ARH-ST-128 B
Distribution Categories UC-4, UC-70

RESEARCH AND ENGINEERING DIVISION
SEMIANNUAL REPORT
KK PROCESS DEVELOPMENT AND TECHNOLOGY
MAY 1, 1975 THROUGH OCTOBER 31, 1975

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April 1976

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RICHLAND, WASHINGTON 99352

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ABSTRACT

This document represents the second of a series reporting on a semiannual basis the activities supported by KK funds in the areas of process development. These research and engineering activities have the goal of improving the performance of the plutonium processing and waste management programs being operated by the Atlantic Richfield Hanford Company.

RESEARCH AND ENGINEERING DIVISION
SEMIANNUAL REPORT

KK PROCESS DEVELOPMENT AND TECHNOLOGY
MAY 1, 1975 THROUGH OCTOBER 31, 1975

INTRODUCTION

This document describes the scientific investigations and engineering application programs being sponsored by KK funds under the direction of Atlantic Richfield Hanford Company's Research and Engineering Division. The document has been divided into 10 program areas--1 associated with plutonium production and 9 with managing the wastes generated during production. Each of these program areas is divided into the activities necessary to effectively present the technical information.

The report titles are those identified in the program plans and the ARHCO code listings. The program manager responsible for defining the program objectives and ensuring that adequate resources are available to perform the work is identified, as well as the principal investigator who is responsible for directing the daily work.

This report is intended to present progress and is not a total program plan for each activity. Interested individuals are invited to communicate with the program managers for planning information and to offer comments.

Each report is presented with sufficient background for the reader to understand the scope and objective of the program, a brief summary of prior work, a review and analysis

of the work conducted during the report period, and work planned for the next six months. Pertinent reports issued during this period are listed.

SUMMARIES

Page

PLUTONIUM FINISHING PLANT

PLUTONIUM PROCESS TECHNOLOGY

Plutonium Reclamation Facility Waste Solidification 9

The Z Plant aqueous salt waste concentrate can be reliably dried on a drum-type drier. An average decontamination factor of 10^4 , which is adequate to meet environmental release standards, can be achieved using two stages of evaporation.

Continuous Monitoring of Liquid Effluent for Plutonium 11

Several sources of electrical noise and a contamination mechanism were identified as adversely affecting the accuracy and precision of the monitor.

Plutonium Solvent Extraction Model 12

Flowsheet development by computer modeling has enabled the construction of alternative flowsheets which improve process efficiency and reduce liquid waste discharge.

Solid Plutonium Nitrate 13

Large-scale production of plutonium nitrate crystals is possible. Process optimization and storage stability must be investigated before engineering recommendations can be made.

PageWaste Treatment Column Improvement

14

Laboratory studies identified the need for an improved interface indicator, interface controller, and a special holddown device on the production waste treatment columns.

PLUTONIUM SCRAP DISSOLUTION AND PROCESSING DEVELOPMENTPlutonium Oxide Dissolution

16

The continuous addition of plutonium-bearing scrap and HNO_3 -0.1M HF into the dissolver could significantly increase the recovery and throughput of plutonium.

Amine Solvent Extraction of Plutonium

18

The superior chemical and radiolytic stability of Amberlite LA-2[®] makes an amine extraction process particularly well-suited for eventual use in the Plutonium Reclamation Facility with scrap containing significant concentrations of ^{241}Pu and ^{240}Pu .

Bidentate Organophosphorus Extraction of Americium and Plutonium

20

Mixer-settler tests with actual Z Plant acid CAW solution have successfully demonstrated a DHDECMF flowsheet for reduction of both the plutonium and americium content of this waste stream to well below actinide-free (<10 nCi/g) levels.

FRACTIONIZATION

SLUICING AND B PLANT

24

Characterization of the 101-AC sludge indicated slow liquid-solid phase separations would be experienced during sluicing; however, with the reduced processing rates projected for B Plant, phase separation is not expected to be a problem.

PageSTRONTIUM SOLVENT EXTRACTION

25

Laboratory tests have shown that citric acid may be substituted for a portion of the HEDTA and EDTA chelating agents in the solvent extraction feed.

ENCAPSULATIONCESIUM ENCAPSULATION

28

Design drawings for the tilt-pour melter equipment were completed and the decision made to concentrate the cesium chloride in the melter rather than in a separate evaporator.

CAPSULE DECONTAMINATION

30

Laboratory tests have shown that capsules contaminated in the cell can be decontaminated in a matter of minutes to ~200 counts per minute using electropolishing.

CONCENTRATION, TERMINAL LIQUOR, SALT CAKE,
AND SLUDGE CHARACTERIZATIONINTERSTITIAL LIQUOR REMOVAL

32

Compressed air and imbibition displacement of interstitial liquids from salt cake were found ineffective. A mathematical model was developed which appears to describe liquid flow in salt cake.

TERMINAL LIQUOR DISPOSITION

35

The investigation of partial neutralization and other processes indicates that methods to significantly reduce the volume of terminal liquors are feasible.

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<u>ALUMINUM REMOVAL FROM HIGH-LEVEL RADIOACTIVE WASTE</u>	40
The Bayer and Silica processes for removing aluminum from high-level waste may not be useful because of development time required to bring the processes into full-scale operation.	
<u>CHEMICAL AND PHYSICAL CHARACTERIZATION OF SALT CAKE</u>	42
A variety of physical and chemical tests can now be performed to characterize salt cake core samples.	
<u>SALT CAKE CHARACTERIZATION (CORE SAMPLER DEVELOPMENT)</u>	44
Preliminary tests have proven that the rotary core drill wire line retrieval method is a viable technique for recovering samples from the waste tank.	
<u>TANK OPERATIONAL CRITERIA</u>	46
The allowable operating temperatures for the 241-SX and 241-U Tank Farms are discussed. Storage criteria for tank usage are being finalized.	
<u>WASTE TANK LEAK DETECTION</u>	48
Determining the interstitial liquid level in salt cake has proved more difficult than expected. The detection of tank leaks by the electrical conductivity of the soil around the tanks has been evaluated experimentally and appears promising.	
CONTAMINATED SEDIMENT CONTROL AND BIOLOGICAL UPTAKE	
<u>SURFICIAL CONTAMINATION - CRIBS, TRENCHES, SWAMPS, AND PONDS</u>	51
Characterization of the Hanford Redox Swamp was completed and characterization of other locations is discussed. The measurement and evaluation of parameters important to transport mechanisms, and evaluation of parameters important to transport mechanisms emphasize the need for <i>in situ</i> environmental instruments.	

PageSOIL STABILIZATION

55

Immobilization of loose soil with surface affixant M166[®] was demonstrated. An asphalt emulsion was successful in stopping a simulated subsurface water line leak and an actual underground coupling leak. Surface fixation with an asphalt emulsion was accomplished with some equipment difficulty. Further evaluation of subsurface injection and spraying equipment is indicated.

DECONTAMINATION/IMMOBILIZATION

58

Mobile equipment evaluation is continuing and radionuclide removal processes are being devised to reduce concentrations in liquid effluents.

RADIONUCLIDES IN SOIL-PLANT SYSTEMS

61

The concentration factors in tumbleweed and cheat-grass were determined for ^{137}Cs , ^{90}Sr , and ^{99}Tc . It appears possible to predict plant uptake by measuring the concentration of radionuclides in the soil.

RADIONUCLIDES IN TERRESTRIAL PLANT-ANIMAL SYSTEMS

64

Ecological characterization studies of small mammals and invertebrates near the B-C Crib controlled zone and Redox Swamp areas has been completed.

RADIONUCLIDES IN AQUATIC BIOTA AND SEDIMENTS

69

No seasonal cycling of ^{137}Cs levels in coots has been observed. A preliminary analysis shows that a human eating a Hanford coot per day would reach an equilibrium level of <2% of his maximum permissible body burden. The probability of a Hanford coot being among those retrieved by a hunter on the Pacific flyway is about 0.12%.

ACTINIDE SEDIMENTS

ACTINIDE TRENCH CHARACTERIZATION

72

A new hood facility was readied for totally contained drilling through the bottom of the 216-Z-12 Trench. Tests indicated that the detection of actinides in sediments sampled >10 meters below the bottom of trenches will require a new sample preparation hood and the utilization of more sensitive analytical techniques.

GROUNDWATER HYDROLOGY

77

A number of reports and maps were issued that describe the groundwater hydrological regime under Hanford.

TANK FARM GEOLOGY

82

The distribution of radionuclides within the 241-A and 241-T Tank Farms correlates with the geologic maps and cross sections.

TRANSPORT STUDIES

MOISTURE TRANSPORT STUDIES

85

Additional lysimeters are needed to characterize the moisture movement in the tank farms and adjacent to solid and liquid waste disposal areas.

AIRBORNE TRANSPORT STUDIES

88

During May and June of 1975, basic data on the relationship between surface contamination and the amount resuspended were developed. The need for additional work is discussed.

INSTRUMENTATION AND CHARACTERIZATION

ENVIRONMENTAL INSTRUMENTATION

91

Field instruments to rapidly and accurately characterize the concentration, amount, type, and distribution of radionuclides in the environment are discussed.

WASTE CHARACTERIZATION

97

The identification of means by which radionuclides at Hanford can enter man's environment are being studied. Meteorological and biological driving forces are discussed.

ANALYTICAL METHODS DEVELOPMENT

ACTINIDE ANALYTICAL PROGRAM

100

An actinide separation using Aliquat-336[®] and TTA for Pu and Np analyses and DBDECMP for Am analysis provides reliable actinide results at levels two times MPC for a control zone.

RADIATION ANALYSIS SYSTEMS DEVELOPMENT

103

Five new detectors were brought on line, two of which were newly developed. The Gamma X-Ray Data Reduction (GXDR) is now perfecting data reduction for 17 pulse height analyzer systems as opposed to 8 in the last report period. Concurrently, the GXDR system is being updated on schedule to perform at higher levels of efficiency and accuracy.

PLUTONIUM FINISHING PLANT

PLUTONIUM PROCESSING TECHNOLOGYPlutonium Reclamation Facility Waste Solidification

Program Manager: R. E. Felt
Section Manager: R. E. Felt
Principal Investigators: G. D. Barnhill
P. C. Ely
M. R. Fox
T. R. Haddad
J. C. Petrie
Activity Code: B04T3

Objective and Scope

This project's goal is to develop a concentrating and drying process for converting Z Plant aqueous salt waste to a solid suitable for retrievable transuranic storage.

Prior Work

Laboratory hot plate drying of Z Plant aqueous salt waste samples was completed.

Progress During Report Period

Laboratory studies characterizing the Z Plant aqueous salt waste were completed.

Drying synthetic Z Plant aqueous salt waste on wiped-film and drum-type drying equipment was observed at vendor pilot plants. The wiped-film driers were difficult to control whereas the drum driers operated satisfactorily and produced a suitably dry product. The drum drier data yielded a preliminary sizing of a drum drier capable of handling the waste from Z Plant. A laboratory-size twin-drum drier has been purchased and installed at Redox Plant to obtain additional drying data.

Vapor-condensate-decontamination factors for plutonium in Z Plant aqueous salt waste were tested in the laboratory. Limiting the liquid entrainment in the off-gas system yielded a decontamination factor (DF) of 10^6 for condensate produced from the evaporation of Z Plant high-salt waste solution. A DF of about 10^5 was also demonstrated in the second evaporation cycle. The overall DF of about 10^{11} exceeds the minimum design requirement of the Z Plant Waste Solidification program.

Evaluation of Effort

The Z Plant aqueous salt waste concentrate can be reliably dried on a drum-type drier. A unit capable of handling Z Plant aqueous waste production will be small enough for installation within a containment enclosure.

Vapor-condensate Pu decontamination factors of 10^5 to 10^6 can be achieved across each stage of concentration equipment. An average decontamination factor of 10^4 is adequate using two stages of concentrating equipment to produce process condensate that meets environmental release limits.

Future Work

The new pilot-plant unit will be used to obtain additional data on drying Z Plant aqueous salt waste concentrate in drum driers. These data will include heat transfer coefficients, corrosion evaluations, determination of the maximum allowable operating steam pressure, and correlation of drier drum r/min versus drying steam temperature.

Continuous Monitoring of Liquid Effluent for Plutonium

Program Manager: R. E. Felt
Section Manager: D. E. Braden
Principal Investigator: G. E. Martin
Activity Code: B04T2

Objective and Scope

This program's purpose is to develop equipment and methods to reliably monitor for Pu at the maximum permissible concentration (MPC) in liquid effluent from Z Plant.

Prior Work

The monitoring equipment was installed, and many hydraulic problems were solved.

Progress During Report Period

Electrical noise adversely interferes with the alpha count rate of the monitor. Several sources of electrical noise have been identified. Work has begun to eliminate the noise interference problem.

The monitor traps air when the sample steam flow stops. The trapped air splashes contamination on the detector when flow is restored. A system has been designed for decoupling the monitor from the sample stream when flow stops. Fabrication of the equipment has begun.

Evaluation of Effort

A reduction of the electrical noise interference should improve the accuracy of the count rate. The count rates are very low, which makes the system extremely sensitive to higher frequency radiation.

Decoupling the monitor from the sample stream is

expected to eliminate contamination of the detector by flow stoppage, which is an important factor in reliable service.

Future Work

Future work will focus on the elimination of electrical noise and evaluation of the decoupler system.

Plutonium Solvent Extraction Model

Program Manager:	R. E. Felt
Section Manager:	R. E. Felt
Principal Investigator:	L. A. Fort
Activity Code:	B04T1

Objective and Scope

The objective is to develop a mathematical model of the Plutonium Reclamation Facility (PRF) solvent extraction process using the SEPHIS program and to study the existing flowsheets and evaluate changes for improved process performance. As comprehensive equilibrium data for the distribution of plutonium and nitric acid into new process solvents become available, the model will be used to develop new flowsheets.

Prior Work

None.

Progress During Report Period

The PRF solvent extraction flowsheets have been modeled. Alternative flowsheets have been constructed for improving process efficiency, reducing the quantity of

liquid wastes discharged, and reducing the plutonium content of the waste stream by a factor of 10.

Evaluation of Effort

Computer modeling has enabled the construction of alternative flowsheets that improve process efficiency and reduce liquid waste discharge. The computer method of analyzing complex solvent extraction problems should improve control of the process.

Future Work

Develop new flowsheets as comprehensive equilibrium data for new process solvents become available.

Solid Plutonium Nitrate

Program Manager:	R. E. Felt
Section Manager:	R. E. Felt
Principal Investigator:	P. C. Ely
Activity Code:	B04T1

Objective and Scope

The objective of this study is the evaluation of dried plutonium nitrate crystals as an alternative shipping form to PuO_2 . The work will determine the possibility of producing the crystals in quantity, the optimum crystal production conditions, and the impact of storage on the chemical and physical properties of the crystals.

Prior Work

None.

Progress During Report Period

Two kilograms of crystalline plutonium nitrate were produced having an apparent molecular weight equivalent to $\text{Pu}(\text{NO}_3)_4 \cdot 10\text{H}_2\text{O}$. The material was markedly hygroscopic.

The molecular weight of $\text{Pu}(\text{NO}_3)_4$ crystals is dependent on the temperature and vacuum used during the drying cycle. Crystals with molecular weights between PuO_2 and $\text{Pu}(\text{NO}_3)_4 \cdot 5\text{H}_2\text{O}$ were produced using temperatures between 80° and 120° C and vacuum between 100 and 500 microns. Process conditions for producing specific molecular weight products have not been fully defined.

Evaluation of Effort

The work has demonstrated that large-scale production of $\text{Pu}(\text{NO}_3)_4$ crystals is feasible. The process conditions required to produce specific compounds have yet to be fully defined and require a more extensive experimental program using new equipment.

