Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Integrated Waste Screening System Demonstration

Applicant:: Battelle Energy Alliance and C3 Corporation

Principal Investigator: Douglas Akers (BEA), Judd Hamilton (Ceramic Cement)

Date of Application: May 12, 2014

Amount of Request:$298,000

Total Amount of Proposed Project: $600,000

Duration of Project::6 months

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

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ABSTRACT

Objective:

The objective of this project is to demonstrate the first phase of 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 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. The first phase of this project to be funded through this grant is to demonstrate the ***Packaged and Piping Waste Screener (PPWS)*** and provide education and training on the technology**.** The PPWS is designed to quantitatively characterize the TENORM content (in pCi/g) of wastes and to segregate filter socks, drummed wastes, and tanked wastes at either the drill site or during the waste disposal process based on TENORM content. The PPWS process will allow the TENORM wastes to be segregated and disposed of at either licensed commercial or higher-level waste sites whereas <5 pCi/g wastes can be disposed of or reused in other applications. Also, this project will demonstrate the X-Rok ceramic cement product developed by Ceramic Cement Corporation (C3). The X-Rok ceramic cement has unique capabilities for solidifying and encapsulating acidic and salt-containing wastes as well as TENORM content and may allow reuse of non TENORM wastes in applications such as aggregate for roads.

The demonstration of the PPWS and waste form technology will be performed at the Bakkan Western waste processing facility as well as at a TENORM waste processing facility. This project has been discussed with a number of groups from North Dakota who are developing letters of support. Interested parties include the N.D state health department, the Petroleum Council, Northern Improvement Co. and Aon Insurance.

Expected Results: The anticipated results from this demonstration program is that the INL PPWS technology can rapidly (~30 seconds depending on the container size) segregate nonradioactive (<5 pCi/g) waste filter socks, drums containing filter socks, large disposal bags, and tanked wastes from radioactive TENORM wastes. This project will clearly demonstrate to the oil and gas industry, the state of North Dakota, insurance companies, and the 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.

Duration: The overall duration of this project is 4 months which includes development activities at the INL (3 months) and a 1 month demonstration program at one North Dakota waste site.

Total Project Cost: The total estimated cost of this project including both development and testing is $$600K. Of this total $302K will be provided as in kind support by the INL or as funding from C3 Corporation

Participants:

Primary participants in this project are INL staff, C3 personnel, the Bakkan Western 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 (i.e., Aon 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 significant cost benefits due to the reduction in personnel radiation exposure, risk reduction, insurance costs and improved public perception that the wastes are being properly disposed of at appropriate waste sites.

Primary participants in this project are INL staff, C3 personnel, the Bakkan Western 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 (i.e., Aon insurance).

Discussions with Aon insurance 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 NORM due to improved data on the quantities and what needs to be treated. Accurate measurement and segregation will allow a majority of the generated material to be treated as ordinary land fill.

The objective of this project is to demonstrate the first phase of 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 Idaho National Laboratory (INL). Exhibit A describes the overall $3.5M Integrated Demonstration Program that not only provides the development of four monitoring systems but has a significant education and training component. The first phase of this Integrated Waste Screening System (IWSS) project being proposed by BEA is composed of 4 monitoring systems that can be used at all stages of the oil and gas waste production and disposal process from the initial removal of waste at the drill site through the characterization of wastes that have already been disposed of at current disposal sites.

Phase I will demonstrate the ***Packaged and Piping Waste Screener (PPWS)*** - This monitor will be used to characterize and segregate filter socks, drummed filter sock wastes, large bagged wastes and tanked wastes at either the drill site or during the waste disposal process. This screener will allow low and high level packaged or tank radioactive wastes to be segregated and disposed of at either commercial or high-level NORM waste sites at the well head. Also, development of waste forms suitable for shale wastes will be developed using the X-Rok ceramic cement which is specialized cement suitable for highly acidic or salty wastes that may contain TENORM.

Initial PPWS systems development is based on and utilizes existing BEA equipment and X-Rok materials. Initial testing and development for this project will be performed at the INL followed by a field demonstration at a site in North Dakota. Currently, discussions are underway between BEA and Bakkan Western on utilization of their waste processing site for initial demonstration testing as well as a TENORM disposal site for filter sock and container testing. 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 of these highly automated technologies are suitable for use by operators with limited technical training. These waste detection systems can be rapidly adapted for characterization and segregation of Bakkan shale NORM wastes.

