Oil and Gas Research Program

North Dakota

Industrial Commission

Amended Application

Project Title: TENORM Characterization and Disposal

Phase 2A-Integrated Waste Screening System (IWSS) Bulk Characterization and Segregation Demonstration

Phase 2B- X-Rok Encapsulation Demonstration

Applicant: Battelle Energy Alliance, LLC (BEA) and Ceramic Cement Corporation (C3)

Principal Investigator: Douglas Akers (BEA),

Date of this Application: April 15, 2015

Amount of Request:
IWSS Phase 2A - $350,000
X-Rok Phase 2B - $100,000

Total Amount of Proposed Project:
Phase 2A and B - $900,000

Duration of Project: Phase 2A - 6 months
Phase 2B - 3months

Proposed Starting Date: Upon Approval

Point of Contact (POC): Douglas Akers , Battelle Energy Alliance POC Telephone: (208) 526-6118, cell 208 520-6269POC E-Mail Address: Douglas.Akers @inl.gov / POC Address: Douglas Akers , Battelle Energy Alliance, PO Box 1625, MS 2114, Idaho Falls Idaho, 83415

Ceramic Cement Corporation (POC): Judd Hamilton, Ceramic Cement Corporation, ph. 206-935-7161 / Judd@CeramicCement.com

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Transmittal and Commitment Letter

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ABSTRACT

Objective:

Phase 2A - The objective of Phase 2 is to demonstrate the Integrated Waste Screening System (IWSS) Bulk Characterization and Segregation technology being developed by Battelle Energy Alliance, LLC (BEA) the Management and Operating contractor at the Dept. of Energy's Idaho National Laboratory (INL). Exhibit A describes the overall $3.5M Integrated Demonstration Program and Exhibit B is a presentation showing the various monitoring systems being developed. Phase 2A of this project, to be funded through this grant, is to demonstrate the ***Volume Waste Screener (VWS)*** technology that includes two separate methodologies. VWS-1 will characterize both bulk containers (e.g., 8 m^3 roll-off containers) and VWS-2 is for conveyor assay and segregation of loose debris and sludge. Both VWS technologies are designed to quantitatively characterize the Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) content in picocuries per gram (pCi/g) of wastes and to segregate bulk containers of waste or loose debris at the drill site, collection site or the disposal site.

The IWSS-VWS processes will allow the TENORM wastes to be segregated and be disposed of at either licensed commercial or higher-level waste sites whereas <5 pCi/g wastes can be disposed of in commercial landfills or reused in other applications. Following initial development work at the INL, a demonstration of the IWSS-VWS technologies will be performed at the Secure Energy Collection and TENORM waste processing facility in Keene North Dakota and at the Secure Energy Williston Disposal site or at another site proposed by the Oil and Gas Commission. This project has been discussed with a number of groups from North Dakota who have developed letters of support for this program. Interested parties include the North Dakota State Health Department, the Petroleum Council, Northern Improvement Co. and Aon Insurance.

The previous Phase 3 X-Rok radiated waste containment demonstration program portions of which are now proposed to be included in the Phase 2B funding cycle with directly related IWSS / X-Rok/Bakken radiated waste detection, containment, solidification solutions to be further tested and demonstrated in a revised Phase 3 grant description. The primary objective Phase 2B is to concurrently demonstrate the suitability of X-Rok for solidification, encapsulation and shielding of Bakken Shale Wastes, including the solidification of IWSS segregated, non-radiated TENORM into leach-proof, salt resistant, environmentally safe by-products such as concrete aggregate. Consequently the X-Rok demonstration will not only include encapsulation and demonstration shielding it will also include the capability of the X-Rok to generate environmentally safe products from North Dakota oil wastes.

Expected Results: The Phase 2A demonstration program expects to validate the VWS technologies as clearly capable of rapidly segregating nonradioactive (<5 pCi/g) bulk waste in 8 m^3 roll- off containers (VWS-1) or loose debris and sludge (VWS-2) from radioactive TENORM wastes. Phase 2 intends to clearly demonstrate to the oil and gas industry, the state of North Dakota, insurance companies, and the United States Environmental Protection Agency (EPA) that an acceptable low-cost low-manpower solution to on-site waste segregation can be made available and implemented quickly in the North Dakota oil fields utilizing existing oil field staff.

Phase 2B – The Phase 2B project will demonstrate the suitability of the IWSS / X-Rok technologies for successfully monitoring, encapsulating and durably containing Bakkan lower and higher level shale waste forms. Within this revised and proposed Phase 2B project description the environmentally safe creation and use of IWSS segregated TENORM waste by-products will also be included.

Duration: The overall duration of the Phase 2A project is 6-months, which includes development activities at the INL (4 months) and a 1-month demonstration program at one North Dakota waste site. The Phase 2B project will have a period of 3 months as ongoing work at the INL will contribute to the overall program

Total Project Cost: The total estimated cost of the Phase 2A, including both development and testing, is $700K. Of this total, $350K will be provided as in kind support by the INL or as funding and/or in kind funding from the Ceramic Cement Corporation (C3). Phase 2B will provide initial testing At a cost of $100K with $100K of funding and in kind efforts will be provided by Ceramic Cement Corporation (C3).

Participants:

Primary participants in this project are BEA staff, C3 personnel, the Secure Energy waste processing site and a TENORM disposal site. Interested observers include the North Dakota State Health Department, oil and gas industry personnel, as well as oil and gas and insurance company representatives (e.g., Aon, plc insurance).

PROJECT DESCRIPTION

Objectives: Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) is widespread, and is a secondary waste in oil and gas production facilities throughout the world. Significant quantities of TENORM are now being produced in North Dakota and other parts of the world that require new waste sorting, treatment and disposal methods. New approaches to address TENORM waste characterization and disposal from the Bakkan shale oil and gas industry need to be developed. Only about 25% of oil field wastes are TENORM per the state and EPA guidelines of >5 pCi/g. These wastes may require special handling and disposal methods. Consequently, characterization and segregation of TENORM wastes can significantly reduce 1) the amount of waste generated that needs an engineered disposal path, 2) the risk of potential environmental and human contamination, 3) radiation exposure and 4) disposal costs to the state and the oil and gas industry. In addition, there are significant cost benefits due to the reduction in disposal costs, reduced insurance costs, and improved public perception that the wastes are being properly disposed of and monitored at appropriate waste sites.