Future Work

At this time there is no further work planned for this program.

Waste Treatment Column Improvement

Program Manager:	R. E. Felt
Section Manager:	R. E. Felt
Principal Investigator:	P. C. Ely
Activity Code:	B04T3

Objective and Scope

The objective of this work is to evaluate potential changes in the continuous waste treatment facility equipment and flowsheet for improved solvent extraction recovery of americium and plutonium. New extraction columns and process solvents will be tested.

Prior Work

None.

Progress During Report Period

Installation and preliminary testing of the three-column pilot facility have been completed. Two problems common to the plant columns have been identified: the capacitance probe for detecting the position of the aqueous-organic interface in the column gives erroneous indications because air registers the same as organic; and the interface controller on the upstream column(s) does not provide a smooth, continuous flow of organic to the cascade downstream column(s).

The pilot glass columns could not be packed tightly enough with Kynar[®] (Pennwalt Corporation) plastic Intalox saddles to prevent the packing from moving up and down with the pulse wave, thus decreasing the column's efficiency. A special hold-down device may reduce this movement.

Evaluation of Effort

Work has demonstrated the need for an improved interface indicator, interface controller, and special hold-down device for pulsed packed columns.

Future Work

Column efficiencies will be determined by varying pulse conditions, using other types of column packing material, using different sieve and nozzle plates, changing flowsheet conditions, and using new process solvents.

PLUTONIUM SCRAP DISSOLUTION AND PROCESSING DEVELOPMENT

Plutonium Oxide Dissolution

Program Manager:	R. E. Felt
Section Manager:	H. Babad
Principal Investigator:	D. A. Dodd
Activity Code:	B1350

Objective and Scope

The purpose of this study is to better understand the dissolution behavior of plutonium dioxide (PuO_2)-- understanding which will be used to improve the recovery of plutonium from scrap. This work will determine the dissolution and leaching conditions most compatible with those of the Plutonium Reclamation Facility. Because the stored scrap is highly variable in matrix and composition, this study considers as many scrap forms as practical.

Prior Work

Controlled batch and semicontinuous dissolution tests were conducted on PuO_2 prepared from oxalate, metal, and oxide sintered to 1400°C . These tests showed that the continuous system is superior to the batch contact and that 0.1 to 0.2M fluorine in 12M HNO_3 is sufficient to dissolve plutonium. Increasing the surface area by grinding

increases the dissolution rate by as much as a factor of 20.

Alternative dissolver solutions and nonaqueous methods have not shown significant improvement over the nitric acid-hydrofluoric acid system.

Progress During Report Period

Preliminary tests were performed on a number of ash and PuO_2 samples using 48% HF as a pretreatment; Pu is then dissolved with 1 to 2M HNO_3 -1M aluminum nitrate nonahydrate (ANN), and siliceous material is dissolved by the HF while the Pu remains insoluble. After filtration the plutonium fluoride is dissolved. The data indicate marginal improvement for the scrap forms tested. In one test on incinerator ash a significant improvement was noted. Plutonium recovery was not enhanced by the HF pretreatment in those tests in which the carbon content was high, such as incompletely incinerated scrap.

Approximately 99% of the Pu was recovered in the laboratory from high-carbon scrap using a potassium hydroxide-sodium peroxide ($\text{KOH-Na}_2\text{O}_2$) fusion, after which the fused material was dissolved in HCl. The Na_2O_2 increases the rate of carbon oxidation and allows chemical attack on the contained Pu. This oxidation occurs rapidly and care must be exercised during the Na_2O_2 addition. This rapid reaction was observed during the development of this technique at Battelle, Northwest Pacific Laboratories (BNW).

Evaluation of Effort

Process modifications to allow continuous addition of Pu-bearing scrap and HNO_3 -0.1M HF seem to represent the most significant improvements to Pu recovery in our existing facilities.

Future Work

Additional tests will be performed on ash to judge the effectiveness of HF pretreatment to Pu and the fusion techniques that are applicable to process facilities.

Amine Solvent Extraction of Plutonium

Program Manager:	R. E. Felt
Section Manager:	H. Babad
Principal Investigators:	W. W. Schulz D. G. Bouse
Activity Code:	B1350

Objective and Scope

The objective is to improve solvent extraction performance in the Plutonium Reclamation Facility while decreasing costs by developing an amine plutonium extraction process to replace the currently used tributylphosphate (TBP) process.

Prior Work

Plutonium extraction capacity and other chemical and physical properties of CCl_4 and trichlorobenzene (TCB) solutions of Amberlite LA-2[®] (Rohm and Haas Company), a high-molecular weight secondary amine, were studied intensively. The principal advantage of the LA-2 solvent over the presently used 20 vol% TBP- CCl_4 extractant is the greater chemical and radiolytic stability. For example, after exhaustive stripping with dilute HNO_3 , an irradiated LA-2 solvent retains only about 0.3 mg Pu/liter for each watt-hour of absorbed energy, compared with a retention of

56 mg Pu/liter by an irradiated, stripped 20 vol% TBP-CCl₄ solvent.

Comprehensive equilibrium data were obtained for the distribution of Pu and HNO₃ between 30 vol% LA-2-CCl₄ solvent and various aqueous solutions [0.1 to 4.0M HNO₃-0.0 to 1.0M Al(NO₃)₃-0.0 to 0.25M HF] containing 1, 10, 30, and 60 g/liter Pu. These data were used to devise a new amine plutonium extraction process. The new process involves operation of only the CA (extraction), CC (strip), and CO (solvent wash) columns. An HNO₃-HF solution is used in the solvent wash column to remove small amounts of Pu which are not stripped in the CC Column. Chemical flowsheets for this conceptual process were satisfactorily demonstrated in mixer-settler runs at 25° C using both 30 vol% LA-2-CCl₄ and 30 vol% LA-2-TCB solvents.

Progress During Report Period

Having demonstrated in laboratory studies the technical feasibility and operability of a reflux amine plutonium extraction flowsheet, current emphasis is on mathematical modeling of the amine system and on computer-assisted design and testing (using the program SEPHIS) of optimum reflux and once-through flowsheet conditions. The comprehensive equilibria data obtained earlier provide the input for the mathematical modeling.

Because of a deliberate decision to emphasize development of a bidentate Am-Pu recovery process, only slight progress was made in modeling the LA-2 extraction system. Comparisons of equilibrium organic phase plutonium and, particularly, nitric acid concentrations, were made with concentrations expected from known secondary amine extraction mechanisms and stoichiometries. Acidities of

LA-2 phases containing high (≥ 20 g/liter Pu) concentrations of Pu appeared in reasonable agreement with unexpected concentrations. At lower organic phase Pu concentrations, however, HNO_3 concentrations of the LA-2 phases were higher than expected. This discrepancy may be due to failure to completely convert the LA-2 from free base-form to nitrate-form before extraction of plutonium and nitric acid. Additional batch contacts were in progress at the end of the report period to resolve this question.

Evaluation of Effort

The superior chemical and radiolytic stability of Amberlite LA-2, compared with that of TBP, makes an amine extraction process well-suited for use in the Plutonium Reclamation Facility, particularly with scrap containing significant concentrations of ^{241}Pu and ^{240}Pu . The potential benefits of the LA-2 are great enough to warrant a continuing effort to computer model the LA-2 extraction system and devise optimum chemical flowsheet conditions.

Future Work

Batch contacts will be made to obtain additional plutonium and nitric acid distribution data and to correct deficiencies noted in the first attempts to computer model LA-2 extraction systems. These new data will be used in further computer modeling work. Additional contacts will be made to complete acquisition of equilibrium distribution data for the $\text{HNO}_3\text{-Al}(\text{NO}_3)_3\text{-HF-Pu}(\text{NO}_3)_3\text{-UO}_2(\text{NO}_3)_2\text{-LA-2-CCl}_4$ system.

Bidentate Organophosphorus Extraction of Americium and Plutonium

Program Manager: R. E. Felt
Section Manager: H. Babad
Principal Investigators: W. W. Schulz
D. G. Bouse
E. C. Martin (BNW)
Activity Code: B1350

Objective and Scope

The principal objective of this task is to develop technology for reducing the americium and plutonium content of the Plutonium Reclamation Facility (PRF) to actinide-free (≤ 10 Ci/g) levels. A secondary objective is to develop and demonstrate a bidentate organophosphorus solvent extraction process to recover both Am and Pu directly from PRF current acid waste (CAW), thereby avoiding the pH adjustment step required by the present dibutylbutylphosphonate (DBBP) extraction system.

Prior Work

Laboratory work yielded data on the equilibrium distribution of Am, Pu, HNO_3 , and various impurity metals (e.g., Ca^{2+} , Mg^{2+} , etc.) between aqueous HNO_3 - $\text{Al}(\text{NO}_3)_3$ -HF solutions and 30 to 40 vol% DHDECMP- CCl_4 and trichlorobenzene (TCB), and 30 vol% DBDECMP- CCl_4 solvents. DHDECMP is an acronym for dihexyl-N,N-diethylcarbamylenephosphonate; DBDECMP is dibutyl-N,N-diethylcarbamylenephosphonate, and both are available from the Wateree Chemical Company, Lugoff, South Carolina.

Technical-grade DHDECMP and DBDECMP contain an unidentified impurity with an affinity for Am(III) and Pu(IV) at low-acid ($\leq 0.25M$) concentrations. Suitable acid

hydrolysis washing procedures were developed for purifying the DHDECMP; DBDECMP was purified by vacuum distillation. Stability of the 30 vol% DHDECMP extractant to alpha radiolysis was found to be excellent over the range of exposure expected in PRF application (2 to 10 watt-hour/liter). Effects of cross-contamination of mainline 20 vol% TBP-CCl₄ solvent with DHDECMP were determined. These efforts culminated in a conceptual chemical flowsheet which was successfully demonstrated in mixer-settler tests with actual CAW solution as feed. This new flowsheet increased overall Am recovery to >90% from the 60 to 80% obtained with the present DBBP flowsheet. [Actually, the DBDECMP flowsheet provided a nearly actinide-free (<10 nCi/g) waste.] A major disadvantage of the DBDECMP extractant is its high (~60 g/liter) solubility in dilute HNO₃; this advantage was deemed serious enough to eliminate any further consideration of plant-scale use of DBDECMP solvents.

Progress During Report Period

Some 15 mixer-settler extraction column runs were completed using 30 and 40 vol% DHDECMP-TCB solvents and two different batches of Plant CAW as feed. Flowsheet conditions for reproducible reduction of the ²⁴¹Am concentration of acid CAW to <10 nCi/g were established. Previous work showed that Pu(IV) is at least 10 times more extractable than Am(III). Thus these mixer-settler runs established conditions for producing an actinide-free waste.

There was significant progress in characterizing the nature of impurities in as-received DHDECMP and devising alternative (to acid hydrolysis) purification procedures. Nearly pure DHDECMP can be prepared by vacuum distillation at 140° C and 0.2 torr. Examination of residues and

distillates obtained in vacuum distillation of commercial DHDECMP indicates that the impurity of chief concern is an organophosphorus acid, presumably resulting from incomplete esterification of the starting organophosphorus compound. A new and simple wash procedure for removing the offending acid impurity from commercial DHDECMP was devised. This new procedure uses an inexpensive chemical at 25° C, and, based on preliminary americium distribution data, will likely obviate the need for acid hydrolysis or vacuum distillation purification methods. A Report of Invention describing this new solvent cleanup procedure is being prepared.

A cyclic alpha radiolysis-solvent wash experiment was started to determine the useful life of a DHDECMP extractant under PRF conditions. A 30 vol% DHDECMP-TCB solvent containing ^{241}Am stands until an absorbed dose of 15 watt-hour/liter has been accumulated; after washing, the solvent's americium extraction and stripping properties are compared with those of virgin solvent. This pattern approximates that expected for a DHDECMP solvent in the PRF. To date the first irradiation cycle has been completed.

Evaluation of Effort

Excellent, and steady progress has been made to achieve the objectives of this research task. Work this last report period has led to what appears to be a simple, effective wash procedure for purifying as-received DHDECMP--the last key element needed for a practical bidentate Am-Pu extraction process. Such a process could be operated in suitable new equipment in the PRF to reduce the Am-Pu concentrations of CAW solution to, or below, 10 nCi/g. Generation of such an actinide-free solution would greatly simplify PRF waste disposal operations.

Future Work

Mixer-settler tests will be completed to define and demonstrate satisfactory bidentate process Am-Pu partition (S1) column and Pu-strip (S2) column flowsheet conditions. Cyclic irradiation-carbonate wash alpha radiolysis studies will be extended through at least three cycles (15 watt-hour/liter each cycle). Mixer-settler extraction and partition column runs will also be made with DHDECMP solvents purified by the newly discovered washing procedure.

FRACTIONIZATION

SLUICING AND B PLANT

Program Manager:	R. E. Felt
Section Manager:	H. Babad
Principal Investigators:	J. E. Horton J. S. Buckingham
Activity Code:	B07T4

Objective and Scope

The objective of this activity is to characterize sludges from underground waste tanks and to provide engineering laboratory assistance for the AR Vault/Sluicing program.

Prior Work

Samples of sludge from A- and AX-Tank Farms tanks were characterized chemically and physically before being sluiced. Attempts to improve liquid-solid phase separations by the use of flocculating agents were investigated and used with some success.

Progress During Report Period

A sample of sludge from the final AX-Tank scheduled to be sluiced, Tank 101-AX, was characterized. The $^{89,90}\text{Sr}$ concentration in the sludge was 28.2 Ci/liter. Ninety seven percent of the sludge particles were smaller than 50 μm and 13% were smaller than 10 μm . When the sludge was acidified with nitric acid, 73% of the strontium dissolved. An additional 22% of the strontium dissolved when the undissolved sludge was first treated with sodium hydroxide and then with additional nitric acid.

Evaluation of Effort

Characterization of the 101-AX sludge indicated that the liquid-solid phase separations would be slow during sluicing; however, with the reduced processing rates projected for B Plant, phase separations were not expected to influence the throughput rate.

Future Work

Sludge from Waste Tank 241-C-105 will be characterized.

STRONTIUM SOLVENT EXTRACTION

Program Manager:	R. E. Felt
Section Managers:	H. Babad R. E. Felt
Principal Investigators:	J. S. Buckingham D. G. Bouse J. E. Horton S. S. Koegler
Activity Codes:	B07T0, B07T1

Objective and Scope

The purpose of this work is to improve the efficiency and cost of operation of the solvent extraction process for strontium removal from Purex Acidified Sludge (PAS).

Prior Work

The synergistic effect of tributylphosphate (TBP) was investigated for the solvent extraction of strontium into *di*(2-ethylhexyl)phosphoric acid (HDEHP). Citric acid was investigated as a complexant for iron and aluminum in PAS.

Progress During Report Period

The synergistic effect of TBP on the extraction of strontium into HDEHP was further investigated. Results confirmed 0.3 to 0.35M as the optimum TBP concentration. However, synergism was much less pronounced in this solvent extraction system than in earlier experiments.

Batch contact equilibrium data were generated for strontium and sodium in 0.5M HDEHP. Equilibrium data were also generated for calcium, iron, and aluminum from synthetic PAS. These data were correlated into a chemical model for solvent extraction. The model was incorporated into the solvent extraction computer program SEPHIS. With the addition of subroutines for chelation and hydrogen ion buffering, a computer simulation of the 1A (extraction) and 1S (sodium scrub) Columns was developed.

Several chelating agent blends were evaluated in solvent extraction batch contacts. Extraction of strontium and impurities were not markedly different for any of the six chelating agent blends in which up to 60% citric acid was used. A computer program designed to predict the ability of different chelating agent blends for B Plant solvent

extraction was developed from solvent extraction data under various conditions. The program was modified and added to SEPHIS as a subroutine.