Methodology:

The methodology to be used for Phase I of this waste segregation project is to 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 as well as a support assembly to hold detection system will be developed. Specific BEA technologies, already developed, will be utilized in the PPWS demonstration project 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
-

The PPWS demonstration system that will be used to characterize the distribution of NORM radioactive materials in containerized wastes from the shale drill waste disposal process will utilize elements of the above technologies. Principal radionuclides that will be measured by the PPWS will be measured directly or determined from measurements 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} Ra). Radon daughters will be used to determine radium content.

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.

In addition, the X-Rok technology, which can be used with both high salt content and low pH waste, which cannot be solidified with Portland cement will be demonstrated on a range of waste types at the site. 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 also clearly 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 anticipated results from this program are that it will be clearly demonstrated that BEA technology can rapidly (<30 seconds) segregate nonradioactive (5 pCi/g) waste filter socks, drums and tanked wastes from radioactive NORM wastes and clearly demonstrate 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 waste segregation issues is available and can be implemented quickly in the North Dakota oil fields.

Further, the demonstration of the X-Rok technology will clearly demonstrate an encapsulation technology suitable for the rapid solidification and encapsulation of Bakkan shale wastes that is not leachable, prevents radiation exposure from radioactive wastes and the release of radon gas from the waste.

Facilities:

The primary facilities to be used for this test program are INL laboratories and one or more demonstration sites in North Dakota. The current primary facility for the field demonstration is the Bakkan Western waste processing facility which is currently in startup mode. In addition, a well head site is proposed that has not yet been identified where wastes can be rapidly characterized in a field environment. These facilities will be used to demonstrate the capability and speed of the technology as well as its use in a field environment.

The X-Rok testing will primarily be performed at INL with wastes shipped to the INL for testing.

Resources:

Shown below are the development and demonstration tasks as well as the cost for the initial Phase 1 demonstration program.

Table 1 Bakkan Shale Phase 1 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**				
	1.1	Design and procure detector stand, drum rotator computer and translation stage (collimator available)	100	55	38	38
	1.2	Available hardware- detector and data acquisition system	79			79
	1.3	Develop interface, data acquisition and analysis software		250	55	55
	1.4	Assemble and test prototype PPWS		250	55	55
	1.5	Field Demonstration ND (1-2 months)	20	320	75	95
	1.6	Project Management reporting and meetings	4(travel)	100	22	26
	1.7	PPWS program cost				**348**

		X-Rok Test Program				
	2.1	Waste Form acquisition and testing (INL)				**100**
	2.2	Waste Form acquisition and testing (ND)	20	320	75	95
	3.1	**Education and training**				**57**
		Total Demonstration Project Cost				**600**

Techniques to Be Used, Their Availability and Capability:

The methodology to be used for Phase I of this waste segregation project is to use BEA specialized gamma spectrometry measurement systems that have been developed for the rapid characterization of nuclear wastes in a field environment by operators with very limited training. The primary technology is high-speed gamma 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
- 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 representative system used for drum transuranic waste monitoring.

Environmental and Economic Impacts while Project is Underway:

This project is a nondestructive assay method that demonstrates technology on existing waste streams in North Dakota. All development and testing work at the INL including the X-Rok waste form testing 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.

Ultimate Technological and Economic Impacts:

The identified technology development program will result in a verifiable waste characterization and segregation program adaptable to anywhere in the oil and gas industry to reduce volumes and provide verifiable data on the quantities of radioactive waste produced and the safety of the disposed waste. This process is similar to the waste characterization processes developed for BEA nuclear wastes.

Why the Project is Needed:

This process is needed to provide a verifiable waste characterization and segregation process that in addition to providing a basis to meet North Dakota regulatory requirements as well as reducing the quantities of radioactive waste and the costs 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.

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 (<30 seconds) segregate nonradioactive (5 pCi/g) waste filter socks, drums and tanked wastes from radioactive NORM wastes and 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 utilize 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 this technology will clearly enhance the 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. Also it will provide new higher tech jobs in this new industry.

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 CRADA with GE Nuclear Fuels, and work on both nuclear fuels characterization for the RERTR and 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 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 Hanford waste site and a rapid transuranic materials characterization system, the Fissile Material Monitor, being used at the INL RWMC complex. Currently a technology reviewer for NNSA.

POSITIONS HELD

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.

EXPERIENCE:

1998- present – 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 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" 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 - 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 fuel examination programs. Performed methods development for new 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 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

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.