Discussions with Aon, plc indicate that their risk assessment and costs for oil and gas companies can be reduced through a well-developed characterization and waste segregation program. Segregation of waste will greatly reduce the amount of material being treated as TENORM due to improved characterization data on the quantities of waste generated and the smaller volume of waste that requires disposal as TENORM waste. Accurate IWSS-VWS characterization and segregation will allow a majority of the generated waste to be treated as ordinary land fill waste without any special disposal requirements.

Phase 2A will demonstrate the Integrated Waste Screening System (IWSS) being developed by Battelle Energy Alliance, LLC (BEA) the Management and Operating contractor at the Dept. of Energy's (DOE) Idaho National Laboratory (INL). Exhibit A describes the overall $3.5M Integrated Demonstration Program that provides the development of four monitoring systems and a significant education and training component. The VWS screening technologies project will demonstrate 2 monitoring systems (i.e., one to monitor large containers prior to disposal and the second is a conveyor based segregation system).

Phase 2A will demonstrate the ***Volume Waste Screener (VWS)*** technologies. The VWS-1 utilizes 1 or more detectors to characterize the contents of large 8 m^3 roll-off or loaded trucks and the VWS-2 technology is a direct conveyor assay of loose debris when it is being unloaded at a collection site or waste site. The VWS-1 technology will be used to characterize and segregate large-volume wastes in 8 m^3 roll-offs or other large containers at the drill site or during the waste collection and disposal process. The VWS-1 screener will allow low and high level radioactive wastes to be segregated and disposed of at either commercial or high-level NORM waste sites. Low activity (< 5pCi/g) waste can be disposed of at commercial landfills or it may be suitable for alternate uses. Based on the INL's unique technology, characterization can be performed at any time after the waste is generated at the well head if the time since container loading is known or if two series of measurements are performed.

VWS-1 and VWS-2 systems development will build upon existing INL technology and primarily utilizes BEA equipment already available. Initial testing and development for this project will be performed at the INL followed by a field demonstration at sites in North Dakota. It is expected that the demonstration projects will be performed at Secure Energy sites in North Dakota. In addition, discussions have been held with Scott Radig of North Dakota Department of Health on their participation in this demonstration program.

BEA is a leader in the development of innovative nuclear measurement technologies suitable for characterization of nuclear wastes. Many other previously deployed, highly automated, technologies are suitable for use by operators with limited technical training. These earlier nuclear waste detection systems can be rapidly adapted and customized for characterization and segregation of the radionuclides found in Bakkan shale TENORM wastes.

Phase 2B - The X-Rok technology, which can be used with both high salt content and low pH waste, will be demonstrated on a range of waste types at the field site following initial testing and demonstration at the INL during Phase 2. The waste forms will be evaluated and cored to assure complete solidification. Further samples will be leach tested using the ANSI 16.1 test to assure that the waste is not leachable as well as other tests that address compression strength, load capacity, and radiation shielding. It will be demonstrated that X-Rok prevents the release of radon gas and shields the radon daughter gamma rays to prevent personnel radiation exposure outside the waste form.

Methodology:

Phase 2A of this waste segregation project will use BEA's specialized gamma spectrometry measurement systems that have been previously developed for rapid characterization of nuclear wastes in a field environment by operators with very limited training. For this initial demonstration project, existing, BEA patented measurement systems (detailed descriptions provided on request) will be modified for use on Bakkan shale waste socks, drums and tanks. Appropriate hardware and software changes will be made to adapt the existing technology for use on shale waste containers. Expertise from the development of a number of patented BEA technologies will be utilized in the IWSS demonstration project. These technologies include:

- Drum and package assay monitor for transuranic wastes
- Rapid waste screener for waste in in 3ft x 4ft trays
- Conveyor assay monitor for decontamination and decommissioning wastes
- Subsurface monitor used for characterization the distribution of waste in nuclear waste sites
- Elevated detector system for unpackaged wastes
- Excavation monitoring system
- Mobile cart mounted survey system for rapid characterization of waste site surface areas
- Underwater characterization system for nuclear fuels

The VWS-1 and VWS-2 demonstration systems will utilize elements of the above technologies to rapidly develop the IWSS-VWS demonstration systems. Principal radionuclides that will be measured by the VWS will be measured directly or determined by the measurement of daughter products. Primary radionuclides to be measured are uranium (e.g. ^{238}U), Thorium (e.g.^{228}Th) and mobile radium (e.g. $^{226-228}$ Ra). Current technology requires a 30 day delay to allow the radon daughter products to reach equilibrium with the $^{226-228}$ Ra prior to characterization. However, INL's unique technology allows all measurements to be performed even shortly after the waste is generated at the well head thereby allowing disposal requirements to be defined shortly after the waste is generated. Depending on the waste characteristics, a second measurement may be performed.

Development of the prototype IWSS can be completed on an expedited basis because of the already developed BEA expertise and the ability to utilize existing equipment. Appropriate BEA software, detector, and data acquisition systems will be made available for this project. The availability of the suitable hardware and software will allow an expedited development and testing schedule as discussed below.

Phase 2B will utilize C3s unique X-Rok formulation and will demonstrate the ability of this material to encapsulate and shield Bakkan Shale wastes. Initial testing will be performed at the INL with follow on efforts in North Dakota. Initial test waste forms will be evaluated and cored to assure complete solidification. Further samples will be leach tested using the ANSI 16.1 test to assure that the waste is not leachable as well as other tests that address compression strength, load capacity, and radiation shielding. It will be demonstrated that X-Rok prevents the release of radon gas and shields the radon daughter gamma rays to prevent personnel radiation exposure outside the waste form.

Anticipated Results:

The Phase 2A program will clearly demonstrate that BEA technology can rapidly segregate nonradioactive (5 pCi/g) volumetric waste from radioactive TENORM wastes at the well head shortly after the waste is generated. Further this demonstration will clearly provide evidence to: 1) the oil and gas industry, 2) the state of North Dakota, 3) the insurance companies, and 4) the EPA that an acceptable low-cost, low-manpower, solution to TENORM waste segregation issues is available and can be implemented quickly for the North Dakota oil fields.

Phase 2B will demonstrate the suitability of the X-Rok technology as an encapsulation technology suitable for the rapid solidification and encapsulation of Bakkan shale wastes. Further it will be demonstrated that X-Rok prevents radiation exposure from radioactive wastes and the release of radon gas from the waste, while also safely binding up significant portions of TENORM waste into useful by-products.