A process was developed that recovered a portion of the chelating agent, ethylenediaminetetraacetic acid (EDTA), from synthetic solvent extraction waste. The process is only viable for feeds in which the EDTA makes up greater than 50% of the total chelating agent.

A computer study was made to determine the factors affecting strontium losses from solvent extraction during the processing of sulfate rework. The study indicated that diluting the feed, lowering the extraction column pH, and increasing the organic-to-aqueous flow ratio would decrease Sr losses.

Evaluation of Effort

Laboratory tests have shown that citric acid may be substituted for a portion of the hydroxyethylenediaminetriacetic acid (HEDTA) and EDTA chelating agents in solvent extraction feed. A 75:25 citrate/EDTA blend with 30% excess of chelate has been tested in the process, but results are inconclusive.

Computer modeling of the B Plant solvent extraction columns is still in the evaluation stage.

The EDTA recovery test showed that usable EDTA could be recovered from synthetic solvent extraction waste. However, since the fraction of EDTA used at B Plant (between 26 and 33.3%) is less than 50%, no EDTA can be recovered by this process with present feeds.

Future Work

A new method for calculating solvent loading and process flow rate is being developed and uses the computer program; thus, work on the solvent extraction computer program SEPHIS will be oriented toward application.

ENCAPSULATION

CESIUM ENCAPSULATION

Program Manager:	R. E. Felt
Section Manager:	R. E. Felt
Principal Investigators:	J. D. Moore T. R. Gallant
Activity Code:	B08T0

Objective and Scope

The objective of this work is to develop a flowsheet and equipment which will load cesium capsules at the desired production rates.

Prior Work

Two cesium chloride solidification processes were selected for parallel development. In one process, the CsCl is dried to a free-flowing powder in a stirred, steam-heated pan drier and the powder is densified in storage capsules by vibratory compaction. In the second process, CsCl solution is dried, melted, and cast into slugs in a tilt-pour vessel. The slugs are then placed in the storage capsules.

Progress During Report Period

Design drawings for fabrication of the pan drier and tilt-pour melter equipment have been completed. Tests with

nonradioactive CsCl powder, a discharge bin, loading mechanisms, and vibrating compactor were performed to verify the design of the pan drier capsule loading equipment. A maximum CsCl density, 62% of theoretical, was achieved by vibratory compaction of the capsule.

A test with nonradioactive CsCl demonstrated that pouring the molten material into the storage capsules mounted under a fill-head is an improvement over the original technique of casting the material in molds and placing the solidified slugs into the capsules. This improvement was incorporated into the tilt-pour melter design. An evaporator vessel for concentrating the CsCl feed solution has been eliminated from the tilt-pour flowsheet since CsCl production schedules can probably be met by performing all evaporation in the tilt-pour melter.

Evaluation of Effort

The cesium equipment development program has been delayed by about 2.5 months from the original schedule. Delays were due largely to the lack of emphasis on equipment design drawings. Approximately one month of this delay can probably be recovered during equipment testing if work is carried out on a two-to-three shift per day schedule and if remotability tests with full-scale equipment mock-ups are conducted concurrently with the prototype tests.

Future Work

Fabrication and installation of the pan drier and tilt-pour melter prototype and mock-up equipment will be completed. Nonradioactive testing will be started.

CAPSULE DECONTAMINATION

Program Manager: R. E. Felt
Section Manager: R. E. Felt
Principal Investigator: D. W. Jeppson
Activity Code: B08T0

Objective and Scope

The purpose of this activity is to provide an efficient in-cell method of decontaminating inner capsules of strontium and cesium.

Prior Work

Chemical baths, water sprays, ultrasonic cleaners, and wire brushes have been used in the production facility. The average time required for decontamination of a strontium capsule using these techniques in the production facility is 8 hours.

Progress During Report Period

Efficient decontamination of waste capsules to non-smearable levels of contamination has been demonstrated in the laboratory. Hastalloy C[®] (Stellite Division of Cabot Corporation) capsules and 316-L stainless steel specimens have been decontaminated to less than smearable background counts [<200 counts per minute (cpm)] by applying 9 volts across an electrolytic cell using phosphoric acid as an electrolyte. The phosphoric acid has been determined to be compatible with Waste Encapsulation and Storage Facility piping and equipment and with the B Plant process.

It has been determined that the capsules are

decontaminated when about 1 mil of the capsule surface is removed by electropolishing. Uneven metal removal from the capsule is prevented by the use of a cylindrical cathode equidistant from the capsule surface.

Contamination has been prevented in the capsule end cap weld by use of a protective metal ring to shield the weld area while handling the capsule in the cell before welding on the end cap.

Equipment has been designed for use in-cell and is currently being drawn up on blueprints for construction.

Evaluation of Effort

Laboratory testing has shown that capsules contaminated in the cell under actual conditions can be decontaminated to nonsmearable quantities in a matter of minutes. Relatively low levels of contamination (5 rads) were used for testing since the capsules were handled in an open hood at the laboratory. In actual production, however, the initial contamination is much higher but the range of decontamination requiring most time in the cell is the 5 rads to the nonsmearable level.

Future Work

Fabrication of the in-cell equipment and brief cold testing of the assembled equipment are planned.

CONCENTRATION, TERMINAL LIQUOR, SALT CAKE,
AND SLUDGE CHARACTERIZATION

INTERSTITIAL LIQUOR REMOVAL

Program Manager: R. C. Roal
Section Manager: R. J. Thompson
Principal Investigators: W. P. Metz
O. B. Schlippacke
Activity Code: B06T2

Objective and Scope

The objective is to design, develop, and demonstrate the technology, methods, and equipment to remove as much interstitial liquid, and to immobilize residual liquid as is technically and economically practicable.

Prior Work

Five areas of investigation were identified for the Interstitial Liquid Removal/Immobilization Development program: (1) characterization of the flow of interstitial liquids in salt cake, (2) improvement of salt well pumping equipment, (3) stimulation of interstitial liquids flow, (4) evaluation of feasibility of residual liquid evaporation as a removal or immobilization technique, and (5) evaluation of the feasibility of *in situ* fixation of interstitial liquids.

Instrument Salt Well facilities for Tanks 241-BY-107 and 241-S-111 were designed, fabricated, and installed for testing. The facilities are expected to provide sufficient data to verify a mathematical model of interstitial liquid flow through salt cake. Dr. Lyman L. Handy of the University of Southern California was retained as a consultant on

the program, and his expertise will provide an independent approach to the flow chracterization problem.

A market survey was conducted among manufacturers of deep-well pumping equipment, and a deep-well jet pump was selected and procured for testing from Goulds Pumps, Inc. A test loop was designed to simulate the salt well pumping environment.

Battelle-Northwest was engaged to provide preliminary feasibility evaluations of various stimulation and immobilization techniques. The Chemical Technology Laboratory began a thorough investigation of techniques for the removal and immobilization of nonpumpable liquids. A study was performed on the feasibility of modifying tank bottom configuration to enhance liquid drainage and showed that any such modifications would be very costly. A test to demonstrate the applicability of oil field, shaped-charge jet perforating techniques for the stimulation of salt well flow, and the safety of these techniques was performed.

The evaporation rate of liquids to the tank vapor space ventilation air stream was calculated and found to be small but potentially benficial. Bench-scale tests conducted to evaluate the feasibility of vibrating the drained salt cake to free additional liquids for removal produced a significant increase in removal liquid.

Progress During Report Period

Data from the 241-BY-107 Instrumented Salt Well facility were obtained. The 241-S-111 Instrumented Salt Well facility has been installed and started up.

The cold testing of a modified commercial deep-well jet pump was completed. The results were sufficiently encouraging to warrant the initiation of design and fabrication of a

unit for in-tank (241-BY-107) installation. A vertical mount, low-capacity, prototype Moyno Pump[®] (Moyno Pump Division, Robbins & Myers, Inc.) assembly was purchased for testing. The use of a 75.7 liter/min turbine pump (mini-pump) for salt well installations was recommended.

Work on the imbibition displacement of interstitial liquids from salt cakes was completed. The effects of compressed air displacement of interstitial liquor were evaluated. Both processes were found to be ineffective for removing interstitial liquid.

The effects of capillary action on interstitial liquid flow have been assessed, and a mathematical model has been developed which appears to adequately describe the liquid flow in salt cakes.

A preliminary evaluation of the potential for evaporation to reduce the amount of terminal liquor was completed and appears potentially beneficial.

Evaluation of Effort

One of the major benefits from the program has been a more thorough understanding of the entire scope of interstitial liquor removal. The impact of that understanding is just beginning to be implemented. The theoretical and laboratory aspects of the program have progressed satisfactorily. The hardware aspects (field work and pump development work) have been slower than anticipated; however, more effort has been shifted to this area.

Future Work

Data from both the 241-S-111 and 241-BY-107 Instrumented Salt Well facilities will be used to evaluate, and compare with, the flow prediction of the mathematical

model. A topical report on the model and its application will be written. The deep-well jet pump will be tested in-tank; the prototype Moyno Pump will be cold-tested. A test proposal for *in situ* drying of sludges and salt cakes will be prepared. Data on salt cake and sludge drying and the CO₂ immobilization study will be reported. A technical assessment of the program activities will be made by Dr. Handy.

Reports Issued

Test report, "Explosive charges Detonated in Nitrate-Organic Mixture with Free Hydrogen Head," Jet Research Center, Inc., Arlington, Texas, April 1975.

W. E. Sande, *Imbibition-Displacement of an Aqueous Interstitial Liquor by an Organic Fluid Containing a Surfactant*, BNWL-B-443, Battelle, Pacific Northwest Laboratories, Richland, Washington, August 1975.

TERMINAL LIQUOR DISPOSITION

Program Manager:	R. C. Roal
Section Manager:	R. J. Thompson
Principal Investigators:	J. S. Buckingham R. I. Donovan D. R. Frazier W. P. Metz W. E. Ogren R. E. Van der Cook G. K. Allen
Activity Code:	B06T3

Objective and Scope

The objective is to develop and demonstrated on a prototype scale a process or combination of processes to convert terminal liquids to acceptable solids for interim storage, preferably in existing underground waste storage tanks.

The activity has two principal emphases:

- Additional volume reduction of terminal liquors in existing evaporators or in a wiped-film evaporator.
- Partial neutralization of the terminal liquor with nitric acid and subsequent evaporation to reduce liquid volume and produce nonhygroscopic solids.

Prior Work

An engineering study to determine the feasibility of alternatives for disposing of terminal liquors for interim storage was completed. The identified feasible alternatives include:

1. Partial neutralization with nitric acid.
2. Selective aluminum removal.
3. Semisolid produced by vacuum evaporation.
4. Semisolid produced by wiped film.
5. Solidification by adding clay in-tank.

A computer program (NEWVAP) that calculates rates, volumes, and concentrations in all 242-S Evaporator-Crystallizer process streams was developed. NEWVAP has helped to optimize current efforts in 242-S concentration and partial neutralization.

Laboratory testing of four proposed flowsheets for

partial neutralization of terminal liquor showed that the solid phase produced was essentially sodium nitrate contaminated with a small amount of mother liquor.

Partial neutralization of synthetic terminal liquor with nitric acid was carried out in the pilot evaporator-crystallizer. The process resulted in a significant volume reduction of the terminal liquors to be fed to the evaporator-crystallizer. For example, when 15% of the sodium hydroxide in the feed was neutralized, the volume of the slurry liquor was 82% of the original feed volume; and when 43% of the sodium hydroxide was neutralized, the volume of slurry was only 36% of the original feed volume.

The quality of the material produced by evaporating waste solutions in BNW's wiped-film evaporator was determined. The product slurries ranged from 14 to 37 wt% solids at 93° to 94° C. The solids content increased to 63 to 85 wt% upon cooling to room temperatures.

A proposal for running tests in the pilot-scale wiped-film evaporators at Savannah River Laboratory was submitted to and accepted by E. I. du Pont de Nemours and Company.

A prototype testing proposal was prepared to demonstrate and evaluate the merits of the clay solidification process on a plant-scale.

Progress During Report Period

An engineering study compared alternative terminal liquor disposition schemes in order to identify the most promising alternative based on operability and minimum volumes of final storable wastes generated. The study considered the processes of partial neutralization, high-temperature concentration, and aluminum removal by the Bayer process or silica addition. The results indicate that

silica addition is more suitable than the Bayer process for the removal of aluminum. The advantage of high-temperature concentration is that aluminum removal and partial neutralization would not be necessary before processing the terminal liquid solutions.

Pilot-plant tests demonstrated that partial neutralization could be accomplished by the existing 242-S Evaporator-Crystallizer facility. The test demonstrated the primary objective of the nitric acid partial neutralization process--satisfactory operation of the 242-S facility during acid addition.

Tests were conducted in the pilot-vacuum evaporator-crystallizer to:

- Determine if NO_x is generated in the pilot plant during partial neutralization under similar conditions to those in the 242-S process test.
- Compare the effects of different nitric acid concentration and acid-slurry mixing methods on the generation of NO_x in the off-gas.
- Determine the cumulative corrosion rates of carbon steel resulting from the original process test.

These tests indicated that NO_x generation decreased as the acid concentration decreased. Better and faster mixing resulting from an acid injection method also decreased NO_x generation.

Synthetic formulations of current and expected Hanford evaporator bottoms liquors were processed in a pilot-scale wiped-film evaporator designed by Savannah River Laboratory, Aiken, South Carolina. The volume of the evaporator product was reduced to as little as 32% of the feed liquor volume.

The extensively evaporated products discharged freely out of the evaporator and solidified upon cooling.

The data obtained at Savannah River Laboratory have been supplemented with additional sample characterizations. Cooling curve (% solids as a function of temperature) and thermal conductivity measurements were obtained; approximate prediction of evaporator product characteristics based on the volume reduction and feed chemistry can now be made.

Evaluation of Effort

The investigation of partial neutralization for the treatment of terminal liquors in this activity has demonstrated its applicability and usefulness for process service. Investigations into evaporation through the Savannah River Laboratory wiped-film evaporator studies have indicated its feasibility for operation on Hanford wastes. A production-scale machine is projected to fill a Hanford double-shell storage tank in approximately 15 months of operation. Either of these methods appears to provide reliable containment of terminal liquor for an interim period, but large-scale testing of evaporation is necessary before final selection of a method. No further work on in-tank clay solidification is planned at this time, since this terminal liquor option appears unnecessary in view of the presently available shell tank space.

Future Work

A second process test will be run at the 242-S Evaporator in November 1975 using a lower nitric acid concentration.

A prototype test of partial neutralization will be carried out in 1976. This test will provide the basis for

the evaluation of future application of the process.

An evaluation of the wiped-film evaporator versus the hot 242-S terminal liquid treatment will be made and a process test will be run during CY 1976 on the more suitable of the two options.

ALUMINUM REMOVAL FROM HIGH-LEVEL RADIOACTIVE WASTE

Program Manager:	R. C. Roal
Section Manager:	R. J. Thompson
Principal Investigators:	J. S. Buckingham J. O. Honeyman W. E. Ogren D. A. Puryear
Activity Code:	B1420

Objective and Scope

The objective is to develop and demonstrate, on a prototype- or process test-scale, the removal of aluminum from terminal liquors and the conversion of the remaining solution to salt cake.

Prior Work

Solubility limits of NaAlO_2 , NaNO_3 , and NaNO_2 were determined as functions of temperature and NaOH concentration. Two aluminum removal alternatives--reaction of silica with the dissolved aluminum, and a Bayer process adaption--were tested in preliminary laboratory studies based on the solubility data of the radioactive wastes.

Progress During Report Period

A market survey provided samples of 21 high surface area silica products. Screening evaluations of the samples identified 7 having acceptable particle size, reaction rate, and silica usage efficiency. Tests were initiated on the acceptable silica products to determine the long-term effects of synthetic liquor on the silica pore structure.