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

Milestone 2 –Complete field testing in Montana – 5 months from start

Milestone 3-Complete X-Rok testing 5 months from start

Milestone 4 – Complete final report 6 months from start

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 detaile co.

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
PPWS development	$230		79	100
X-Rok	50			100
Training	20			21

Please use the space below to justify project associated expenses, and discuss if less funding is available that 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 the technology, software and hardware for the PPWS 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 will also funding patenting of the technology developed.

Ceramic Cement Corporation will provide the ceramic cement, holders for that part of the program. BEA will provide the facilities for the test program as well as measurement equipment and other facility requirements. Other costs will be funded through investments through C3

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 will patent the PPWS technology. C3 already has patents for the X-Rok ceramic cement.

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

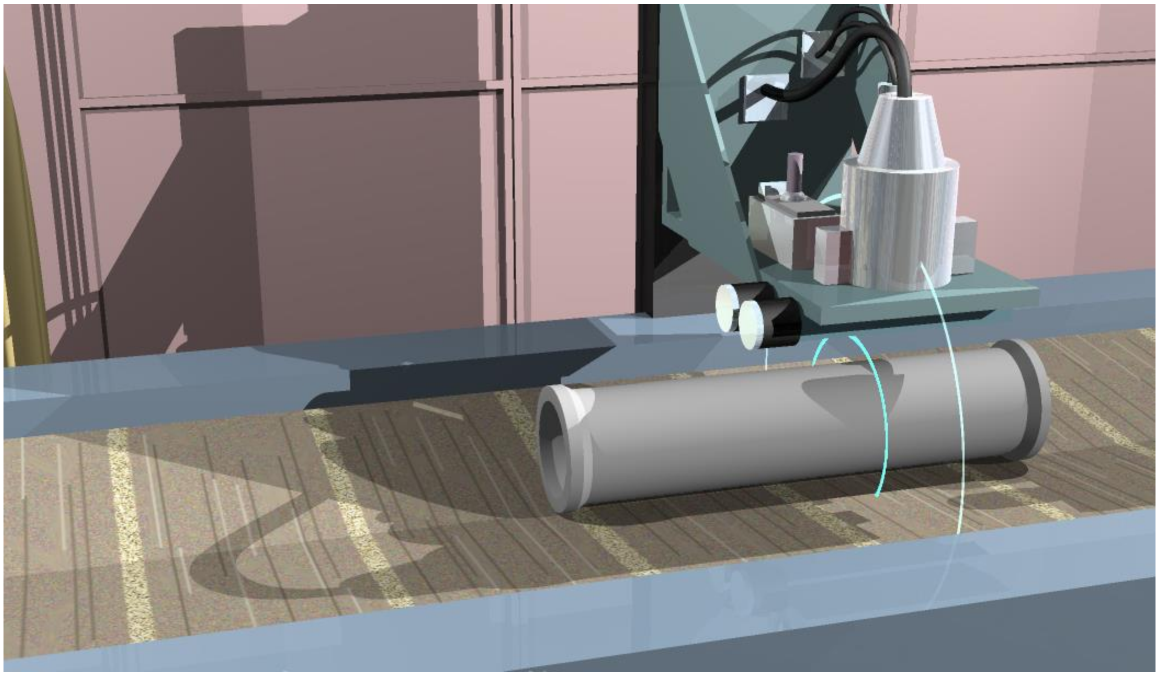
When the package is completed, send an electronic version to Ms. Karlene Fine at kfine@nd.gov, and 2 hard copies by mail to:

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

Questions can be addressed to Ms. Fine at 701-328-3722 or Brent Brannan at 701-425-1237.

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 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.
- ***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 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 prptotype 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 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

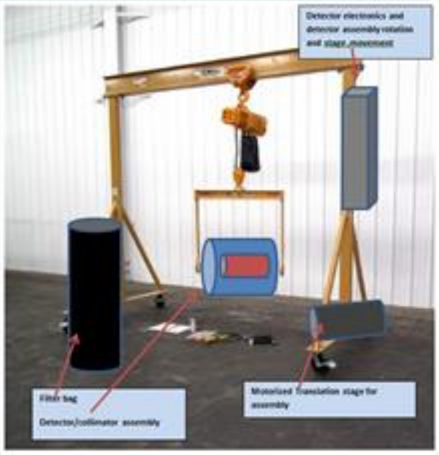
Provide an Integrated Solution for Oil and Gas Radioactive Waste Issues