Facilities:

The primary facilities to be used for both the Phase 2A and 2B test programs are INL laboratories and one or more demonstration sites in North Dakota. The current primary facility that has been identified for the field demonstration is the Secure Energy TENORM collection site. In addition, a demonstration at the Secure Energy waste disposal site is proposed. Demonstrations at field sites will be used to demonstrate the capability and speed of the IWSS technology as well as its use in a field environment.

Resources:

Shown below are the development and demonstration tasks as well as the cost for the initial Phase 2 and 3 demonstration programs.

Table 1 Bakkan Shale Phase 1 Development Tasks and ROM Cost

Task No.	Sub task No.	Description	Hardware /travel Costs($K)	Labor Hours	Labor Cost ($K)	Estimated cost ($K)
2A		**Phase 2 Volume Waste Screening systems VWS-1 -Bulk Container Assay development and testing**				
	2.1	Assemble Mobile VWS-1 monitor for large cargo containers	100	150	34	134
	2.2	VWS-1 INL Available hardware- detector and data acquisition system	40			40
	2.3	Field Demonstration ND (1 months)	20	320	72	92
	2.4	Report		160	36	36
		VWS-1 Demonstration Cost				**302**
		Phase 2 Volume Waste Screening systems VWS-2 -development and testing				
	2.5	Assemble and test Conveyor Assay System	80	300	68	148
	2.6	VWS-2 INL Available hardware includes conveyor system- detector and data acquisition system	77			77
	2.7	Field Demonstration ND (1 month)	20	320	72	92
	2.8	Report		160	36	36
		VWS-2 Demonstration Cost				**353**
	2.9	Project Management reporting and meetings	4(travel)	100	22.5	22.5
	2.10	Education and Training		100	22.5	22.5
		TOTAL PHASE-2 VWS Demonstration Cost				**700**
2B		**Phase 2 X-Rok Test Program**				
	2B.1	Waste Form acquisition and testing				**100**

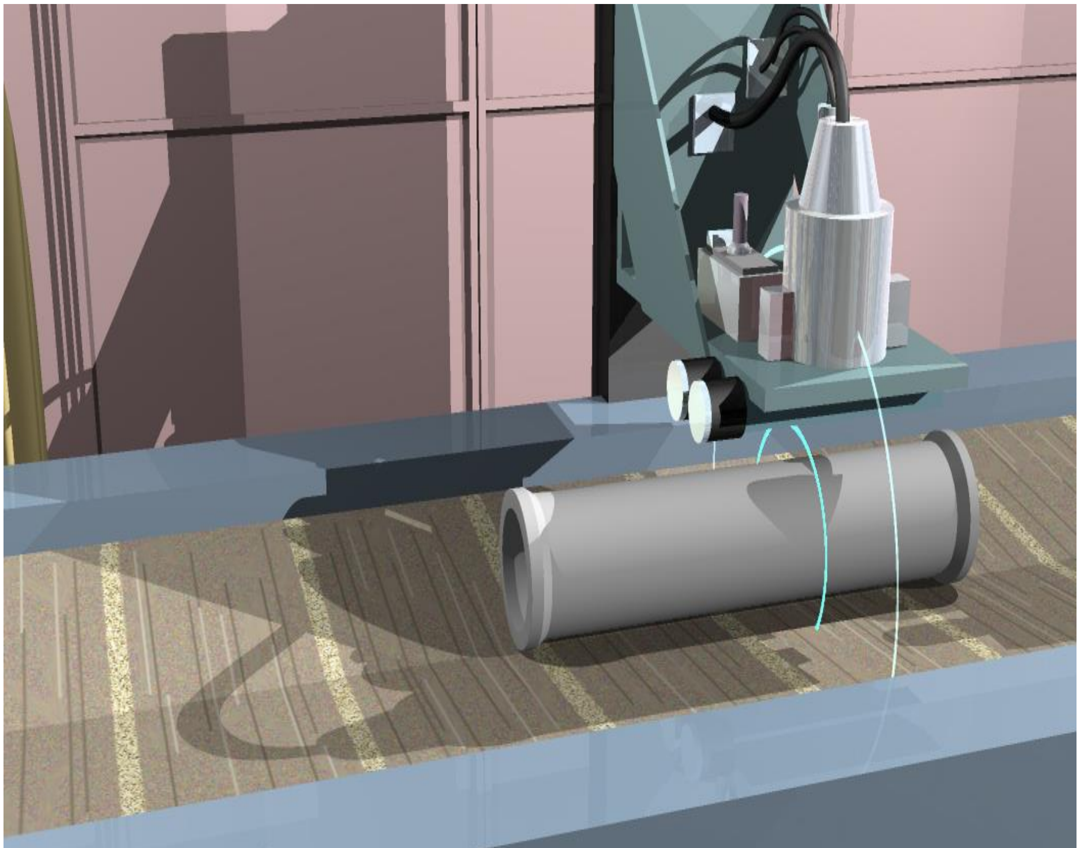
	2B.2	Field Demonstration in North Dakota				**100**
	2B.3	Phase 2 Demonstration Project Cost				**200K**

Techniques to Be Used, Their Availability and Capability:

Phase 2B of this waste segregation project will use BEA specialized gamma spectrometry measurement systems and a computer-controlled conveyor assay system that was developed for the rapid characterization of nuclear wastes in a field environment by operators with very limited training. The primary technology to be used is high-speed gamma ray spectrometry with specialized software and detector collimation that has a number of unique features including:

- Automated accurate assay of contaminated wastes in numerous physical geometries
- Automated assay by untrained operators
- Automated correction for waste density effects using multiple methods
- Automated correction for nonequilibrium Ra-226 daughter concentrations
- Waste segregation detection limits can be specified and system will automatically slow based on waste constituent density and specified MDAs to meet defined detection limits
- System tracks waste inventories by container or bag and maintains continuous tracking and reporting of all data
- Automated systems for calibration and error tracking
- Automated methods to compensate for temperature effects

Shown below is a graphic of the monitoring of debris on a conveyor system and a picture of the VWS-2 prototype conveyor assay system.



Phase 2B will demonstrate the suitability of the X-Rok technology as an encapsulation technology suitable for the rapid solidification and encapsulation of Bakkan shale wastes. Further it will be demonstrated that X-Rok prevents radiation exposure from radioactive wastes and the release of radon gas from the waste.

Environmental and Economic Impacts while Project is Underway:

The Phase 2A VWS-1 and VWS-2 projects are nondestructive assay methods that will be demonstrated on existing waste streams in North Dakota. All development and testing work at the INL will meet BEA safety standards. The testing will demonstrate a safe effective means of characterizing shale wastes and reducing the costs and risks associated with fracking and oil and gas production.