The Bayer process for production of aluminum trihydroxide (gibbsite) from caustic-aluminate-nitrate-nitrite liquors was demonstrated as workable in laboratory-scale equipment. Crystalline gibbsite was grown from synthetic waste solutions by adding nitric acid and seed crystals to the synthetic solution. The pregnant growth solutions were held at 80° C and agitated to maintain a resuspension of crystals in the synthetic liquors. After an induction period of about 24 hr, the seed crystals grew to a maximum diameter of ~125 microns. The effect of the type of synthetic solutions, the concentrations of nitric acid, and various growth conditions were investigated.

A conceptual flowsheet was developed for the Bayer process based on the chemistry information obtained from laboratory investigations. Studies have shown that the major pieces of processing equipment required to perform the Bayer process are not available as existing facilities. A contract for consultation with a Bayer process expert is being arranged.

Evaluation of Effort

The results of efforts to date indicate that aluminum removal from Hanford waste liquors by either alternative may have only limited application. The length of time required for proper development of the Bayer process adaptation

precludes its application, except perhaps for long-term waste management. Problem areas which require further attention for the Bayer process to be considered practical involve solid-liquid separations, product washing, and redissolution of undesirable, fine crystals.

Future Work

Laboratory investigation will identify a candidate silica and suitable Bayer process operating conditions. Engineering studies will identify and evaluate the impact of problems of practical application to determine the feasibility of aluminum removal. Pilot-plant-scale studies will investigate potentially feasible flowsheet alternatives.

CHEMICAL AND PHYSICAL CHARACTERIZATION OF SALT CAKE

Program Manager:	R. J. Thompson
Section Manager:	H. . Babad
Principal Investigator:	V. L. Schuelein
Activity Code:	B06T6

Objective and Scope

In this study, waste tank salt cake core samples will be analyzed for physical and chemical characteristics to determine chemical inventories in the tank and the physical structure of the tank contents; and to define physical properties influencing retrieval, volume reduction, and solidification.

Prior Work

Designing a shielded glove box facility and firming up analytical procedures were the major prior accomplishments.

Progress During Report Period

The equipment and procedures necessary for salt cake characterization are in place. A total of 15 chemical and 12 physical analyses will be made on each sample. Because of the uncertainty of the matrix, some difficulty is expected with physical characterization. A Hassler cell for obtaining permeability data has been developed and installed. This instrument will also be used to measure drainable liquid. A calorimeter which has been installed and calibrated with a resistance-type heat source is currently being calibrated using a radioactive source.

The final design for the shielded glove box facility has been received from Automation Industries, Inc., Vitro Engineering Division. The facility will allow easier and more rapid handling of salt cake core samples.

Salt cake standards and a satisfactory laboratory standards and referee program are in the final stages of completion. These standards will be valuable for controlling desired analytical accuracy of chemical procedures and evaluating analytical accuracy of new procedures.

Chemical characterization capability was increased by the development of methods for analyzing Pu, Am, and Np in a salt cake matrix. Although total alpha has been requested, each tank will be individually analyzed for the actinides.

Evaluation of Effort

All the equipment necessary for characterizing salt cake has been tested with cold synthetic salt cake. Further improvements in the analyses will be made based on actual tank samples.

Future Work

Both chemical and physical analyses will be refined to give more meaningful information to the customer. Areas of exploration include permeability, drainable liquor, and porosity at various temperatures. The shielded glove box facility will be installed as soon as possible. The speed and accuracy of determining the anions Pu_4^{-3} , SO_4^{-2} , NO_3^{-} , and NO_2^{-} will be improved by using a Raman spectrometer which is presently scheduled for completion in March 1976.

SALT CAKE CHARACTERIZATION (CORE SAMPLER DEVELOPMENT)

Program Manager:	R. C. Roal
Section Manager:	R. J. Thompson
Principal Investigators:	M. D. Martin V. L. Schuelein
Activity Code:	B06T6

Objective and Scope

The objective is to design, develop, and demonstrate equipment capable of safely and efficiently retrieving representative samples of in-tank, high-level waste. Laboratory handling techniques and analytical methods for analyzing actinides in the salt cake will be developed and demonstrated. The waste characteristics will be catalogued for ready reference.

Prior Work

All equipment drawings were completed and Work Orders were issued for fabrication of support equipment and for modification to the basic core drilling equipment.

Preliminary tests were completed to demonstrate the basic concept by drilling synthetic salt cake, concrete (without sand or aggregate), and gypsum with a tungsten carbide drilling bit. Successful core samples were obtained from all the materials. The tests indicated that starting the drill bit will be difficult if the surface in the actual tank is hard and smooth.

Other preliminary tests indicated that the carbide bit could seriously damage a tank bottom liner. The use of a resistance meter was found to give a positive indication of tank liner contact. The result of these preliminary tests was to begin designing a system which would shut down the drilling rig when a sudden change in resistance occurs or whenever a slow, downward travel rate of the drill rod is noted.

Progress During Report Period

An integrated system test of the core sampling equipment was conducted to evaluate the equipment's performance under simulated field conditions and to develop contamination control techniques. A soft steel bit, which cannot damage the waste tank steel liner, was used successfully to drill plaster of paris and solid rock salt, but the soft steel would not penetrate portland cement.

Tests of the electrical resistance system indicate that testing in an actual waste tank will be required to establish the workability of the system.

The use of a dual probe system was selected as a means of establishing assured electrical contact with the waste tank liner.

A liquid sampler was designed and fabricated. Tests on water-clay mixtures indicate the sampler will recover thin

slurries or liquids. Additional study is needed to sample thick slurries or pastes.

Drafts of the test plan for in-tank use of the sampler, the sampling flowsheet, and the equipment information manual were prepared. A draft summary of the expected composition of sludges produced by each of the separations processes used during the past 30 years has been prepared.

Evaluation of Effort

The preliminary tests have proven that the rotary core drill-wire line retrieval method is a viable technique for recovering characteristic samples from the waste tanks. They have shown that further effort is needed to develop a reliable system for detecting contact with and preventing damage to the tank bottom liner if tungsten carbide drill bits must be used.

Future Work

A cold equipment demonstration will be carried out to evaluate operating procedures and equipment. The equipment information manual, the test plan for in-tank use, and the flowsheet will be issued. Samples from Tank 241-TX-116, the first tank filled with salt cake, will be taken.

TANK OPERATIONAL CRITERIA

Program Manager:	R. C. Roal
Section Manager:	R. J. Thompson
Principal Investigators:	R. G. Geier R. E. Van der Cook F. R. Vollert
Activity Code:	B06T0

Objective and Scope

The underground waste storage tanks, designed for storing liquids, will be used for interim (tens of years) storage of salt cake. The objective of the program is to develop criteria for tank usage so that operating specifications and standards can be established for filling the tanks with salt cake. Before establishing criteria, the allowable operating temperatures in the tank must be defined.

Prior Work

Analyses were initiated using the finite-element computer program, SAFECRACK, to predict the time-dependent deformation, cracking, and stresses that will occur in the underground waste storage tanks.

Progress During Report Period

The analytical work on the 241-SX and 241-U reinforced concrete structures was continued. Assuming that the SX Tanks have a soil cover of 2 meters, contain a salt cake depth of 7.2 m that has a salt cake heat generation rate of $0.0045 \text{ Btu/hr-m}^3$, and have had a heatup time from ambient to maximum of 151 days, then the maximum temperatures in the salt cake and concrete cylinder wall are predicted to be 149° and 127° C , respectively. Under these conditions the tank structure is stable and safe for long-term operation. If the salt cake heat generation rate is increased to $0.0056 \text{ Btu/hr-m}^3$ and the tank heatup time is decreased to 50 days with a salt cake depth of 7.2 m and a soil cover of 2 m, then the maximum temperature of the salt cake and concrete cylinder wall will be 177° and 154° C , respectively. A preliminary review of the analytical results indicates an adequate safety margin under these conditions.

If the U Tanks have a soil cover of 2.1 m, contain a salt cake heat generation rate of $0.0112 \text{ Btu/hr-m}^3$, a salt cake depth of 4.3 m, and have had a heatup time from ambient to the maximum of 50 days, then the maximum temperature in the salt cake and concrete cylinder wall are predicted to be 188° and 157° C . At these conditions, the concrete structure will experience self-limiting creep and cracking after the structure reaches steady-state conditions. However it is stable and has sufficient integrity for safe long-term storage.

Evaluation of Effort

The data are available to establish a storage criteria for Tanks 241-U. Analysis of similar information for the Tanks 241-SX is nearing completion.

Future Work

Additional analyses of Tanks 241-SX will be made for 9 m of salt cake having a heat generation rate of $0.0064 \text{ Btu/hr-m}^3$. Work will be initiated to define the maximum operating temperatures and maximum loads experienced to date and anticipated in the future in the AX Tank Farm.

WASTE TANK LEAK DETECTION

Program Manager:	R. C. Roal
Section Manager:	R. J. Thompson
Principal Investigator:	J. A. Atherton
Activity Code:	B1440

Objective and Scope

The objective of the program is three-fold:

- To provide improved instrumentation and techniques for monitoring tank liquid level where the liquid level is below the surface of the salt cake.
- To provide for early detection of tank leaks by external monitoring.
- To assess tank integrity and determine the mode and mechanisms by which tank failures occur.

Prior Work

The liquid level gauges [Food Instrument Company (FIC)] have been incorporated into an automatic data recording system. Manual liquid level gauging is currently required only in those instances where individual tank probes fail.

Improvements in dry well monitoring techniques for external leak detection continued. Additional dry wells have been drilled, and the schedule for monitoring by neutron and gamma ray logging techniques has continued on a weekly basis.

Progress During Report Period

An ultrasonic probe was used in Tank 241-S-111 in an attempt to determine the level of interstitial liquid that accumulates below the surface of the salt cake. The probe proved to have insufficient power to penetrate the salt cake.

Air-purged weight factor dip tubes, a sleeved gauge, and a neutron logging dry well were also installed in Tank 241-S-111. The weight factor dip tubes plugged with salt; the neutron logging technique has proved to date to be

insensitive to changes in liquid level of less than 0.3 m; and the sleeved FIC gauge has been plagued with mechanical problems.

The detection of tank leaks by the electrical conductivity of the soil around the tanks has been evaluated experimentally and appears promising. A proposal containing a cost estimate and a time schedule for installing a system around 29 tanks containing liquid has been sent to the Energy Research and Development Administration (ERDA).

The nine corrosion monitoring probes that had been installed in a variety of salt cake-interstitial liquid situations have shown no corrosion after 10 months of exposure. In fact, the measurements obtained from the probes indicate sensor growth either by plating or some other phenomenon.

Evaluation of Effort

Determining the level of interstitial liquid in a salt cake matrix has proved more difficult than expected, partly because the salt cake-interstitial liquid system is at equilibrium at tank temperature. When the cold metal probes are inserted in to the interstitial liquid salt, encrustation occurs and plugging results. To circumvent the plugging, steam purging has been incorporated into the dip tube and the FIC gauge installations.

Future Work

Testing of the interstitial liquid monitoring devices will continue.

A prototype in-place, continuous dry well gamma monitor will be tested to determine its applicability for external leak detection.

One of the nine corrosion probes will be removed for examination in an effort to assess the reason for the measurement aberrations.

If the tank liner thickness monitoring device proves feasible, it will be used to determine the thickness of the bottoms of other tanks.

CONTAMINATED SEDIMENT CONTROL AND BIOLOGICAL UPTAKE

SURFICIAL CONTAMINATION - CRIBS, TRENCHES, SWAMPS, AND PONDS

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Principal Investigators:	K. R. Fecht V. A. Uresk L. E. Bruns
Activity Codes:	B0960, B0961, B0962, B0964

Objective and Scope

One objective of this program is to characterize a typical waste area using existing techniques and those developed under the Public Protection Assurance Program. A second objective is to measure and evaluate parameters important to transport mechanisms (e.g., changes in ^{137}Cs subsurface profiles with time, and soil or contaminant properties important to transport mechanisms).

Prior Work

The U Pond shoreline was characterized for radionuclides. The analytical results from 3 of the 20 one-meter plots near U Pond showed ^{60}Co to be near or at background

levels and other radionuclides (^{137}Cs , ^{90}Sr , and ^{239}Pu) were above background levels. Baseline levels were estimated using analyses of surfaces at the 200 Areas Fire Station and the Hanford perimeter.

The 216-S-16 Redox Swamp area was characterized in three dimensions (X, Y, Z) with random core and ring sampling techniques. In an area of 24,000 m², 500 measurements and calculations were made. At the 216-S-17 Redox Pond, ten 30-cm cores were taken to obtain estimates on the subsurface radioactivity of this now-covered area.

Studies were started on the S-19 Pond area where several 30-cm core samples were taken.

Progress During Report Period

The S-16 Redox Swamp characterization was completed and a portion of the Swamp was surface-immobilized and covered with soil (see "Soil Stabilization Program").

The U Pond work continued with the following major developments. Results from approximately 200 pond bottom samples were received from the LFE Environmental Laboratory under the cooperative BNW - Division of Biomedical and Environmental Research (DBER) - ARHCO aquatic organism program. Battelle-Northwest began developing a screening laboratory under ARHCO sponsorship to reduce costs of analyzing organism and pond sediments, yet cover large areas such as the U Pond in a statistically satisfactory manner. Battelle-Northwest took a series of shore and inland samples for resuspension studies--the results of which are being compiled in a report. Atlantic Richfield Hanford Company has taken a series of pond bottom 30-cm core samples which will be analyzed by several different laboratories as part of the analytical reliability program.

Core samples were taken of the soil-covered S-17 Redox Pond by digging down to the original contaminated surface and then taking 30-cm cores. These samples are to measure radioactivity movement with time in a simple, soil-covered contamination zone that has been seeded with a grass compatible with the environment.

The S-16, S-17 Redox Ponds (see above) and the S-19 Pond area laboratory waste (from 222-S Laboratory) were or are in the process of being analyzed. Core sampling from the S-19 Pond area was initiated during the report period. Samples from the S-16 Ditch were also taken and some analyses have been completed.

Analytical results from random core samples of the S-16 Redox Pond area gave the following estimate of the total S-16 Pond activity.

6 Ci	^{137}Cs
4 g	^{239}Pu
1 Ci	^{90}Sr
1 g	^{241}Am

Initial core sampling began on the Z-19 Ditch (low-level effluent from the Z Plant) with about 10 cores taken and samples prepared for shipment to analytical laboratories.

Evaluation of Effort

The need for environmental *in situ* assay instruments was emphasized by the S-16 Redox Pond study. After affixing 214 m² of the Pond area (the portion containing the bulk of the Pu), the Dev-Van-I equipment was temporarily arranged and a few spots on the 214 m² were monitored. The results showed surprisingly good comparison with laboratory analytical values, though further study is necessary with the *in situ* instrumentation before relying on this approach.

The U Pond results tended to substantiate previous results. Algae, sestons (minute organisms in the algae) and dragon flies had the largest buildup of Pu. Randomly sampled spots on the U Pond shore and away from from U Pond showed:

- Activity levels decrease with increasing distance from U Pond.
- Highest ^{137}Cs was in the overflow ditch.
- No ^{137}Cs was found in the entrance to the Z Plant Ditch, Z-19.
- Strontium-90 was at detection level.
- Cobalt-60 was detectable only in the laundry ditch.
- Highest uranium, 23,000 nanograms/gram, was in the overflow ditch.

Future Work

Work should continue on the U Pond, S-19, and Z-19 characterization.

A program plan will be devised which will include characterization of waste site areas already under study, plus other typical areas such as B Pond, Gable Mountain Pond, the covered T Pond, a transuranic burial ground, and a fission product burial ground.

