will take place during the first quarter of FY 1977.

An evaluation of four gaseous effluent monitoring systems in the Tank Farms (296-A-12, 296-A-17, 296-P-3 and 296-S-18 stacks) will be made in the first quarter of FY 1977.

ANALYTICAL METHODS TECHNOLOGY DEVELOPMENT

Analytical methodology is required to provide support for increasingly demanding concentration measurements of products, effluents, high and intermediate level waste, and for environmental surveillance and research program support. This mission's objective is to provide an integrated development program to meet Atlantic Richfield Hanford Company's needs.

The mission is divided into four major activities. The major activities are dedicated to (1) Analytical Instrumentation Development, (2) Analytical Methods Development, (3) Analytical Computer System, and (4) Field Instrumentation. The four mission activities interrelate and interface with ongoing processing and research programs.

This mission is ongoing through Fiscal Year 1983 while activities are initiated and completed within the mission. Milestones are called out within the activity reports.

ANALYTICAL INSTRUMENTATION DEVELOPMENT

Radiation Analysis Systems Development - W. H. Zimmer

This activity is responsible for the design and application of data acquisition and data reduction systems for nondestructive measurement instrumentation which utilize radioactive emissions. The activity includes the development of radiation detectors, electronic systems, and the data reduction systems needed to analyze gamma, neutron, x-ray and bremsstrahlung radiation.

Alpha Beta Counting Instrumentation - J. K. Hartwell

The automated alpha energy analysis (AEA) system has been configured and all eight inputs tested under computer control. Fabrication of the detector vacuum system has been delayed due to the strike.

The AEA system control software has been written. A continuous television monitor displays the status of all AEA detectors and other automated counting room systems.

Completion of the AEA data reduction software has been delayed 3 to 4 months because of the strike. A data smoothing function and peak fitting function have been developed and tested on limited spectra. Future work will include completion of the detector vacuum system, data reduction software, and testing of the completed system.

Ten Detector Array System - W. H. Zimmer

The 10 detector intrinsic germanium array for environmental gamma energy analysis of bulk samples such as soils, tumbleweeds and filters has been received from Ortec Incorporated. Fabrication of the detector shield and the relocation of a laminar flow hood are delaying the installation and testing of the detector.

Gamma, X-ray Data Reduction Systems - V. W. Hall, W. H. Zimmer and C. P. McLaughlin

The Canberra Scorpio 3000 gamma, x-ray data reduction update system is scheduled to be received the first week in December.

The necessary software code for operating the NOVA 1200 computer in a sequential mode with the Data General operating system (RDOS) and the stand alone ARIS-II program for

gamma analysis is ready for testing after an ARIS-II software update is received from Tracor Northern.

A BASIC program from the National Bureau of Standards which is used to calculate the "best estimate" detector system calibration curve has been incorporated into the NOVA 1220 computer. Detector system calibrations can be followed more closely and calibration data files for each detector can be stored indefinitely on disc. This will permit monitoring and recalculating efficiency curves when needed.

Repairing of the Ino-Tech multichannel analyzer (MCA) has relieved some of the MCA shortage. The interface problems between a Texas Instrument's 733 terminal and the NOVA 1200 still exist and are reducing data reduction capabilities by 50 percent.

Calibration of the well-detector ("U") system was initiated this quarter. This will permit spectral sum-peaks to be used in quantitative analyses of radionuclides which emit coincidence gamma rays. The "Z" detector system calibrations for 65 cc water and soil matrices were completed and are awaiting evaluation. Calibration of the "S" detector system is continuing.

Subcritical Assembly for Low-Level Analysis - W. H. Zimmer

The objective of this activity is the development of a subcritical assembly to be used with delayed neutron counting to determine low levels of fissile isotopes in waste and environmental samples. In addition the activity will provide neutron activation capabilities for analysis of long-lived beta-emitting isotopes and nonradioactive elements.

Reactor Experiments has completed delivery of the CFX pneumatic transfer system and Boeing Computer Services Richland, Inc. has been contracted to write the programs required for controlling the system using the Canberra Industries, Scorpio 3000 computer-analyzer equipment. The Scorpio 3000 system is scheduled for delivery the first week of December, 1976.