Phase 2B will demonstrate the combined effectiveness of the IWSS detection system and X-Rok containment of all forms of radiated Bakkan Shale waste, in both shielded transport containers and long-term storage containers.

Ultimate Technological and Economic Impacts:

Phase 2A VWS technology development programs will result in verifiable waste characterization and segregation programs adaptable to: 1) located anywhere in the oil and gas industry to reduce volumes, 2) provide verifiable data on the quantities of radioactive waste produced, and 3) verify the safety of the disposed waste. This process is similar to the waste characterization processes developed and used at INL nuclear sites. Phase 3 will demonstrate the unique capability of X-Rok for waste solidification and shielding

Why the Project is Needed:

Development of the IWSS Phase 2A is needed to provide a verifiable waste characterization and segregation process that can be used on large containerized or bulk wastes in addition to providing a basis for meeting North Dakota regulatory requirements for TENORM waste will reduce the quantities of radioactive waste that need to be disposed of at specialized waste sites. IWSS development combined with advanced X-Rok radiation / containment methods will also result in cost reductions not only to the oil and gas companies but also to the insurance companies that must address the risk associated with the waste disposal process. Further IWSS development, in conjunction with the superior radiation containment solutions X-Rok ceramic cement provides, will improve public confidence and support by providing a well-defined, solution based and timely approach to the localized characterization and disposal of radiated waste of all description.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The method to be utilized in measuring success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's oil and natural gas resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program; How it will be reporting on the success of the project.

The measurable deliverable for this project is to clearly demonstrate that BEA technology can rapidly segregate nonradioactive (< 5 pCi/g) in large containers or in loose debris from radioactive TENORM wastes. Further, the demonstration project will clearly demonstrate to: 1) the state of North Dakota, 2) the oil and gas industry, 3) the insurance companies, and 4) the EPA that an acceptable low-cost low-manpower solution to waste segregation issues is available and can be implemented quickly in the North Dakota oil fields.

The public and private sectors will both benefit from the outcome of this technology demonstration program. The public sector will now have a verifiable technology that can be used to demonstrate the segregation of low and high activity wastes as well as means to verify the activity in current waste disposal sites. The private sector will reduce costs through waste segregation and the risk of waste disposal issues and consequently the costs associated with insuring their activities.

Development of the IWSS technology will clearly enhance education, research, development and marketing of North Dakota's oil and natural gas resources as it will provide new methods to reduce wastes and costs as well as providing assurance to both the state and the public that there are methods to verifiably assure the safety of the oil and gas industry. Further it will also provide new higher paying technology jobs in North Dakota.

Phase 2B will demonstrate the suitability of the X-Rok technology as an encapsulation technology suitable for the rapid solidification and encapsulation of Bakkan shale wastes. Further it will be demonstrated that X-Rok prevents radiation exposure from radioactive wastes and the release of radon gas from the waste.

BACKGROUND/QUALIFICIATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.

Douglas Akers – Principal Investigator

SUMMARY OF EXPERIENCE

Thirty-eight years of diversified experience focused on 1) nondestructive assay systems development, 2) positron research for materials characterization, and 3) characterization of nuclear and commercial and DOE reactors and facilities. Current projects include the development of specialized materials assay techniques using Spatially Resolved Positron (SRPA) technology with multiple patents, a Cooperative Research and Development Agreement (CRADA) with GE Nuclear Fuels, and work on both nuclear fuels characterization for the DOE's Reduced Enrichment for Research Test Reactors (RERTR) and Advanced Fuel Cycle Initiative (AFCI) programs. Further I am providing extensive support to Hitachi, JAEA and NNSA on the Fukushima accident. Additionally I am providing training on nuclear reactor accidents to the United States Nuclear Regulatory Commission (USNRC) and Canadian nuclear safety commission. Specific new technologies developed recently include a unique vadose zone ^{99}Tc detector system, Multi Detector Probe for subsurface characterization at the DOE's Hanford waste site and a rapid transuranic materials characterization system, the Fissile Material Monitor, being used at the INL's Radioactive Waste Management Complex (RWMC) complex. Currently a technology reviewer for the National Nuclear Safety Administration (NNSA).

<u>POSITIONS HELD</u>

2002-present, Physicist INL Nuclear and Radiological Physics.

1980 - 2002 (Advisory Scientist)
EG&G Idaho, Scientist (1980-1983), Senior Scientist, Principal Investigator (1983-1988), Technical Leader Radiological Physics (1988-1990), Unit Manager (1991-1992), Technical Leader/Scientific Specialist/Principal Investigator,

1976 - 1980Allied Chemical Corporation/Exxon Nuclear Corporation, - Chemist with principal responsibilities in evaluating radionuclide behavior at commercial power reactors, development of radiochemical analysis methods, and environmental research - field and laboratory studies.

<u>EXPERIENCE</u>:

<u>1998- present –</u> Senior advisory scientist with several patents and applications in process with a primary emphasis on radiation measurement systems development, and materials characterization. Specialized measurement systems developed for the Pit 9 project, and other

Non Destructive Assay (NDA) systems designed for fissile material detection and specialized material measurements. R&D 100 award nominee and numerous articles related to radiation measurements, NDA technology and positron annihilation technology.

10/92 -98 Technical Leader/Scientific Specialist/Principal Investigator Radiological Physics technical team, INEEL. Responsibilities have included lead responsibility for a technical team of 9 with research in the areas of radiation assay system development, waste form behavior, sensor development, measurement systems development, and technical support to DOE, NRC and OECD programs related to reactor and facility licensing, offsite dose calculations and environmental monitoring. Current research is in positron annihilation analysis, NDA system development and NRC research. Active "Q" national security clearance.

6/91 - 10/92 Unit Manager, Nuclear and Radiological Physics. Responsible for a unit of 23 professionals and a budget of approximately $5.0M. Acting technical leader for the Radiological Physics section for most of this period.

9/88 - 6/91 Technical Leader/Principal Investigator Radiological Physics section, EG&G Idaho. Lead responsibility for radiation measurement systems development and technical support to NRC and OECD programs related to the TMI-2 accident evaluation and severe accident analysis and licensing support. Other responsibilities include code development of a PC based version of off-site dose calculation models and research support on radiological issues review for the NRC.

