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DOE Helps the EPA Expedite Offshore Regulations for Synthetic-Based Mud

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In the mid-1990s, the U. S. Department of Energy (DOE) took the lead in promoting the use of synthetic-based muds (SBMs) as a pollution-preventing technology and asked the Environmental Protection Agency (EPA) to revise and clarify its offshore regulations. The EPA, in cooperation with industry work groups, has chosen a streamlined approach to resolve SBM discharge regulations. Current regulations and permits do not adequately address SBM issues, a drilling fluid believed to be environmentally friendly. EPA has instead agreed to modify the offshore and coastal effluent limitation guidelines (ELGs).

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Figure 1 Offshore oil platform where SBM samples were taken for EPA analysis.

Drilling fluids

The process of drilling oil and gas wells generates two types of drilling wastes–used drilling fluids (commonly known as muds) and drill cuttings. Historically, the oil and gas industry has used water-based and oil-based muds (WBMs, OBMs) in offshore drilling operations. WBMs, the least expensive and most widely used drilling fluid, may be discharged to the sea, along with associated cuttings, provided that EPA discharge limitations are met. In some situations, however, difficult drilling conditions with reactive shales, deep wells, and horizontal and extended-reach wells may force operators to switch from a WBM to an OBM. In this case, neither the OBM, which contains diesel and mineral oil, nor associated drill cuttings, may be discharged. EPA prohibits any discharge of OBMs and associated cuttings. Instead, the operator must process the OBM for reuse and either inject associated cuttings in a disposal well or haul it to a disposal facility onshore. **Figure 1** shows one of the offshore platforms used to collect SBM samples.

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SBM Qualities

SBMs, which have been developed to replace OBMs, use synthetic organic chemicals as base fluids. In general, SBMs contain no polynuclear aromatic hydrocarbons, exhibit lower toxicity and bio-accumulation potential, and biodegrade faster than OBMs. SBM cuttings are less likely than OBM cuttings to cause an adverse seafloor impact. And although SBMs cost more than OBMs, the nature of SBM-based drilling fluids may permit associated cuttings to be discharged onsite. SBMs also drill a cleaner hole than WBMs, with less sloughing, while generating a lower volume of drill cuttings. Additionally, operators can recycle SBMs whereas WBMs are typically discharged to the sea. The industry has been eager to use SBMs, particularly in the Gulf of Mexico, where drilling has moved into deep water. Current federal regulatory requirements, however, do not adequately address the discharge issue of SBM-based cuttings, and some SBMs continue to be hauled onshore for processing and reuse after the well is drilled.

Federal Requirements

Federal regulatory requirements govern the discharge of drilling fluids and drill cuttings. Offshore ELGs specify that facilities located up to 3 miles from shore, except those in Alaska, may not discharge drilling fluids and drill cuttings. Facilities in Cook Inlet are subject to the same standards used for offshore wells. Facilities located more than 3 miles from shore and all Alaskan facilities may discharge drilling fluids and drill cuttings but must meet the following restrictions:

- No discharge of free oil, diesel oil, or oil-based fluids and cuttings.
- The 96-hr LC-50, a toxicity measurement, must use at least 30,000 ppm.
- Barite used to make the drilling fluid must not contain more than 1 mg/kg mercury and 3 mg/kg cadmium.

The Clean Water Act requires that all wastewater discharges be authorized through a National Pollutant Discharge Elimination System (NPDES) permit. The most recent NPDES permit for the Outer Continental Shelf (Nov. 2, 1998), recognizes that SBMs are distinct from OBMs, although it lacks specific permit language authorizing or prohibiting SBM-cutting discharge.

Efforts

DOE funded Argonne National Laboratory to summarize the advantages offered by SBMs and identify the regulatory barriers that impede widespread use of this innovative and pollution-preventing technology. DOE established an informal synthetic-fluids discussion group based on the Argonne report. The discussion group included representatives from the EPA, DOE, U.S. Minerals Management Service (MMS), and several drilling service and oil-and-gas companies. The EPA used the discussion group to acquire all necessary information for regulatory purposes, motivated by the need to control the waste stream while promoting pollution-prevention technologies.