The Californium Multiplier (CFX) site installation criteria drawings have been completed and Facilities Service, ARHCO assigned to preparing detailed drawings from IRT Corp./ARHCO concept drawings. Design and documentation of the B-1-F interlocks have been completed.

The interlock for the CFX site cover still needs to be completed. The safety analysis report being prepared at ARHCO is 50 percent complete. All non-strike related aspects of the CFX/delayed neutron counter (DNC) system are on schedule except for the CFX transfer system exhaust control, and the rabbit closure, contamination control and disposal study. None of the 200 West plant maintenance and J. A. Jones Construction tasks are on schedule. Continuation of the strike and higher priority plant maintenance tasks will result in delayed milestones.

Approval of ARHCO/IRT CFX construction specifications and B-1-F stairwell are planned in the next quarter. Documentation of the safety analysis for the CFX/DNC should be completed for the next report period. Completion of the rabbit sealing, contamination control and disposal study, the CFX transfer system exhaust control study, and the installation of the pneumatic transfer systems in B-HA and B-1-C are scheduled for the next period.

Inductively Coupled Plasma (ICPES) Multielement
Emission Spectrometer System - C. S. Homi

This activity is designed to develop the spectrochemical instrumentation needed to support ARHCO's analytical needs. Analytical equipment involving the measurement of light emission, absorption, and scattering in the ultraviolet, visible, and infra-red wavelength regions will be developed. One of the major tasks at present is the development of the argon plasma multielement emission spectrometer system (ICPES) for analyzing 30 elements simultaneously in highly radioactive matrices. Such a system will be less expensive, more time responsive and lower in radiation exposure than present methods.

Applied Research Laboratories (ARL) has been selected to supply the spectrometer, plasma generator, and plasma torch containment box. The system will be capable of analyzing 30 elements simultaneously in highly radioactive matrices. In addition the emission from the source may be scanned using an existing monochromator at 180° to the direct reading spectrometer. Bids for fabrication of the hood scrubber and off-gas facility will be submitted off site as soon as ARL completes the containment box design. Preparation of the facilities in 1F of the 222-S Building is pending settlement of the steamfitters' strike. Delays in these items could affect milestones for this activity.

Preparation of standards for the system will begin next quarter. The equipment is scheduled to be received the latter part of the next reporting period.

Oak Ridge National Laboratory (ORNL) Fluorimeter - T. J. Hanson

The electronics and sample chamber for the ORNL fluorimeter has been received. Testing and development of an improved fluorimetric uranium method for plutonium processing operations is being delayed until the fabrication of the sample fusion train is initiated and completed by shops.

Atomic Absorption Carbon Rod Atomizer - T. J. Hanson

The carbon rod analyzer and background correction system for the atomic absorption has been received. Testing and development of new trace element methods for metals in ^{90}Sr and ^{137}Cs product samples will be initiated in the next report period. If applicable the method will permit the analyses of these materials with less exposure to personnel.

ANALYTICAL METHODS DEVELOPMENTActinide Analytical Program - S. J. Johnson

The objective of this activity is to measure quantitatively the concentration of actinide elements in samples from waste tank salt cake, sludges, residual liquor and other high-salt matrices. The analysis will provide highly selective, sensitive analyses such that precise, timely results can be attained by the analytical laboratory.

Work during the report period has been devoted to accumulating statistical data, modifying the electroplating cells to increase throughput and preparation of standard mounts for alpha counting and alpha pulse height analysis. Transfer of the technology and pieces of the equipment for routine use is currently in progress.

Analytical Development for Waste Management

The objective of this multifaceted activity is to provide analytical procedures for rapid, specific measurements of radioactive and nonradioactive constituents in wastes and to transfer the technology developed to the analytical laboratories for routine use.

Laser-Raman Spectroscopy - T. J. Hanson, A. G. Miller

Laser-Raman Spectroscopy is being developed to determine oxy-anion concentrations in complex concentrated nuclear wastes. Up to six anions such as nitrate, nitrite, sulfate, aluminate, chromate or phosphate can now be determined simultaneously by this technique. In addition, carbonate can be measured after a chemical separation is performed. Uranyl nitrate can be measured in the concentration range 5×10^{-4} M to 2M UO_2^{++} with precision about 5 percent. Analytical Laboratory personnel are being trained as Class V laser operators.