3/87 - 9/88 Senior scientist – Three Mile Island Unit 2 (TMI-2) Accident Evaluation Program EG&G Idaho. Principal duties included technical leadership and budget management for a number of research projects related to the TMI-2 accident ($1.5M). Principal area of investigation was the evaluation of core materials and fission product behavior in the damaged TMI-2 reactor core. Other projects include development of an emission gamma ray tomography system used to evaluate the effects of high temperatures and material composition on fission product behavior, and experimental verification of the ORIGEN2 reactor physics code.

9/80 - 3/87 Scientist/Senior Scientist - Applied Physics section, EG&G Idaho. Principal responsibilities included project leader for NRC projects evaluating radionuclide behavior and source terms at commercial reactors and licensing support to the NRC in the evaluation of technical and environmental specifications. Provided direction and/or technical support to portions of the TMI-2 Core Examination and Power Burst Facility nuclear fuel examination programs. Performed methods development for new nuclear fuel examination techniques including development of high rate gamma spectroscopy systems for hot cell and reactor accident applications.

5/76-9/80 Chemist - Radiochemistry and Effluent Monitoring Sections, Allied Chemical Corporation/Exxon Nuclear Idaho Company Inc. Principal responsibilities were evaluating radionuclide behavior at commercial power reactors, development of radiochemical analysis methods, and environmental research - field and laboratory studies. Assignments included analytical risk analysis of accident scenarios and instrumentation for monitoring releases from Pressurized Water Reactor (PWR) steam

REPRESENTATIVE PUBLICATIONS

D. W. Akers, “Detection of Structural Defects Using Photon-Induced Positrons,” Journal of Advanced Materials” (invited), to be published.

D. W. Akers and A. B. Denison, "In-situ Positron Annihilation Analysis Produced by High Energy Photon Induced Neutron Deficient Positron Emitting Nuclei," Applied Surface Science Vol. 194, Issue 1-4, June 21, 2002.

P. Asoka-Kumar, J.H. Hartley, R.H. Howell, P.A. Sterne, Department of Physics, Lawrence Livermore National Laboratory, D. Akers, V. Shah, A. Denison, INEEL “Direct observation of carbon-decorated defects in fatigued type 304 stainless steel,” Acta Materiala, Vol. 50, Issue 7, April 2002

D. W. Akers, A. B. Denison, and F. Harmon(1), "In-situ Positron Annihilation Analysis Produced by High Energy Photon Induced Neutron Deficient Positron Emitting Nuclei," INEEL, and Idaho Accelerator Center (1), Ninth International Workshop on Slow Positron Beam Techniques for Solids and Surfaces in Dresden, Germany September 16-22, 2001.

D. W. Akers and R. K. McCardell, "Core Materials Inventory and Behavior" Nuclear Technology August 1989.

D. W. Akers, E. L. Tolman, M. Nishio, P. Kuan, and D. W. Golden, "TMI-2 Fission Product Inventory Estimates", Nuclear Technology August 1989.

PATENTS (lead inventor on all)

1. Nondestructive Examination Using Neutron Activated Positron Annihilation, D. W. Akers and A. B. Denison,
2. A Method and Apparatus for Photo neutron Activation Positron Annihilation Analysis, D. W. Akers (apparatus and method)
3. Doppler Broadening and Positron Lifetime Analysis of Materials Using Prompt Gamma Ray Analysis, D. W. Akers,
4. FMM Assay System for TRU and other wastes – D. W. Akers and Lyle Roybal,
5. Positron and Proton Storage in an Electromagnetic Field
6. Positron characterization using Prompt Gamma Rays (2010)
7. Tc-99 Annular Beta Spectrometer System detector system
8.

MANAGEMENT

*A description of **how** the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, **and a description of the evaluation points to be used** during the course of the project.*

This project will performed per Battelle Energy Alliance project management scheduling and budget requirements. There are 5 primary milestones.

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

Phase 2 Milestone 1- Completion of VWS-1 initial development and testing in Idaho – 3 months from start

Phase 2 Milestone 2 –Complete VWS-1 field testing in Montana – 5 months from start

Phase 2 Milestone 3 – Complete VWS-1 final report 6 months from start

Phase 2 Milestone 4- Completion of VWS-2 initial development and testing in Idaho – 5 months from start

Phase 2 Milestone 5 –Complete VWS-2 field testing in Montana – 6.5 months from start

Phase 2 Milestone 6 – Complete VWS-1 final report 8 months from start

Phase 3 Milestone 1 Complete basic laboratory testing of Bakkan shale wastes at INL 2 months

Phase 3 Milestone 2 Complete field demonstration after 1 month field trials and report

BUDGET

*Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source, differentiating between cash, indirect costs, and in-kind services. Justification must be provided for operating costs not directly associated to the costs of the project. Higher priority will be given to those projects that have matching private industry investment equal to at least 50% or more of total cost.   (Note ineligible activities or uses are listed under OGRP 2.02) **Please feel free to add columns and rows as needed.***

Please see the budget table in the resources section for more detailed information.

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Phase 2 PPWS development	$350K		BEA -155	C3-$195K
Phase 2-X-Rok	$100K		BEA 25K	C-3 $75K

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

The project expenses have been discussed in the resource section. BEA in this case is providing a computerized conveyor assay system plu s the technology, software and hardware for the VWS as well as facilities and test equipment such as radioactive sources. Hardware costs for the development program are primarily limited to stands for detectors and holders. BEA has also funded patenting of the IWSS technology.

Ceramic Cement Corporation will provide the remaining $195K in funding for Phase2. Further C3 will provide the required $75K contribution for the Phase 2 project

CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should, if possible, be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. Such information must be clearly labeled as confidential and the applicant must explain why the information is entitled to confidentiality as described in North Dakota Century Code 54-17.6. Oil and gas well data that is a result of financial support of the Council shall be governed by North Dakota Century Code 38-08-04(6). ***If there is no confidential information please note that below.***

Confidential information will be design specific information for the PPWS as well as software. All BEA systems are in the patent process. C3 will use proprietary formulations for their part of the test program.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. ***If this does not apply to your proposal, please note that below.***

BEA has filed a patent application for the IWSS technology with the United States Patent and Trademark Office.

C3's X-Rok ceramic cement has been granted full patent rights in the U.S. and globally.

STATUS OF ONGOING PROJECTS (IF ANY)

If the applicant is a recipient of previous funding from the Commission, a statement must be provided regarding the current status of the project.