Efforts will be continued to establish a screening laboratory for analyzing aquatic organism and pond sediments.

SOIL STABILIZATION

Program Manager: M. W. Legatski
Section Manager: M. W. Legatski
Principal Investigators: L. E. Bruns
G. M. Holter
P. J. Wiater
Activity Code: B09T1

Objective and Scope

The objectives of this program are to (1) demonstrate that radionuclides on surfaces of all types (*e.g.*, pristine desert land, worked land, and burned-over areas) can be affixed by chemical agents in combination with ground cheatgrass; (2) demonstrate that subsurface radionuclide-contaminated regions can be affixed by chemicals such as asphaltic emulsions; (3) demonstrate that subsurface pipe and tank leaks can be stopped by grouting; and (4) investigate new affixing agents, preadditives, and methods of injection.

Prior Work

The five most promising field-tested affixants were reduced to three: M166[®] (Dowell Division of Dow Chemical Company), Aerospray 70[®] (American Cyanamid) and Coherex[®] (WAHCO Chemical Company, Golden Bear Division). The best of these was M166, a latex emulsion, and it was used to affix a 8094 m² area around the Redox S-17 Swamp. A laboratory test in which simulated terminal liquor was immobilized using a combination of clay and asphalt emulsion was completed. An asphalt emulsion was field- and laboratory-tested to simulate covering a swamp area. An asphaltic emulsion grout was developed for well grouting.

Progress During Report Period

Approximately 20,225 m² of land bordering the covered and seeded 216-S-16 Redox Swamp were sprayed with M166. Observation of vegetative growth and soil containment in this area continued through the report period.

Approximately 1200 m² of contaminated Redox S-16 Swamp was affixed with an asphalt emulsion. The area was contaminated with greater than 1 nCi Pu/g of soil. The area was then covered with 1 m of new soils, mulched, and seeded with cheatgrass.

Several field tests were completed on the subsurface grouting that was to encompass a simulated underground water line leak with asphalt emulsion. At the request of Waste Management an attempt to immobilize an underground vent line leak at the AX-Tank Farm was completed during this period. The leak in this Dresser Coupling[®] (Dresser Industries, Inc.) was located 3 m below grade level between the 101-AX and 102-AX Waste Tanks. A total of 2271 liters of asphalt emulsion were injected into the subsurface through four injection wells evenly spaced around the area to be covered.

A new vibratory drilling tool was secured to test fast drilling techniques for future grouting experiments.

An experimental trench that simulates a burial trench was constructed for use by ARHCO and BNW. The trench was implanted with lithium chloride and covered with various media to determine which materials will restrict growth into buried radioactive soil and retard resuspension.

Evaluation of Results

The field tests with surface affixant M166 show that loose soil can be immobilized even in high winds, thus preventing surface decontamination from being resuspended. Growth of cheatgrass was retarded because the time of planting was not right for germination. When planting out of season, plans must include some method of irrigation to promote growth of vegetation.

Asphalt emulsion was successful in stopping a subsurface simulated water line leak. The cohesive bond that the asphalt emulsion forms with the soil is semi-rigid and the adhesive properties made a good bond around the pipe. The 102-AX Dresser Coupling leak grouting was carried out on a trial basis without enough data on soil conditions to be assured of a successful grouting operation. Readings in the wells prior to grouting and a month after showed that the subsurface area appeared to be stabilized. An increase in the reading at the lower level indicated that the grouting moved some of the contamination to that level. The reading at the 3.3-meter level remained stable, but an increase in the reading above the Dresser Coupling showed the contamination had moved closer to the surface, probably because of plug flow. Readings will be continued on the wells surrounding this area.

The strip of asphalt emulsion laid in the S-16 Swamp was accomplished with some difficulty, attributed to the equipment used for preparing the surface before spraying and when applying the asphalt solution. Deep tread tracks caused puddling and ridges that required two sprayings of asphalt solution over the designated area. The asphalt truck in the second pass created cracks in the asphalt surface and picked up some asphalt on the tires. Further

evaluation of subsurface injection and spraying equipment will be necessary to develop proper techniques for immobilizing contaminated soil with chemical affixants.

Future Work

The Redox S-16 Swamp asphaltic emulsion strip will be studied. Core samples will be taken above the asphalt layer and in the nontreated area for evaluation of radionuclide movement. Vegetative growths and affixant reliability will also be studied.

Laboratory tests will continue on chemical grouting. Fast drilling tests for grouting are being planned. A simulated test is planned for grouting a tank farm dry well with asphalt emulsion. Stabilization of a burn area with chemical affixants will be attempted.

DECONTAMINATION/IMMOBILIZATION

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Principal Investigators:	L. E. Bruns G. M. Holter P. J. Wiater
Activity Code:	B0970

Objective and Scope

The objective of this program is to develop methods for cleanup and immobilization of radionuclide contamination in surface and subsurface areas, and to develop criteria for cleanup and immobilization of these areas.

A plan of action for treatment of contaminated areas will include use of characterization data and a hazard

assessment to develop criteria, equipment, and techniques for removing and immobilizing radionuclides.

Prior Work

Tests run on the mobile vacuum system identified the need for a secondary filter system for working with contaminated material. An initial study was made of removing and immobilizing surface and subsurface contamination. Investigation of a unit that affixes contaminated soil with bitumen was continued.

Progress During Report Period

Approved prints for the modification of the mobile vacuum system were completed.

Several systems that could be used for pond cleanup work were studied. A presentation on the operation of one of the units, the Mud Cat[®] (National Car Rental System., Inc.), was given by the vendor. Inquiries were also made into the Pneuma Dredge and Hydro-Transport System[®] (Pneuma, Sp. A), which is used extensively in other countries for dredging polluted materials. The Pneuma Dredge appears to have several advantages over the Mud Cat, but further investigation is necessary to verify this.

In conjunction with pond cleanup equipment, some mobile solid-liquid separation equipment will probably be necessary. Several vendors were contacted and work is in progress to devise the necessary flowsheets for liquid-solid separations, affixing agent addition, and solids disposal.

Work began on devising radionuclide removal systems for liquid effluents from the 222-S Laboratory, Laundry, and Z Plant low-level waste. One concept involves the use of a multipurpose column containing various ion exchange media,

chromatographic solvent extraction media (solids), activated carbon, and other media. The goal is to maintain radionuclide concentration in the effluent below MPC.

Evaluation of Effort

Modification of the mobile vacuum system is scheduled to continue.

More complete evaluation of candidate pond cleanup systems is needed before equipment and method of operation decisions are made. Factors to be considered include economics, effectiveness of treatment, amount of solids in the sludge, and reduction of waste volume.

Removal of low-level radionuclides from plant effluents will minimize the problem of waste buildup in ditches and ponds, allowing for effective cleanup of these areas.

Future Work

Installation of the spray system and boom systems on the mobile vacuum unit will be completed shortly. Tests will be run to evaluate filter integrity and to identify any other necessary modifications. The eventual goal is to demonstrate cleanup of a contaminated area. Pond cleanup equipment will be examined further.

Laboratory work will be conducted on U Pond and Z-19 Ditch sediments to determine properties that will affect cleanup operation, such as settling rates, size distributions, and effect of various additives on settling rate and coagulation.

Vendors will be consulted on incineration, pond cleanup, sludge handling, and contaminated sediment removal-immobilization equipment. Initial flowsheets will be devised for pond cleanup.

Recommendations will be made on the type of waste treatment processes necessary for the Laundry, 222-S, and Z Plant effluents.

RADIONUCLIDES IN SOIL-PLANT SYSTEMS

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Coordinating Biologists:	V. A. Uresk E. L. Klepper, BNW
Principal Investigator:	R. C. Routson, BNW
Activity Code:	B09TE

Objective and Scope

This program provides the biological data base needed for prudent management of radioactive wastes at Hanford. The goal is to identify the ecological fate and behavior of radionuclides in the soil-plant system relevant to long-term natural conditions.

Prior Work

The chemical form of radioactives wastes was shown to affect their uptake by plants from Hanford soils in growth chamber studies. Plant uptake of transuranics increased in the presence of the chelates ethylenediaminetetraacetic acid (EDTA) and diethylenetriaminepentaacetic acid (DTPA) and salts of several organic acids, an increase partly due to the increased solubility in the soil solution.

Plants with roots growing through a zone of transuranics transported the nuclear material downward, thus suggesting that the roots are a major transuranic sink while the shoot concentration is limited. Uptake of radionuclides

from deeper layers is higher in tumbleweed than in cheatgrass because of tumbleweed's deeper penetrating root system.

Tumbleweed's uptake of ^{90}Sr and ^{137}Cs was measured in uniformly amended soil as a function of soil radionuclide concentration and plant age. Cesium and strontium uptake was measured over three and five orders of magnitude of soil concentration, respectively, at 8 and 12 weeks of plant age. Concentration factors (ratio of $\mu\text{Ci/g}$ in the soil to the plant on an oven-dry basis) were found to be independent of soil concentration over these broad concentration ranges. Plant uptake was about 300 times higher for strontium than for cesium at both 8 and 12 weeks. Concentration factors doubled for both strontium and cesium between 8- and 12-week harvests.

Progress During Report Period

A growth chamber study measuring the tumbleweed and cheatgrass uptake of ^{99}Tc as a function of measurable soil properties was conducted. Five soil types from the Hanford Reservation were collected for the experiment: Burbank sand, Rupert sand, Lickskillet silt loam, Ritzville silt loam, and Warden silt loam. Each soil was air-dried, screened, uniformly spiked, and mixed in a V-blender with 1 μg of ^{99}Tc per 1000 g of soil. Four 1000-g replicates and a control of each soil were planted with tumbleweed or cheatgrass seeds. The plants were harvested at 1-, 2-, and 3-month growing intervals. Initial data showed that on all soil types technetium uptake by tumbleweed and cheatgrass was greater than for any other radionuclide previously measured. The greatest uptake occurred in Rupert sand and the least in Lickskillet silt loam. The ratio of radionuclides in the plants versus the soil indicates that Tc was

concentrated to levels as high as 400 times that of the soil substrate. Uptake was greatest during the first month and decreased in the next 2 months. Mass balance estimates showed that the bulk of the activity was accounted for in the soil and plant shoots, indicating that a portion of Tc was sorbed by the soil and was less available for uptake late in the growth cycle.

Evaluation of Effort

The concentration factors (CF) determined for ^{137}Cs , ^{90}Sr , and ^{99}Tc may be used to predict the plant uptake of these nuclides by measuring their soil concentration. The fact that CF values were constant over broad concentration ranges strongly suggests that CF values can be reasonably extrapolated to even the lowest field concentration for making realistic food chain transfer and dose-to-man estimates. The nearly two-fold increase in CF values from 8 to 12 weeks for both ^{137}Cs and ^{90}Sr suggests that tumbleweed growing near waste sites should be eradicated early in its growth cycle.

Future Work

Work will continue to measure the biological availability of ^{99}Tc as a function of soil properties and waste composition. This work will be extended to include ^{90}Sr , ^{137}Cs , ^{239}Pu , and ^{241}Am . The data will be used to develop predictive capability for estimating biological availability on the basis of simple chemical tests. Previously contaminated soils will be used to test and verify the developed predictive equations.

RADIONUCLIDES IN TERRESTRIAL PLANT-ANIMAL SYSTEMS

Program Manager: M. W. Legatski
Section Manager: M. W. Legatski
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F. J. Cline
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D. W. Uresk
Activity Code: B09TE

Objective and Scope

These studies are to conduct an ecological characterization of plants and animals inhabiting waste management zones and to determine their actual and potential role in exposure, concentration, transport, or dispersal of radioactive wastes.

Prior Work

About 10 years ago a buried radioactive waste site was penetrated by animals, resulting in the dispersal of cesium and strontium over several hundred acres of nearby land within the Hanford boundary. The black-tailed jackrabbit population was the major dispersal agent, depositing "hot" fecal pellets and urine spots. The resulting pattern of contamination was determined by a ground survey and mapped.

A study analyzing the plant communities near the B-C Cribs Controlled Zone and former Redox Swamp area provided information concerning species frequency, shrub size,

canopy cover, micronutrient and macronutrient composition, and soil composition.

Small mammals have been live-trapped monthly since May 1974 in the study area adjacent to the B-C Cribs Controlled Zone. Captured animals were identified, weighed, their sexes and reproductive conditions ascertained, and their toes clipped to permit recognition during subsequent trapping sessions. This procedure allows for evaluation of home-range area, reproductive success, and population structure. The Great Basin Pocket Mouse comprised 95% of the catch.

Within the B-C Crib and Redox Swamp study areas, invertebrate populations have been studied since May 1974. Transfer pathways were defined through determining food habits and behavior of common species.

Food habits of the black-tailed hare were identified by comparing plant fragments in fecal pellets with a reference collection of plants growing in the study area. Yarrow was the preferred plant species while cheatgrass, the dominant herbaceous species, and tumbleweed, a known accumulator of ^{90}Sr , did not occur in the diet.

Waste management information on habitat requirements, food habits, burrowing behavior, position of food chain, and potential for long-distance dispersal of contamination was summarized for the 25 species of mammals living on the Hanford Reservation.

Progress During Report Period

A survey begun May 1974 of the small mammal population near the B-C Cribs study area is scheduled to be concluded in November 1975. Results of the study are being summarized

in a BNW document. Comparisons of species diversity, density, weight, reproductive success, and home-range of the B-C Cribs area population are being made with a population found in a control area not close to a waste management zone.

A census begun May 1974 of invertebrate populations inhabiting the B-C Cribs and Redox Swamp study areas is scheduled to be completed in November 1975. A BNW Document describing the grasshopper populations, their dietary habits, and seasonal abundance has been completed. This information will be used in identifying potential radionuclide pathways between plants and insects.

Sampling of small mammals for radiochemical analysis began April 1975 in five areas representing different habitat types near U Pond. The sampling is to determine the species present, the level of radioactivity in the tissues, and the differences, if any, in body burden levels due to species or habitat differences.

Various techniques have been tested for implantation of thermoluminescent dosimeters (TLD) in mice. Preliminary data show that mice living near U Pond in the meadow between the U-14 and Z-19 Ditches have the highest ^{137}Cs levels, ranging between 23 and 160 pCi/g for the muscle-bone fraction.

Birds of prey, which are among the top carnivores in the food chain, can potentially contribute to the nuisance spread of radioactive waste. A study of the birds of prey on the Hanford Reservation began April 1975. The objectives are to determine their dietary habits, body burden levels, and potential for uptake and transport of radiocontamination. Time-lapse cameras placed near Swainson's hawk nests photographically recorded the behavior and feeding habits

from time of hatching until the birds left the nest. Prey items, regurgitated pellets, and fecal samples were collected to determine food habits and radionuclide content. Thus far only one hawk nest near the 200 East Area contained feces and pellets with measurable ^{137}Cs activity, registering 2X background.

Another program was established to characterize the plants growing on burial grounds by age, by identifying the pattern of vegetational succession with time, and to determine radionuclide levels in the plants growing on the burial grounds and in a control area. The burial grounds sampled to date include 216-U-12, 216-Z-7, 216-Z-9, 218-W-9, and 218-W-3. Cheatgrass and tumbleweed were the most abundant plants growing on the burial grounds although a total of 19 species of plants were present. Although the ages of the burial grounds varied considerably, the vegetation was similar in composition. The 216-Z-7 burial ground was the oldest (1947) and showed an increase in cheatgrass, tumble-mustard, and fringed chickweed. Bursage was significantly higher on 216-S-9, the youngest of the sites (1965). Vegetation samples were collected and prepared for radiochemical analysis, but that information is not yet available. Stoniness of the soil at the various sites was measured with a soil penetrometer so that a correlation between vegetation characteristics and soil stoniness might be drawn. The averages for soil penetration ranged from 7.6 to 14.5 cm, indicating extreme stoniness.