Analytical support was provided to the evaporator-crystallizer pilot plant using this technique. This development work has progressed in accordance with established milestones.

Automation of the instrument and documentation of the development efforts and operating experience will begin during the next report period.

Technology For Standards Preparation and Measurements -

T. J. Hanson, A. G. Miller

In order that analyses on samples of radioactive wastes, (liquid or solid), can be evaluated and found valid, the

ability to measure the analyte must be demonstrated on a material of known composition.

This standard should be similar to the sample. The result of this activity is the technology for the Standards Laboratory, Quality Assurance, to use in preparing standards for the quality control program. The technology has been developed for two concentrated multicomponent waste liquor solutions and a synthetic salt cake solid. Independent characterization of the salt cake standard shows statistically significant weak and strong points in the analytical methods in use. Improvements to those methods found inadequate are in progress.

Physical characterization methods have been applied to salt cake in some cases without a reference standard. Industrial materials which might be used are being investigated. Characterization of the salt cake standard will be completed during the next report period.

A sludge standard to simulate waste tank sludge will be prepared during the next report period.

Plutonium Assay - C. S. Homi, T. G. Ibsen

The objective of this activity is to provide analytical methods which are superior to existing methods in accuracy, precision, and/or cost effectiveness. The methods developed must qualify as suitable for FFTF fuel and safeguards control of fissile material.

An amperometric plutonium assay is being developed to replace the traditional chemical assay procedure. The amperometric assay will minimize reruns by eliminating vague

and drifting potentiometric endpoints. All measurements of sample and titrants are made by weight. Titrant used is a relatively stable potassium dichromate, a primary standard from National Bureau of Standards. Limited precision data indicates that the relative standard deviation for nine aliquotes removed from a single stock solution is 0.04 percent. Data were collected on two consecutive days.

Microprocessor programs for both data acquisition and reduction are completed and are ready for debugging. The program will provide statistical calculations for the measurement.

Glovebox and equipment modifications are required before additional statistical data can be generated during the next report period. Better dissolution techniques will be investigated.

Analytical Assistance

The objective of the analytical assistance activity is to collect those short-term projects performed for the Analytical Services or other Research members. It also includes significant isolated accomplishments of chemists which are not included in Five-Year Technology Plans.

Cadmium Analysis By X-ray - S. G. Metcalf

Cadmium analyses are required for the criticality safety analysis of the sediments mined from the Z-9 disposal site. The accepted measurement method has been atomic absorption spectroscopy, but due to perturbations it was desirable to have an alternate method. An X-ray spectroscopic method was perfected and the technology for the determination was transferred to the analytical laboratory performing the routine analysis.

ASTM Method Acceptance - C. S. Homi

An analytical method entitled "Suggested Method for Optical Emission Spectrometric Analysis of Plutonium Dioxide by the Silver Chloride - Lithium Fluoride Carrier Technique" by C. S. Homi will appear in the next ASTM E-2 Supplement publication.

Air Sample Counting Detectable Limit - J. K. Hartwell,
R. N. Diebel

The detection limit, the amount of material which must be present in order to be detected with 95 percent confidence, for the 234-5 Laboratory air sample counting method has been estimated. This value was calculated for the counting system only and did not consider fluctuations in collection data.

If no radon-222 or thoron-220 daughter activity is detected by the coincidence counter, the technique has an estimated detection level of 2.8×10^{-14} $\mu\text{Ci/cc}$ for a weekly sample of 2.5 cubic feet per minute (CFM) air flow and of 9.7×10^{-14} $\mu\text{Ci/cc}$ for a daily sample with air flow of 5 CFM. If high concentrations of radon and thoron daughters are present, the detection levels are increased to about 4×10^{-13} $\mu\text{Ci/cc}$ for the 2.5 CFM weekly sample and 1×10^{-12} $\mu\text{Ci/cc}$ for the 5 CFM daily.