- 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

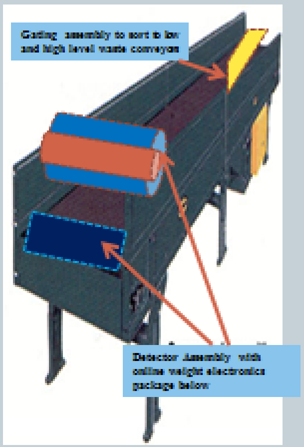


- Rapid segregation of filter bags and drummed waste in as little as 30 seconds
- Useable in motorized mode for isolating hot spots on piping
- Verify radioactive waste presence in tanks or other locations
- Simplified IWSS interface for operators with 3-4 hours training
- System based on 20 years INL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

VWS for High Volume Waste Segregation

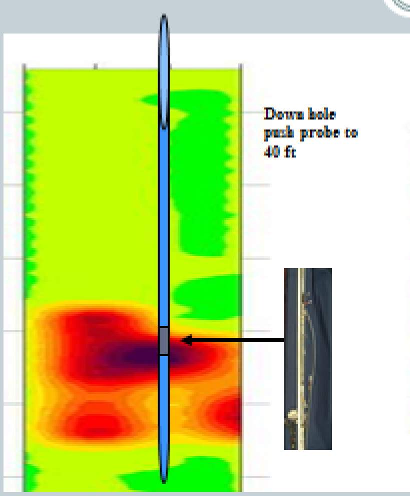
- Rapid segregation of high volume waste cuttings during dumping for segregation
- Reduce waste volumes by 75% or more
- Automated sorting and characterization of actual radioactive material content
- Simplified common IWSS interface

VWS for High Volume Waste Segregation



- 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

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

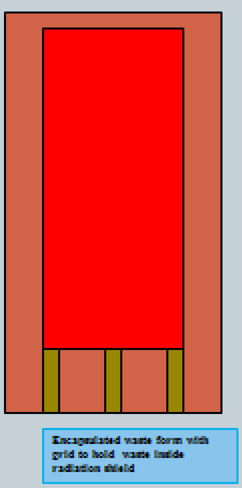
Brown Field Basin Scanner for Examination of Ponds or areas where below water contamination present

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

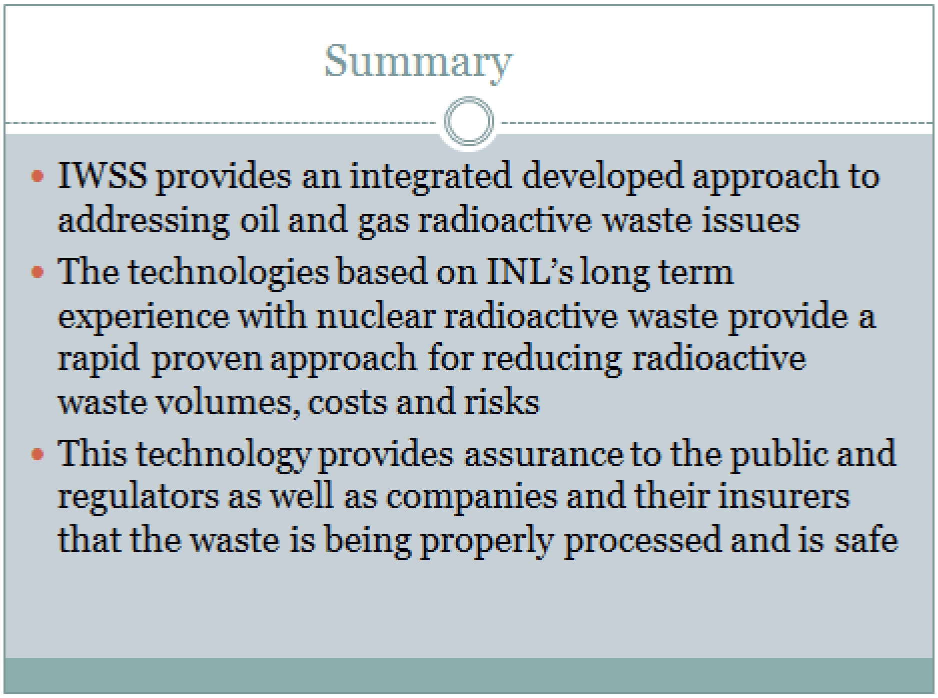
IWSS Waste system Capabilities

- 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