No prior projects

When the package is completed, send an electronic version to Ms. Karlene Fine at kfine@nd.gov, and 2 hard copies by mail to:

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

For more information on the application process please visit:
http://www.nd.gov/ndic/ogrp/info/ogrcsubgrant-app.pdf

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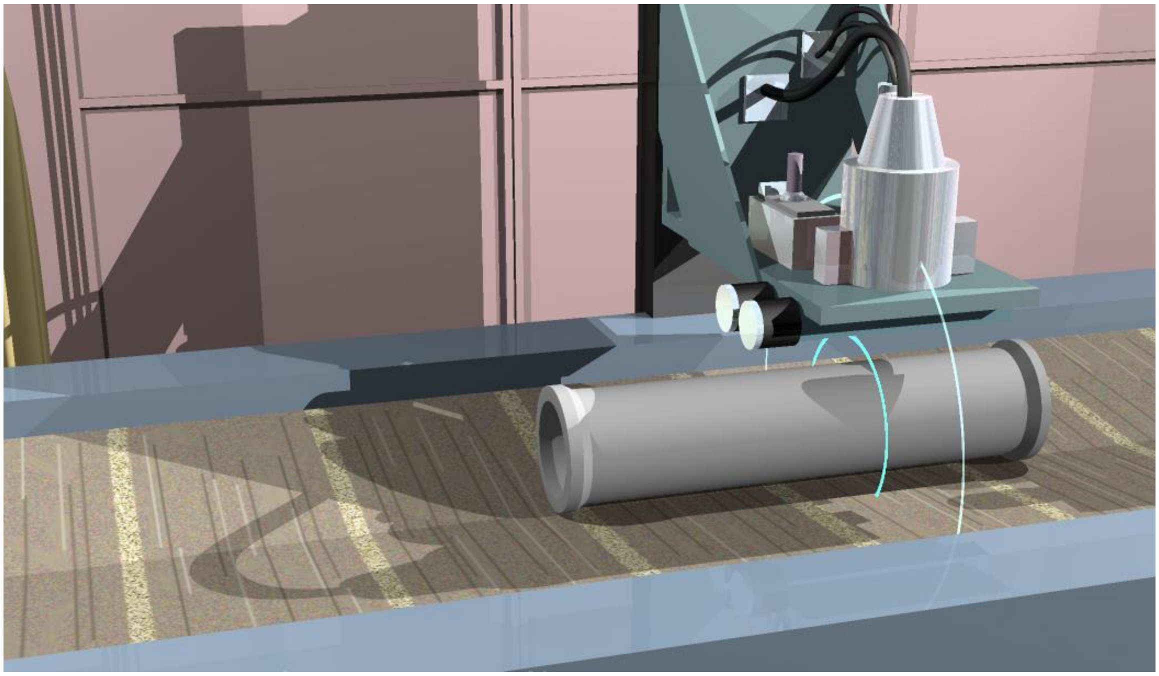
Exhibit A



Bakkan Shale Integrated Demonstration Project (BSIDP)

(Draft- Proprietary)

Introduction

The problem of Naturally Occurring Radioactive Material (NORM) is widespread, in oil and gas production facilities throughout the world. The American Petroleum Institute (API) has sponsored studies to characterize accumulations of NORM in oil field equipment and to evaluate methods for its disposal. However, because of the significant quantities of NORM now being produced in North Dakota and other parts of the world, new approaches to addressing NORM waste characterization and disposal problems, which need to be addressed. The purpose of this proposal is to document the scope, nominal schedule and Rough Order of Magnitude (ROM) costs for a Bakkan Shale Integrated Demonstration Project (BSIDP) to demonstrate an integrated approach for the characterization, segregation, and disposal characterization of NORM wastes from the initial NORM production process through the characterization of wastes that have already been disposed of at NORM waste sites. The goal is to develop and demonstrate an Integrated Waste Screening System (IWSS) that is composed of 4 monitoring systems that can be used at stages of the waste production process from the initial removal of waste at the drill site through the characterization of wastes that have already been disposed of at current waste sites. The BSIDP will demonstrate a qualified and verified characterization process to insurance groups and local, state, and federal regulatory agencies so that it can be used as a standard for characterization and disposal of NORM wastes throughout the world. Specific goals of the IWSS project are to utilize INL's expertise in the development of nuclear waste technologies for the BSIDP to demonstrate their capabilities to:

- Rapidly characterize NORM wastes during the production and transport of the waste,
- Segregate low-level from high level NORM wastes for different disposal pathways
- Characterize already developed NORM waste sites to assess NORM inventories and the need for remediation and
- Characterization surface soils around well drilling and waste sites to assess contamination levels and remediation requirements.

The Idaho National Laboratory (INL) has been a leader in the development of innovative nuclear measurement technologies suitable for the characterization of nuclear wastes. Many of these technologies are highly automated and are suitable for use by operators with limited training. Appendix A shows a number of INL technologies that have been developed for nuclear waste characterization. Specific technologies include:

- Drum and package assay monitor for transuranic wastes
- Rapid waste screener for waste in 3ft x 4ft trays
- Conveyor assay monitor for decontamination and decommissioning wastes
- Subsurface monitor used for characterization the distribution of waste in nuclear waste sites
- Elevated detector system for unpackaged wastes
- Excavation monitoring system
- Mobile cart mounted survey system for rapid characterization of waste site surface areas

The expertise used in the development of these waste assay systems will be used to develop the proposed Bakkan Shale IWSS, which includes monitors for use at each stage of the shale waste disposal process. The proposed IWSS is composed of the following monitoring systems:

- ***Packaged and Piping Waste Screener (PPWS)*** - This monitor will be used to characterize and segregate drummed and bagged wastes at either the drill site or during the waste disposal process. Also the system will be suitable for the characterization of scale on piping. This process will allow packaged or drill piping to be segregated and disposed of at either commercial high-level NORM waste sites.
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- ***Volume Waste Screener (VWS)*** - This monitor is used for the monitoring of bulk wastes such as truck load quantities of cutting. The waste is processed from the truck to either a gated conveyor waste screener that automatically separates the wastes into high and low activity categories or to large trays where the wastes can be rapidly segregated.
- ***Subsurface Waste Characterization System (SWC)*** - This monitor will be used to characterize the distribution of already buried wastes. Multiple tubes will be pushed down through and below the waste site to depths of 30-40 ft. using a push probe system. The detector assembly will be translated inside the tubes to automatically characterize the distribution of the wastes. These data can then be reconstructed into a 3-D model of the waste distribution to allow for remediation and segregation if

necessary or to determine if radioactive material has migrated below the bottom boundary of the waste site.