ANALYTICAL COMPUTER SYSTEM - D. L. Anderson, W. F. Bauer

The objective of this activity is to interface all major analytical instrumentation to a computer system for control, data acquisition and data reduction. The activity is designed

to provide a common data base for all laboratory computer systems, reduce data handling, increase information availability, minimize training time and provide more cost effective analytical service.

Laboratory Analytical Automation

CAMAC-Laser Link

A CAMAC serial highway, using a laser data communication link was successfully implemented between the 222-S and 234-5 buildings. This will permit data from 234-5 analytical systems to be transmitted to the 222-S building computer system for storage or data reduction. The communications link was tested under different weather conditions, times of day, and lengths of time. Observed error rates in the transmission test are not expected to affect the accuracy of transmitting data. The link will not be applicable in severe weather conditions (heavy rain or dust) and may be affected by high temperatures. Future plans include an evaluation of the temperature problem, writing of application software and integration of the link into the 222-S Real Time System.

FIELD INSTRUMENT DEVELOPMENT - L. E. Bruns

The activity objective is the development of field instrumentation which can be used to obtain data on the physical and radiochemical characteristics of the various waste sites in the 200 Areas. It is also expected that this data along with the instrumentation will provide a basis for the long-term surveillance of these sites.

Beta Assayer

The beta assayer for assaying ^{90}Sr and other beta emitters in the field is being devised and constructed by Battelle Northwest for ARHCO. The wheel mounted instrument package will weigh about 100 lbs and be able to monitor horizontal surfaces, ring cores, and compacted vegetation such as Russian Thistle. Vendor delay in shipping the electronics may result in a slip in the assembly schedule but should not affect the completion date on equipment testing.

Dev-Van-I

Dev-Van-I is still awaiting mounting of existing electronics, generator, air-conditioning, plastic top, and auxiliaries.

Improved detectors were investigated using CdTe and intrinsic silicon crystals to detect ^{241}Am and ^{239}Pu . The intrinsic silicon was able to detect and separate ^{241}Am and ^{239}Pu at the 10 nCi Pu/g level by using the L-X-ray. The low atomic weight of silicon and its machinability may make it a superior field L-X-ray unit over the intrinsic germanium system. The CdTe system showed no significant improvement over the well known NaI(Tl) system.

Dev-Van-II

Proposals were requested from three companies for a logger-van system which would be used with appropriate detectors, some of which are currently on site, to measure subsurface radionuclides in the field. The objective of having the unit on site by April 1977 will be influenced primarily by whether a waiver can be obtained to buy the van chassis from the equipment supplier rather than through Government Services Administration. If this waiver can not

be obtained, the milestone will be delayed a year and increase ARHCO's cost. In addition to the available gamma detectors, neutron detector systems which have directional and coincidence correction capability will be developed and purchased.

"Passive" Activation System

Use of metal foils sensitive only to neutrons can be valuable for estimating the Pu concentration in subsurface sediments, salt cake and on surfaces. They can also be used to estimate neutron dose rates. Regardless of the gamma field, this technique allows measurement of Pu in the nCi Pu/g range. Initial studies involved qualitative field testing in (1) a high-level waste tank, (2) a Pu slurry retention tank, 361-Z, (3) plutonium storage areas, (4) Z-9 Crib, and (5) other cribs and work areas. Values in the nCi range for Pu were estimated in gamma fields in the 10 rad magnitude.

To obtain the best sensitivity and accuracy the type of metal, geometry of foil, moisture alpha-n, matrix, and isotopic effects, will be evaluated in a laboratory facility. The unit is 1.2 meters in diameter and one meter high. It will contain various well casings for detector, source, and moisture measurements. The unit will be filled with a typical 200 Area plateau sediment matrix. At the end of the quarter the unit was completed with sediments added. Moisture measurements will begin in November as well as initial experiments using a plutonium fluoride source.

Calibration Facility

To calibrate and test subsurface assay systems and to obtain environmental data such as sediment absorption coefficients, three calibration tanks will be placed in the

subsurface near the Redox building. Two tanks 1.2 meters in diameter will be 4 pi calibration systems, one containing Ru, the other Pu. The large calibration tank, 3 meters in diameter, will contain four different matrices and fixed wells for source and detector emplacement. All drawings are completed and the large tank is about 25 percent completed. J. A. Jones is performing this work and the milestone for emplacement of these tanks, February 1977, will be directly dependent on the length of the current strike.