Distinguishing Definitions

As part of the coastal ELGs, the EPA amended definitions for offshore and coastal drilling fluid subcategories, distinguishing definitions between SBMs, WBMs, and OBMs, while noting that coastal ELGs do not always apply to SBM discharges. For example, the discussion groups showed that the static sheen test, used to check for crude oil contamination in WBM discharges, does not apply to SBM testing because synthetic fluids can dissolve crude oil and carry it to the seafloor without creating sheen. Additionally, they showed that the toxicity test, used for WBMs, does not apply to SBM testing because it uses the suspended particulate phase of a sample whereas SBMs are found in the sediment phase.

The EPA recommended that gas chromatography be used as a confirmation tool, assuring the absence of crude oil contamination. The EPA recommended that benthic toxicity tests be conducted on synthetic materials prior to discharge. The EPA intents to evaluate bio-accumulation and biodegradation tests as indicators of the rate of recovery for seafloor cuttings piles. In late 1997, the EPA announced it would modify the offshore ELGs to include requirements for SBM discharges and cuttings. This process often takes 4 to 6 years. Fortunately, the EPA recognized the oil and gas industry's need to resolve the SBM discharge issue in a shorter time frame, and recognizes the environmental benefits of using SBMs on a wider basis. The final rule is scheduled for December 2000.

Synthetic Fluids Discussion Group

The Synthetic Fluids Discussion Group formed a steering group including representatives from the EPA, DOE, MMS, industry, and a non-governmental organization, and established technical work groups to respond to the EPA's needs for technical information.

Analytical Work Group

The Analytical Work Group serves to identify those methods used for determining the presence of crude oil or other petroleum oils in samples of SBM. Ideal methods must be quick, inexpensive, and accurate. Additionally, the group tries to find ways to estimate the detection frequency levels under varying concentrations of crude oil contamination.

The work group investigated a total of 13 candidate replacement analytical methods, presenting these to the EPA in the spring of 1998. The EPA selected the reverse-phase extraction (RPE) method for offshore use, combined with baseline gas chromatography and mass spectrometry (GCMS) analysis to be conducted onshore. In the RPE method, operators extract samples of SBM through small, reverse-phase, filter cartridges, which are then examined under ultraviolet lighting. A fluorescent glow indicates crude-oil contamination. This inexpensive method can be performed quickly in the field, providing a pass or fail result.

Figure 2 Vibratory centrifuges, used to recover additional drilling fluid from larger drill cuttings, have shown great promise when working with synthetic-based muds.

Cuttings Work Group

The Retention on Cuttings Work Group studies methods that can be used to monitor the percentage of SBM retained on cuttings and the quantity of SBM discharged. Additionally, this group applies economic and performance measures for the various solids-separation devices. **Figure 2** shows a vibratory centrifuge used with the SBMs.

In the Gulf of Mexico the study showed that on average, 12% of the SBM drilling fluid remains within the cuttings after being processed through the primary and secondary shale shakers (**Figure 3**). In the summer of 1998, the work group developed two independent methods – retort and mass balance – to determine the amount of SBM discharged. The retort procedure measures the amount of water and base fluid in samples of both SBM and drill cuttings. In the mass balance method, the volume of SBM lost downhole must be estimated and added to the amount assumed to be discharged with the cuttings. The EPA plans to use these data to aid in method selection for the final SBM regulations–either retort or mass balance.

Toxicity Work Group

The Toxicity Work Group strives to identify toxicity bioassay procedures that can measure SBM toxicity and discharge levels. Sediment toxicity tests typically run for 10 days or longer. Because SBM tests take 6 days longer than WBM tests, sediment tests become more

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costly and less convenient as a compliance measure, especially since offshore operators do not have adequate space to store muds and cuttings for the required period of time.

When tests use the bioassay procedure specified for WBMs, most SBMs demonstrate very low toxicity, due to the inability of SBM to disperse in water. WBMs tend to concentrate in the suspended particulate phase of the sample, while SBMs concentrate in a sediment phase. If operators run bioassay tests on the suspended particulate phase of an SBM sample, the test organisms will not be exposed to the contaminants in the SBM.