A study has been established to assess the potential for invasion of burned wastes and subsequent uptake of radionuclides by roots of specific plants. Approximately 50 plants have been excavated at two sites. The deepest rooted plants found so far are sagebrush, rabbitbrush, tumbleweed,

and hopsage which rooted to depths over 180 cm (6'). Bur-sage, needlegrass, desert parsley, aster, ricegrass, and balsam root rooted to depths between 100 and 180 cm. Samples of roots at various depths were also taken to determine rooting density as a function of depth.

In November 1974 vegetative cover plots were established on soil fill overlying a portion of S-17 Pond site to determine which treatment would be most successful in protecting the soil against wind erosion and prevent invasion of the area by undesirable deep-rooted plants. Thus far all soil treatments have aided in the establishment of cheatgrass on the plots. However, a clay/straw combination produced the greatest biomass of cheatgrass--over three times that of the untreated control plot. Clay alone was nearly as successful as the clay/straw combination, but straw alone was scarcely more successful than the untreated control.

Evaluation of Effort

Ecological characterization studies of plants, mammals, and insects near the B-C Crib Controlled Zone and Redox Swamp areas have been completed. Significant progress has been made in identifying radiocontaminant pathways through the food chain by dietary analysis of black-tailed hares, birds of prey, and common insects.

Plant species whose roots may potentially invade buried radioactive wastes have been identified. Soil treatments beneficial in establishing a successful vegetative cover in disturbed areas have been devised and tested.

Future Work

Food habit studies of common insects will be completed and documented. Radiotelemetry will be used to delineate the home ranges of birds of prey. Implantation of TLD's in small mammals living in radiation zones will be used to assess their dose rates. Characterization of species and radionuclide levels of plants growing on burial grounds of different ages will continue. Rooting characteristics of native plants will be further studied.

Reports Issued

D. W. Uresk, J. F. Cline, and W. H. Rickard, *Diets of Black-Tailed Hares on the Hanford Reservation*, BNWL-1931, Battelle, Pacific Northwest Laboratories, Richland, Washington, April 1975.

RADIONUCLIDES IN AQUATIC BIOTA AND SEDIMENTS

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Coordinating Biologists:	V. A. Uresk E. L. Klepper, BNW
Principal Investigators:	R. E. Fitzner, BNW R. G. Schreckhise, BNW
Activity Code:	B09TE

Objective and Scope

In these studies the pathways of radioactive materials discharged to a cooling water are being followed through the aquatic food web, including waterfowl.

Prior Work

Experimental goldfish confined to areas of higher radioactivity accumulated twice as much ^{137}Cs as did fish confined over sediments of lower activity.

The ^{137}Cs concentration in experimental ducks confined to the pond was approximately the same as that of resident coots, but higher than that of transient waterfowl.

A 2.5-year survey of waterfowl use of radioactive waste ponds was completed and documented. Between September 1971 and March 1974 one hundred twenty-six species of birds were observed using the ponds and their associated vegetation. Those species most important to waste management considerations were waterfowl that settle in fairly large numbers on the ponds during autumn migration and, in some cases, nest in the area. Their feeding habits offer the opportunity for ingestion of radionuclides from vegetation and aquatic sediments, and by migrating out of the area they may become part of the human diet because of the hunting season.

A study of the seasonal body burden levels and dietary habits of coots living on Gable Mountain, B Pond, and U Pond was initiated June 1974. Residence times and migratory distances were studied by banding the birds with U.S. Fish and Wildlife Service tags.

Radioanalysis of 63 coots was completed. Radiochemical analyses of muscle, liver, and bone were completed for 12 coots collected at Gable Mountain Pond and 1 control coot collected on the Yakima River. The ratio of the ^{137}Cs found in the Gable Mountain coots to the control coot was 1627 in muscle tissue, 3522 in the liver, and 73 in the bone. The average body burden for the Gable Mountain coots was 141 pCi/g.

Progress During Report Period

Waterfowl are observed on 200 Areas waste ponds throughout the year. They may migrate long distances and be shot for consumption by hunters. The American Coot, which is the most abundantly breeding bird on 200 Areas waste ponds, was selected for extensive sampling because it is an omnivorous bottom feeder and offers a "worst possible case" in studies investigating the accumulation and transport of radioactive materials by migratory birds.

During this report period 55 coots were collected at Gable Mountain, B Pond, and U Pond for radiochemical analysis. The average ^{137}Cs concentrations for total body burden levels of adult coots collected at Gable Mountain, B Pond, and U Pond were 168, 19, and 97 pCi/g, respectively. Control coots collected on the Yakima River and at the Columbia Wildlife Refuge near Othello, Washington, showed background fallout ^{137}Cs concentration levels of 0.26 pCi/g.

Stomachs of collected birds are being saved for dietary analysis.

Evaluation of Effort

There does not appear to be any seasonal cycling of ^{137}Cs levels in the coots. The information collected during this time period did not significantly affect the conclusions reached in the previous semiannual, which reported that equations used to assess dose rate to man show that a human consuming an average Gable Mountain coot per day would reach an equilibrium level of less than 2% of his maximum permissible body burden. Coots constituted 4.7% of the total retrieved waterfowl game bag based on Pacific Flyway 1971 data reported by the Bureau of Sport Fisheries and

Wildlife. The probability of a Hanford coot being among those retrieved would be about 0.12%.

Future Work

The investigation of body-burden levels and dietary habits of coots on 200 Areas waste ponds will continue until Fall 1976. Additional emphasis will be given to determining radionuclide levels in eggshells and embryos.

ACTINIDE SEDIMENTS

ACTINIDE TRENCH CHARACTERIZATION

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Principal Geologist:	S. M. Price
Activity Code:	B0965

Objective and Scope

The objective of this program is to characterize the chemistry and distributions of the actinides and their compounds, particularly plutonium and americium, present in sediments underlying liquid waste disposal facilities in the 200 Areas of the Hanford Reservation. The scope includes the following tasks: (1) locate the zones of greatest actinide concentrations and assess their nuclear reactivities; (2) delineate the distribution of actinides beneath the facilities; (3) characterize the mineralogical locations of actinides within the sediment samples; (4) characterize the potential migration behavior of Pu and Am in the ground under present and possible future environmental conditions; and (5) determine immediacy and priority of implementing

migration control measures for approximately 20 trenches containing the highest actinide inventories.

Prior Work

The Actinide Trench Characterization program was formally initiated in FY 1973. Since then, three test holes have been drilled, all under conditions of total containment, through the 216-Z-9 and 216-Z-1A Trenches.

Assessment of the reactivities at both the 216-Z-9¹ and the 216-Z-1A Trenches by neutron pulsing indicates that the probability of attaining criticality at these sites is essentially nonexistent if they are left in an undisturbed state.

Analysis of samples acquired by drilling revealed that the greatest measured concentration of ^{239}Pu , $\sim 10^6$ $\mu\text{Ci/liter}$ of sediment, occurs just below the bottom of both the 216-Z-9 and 216-Z-1A Trenches. This concentration decreases to $\sim 10^3$ $\mu\text{Ci/liter}$ of sediment within the first 2 meters of the underlying sediment columns and to ~ 10 $\mu\text{Ci/liter}$ of sediment (approximate limit of ^{239}Pu detection) at the 10-m depth. The ^{241}Am levels decrease similarly: from a maximum concentration of $\sim 10^5$ $\mu\text{Ci/liter}$ of sediment just below the bottom of both facilities to < 10 $\mu\text{Ci/liter}$ of sediment at the 10-m depth.

Alpha sensitive autoradiography of relatively undisturbed sediment cores from the two sites revealed two types of Pu occurrence--the "particulate" and the "nonparticulate." The "particulate"-type consists of discrete PuO_2

¹Complete details published in *Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench*, compiled by A. E. Smith, US-ERDA Report ARH-2915, Atlantic Richfield Hanford Company, Richland, Washington, December 1973.

particles varying from 5 to 100 μm in diameter. These particles were released to the trenches as part of the original waste stream and were trapped in the upper 1 m of the sediment column by filtration. The "nonparticulate"-type of Pu was originally disposed of as soluble Pu(IV). This second type penetrated deeper within the sediment profile and was deposited in association with silicate hydrolysis of the sediment fragments.

Progress During Report Period

Much of the period was spent in preparation for totally contained drilling through the bottom of the 216-Z-12 Trench. This included the completion and installation of a new containment hood at the site. The new containment hood resembles the facility previously used for totally contained drilling at the 216-Z-9 site. However, the new hood is larger and is equipped with a hydraulic drill rod and casing puller.

During the break between drilling at the 216-Z-9 site and relocation at the 216-Z-12 site, the hood assigned to ready actinide trench samples for analysis was used to process other more highly contaminated materials. Subsequently, in preparation for the handling of the 216-Z-12 samples, Chemical Technology Laboratory (CTL) personnel thoroughly cleaned the facility and ran tests to determine the resultant level of background contamination after the cleansing. The results of these tests indicated that the level of contamination contributed by the hood was $<15 \mu\text{Ci } ^{239}\text{Pu/liter}$ of sand and $\sim 10^{-2} \mu\text{Ci } ^{241}\text{Am/liter}$ of sand. Analysis of the control samples used in the tests by gamma energy analysis also indicated that at a standard counting time of 50 min/sample, the detection limit was $<15 \mu\text{Ci } ^{239}\text{Pu/liter}$ of sand and $\sim 10^{-3} \mu\text{Ci } ^{241}\text{Am/liter}$ of sand. The

total results of the tests indicated that the detection of actinide contamination below the specified values would require new hood facilities and the utilization of a more sensitive analytical technique. Plans to obtain a compartmentalized sample preparation hood, in which the background level could be controlled in each compartment, were subsequently formulated with CTL personnel. Methods of sample preparation and analytical techniques that could detect lower levels of actinide contamination were also investigated.

Reactivation of the gamma energy analysis system during the report period allowed the analysis of a backlog of 216-Z-9 samples by CTL personnel. The results of the analyses indicated that the actinide contents of the samples are lower than the detection limits discussed in the previous paragraph. Consequently, improved sample preparation facilities and more sensitive analytical techniques must be made available before the actual contamination levels of these samples can be determined.

Sludge from Tank 361-Z was also sampled. The need to obtain a representative sample from the south end of the tank (for reactivity assessments) was met with the development of a compartmentalized valve sampler. However the same tool was unsuccessful in obtaining a sample from the north end of the tank because of the thicker consistency of the sludge in this area. Designs for new tools capable of acquiring samples in this area were subsequently formulated.

Evaluation of Effort

Availability of the new hood facility should facilitate as well as accelerate drilling operations conducted at the 216-Z-12 Trench. The new hood permits more room to carry

out sampling maneuvers and to store necessary sampling equipment (thus saving on "bagging in and out" time). Use of the hydraulic drill rod and casing puller should serve to mechanize a portion of the sampling operation that had been performed manually.

Tests conducted by CTL personnel allowed more accurate determination of the current limitations of the sample preparation and analytical facilities. The effort was somewhat negated because of the use of the sample preparation facility following these tests for the processing of Tank 361-Z samples. The background level of the hood facility must now be redetermined before samples from the 216-Z-12 Trench can be processed. The test results, however, were sufficient to indicate the need for a new hood facility. The tests were also sufficient to indicate a need for more sensitive analytical techniques to determine the actinide content of samples from greater than ~10 m below the bottom of trenches.

Future Work

The major objective during the next report period is the completion of one test well each through the bottom of the 216-Z-12 and the 216-Z-18 sites. Determination of the mineralogical location of the actinides in the sediments from these test wells will also be instigated. In addition, test wells at the 216-Z-1A(b), 216-Z-12, and 216-Z-18 sites will be prepared for pulsing.

Report Issued

S. M. Price and L. L. Ames, *Characterization of Actinide-Bearing Sediments Underlying Liquid Waste Disposal Facilities at Hanford*, ARH-SA-202, Atlantic Richfield Hanford Company, Richland, Washington, November 1975.

HYDROLOGY

GROUNDWATER HYDROLOGY

Program Manager: R. A. Deju
Section Manager: R. A. Deju
Principal Investigators: R. C. Arnett
R. K. Ledgerwood
Activity Code: B09T2

Objective and Scope

The goal of the work is to characterize the present and future groundwater flow regime of the Hanford Basin. This will involve characterizing the present and future flow regime of the unconfined aquifer; characterizing the present and future flow regime of the confined aquifer(s); determining the capacity of the present well monitoring network to define present and future water tables; and defining and characterizing the major lithologic units controlling groundwater movement.

Prior Work

A review of the groundwater monitoring network, including an analysis of all well structures, and the setting of criteria for administering the ARHCO portion of the program was initiated. Pumping equipment was acquired and the pump testing program initiated. Eighteen wells were cleaned up and improved before testing. The first test was completed using Wells 699-15-15A and 699-15-15B.

The hydraulic characteristics of the Hanford Reservation were studied using 30 pumping tests conducted on the unconfined aquifer underlying the Reservation. Driller logs for these wells were calibrated for transmissivity and hydraulic conductivity using the results of the pumping

tests. Calibration results were applied to over 300 driller logs from wells that have not been pump-tested. The analyses produced a comprehensive areal coverage of the average transmissivity and hydraulic conductivity of the unconfined aquifer. Vertical variations in these properties were examined using driller logs, pumping tests at various penetrations, and samples. A comprehensive analysis of the data was then used to explain the depositional history of the area and the hydrologic implications of the predicted events.

Progress During Report Period

The Tektronix 4014[®] (Tektronix, Inc.) computer terminal and associated hard copy unit were moved to the 202-S Building. Some difficulty was encountered in establishing communication between the terminal and the PDP 11/45[®] (Digital Equipment Corporation) computer at BNW, but the terminal is now in operation. Preliminary conversion of several of the data base display programs for access by the 4014 terminal has been completed, and Ground Water Management is proceeding to improve the usefulness of the terminal to ARHCO decision-makers.

A system change made in July 1975 at the BNW PDP 11/45 computer has required extensive effort to adapt previous software to the new system. Some additional work will be required to adapt the interactive capability presently demonstrated on the BNW Univac Scope[®] (Sperry Rand Corporation) and PDP 9[®] (Digital Equipment Corporation) computer to the 4014 terminal.

A controller program has been written to display the Hanford map on the 4014 terminal and run travel time programs including the generation of instantaneous streamlines from points selected using the terminal's cursor.

The travel time program has been converted for use in the PDP 11/45, thus making the program accessible from the ARHCO 4014 terminal and allowing calculation of pathlines. During the conversion, the method of storage of surface data was restructured to provide a more rapid access by the program, and the PDP-9 program was redesigned to act as a controller for the new program.

A model study was conducted to predict changes in the water table over the period 1975-1995. This study was coupled with a prediction-verification study where the same mathematical model was used to predict 1968-1973 water table levels using 1968 data as input. Seven areas where the difference between the predicted and observed groundwater potential for 1968-1973 surfaces exceeds 1.5 meters were identified. In general, the areas of high difference coincide with areas of low-data density or steep gradients in the water potential. Most often the model-predicted results are lower than the observed values, indicating low estimates for some inflow rates as suggested by Mr. W. K. Summers and Dr. R. A. Deju, Consultants.

A report on the water export system into the 200 Areas was completed by Mr. W. K. Summers and Associates under the direction of Ground Water Management personnel. During the investigation upon which the Summers' report is based the Export System and the Distribution System were reviewed and the active waste disposal sites were visited and the mode of monitoring inspected. Because monitoring has been carried out primarily on waste waters that might contain radionuclides or nitrates, the volume of liquid waste disposal to the ground is not known with sufficient accuracy to permit reliable prediction of the disposition of radionuclides in the groundwater flow systems. The volume of water

discharged to waste in the 200 Areas is known only to about 20% of the true value.