Void Volume Detector

A proposal was received from Holosonics Incorporation for detecting void volumes in the subsurface. It utilizes a radar electromagnetic wave principle and appears to be an improvement over the initial method (also proposed by Holosonics) which was a transfer impedance technique.

Requests For Instrumentation

A request was made for instrumentation from Waste Solidification Engineering and Design Section that could detect salt cake density, porosity and voids. The only system that appears feasible thus far is use of in-well ^{252}Cf activation.

ENVIRONMENTAL CONTROL TECHNOLOGY
MANAGEMENT OF SURPLUS FACILITIES AND EQUIPMENT

DISPOSITION METHODS RESEARCH AND DEVELOPMENT

Contaminated Equipment Volume Reduction - D. C. Nelson,
Program Manager

This program proposes to demonstrate that multi-ton, stainless steel vessels can be cut into small pieces and subsequently melted, thereby reducing the storage volume by up to a factor of 20, in addition to greatly improving the quality of the material to be stored. Emphasis is being placed on the arc saw, the size-reduction tool, and a cold-wall vacuum furnace for melting. Cold testing of size-reduction and volume-reduction equipment will begin by the end of fiscal year 1978. Hot testing of size-reduction equipment will begin in FY 1981, and hot tests with volume-reduction testing will begin in FY 1982.

Decontamination Evaluation - G. A. Beitel

The purpose of this activity is to evaluate costs and secondary waste generation associated with equipment decontamination as a precursor to volume reduction. A decontamination test on a Purex dissolver has been planned to provide this information.

There was no action on this task during the quarter due to manpower limitations caused by the Hanford Atomic Metal Trades Council strike in April. The original milestone completion date of June 1976, has as a result slipped

considerably. The task should be completed by January 1977. Since no other tasks are contingent upon this task, this delay does not have any significant impact upon the program.

Size Reduction Evaluation - G. A. Beitel

This activity attempts to devise a system which can demonstrate that large, multi-ton stainless steel process vessels can be safely, rapidly, and remotely cut into small pieces that will be easier to handle and melt down.

Functional criteria for a 16 inch and a 48 inch arc saw were prepared and the request for bid on a design and build contract for the saws was completed. A bid is anticipated by the end of October 1976. The 16 inch saw will be used for training and pretesting. The 48 inch saw will be used in large scale size-reduction demonstrations.

A size-reduction test stand on which to test the arc saw was designed. Upon review, it no longer appeared to be adequate. Several new variations are now under consideration. This effort will continue throughout the next quarter. The time required to produce a satisfactory design should not, however, cause any delay in the completion of the size-reduction system, which is milestone for the third quarter of FY 1978.

Identification of a site which can be used to test the furnace and saw continues to be a problem. No existing facility has yet been identified which is both suitably sized and available for use. Last quarter's idea of using the remote shop and decontamination cell of the Redox canyon building was abandoned because of the anticipated difficulty of moving clean equipment through a radiation zone. It now appears that a steel shell building is the best option. Capital funds for such a facility will not be available until FY 1978. This may cause some delay or inconvenience, towards the latter part of FY 1977.

Volume Reduction Evaluation - G. A. Beitel

This activity attempts to determine whether radioactively contaminated equipment can be safely melted and cast as a product acceptable for final storage. The specific objective is the design of a low-maintenance, remotely operated meltdown system incorporating maximum fume control. In support of this work, experimental meltdown of contaminated stainless steel pipe samples has been planned to provide information regarding the melting process.

A contract was negotiated with ReTech, Inc., for the detailed design of a cold-wall vacuum furnace of sufficient size to melt 1,000-pound individual batches of stainless steel scrap. The contract began in the last week of May and was completed on September 30, as scheduled. During the next quarter a bid package for fabrication of the furnace will be prepared and sent out for competitive bids.

The proposed slag separation tests with contaminated steel samples were not conducted because of manpower limitations. This work will be reactivated during the next quarter.

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