- ***Brown Field Surface Characterization (BFSC)*** - This monitor is a cart-mounted detector and GPS that allows the rapid characterization of the distribution of radioactive wastes around either well sites or disposal sides to assess remediation requirements and the depth of potential radioactive material at the site.

The identified IWSS systems can be used to characterize the distribution of NORM radioactive materials in all areas of the shale drill waste disposal process. Principal elements and radionuclides that will be measured by all systems or will be determined by scaling from daughter products such as the radon daughters are uranium (e.g. ^{238}U), Thorium (e.g.^{228}Th) and mobile radium(e.g. ^{226}Ra). Development of the prototype IWSS can be done on an expedited basis because of the already developed expertise as shown in Appendix A and the ability to utilize existing INL equipment such as the conveyor waste assay system shown in Figure 1 and software, detector and data acquisition systems that can be made available for this project. The availability of the suitable hardware and software will allow an expedited development and testing schedule as discussed below. The proposed scope, schedule and ROM budgets are described below. Based on prior it is estimated that the developed technologies can be rapidly adapted for other waste types at commercial sites such as heavy metals and organic wastes

Figure 1 Prototype Conveyor Waste Assay System

+Work Scope, Duration Deliverables and ROM Costs

The Bakkan Shale Integrated Demonstration Project is being proposed as a multiple phase development and demonstration project. The three phases of the project are described below along with the scope, duration, deliverables, and estimated associated with each phase. It is anticipated that initial work will be performed at the Idaho National Laboratory and Idaho Stated University with the technology and intellectual property being transferred to a private company in Phase III. The entire duration of the project is expected to be 1 year. No cost estimate has been developed for Phase III as the scope for the final development of commercial systems will be based on Phases I-II.

The three phases of the project, general scope and duration are:

Phase 1 – IWSS Development and Testing – Duration 5 months

Phase 2 – On-Site Testing and Field Optimization in North Dakota –Duration 3 months

Phase 3 – Development and Test of Final IWSS / X-Rok Systems for Field Deployment and Sales – Duration – 4 months

The scope, budget and deliverables for the three phases of the project are shown below:

Phase 1 - IWSS Development and Laboratory Testing – Duration -5 months

The principal goals of this phase of the project are to develop and test the IWSS monitoring systems. As noted above, some of the software and hardware needed for the development program is available, which allow development work for the four monitoring systems to be expected.

The scope and budget for the development effort for the four systems is shown below.

Table 1 IWSS Development Tasks and ROM Cost

Task No.	Sub task No.	Description	Hardware Costs($K)	Labor Hours	Labor Cost ($K)	Estimated cost ($K)
1		**Packaged and Piping Waste Screener (PPWS)-development and testing-footnote a**				
	1.1	Design and procure detector stand, drum rotator computer and translation stage (collimator available)	18	100	23	118
	1.2	Available hardware- detector and data acquisition system	0			

	1.3	Develop interface, data acquisition and analysis software		75	17	75
	1.4	Assemble and test prototype PPWS		75	17	75
	1.5	Total System Cost				**268**
2		***Volume Waste Screener (VWS) Development and Testing***				
	2.1	Design and procure intake hopper with weighing system, gated sorter stage, and computer	33	100	23	133
	1.2	Available hardware- conveyor system detector and data acquisition system	0			
	2.2	Develop interface, data acquisition and analysis software		100	23	100
	2.3	Assemble and test prototype PPWS		200	45	200
	2.4	Total Cost				**433**
3		***Subsurface Waste Characterization System (SWC)***				
	3.1	Design and procure subsurface detector assembly and cable	15	100	23	115
	3.2	Available hardware- detector and data acquisition system	0			
	3.3	Develop interface, data acquisition and analysis software		50	11	50
	3.4	Assemble and test prototype SWC		100	23	100
	3.5	Total Cost				**268**
4		***Brown Field Surface Characterization (BFSC)***				
	4.1	Design and procure cart system and detector assembly	15	100	23	115
	4.2	Available hardware- detector and data acquisition system	0			
	4.3	Develop interface, data acquisition and analysis software		100	23	100
	4.4	Assemble and test prototype BFSC		200	45	200

	4.5	Total System Cost				**218**
		Total IWSS Cost				**1188**

Phase 2 – On-Site Testing and Field Optimization in North Dakota –Duration 3 months

The principal goals of this phase of the project are to field test the IWSS system in North Dakota and optimize the design of the system for the development of final field use systems.

Table 2 On-Site Testing and Field Optimization

Task No.	Sub task No.	Description	Hardware Costs($K)	Labor Hours	Labor Cost ($K)	Estimated cost ($K)
1		**Package, Ship and Assemble Systems North Dakota**				
	1.1	Package and Shipping	10	100	23	110
	1.2	Reassemble systems in North Dakota including travel and 3 staff and travel - 2 weeks	18	240	54	258
	1.3	Testing in North Dakota - 1 month - 3 staff including travel	24	640	144	664
	1.4	Package and Return equipment to Idaho		75	17	75
	1.5	Total Cost				**1107**

Phase 3 – Development and Test of Final IWSS / X-Rok detection, separation and containment Systems for Field Deployment and Sales – Duration – 4 months

The scope of Phase III is to utilize the design information developed to date and the testing performed in North Dakota to develop the final operational systems and to obtain approval of the final integrated systems for regulatory applications. The technologies developed will be transferred to an external company for commercialization.

Exhibit B

Radioactive Material Integrated Waste Screening for Oil and Gas Risk Reduction

Shale Waste Issues and Problems to be Addressed

- New regulatory requirements on the segregation and disposal of oil and gas radioactive wastes
- Potential risk and cost of adverse regulations and lawsuits related to personnel radiation exposure and waste disposal
- Significant quantities of waste contain radioactive uranium, thorium and concentrated radium wastes that generate radon gas
  - Only about 25% of waste is radioactive (EPA)
  - Significant types of wastes including bagged and drummed wastes piping and large volumes of waste cuttings generated
- Waste sites are indiscriminately being filled with both contaminated and nonradioactive wastes
- No verifiable monitoring of safe disposal and migration of radioactive wastes out of the waste site