A comprehensive review was made of drilling, water sampling, water analyses, and quality assurance used in the groundwater monitoring program. Work was continued during the reporting period on completing the inventory of all wells that can be used for monitoring the Hanford groundwater regime.

A map of the water table has been prepared using the July 1975 readings. This map has been reviewed and issued for internal use. No significant changes in the water table were observed between the July and December 1975 readings. Detailed water table and depth to water maps of the 200 Areas were also issued.

Results of pumping tests at locations 699-15-15 and 699-S6-E4 were interpreted. Values of hydraulic conductivity, transmissivity, and storage were obtained. It appears that the specific storage of the unconfined aquifer is very low. Ten new wells were drilled during the period. Samples were taken at 1.5-meter intervals. These wells are to be used for pump testing. Maps of the detailed geology of all pumping test sites were completed and are being used to plan each new test. Pumps have been installed at site 699-62-43 and at the new wells on the old Hanford townsite.

Ten groundwater wells drilled during May and June were grouted. Installation of this cement near-surface seal conforms to Washington State well grouting regulations. These grout seals will prevent any waters from unintentionally flushing down alongside the well casing and into the groundwater flow system.

Sieve analyses were completed for all sediment samples collected during the Spring drilling of 10 groundwater wells. The wells were designed for use in the pump testing program. Approximately 350 samples were sieved with the percentages of various sedimentary fractions being determined for each sample. This information will permit geologic characterization of each pumping test location.

Evaluation of Effort

All work is on schedule. Some difficulties were encountered in drilling the pump test wells but the techniques were refined and improved, and the work was completed as planned.

Future Work

Work scheduled for the coming six months includes completion of the overall evaluation of the adequacy of the groundwater monitoring network. A report on this evaluation will be issued by February 1976.

Work in the area of groundwater modeling will include improvements and sensitivity analyses to the Variable Thickness Transient Flow Model (VTT), reevaluation and five-year simulation of transmissivity data, extension of the software package for the 4014 console, and analyses of groundwater flow data utilizing the transport model.

Several additional wells will be drilled, primarily to define the shape of the groundwater mound under 200 West Area and to define the hydrologic characteristics of the underlying sediment. The pumping test program will continue as scheduled.

Reports Issued

W. K. Summers, *Water Import and Waste Disposal Measurements in the 200 Areas of the Hanford Reservation*, CA-198-WKS-1, W. K. Summers and Associates, August 1975.

TANK FARM GEOLOGY

Program Manager: M. W. Legatski
Section Manager: M. W. Legatski
Principal Investigators: W. H. Price
K. R. Fecht
Activity Code: B05T2

Objective and Scope

The objective of this program is to document (using cross sections and maps) the structure and stratigraphy of the partially saturated sediments underlying the 200 Areas Tank Farms and to locate and quantify the radionuclides in the ground around the tanks.

Prior Work

The Hanford Well Library, located in Igloos T-105 and T-106 behind the 200 West Area, was completed. All sediment samples from drilling on the Hanford Reservation will be cataloged and stored at this location.

Prior to May 1, 1975, 7,839 sediment samples had been sieved and analyzed for calcium carbonate. These data were input into ROCKSAN Computer Program, which categorizes the sediments into 19 classes. Samples from the 241-T and 241-TX Tank Farms were visually examined and ROCKSAN data presented on geologic cross sections and maps. Samples from

the same sediment class were composited for hydraulic analyses.

Gamma log analysis of wells around Tank 241-T-106 showed a decrease in gamma radiation proportional to the ^{106}Ru decay curve. Two instances of increased activity were attributed to lateral migration of radionuclides.

Progress During Report Period

To date 10,419 sediment samples have been analyzed and input into the ROCKSAN computer program. The ROCKSAN data and sediment samples for the 241-A, 241-AX, and 241-SX Tank Farms have been examined and geologic cross sections and maps prepared.

Battelle-Northwest is testing the laboratory equipment for determining the hydrologic properties of the sediments in the vadose zone beneath the tank farms. Draining and imbibition curves are being measured for matrix potential versus saturation and for relative hydraulic conductivity of the nonwetting phase versus saturation. To date 654 determinations of a total 1,641 determinations have been completed. Oregon State University is analyzing splits of the same sediment samples to provide quality assurance to the program.

Five dry wells were drilled in the 241-T Tank Farm to show the distribution and activity of the radionuclides leaked in 1975 to the sediments from Tank 241-T-106. Gamma energy analysis has been determined for 60% of the sediment samples from these wells. The wells were logged with a lithium drifted germanium [Ge(Li)] detector and these data will be compared with the results from laboratory gamma energy analysis.

A study as conducted to quantify the volume of the Tank 241-A-104 leak. Geologic cross sections were drawn to determine the stratigraphy of the unconsolidated sediments. The leaked detection laterals were logged with neutron, Geiger-Muller, and Ge(Li) detectors. A report of the findings and conclusions is in preparation.

Evaluation of Effort

Work to date has demonstrated that the sediments in the vadose zone can be characterized. The distribution of radionuclides within the 241-A and 241-T Tank Farms correlates well with the geologic maps and cross sections prepared and indicates their usefulness in evaluating the impact of future tank leaks and the stability of past leaks.

Future Work

Geologic cross sections and maps will be completed within the next reporting period. The testing of laboratory equipment for determining hydrologic properties of the sediments will also be completed and evaluated. End members of the different sediment classes will be analyzed by BNW for their hydrologic properties to determine if the properties can be equated to the different stratigraphic units presented on the geologic maps of the tank farms. Oregon State University will provide the quality assurance for these analyses. Selected sediment samples will undergo mineral analysis to aid in defining the future course of mineral-waste reaction studies. Within the next reporting period reports will be issued on Tank 241-A-104 and Tank 241-T-106 leak investigations.

TRANSPORT STUDIES

MOISTURE TRANSPORT STUDIES

Program Manager: M. W. Legatski
Section Manager: M. W. Legatski
Principal Investigator: D. J. Brown
Activity Code: B09TC

Objective and Scope

The objective is to determine the rate and direction of moisture movement, caused by precipitation, in the partially saturated sediments underlying the 200 Areas; and the effect of this movement on radionuclides retained by these sediments. This information will be used to make decisions and determine the action necessary to assure control of these radionuclides.

Prior Work

The moisture distribution in two instrumented lysimeters located about 1 mile south of the 200 East Area has been determined routinely since January 1972. The data have consistently shown that the moisture entering the ground from precipitation moves downward to a depth of about 4.5 meters and then back toward the ground surface where it is evaporated back to the atmosphere. The maximum moisture content is usually reached in early February (13 to 15 vol%) and the minimum in late September to mid-October (4.5 to 5.5 vol%). The average moisture content at the 5.5-meter depth is 6.0 vol%.

Equations have been written describing flow of water, vapor, and gas in partially saturated sediments under non-isothermal conditions. The development of an algorithm for the solution of these equations was started.

Progress During Report Period

The sediment moisture profile for the open- and closed-bottom lysimeters was remeasured monthly during the report period. The neutron probe, used to determine moisture content in the lysimeters, is gradually losing its sensitivity and an apparent voltage displacement gave moisture contents 0.7 vol% above those measured during previous report periods. The moisture profiles are identical except for the 0.7 vol% displacement.

The minimum moisture content recorded was 4.9 vol% at the 2-m depth in the open-bottom lysimeter--4.2% if the shift due to probe sensitivity is not taken into account. The average moisture content below 7 m is 6.7 vol%, indicating the sediments near the ground surface continue to be desiccated during the dry, hot summer months. All of the moisture which entered the ground from precipitation during the 1974-1975 rain year has been evaporated into the atmosphere.

Progress continued on the algorithm for the solution of the system of equations describing nonisothermal flow of water, vapor, and gas in partially saturated sediments. Orthogonal collocation on finite elements is the method used for spatial discretization. A modification was made to Gear's method to solve the initial value problem in time. Transient and steady-state analyses of two hypothetical situations were programmed for a one-dimensional solution using the algorithm as now developed.

Evaluation of Effort

While the movement of moisture in the lysimeters is consistently back toward the ground surface, the sediments in the lysimeters are not representative of those in the

200 Areas Tank Farms. Additional lysimeters are needed to characterize the moisture movement in the tank farms and adjacent to solid and liquid waste disposal areas. These lysimeters should be instrumented to measure the movement of salt tracers in the sediments. The data obtained from these lysimeters can provide the verification of the mathematical model under development.

The algorithm for the solution of the mathematical model must be improved to provide numerical solutions over the broad range of values anticipated for the properties of the Hanford sediments. Assumptions now made for the algorithm must be shown to be credible or removed. Better measurements of critical sediment properties must be obtained to assure the development of a credible algorithm.

Future Work

Lysimeters of a new design will be prepared for installation in 200 East and 200 West Areas Tank Farms. These lysimeters will have the capability of monitoring the movement of salts in the ground. The two existing lysimeters will continue to be monitored on a monthly basis during the next report period.

Critical sediment properties will be measured using the best techniques available. Where techniques have not yet been developed for measuring selected properties, research will be initiated to provide the required technology.

AIRBORNE TRANSPORT STUDIES

Program Manager: M. W. Legatski
Section Manager: M. W. Legatski
Principal Investigators: L. E. Bruns
G. A. Sehmel (BNW)
Activity Code: B09TB

Objective and Scope

The objective of this project is to aid in evaluating the potential inhalation hazards arising from operating the reprocessing facilities and maintaining the radioactive waste storage sites. Airborne releases due to changes in both physical conditions and aerodynamic processes that affect the behavior of radioactive particles in the environment are studied. Experiments are performed to measure the quantities and characteristics of airborne particles released. The influence of fire, mechanical surface stresses, wind, and other meteorological variances in resuspension, transport, and trajectories of radioactive particles are also to be investigated. This program develops basic data such as relationships between surface concentrations and amount resuspended.

Prior Work

Prior work relating to particulate resuspension has been conducted under the heading of "Waste Characterization."

Computer programs that calculate the airborne concentration of material resuspended were improved to reduce costs and increase efficiency.

Old meteorological telemetering systems were proven to be inadequate and criteria for a new system were developed.

Work was initiated on a model to produce a representation of the boundary layer flow over the existing terrain.

An acoustical sounding device was tested to provide a more realistic simulation of the diurnal behavior of the mixing layer and also to incorporate this into the transport and diffusion model.

Further capability was developed in the area of computer display of data and model output, and progress continued on the study of convective vortices (dust devils).

Progress During Report Period

Funding for this program was cancelled for FY 1976; therefore the work reported covers only the months of May and June 1975.

Continued studies on the Z-19 Ditch showed the variation of resuspension with wind speed and other climatic conditions and height. Some wet chemistry results were obtained on plutonium in the filters.

Data accumulated from the mobile high-volume sampler were studied for possible use in resuspension programs at localized waste sites.

Localized wind fields and overall Hanford (plus surrounding area) wind fields were studied. Vertical shear, wind speed, and direction of a single locality were compared with the overall wind field movement. Various computer models were being devised to predict the wind field movement.

In a safety analysis of B-C Crib Area, three-dimensional isopleths of resuspended air concentrations were adapted to display these isopleths on 35-millimeter film.

Evaluation of Results

A continued literature study and work with other sites indicate the desirability of resuming this program so that questions concerning contribution of radionuclides to the atmosphere from the 200 Areas plateau can be further investigated--for instance:

- Does the radioactive airborne contribution from the 200 Areas pose a problem to onsite personnel?
- What is the mR/yr exposure contribution from the 200 Areas plateau?
- Is activity gradually moving outward from the 200 Areas because of resuspension and deposition?

The Z-19 resuspension studies indicated Am values 42 times above fallout but less than 1.0% of MPC. Some wet chemistry Pu analyses of filters showed a Pu value of 4.5×10^{-17} $\mu\text{Ci}/\text{cm}^3$ at winds of 1.3 to 3.6 m/sec and of 4.5×10^{-16} $\mu\text{Ci}/\text{cm}^3$ at winds of 6 to 9.5 m/sec. The lower amount is in the fallout range; the higher is 5 to 10 times above fallout but less than 0.1% of MPC. The variation with height, 1 to 30 meters, is relatively constant. Further work is needed to explain this apparent constancy with height even when above the fallout range.

The work with the high-volume mobile air sampler indicates several areas where resuspension towers should be placed. Downwind of tank farms and Z Plant areas should be studied since they show 1 to 3 orders of magnitude above fallout at wind speeds in 6 to 9 m/sec range.

Local and overall windfield pattern studies coupled with resuspension work shows that airborne radioactive movement models may well be able to be computerized. More

meteorological stations could be placed throughout the 200 Areas to better define terrain and topographical effects.

Future Work

No work will be performed during the next six months because of a lack of funding.

INSTRUMENTATION AND CHARACTERIZATION

ENVIRONMENTAL INSTRUMENTATION

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Principal Investigators:	L. E. Bruns G. M. Holter P. J. Wiater
Activity Code:	B1430

Objective and Scope

The objective of these studies is to develop field instrumentation and auxiliary equipment that will accurately and rapidly characterize the concentration, amount, type, and distribution of radionuclides on soil surfaces, in ponds and ditches, and subsurfaces. Whenever possible radionuclides will be assayed *in situ*; sensitivity is desired in the range of nano to pCi/g of soil or water. Auxiliary equipment includes void-volume detectors, airborne particle size detectors, and toxic nonradionuclide monitoring systems.

Prior Work

An experimental ^{90}Sr field assay instrument was devised and laboratory-tested in the presence of ^{137}Cs with favorable results. Two types of plutonium *in situ* assay systems were studied: one is being developed by National Nuclear Corporation (NNC) and another by BNW. The metal foil (or wafer) system for measuring Pu was successfully used in the 105-B Waste Tank with its high-fission product concentration, in Pu storage areas, and in glove box hoods. One of the argon low-level dosimeters was turned over to the Quality Assurance Department. Surface and in-well field studies were made with temporarily devised Ge(Li) *in situ* assay systems pending completion of Dev-Van-I and Dev-Van-II which will house this equipment. Special thermoluminescent detectors (TLD's) were devised and set up on the U Pond area to determine dose rates above 1.3 rads/yr, the limit of the argon dosimeter. New concepts studied included ^{252}Cf activation systems for in-well measurement of Pu, U, porosity, density, moisture, and nonradionuclides and for drum-counting heavy density material at the 10 nCi Pu/g level.

Progress During Report Period

The ^{90}Sr *in situ* assayer was laboratory-tested by BNW and is being considered for adaptation to a mobile configuration. An Intrinsic Germanium (IG) *in situ* instrument for low-level Pu assay was being reviewed, as well as ^{252}Cf neutron activation systems for in-well measurements and for monitoring drums of heavy density material at the 10 nCi Pu/g level.

Further design work was completed on Dev-Van-I, and a temporary setup was devised in the van so that a field test could be made. A test was made on the portion of the Redox

S-16 Swamp that was affixed with an asphaltic emulsion.

All the detectors and electronics are onsite for Dev-Van-II, the subsurface *in situ* assayer. A used van was received but is in need of extensive overhauling before it can be used. Temporary *in situ* subsurface assay equipment was devised and initial test data were accumulated on both vertical and lateral wells.

More data were accumulated on the use of metal foils for determining the Pu concentration in glove box hoods, drums, waste tanks, and cribs. Copper, zinc, and magnesium foils were field-tested; other foils under laboratory study are antimony, lanthanum, and manganese.

An initial test in the U Pond using specially designed TLD's included Pond bottom, above bottom, and along the shore. The purpose of TLD's is to determine the potential dose rate in low-level waste areas in the range from 1.3 to 100 rads/yr; less than 1.3 rads/yr are covered by the argon dosimeter.

A directional neutron *in situ* plutonium assayer was tested in conjunction with NNC. It was tried in Z-1-A, Z-12, and Z-9 Pu Cribs; and in Pu glove box hoods. National Nuclear Corporation is also preparing a CdTe detector for testing.

An important milestone for assuring reliability of all the *in situ* instruments is a calibration tank. Plans were made for the tank and for necessary standards. The tank will contain four different matrices of sediments in a quadrant arrangement.

A proposal was received from Holosonics, Inc., for testing a void-volume detector. The principle involves transfer impedance and the unit can be some distance away

from the suspected void area. The proposal would include filling a crib with a known void volume and noting the changes as it is being filled.

Evaluation of Effort

Laboratory experiments using a ^{90}Sr assayer were promising. Strontium was detected at nCi/g levels in the presence of gamma-emitters. Cesium, ruthenium, cerium, and silver were also measured.

Paper studies on in-well monitoring indicate that the ^{252}Cf neutron activation method could potentially measure Pu at the 10 nCi/g level. The in-well system can theoretically measure soil composition, moisture content, porosity, or other matrices such as salt cake, density of soil, and plutonium and uranium concentrations in the soil. It might also be used to measure the subsurface continuity of affixed contaminated plumes (see "Soil Stabilization").

Two methods for monitoring plutonium in drums at the 10 nCi/g-level appeared feasible:

1. For densities of 1.0 or less, a large crystal area. NaI(Tl) similar to one at Los Alamos Scientific Laboratory could be used.
2. For densities greater than 1.0, a ^{252}Cf neutron activation system could be used.

The initial Dev-Van-I tests for *in situ* surface monitoring were promising. Plutonium was estimated and found to be in the 10 nCi Pu/g range. Cesium as low as 1 nCi/g was assayed; europium was detected at less than 50 nCi/g. The results agreed surprisingly well with laboratory analytical values. It was determined that the 1024 analyzer would be returned to the factory for stabilization improvements.

Temporary use of Dev-Van-II equipment has provided valuable test data and aided tank farm operations in assessing immediate problems such as pipe and tank leaks. The in-well, *in situ* Ge(Li) and special NaI(Tl) detectors have been instrumental in determining:

- That the leaks in the 241-AX Tank Farm were mainly from underground piping and not from the tanks.
- Whether activity is channeling around a well casing or whether it is diffused into sediments.
- The size of the leak under Tank 104-A, the shape of the plume, and the variation of each isotope concentration with depth.
- The subsurface behavior of the radionuclides when a contaminated underground region is stabilized.

The use of metal foils for detection of Pu at the 10 nCi/g and higher levels is promising, although much work is needed before good reliability can be placed on the foils. The calibration tank will help to establish this reliability along with continued laboratory and field tests. The foil technique appears to be feasible for estimating the plutonium concentration in glove box hoods and in waste tanks with high amounts of fission products.

The TLD's succeeded in determining the dose in waste sites where the dose rate was between 1.3 and 100 rads/yr. It was successful in the low-level U Pond area. Specially devised TLD capsules might be used to determine the Cs and Am in high-level waste tanks.

The directional neutron counter of NNC's was useful for determining Pu values *in situ* via dry wells and in glove box hoods. The detector should be excellent for following the

month-to-month diffusion in the subsurface, thus minimizing field sampling, sample preparation, and laboratory analyses. Problems with the initial in-well tests included: (1) clumsy to handle, (2) difficult to directionally orient, (3) shifting readings due to voltage changes, (4) equipment not sufficiently durable, and (5) not satisfactory in a high-gamma field. The first four problems can be easily corrected; and the fifth, though not a problem in transuranic-only waste sites, may be minimized in a high-fission product area. Atlantic Richfield Hanford Company has asked NNC to estimate the cost of a final unit that will be light-weight, durable, easily directionally oriented, and capable of interchanging gamma and coincident neutron-detector assemblies.

The Hologonics transfer impedance system was successfully used on the Alaska pipeline. If it can determine void volume before the equipment is over the subsurface void region, it would enhance the safety of operations at burial ground and crib and trench sites.

Future Work

All instruments tested to date will be further evaluated, thus providing the opportunity to document the argon dosimeter; the alpha water monitor at the 0.1 MPC level; and the work to date on metal foils, gamma surface, in-well instruments and directional-neutron counters. Completing Dev-Van-I and starting the assembly of Dev-Van-II will be emphasized.

Effort will be directed to: (1) adapt the ^{90}Sr beta assaying to field use; (2) set up the calibration tank; (3) work on metal foil neutron activation; (4) continue field tests with the BNW-ARHCO temporary $\text{Ge}(\text{Li})$, $\text{NaI}(\text{Tl})$, in-well,

in situ gamma assayers; (5) estimate the cost of the final directional-neutron monitor system and purchase same; (6) continue paper study on the intrinsic germanium *in situ* Pu assayer and ^{252}Cf systems; and (7) field-test the Holosonics transfer impedance, void-volume detector.

Testing of NNC's CeTe unit is planned, as well as continued study of instruments for real-time measurement of activity buildup on gas filters of all types.

Reports Issued

National Nuclear Corporation, Feasibility Test of NNC Directional-Fast Neutron Counter, June 10, 1975.

WASTE CHARACTERIZATION

Program Manager:	M. W. Legatski
Section Manager:	M. W. Legatski
Principal Investigators:	L. E. Bruns G. M. Holter P. J. Wiater
Activity Code:	B1430

Objective and Scope

This program's purpose is to identify locations, the physical and chemical properties, and the means by which radionuclides at Hanford can enter man's environment. The characterization studies will consider movement of radionuclides as a result of meteorological and biological driving forces.

Prior Work

Work continued on obtaining reliable field samples. Prepared samples were sent to laboratories to establish reliability of low-level environmental analyses. Environmental instruments were developed to estimate three-dimensional isotopic concentrations. Work was started on determining physical properties of the actinides and environmental interactions. Resuspension factors and fallout studies were initiated to establish a better baseline for resuspension studies at the U Pond, B-C Crib area, and the S-19 Ditch. Atmospheric models were developed for optimum selection of telemetering towers for determination of wind-field patterns.

Progress During Report Period

A new type of sampler was developed for obtaining core samples at plant root depth or animal burrowing depth, about 3 to 4 meters.

A Hazards Available equation was developed that relates a source of radionuclides, the transport factors for moving the radionuclides, and the interaction of this material with man with the risk to man.

$$\text{Hazard Available} = \log_{10} \text{Transport Factors} + \log_{10} \left[\frac{\text{isotope concentration}}{\text{MPC}} \right]$$

$$\text{Hazard Index} = \log_{10} \left[\frac{\text{isotopic concentration}}{\text{MPC}} \right]$$

The equation can be modified to show airborne transport to man from a given waste site.

Work on resuspension factors continued in the U Pond and S-19 Ditch areas. Considerable data have been

accumulated on variance of resuspended radionuclides with height and meteorological conditions. A ground survey of the U Pond shore and inland areas added more information to the surface characterization for estimation of resuspension factors.

A mobile, high-volume air sampling system was tried throughout the 200 Areas to spot waste regions giving the major resuspension problems. By the end of the report period 45 locations were tested for resuspension. The unit was placed downwind of selected sites and operated for several days--the number of days depending on the wind speed and the area. For comparison purposes, work was initiated to equate results to some normalized conditions. The mobile unit was used on the west boundary of the 200 Areas to establish a baseline fallout region. Resuspension towers will be located where activity buildup on the filters is not affected by the 200 Areas plateau or the 100 Areas.

Evaluation of Results

The root depth sampler requires further development to improve penetration into the sediments and to obtain a complete core. The vibratory drill technique could be investigated in this regard.

The Hazards Available (HA) gives an equation to relate the magnitude of the potential hazard to man to a hazardous source. Each factor in the equation will require study to ensure all variables are understood. More work is necessary to determine the significant transport factors. Time and instantaneous meteorological conditions are important variables. Worst cases should be considered in determining HA to man.

The mobile high-volume sampler has been helpful in finding baseline areas. It appears that the zone that encompasses the Yakima Barricade is free of contamination effects from the 200 Areas plateau.

Future Work

Improvement of samplers will continue, and experiments will continue on the use of the vibratory drill.

A report of the Hazard Index of several waste sites will be issued.

Methods for determining the radionuclide species present in ditch and pond sediments will be investigated. Particle size, density, and porosity will be determined in various types of soil-radionuclide wastes.

ANALYTICAL METHODS DEVELOPMENT

ACTINIDE ANALYTICAL PROGRAM

Program Manager:	H.	Babad
Section Manager:	H.	Babad
Principal Investigators:	W. I. Winters	
	S. J. Johnson	
Activity Code:	B09T6	

Objective and Scope

The objective of this work is to develop fast and reliable analytical methods for concentrating and determining trace-amounts of actinides in various Hanford nuclear wastes.

Prior Work

During the last report period actinide separation methods using various extractants were evaluated on a limited number of samples. A number of problems with these extractants were found. Aliquat-336[®] (General Mills, Inc.) gave adequate plutonium recoveries (80%) but inconsistent americium results (50 to 80%). Dihexyl-N,N-diethylcarbamylnmethylenephosphonate (DHDECMP) was considered inadequate for routine analysis of actinides because of its poor stripping characteristics. Accurate acid adjustments for the thenoyltrifluoroacetone (TTA) extraction of Pu were difficult and caused very low Pu recoveries.

The Aliquat-336 method was further developed to determine the distribution of Pu, Np, U, and Am through the procedures. These results, in addition to those obtained from earlier experiments, indicate that a single solvent system may not be effective for actinide partitioning.

Progress During Report Period

Solvent extraction systems for separating actinides from Hanford nuclear waste using Aliquat-336, DBDECMP, and TTA were studied in greater detail. Application of these systems to actual samples produced data indicating that actinides may be found in significant levels in either the liquid or solid phase of waste tank samples. Based on developmental work and actual sample application, the finalized procedure will probably use Aliquat-336 and TTA extraction for separation of Pu and Np, and DBDECMP for separation of Am.

Electrodeposition equipment was acquired, set up, and methods tested on actual samples with encouraging results. These methods will produce cleaner mounts for alpha energy

analysis when applied to actinide solutions that have undergone prior separation by solvent extraction. The variables evaluated were electrolyte concentration, current density, and deposition time.

Spectrophotometric methods using thoron and arsenazo III as color developing reagents were surveyed and a potential method using arsenazo III outlined for further development. A spectrophotometric method for determining uranium using 2-(5-bromo-2-pyridylazo)-5-diethylphenol (bromo-PADAP) was developed and successfully applied to the analysis of nuclear waste solutions.

Evaluation Of Effort

An actinide separation method using Aliquat-336 and TTA for Pu and Np analyses and DBDECMP for Am analysis will provide the most reliable actinide results. Electrodeposition will improve the reliability of the analyses and increase capabilities to include curium isotopes by providing superior alpha energy analyses. Results from present analytical methods are adequate for samples containing actinides at levels two times greater than MPC limits for a controlled zone. However these methods require a considerable amount of analytical time and cost and their reliability should be improved at actinide levels near MPC. The total U method developed is adequate and will require only an interfering ion study for completion. However a method is needed for isotopic U analyses. More work is needed to develop a total thorium procedure. With the completion of this work, methods for determining Pu, Np, Am, Cm, U, and Th in Hanford waste will be available.

Future Work

Capabilities in electrodeposition and alpha energy analysis will be expanded and improved. Electrodeposition techniques compatible with separation methods will be developed. A spectrophotometric U method will be completed and documented. Materials isolated by this method will be analyzed for U isotopes. The thorium spectrophotometric method will be developed and evaluated on actual samples. Efforts will be continued to shorten these analytical methods.

RADIATION ANALYSIS SYSTEMS DEVELOPMENT

Program Manger:	H.	Babad
Section Manager:	H.	Babad
Principal Investigators:	W. H. Zimmer	
	V. W. Hall	
Activity CODE:	B06T8	

Objective and Scope

The objective of this program is to design and apply technologically superior data acquisition and reduction systems to all phases of nondestructive measurement instrumentation that utilize radioactive emissions.

Prior Work

Two Tracor Northern, Inc., NS-660 data reduction systems oriented to gamma energy analysis and one NS-880 oriented to X-ray range energy analysis were placed in service. These three systems with their associated custom programs comprise the Gamma, X-Ray Data Reduction (GXDR)

system, whose purpose is to provide all of ARHCO with automatic data reduction of radiation spectral data received on magnetic tape cassettes.

Seventeen satellite analyzer-cassette recorders are currently producing data for GXDR system action and more systems are soon to be added. Semiconductor detector and acquisition systems were initiated for energy analysis of radioactive and nonradioactive constituents in bulk environmental samples, of low-level crib and tank leak soil cores, of low-level air filter samples, of evaporator products and effluent samples, and of other research and development programs.

Progress During Report Period

Two of the four improvement phases of the GXDR system were completed: the establishment of communication between the four 4096 channel pulse height analyzers in the ND 50/50[®] (Nuclear Data, Inc.) and the Nova 1220[®] (Data General Corporation), and the establishment of communication between the Nova 1220 and the CAMAC Nova 830[®] (Data General Corporation). The programming of the GXDR system for gamma and activation analysis data reduction to our specifications has been completed.

A gamma detector system (Z) capable of detecting low-level environmental activity has been developed and placed in service. The system consists of two large, primary Ge(Li) detectors in an NaI(Tl), Compton suppression detector annulus. The targeted five-fold improvement in sensitivity over the single primary (γ) detector system has been achieved.

A new three-detector, low-activity system, S₃, has been installed. The companion R₃ detector system was repaired

and is in service. The Duode[®] (D). (Princeton Gamma-Tech) detector has been installed as a single detector for mid-activity analysis.

An intrinsic germanium detector (G) has been evaluated and placed in service for high Z,K X-ray analysis, fluorescence analysis with isotopic excitation sources, and non-destructive Pu isotopic analysis. Development of this system is not complete.

Plutonium isotopic data were generated by data reduction in the GXDR system for the Nondestructive Assay group.

Evaluation of Effort

Five new detector systems were brought on-line including the Z environmental level system which has been under development for nearly two years. Four detectors were out of service. Two of these were repaired and the third, an old Si(Li) mobile detector (N), replaced with a higher performance detector (K). The well Ge(Li) detector (U) has been out for repair throughout the report period and remains to be evaluated.

The GXDR system is receiving input from 17 pulse height analyzers instead of the eight in the previous report period. Many of these analyzers acquire data 168 hours a week. Despite the required down-time to complete Phases 1 and 2 GXDR updates, the system is providing gamma data reduction on a current basis (one shift/day) for all 17 data acquisition systems.

Future Work

Phase 3 of the GXDR update is the installation of a Diablo 44 dual disc, 32 K words of memory and Multiprocessor Communications Adapter (MCA) linkage between the GXDR Nova

1200'S. Phase 3 will be completed in December 1975 and is targeted to reduce data reduction time 10-fold while improving its quality. Phase 4, the acquisition of an X-ray data reduction system and the linkage of it to the GXDR system Nova computers via CAMAC, is scheduled for completion by September 1977.

Additional work includes:

- Updating the GXDR custom software to reduce 8000 channel spectrum, perform computer disc assisted data reduction, reduce cyclical activation analysis acquisition data, and report total analytical precision instead of counting precision only.
- Evaluate and place in service a well Ge(Li) detector system for low activity, sum peak analysis.
- Begin the use of the GXDR Phase 2 update, the MCA linkage between GXDR Nova 1220 computer and the CAMAC Nova 830 computer.

Report Issued

W. H. Zimmer, *Gamma X-Ray Reduction System*, Vol. 1, ARH-ST-114-1, Atlantic Richfield Hanford Company, Richland, Washington, December 1974.

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