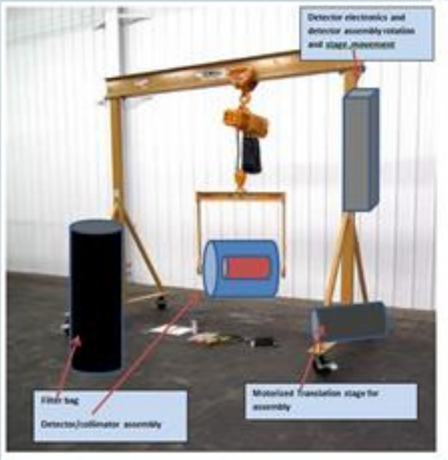
Provide an Integrated Solution for Oil and Gas Radioactive Waste Issues

- An integrated solution to oil and gas risk and regulatory issues is being developed by the Idaho National Laboratory (INL) and C3
- Working with regulatory agencies in North Dakota to assure that the technology meets all regulatory requirements
- The Integrated Waste Screening System (IWSS) utilizes technology developed by the INL for the nuclear industry is being adapted for oil and gas radioactive wastes (patent pending)
  - Four monitoring systems are included in the patent pending technology that address types of oil and gas waste being generated as well as waste site and spill monitoring around wells and disposal sites
  - Well tested technology with simplified easy-to-use operator interfaces
  - Rapid development and implementation based on 25 years of developed technology
- A radioactive-material encapsulation technology (C3), with significant improvements over Portland cement
- Provide assurance to stakeholders that the waste is being optimally processed and disposed of at safe secure waste sites
- Provide training on dangers, methods for characterization and encapsulation of wastes

IWSS Monitors/Segregates Waste at All Stages of the Generation Disposal Process

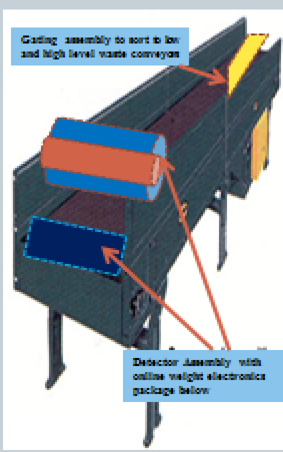
- Packaged Waste Screener (PWS) – Mobile system for onsite segregation
  - Filter bags
  - Drummed waste
  - Tank waste
  - Piping waste
- Volume Waste Screener (VWS)– Rapid conveyor segregation during unloading at packaging or waste site facilities
  - Trucked waste- Cuttings
  - Contaminated soils
- Subsurface Waste Screener (SWS)– Downhole probe for subsurface characterization of existing waste sites
  - Characterize waste site to evaluate the presence of radioactive material and below the waste site to assess migration
- Brown Field Surface Characterization – Small SUV truck mounted
  - Spill or characterization around facilities for contamination

Packaged Waste Screener – Well head or packaging facility rapid screening



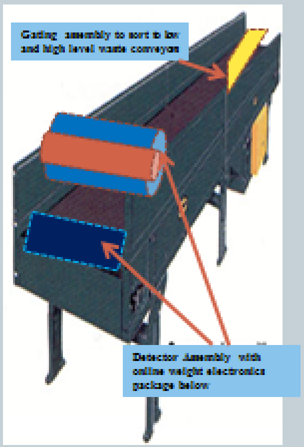
- Rapid segregation of filter bags and drummed waste in as little as 30 seconds
- Useable in motorized mode for isolating hot spots on piping
- Verify radioactive waste presence in tanks or other locations
- Simplified IWSS interface for operators with 3-4 hours training
- System based on 20 years INL development

VWS for High Volume Waste Segregation



- Rapid segregation of high volume waste cuttings during dumping for segregation
- Reduce waste volumes by 75% or more
- Automated sorting and characterization of actual radioactive material content
- Simplified common IWSS interface

VWS for High Volume Waste Segregation



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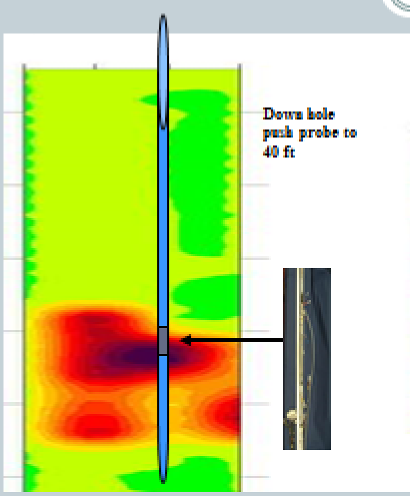
SWC performs rapid location of high activity wastes and migration below site



- Down hole probe can rapidly and automatically characterize waste site for remediation or to assess migration below site
- Regular monitoring of site to assess changes
- Quantitative assessment of inventories
- Simplified IWSS interface

Brown Field Surface Screening for Spills or Contamination

- Rapid 2.5 mile per characterization of spills or areas where contamination may be present
- Depth analysis of waste depth
- GPS mapping of contamination
- Regular monitoring of site to assess changes
- Quantitative assessment of inventories
- Simplified IWSS interface

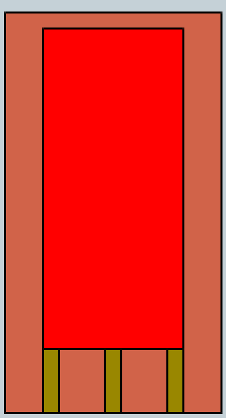
Brown Field Basin Scanner for Examination of Ponds or areas where below water contamination present

- Multidetector system(NaI) for increased throughput of underwater examination of settling ponds
- Monitor contamination buildup and define remediation requirements

IWSS Waste system Capabilities

- Automated assay by non technical operators
- Automated accurate assay of contaminated wastes in numerous geometries due to density assessment during measurement
- Automated correction for density effects (utilizes laser scanner to determine envelop volume and configuration)
- Waste segregation detection limits can be specified and system will automatically slow waste processing ,rates based on waste constituent density and specified MDA' s to meet defined detection limits.
- System tracks waste inventories by box or container for the segregated wastes

X-Rok Ceramic Cement Solidifies Oil Wastes and can be Used for Encapsulation of Highly Radioactive Wastes



- Encapsulated waste Form with 3 in outer layer prevents radiation and radon release
- Patented X-Rok cement is useable for many waste streams that cannot be solidified with Portland
- Suitable for use on high salt and acidic wastes
- Waste site liners are more resistant to attack

Summary

- IWSS provides an integrated developed approach to addressing oil and gas radioactive waste issues
- The technologies based on INL's long term experience with nuclear radioactive waste provide a rapid proven approach for reducing radioactive waste volumes, costs and risks
- This technology provides assurance to the public and regulators as well as companies and their insurers that the waste is being properly processed and is safe