A contractor was hired to test six types of SBMs using four types of toxicity tests. As of July 1999, tests indicated no clear-cut best performer, and testing continues. The EPA also intends to conduct independent research on the sediment toxicity of the base fluids and on the effects of drilling fluid composition such as barite content, emulsifier package, aqueous phase composition, and crude oil contamination. It may be unnecessary to perform sediment toxicity tests at the point of discharge, and toxicity levels may be controlled through the base fluid and controls on crude oil contamination.

Figure 3 View of the shale shaker used to separate muds from cuttings.

Seabed Effects and Biodegradation

WBMs produce short-term, minor impacts on the seabed, whereas OBM cuttings introduce long-term, more severe impacts. The Seabed Effects Work Group intends to design a multi-year survey to examine the impacts of SBM cutting discharges on seabed abundance and diversity at several discharge sites. For offshore NPDES permits, it can also serve as the basis for the ocean discharge criteria evaluation required by the Clean Water Act Section. DOE and MMS have agreed to contribute partial funding for the seabed survey.

In August 1997, the EPA provided the work group with a week's worth of time on its research vessel. Crews collected SBM samples from around three platforms in the Gulf of Mexico (**Figure 1**). The EPA collected sediment samples to analyze benthic abundance and diversity data. Additionally, the Biodegradation Work Group is investigating the available types of procedures for estimating biodegradation.

Options Under Consideration

In February 1999, the EPA proposed a regulation on SBMs that considered two options: a discharge option and a zero-discharge option. The EPA chose the discharge option for the proposal because it believes that the water quality impacts of appropriately controlled SBM discharges are less harmful to the environment than the non-water quality environmental impacts (fuel use, air emissions, etc.) that would occur if zero discharge had been selected. The EPA also believes the discharge option will encourage the further use and development of SBMs as a pollution-prevention technology. The proposed regulations present control measures the EPA thinks are adequate and appropriate. Through the work groups, the EPA has worked with industry to address the determination of polynuclear aromatic hydrocarbon content, sediment toxicity, biodegradation, SBM discharge quantity, and the contamination of fluids and cuttings by formation oil. The EPA would prefer to control sediment toxicity at the point of discharge instead of controlling the base fluid. Control at the point of discharge, however, requires further development.

Acknowledgments

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DOE Tackles NORM

By Viola Rawn-Schatzinger,
RMC, Inc.

Introduction

DOE began in the early 1990s to study Naturally Occurring Radioactive Materials (NORM) in oil and gas production activities. Focus of the DOE sponsored NORM projects was on three areas: development of sampling techniques and databases; study of technologies to identify and dispose of oil and gas field generated NORM wastes; and regulatory issues on NORM disposal at Federal and State level.

NORM in oil and gas wastes forms as scales and precipitates, and as radon gas emanation from sediments and in produced water. NORM accumulations resulting from oil and gas operations as primary radionuclides are radium Ra^{226} of the uranium U^{238} decay series, and radium Ra^{228} of the thorium Th^{232} decay series. The long term potential for disposal problems is reflected in the half-life of the elements in the decay series, as seen in **Figure 1**.

The intent of the study was not to assess the radiation risk associated with NORM, but to provide data and recommendations for environmental policy decisions by state and federal government agencies. Currently there are no federal regulations for the disposal of oil field NORM wastes. Several states have some regulations, and others are considering regulations or disposal recommendations. Several projects were sponsored by DOE to study the existing and proposed regulations in those states. To enhance the ability of states and federal government to make regulations, feasibility studies and databases on sampling techniques, current disposal methods, potential technologies, and their effects on the environment were made.

DOE NORM Program

In 1991 DOE and the American Petroleum Institute (API) implemented a program to characterize NORM in the oil and gas industry. Four tasks were recognized: 1) review all literature and regulations on NORM, 2) prepare and field test sampling and analysis plans, 3) collect and analyze samples, 4) summarize the data in a final report.

Among the different agencies cooperating on the NORM disposal studies were Argonne National Laboratory; Lockheed-Martin Idaho Technologies; Idaho National Engineering & Environmental Laboratory; Department of Environmental Quality, Mississippi Office of Geology; Research Institute of Pharmaceutical Science, University of Mississippi; Mississippi Mineral Resources Institute; State of Michigan Department of Environmental Quality; and the National Petroleum Technology Office, with

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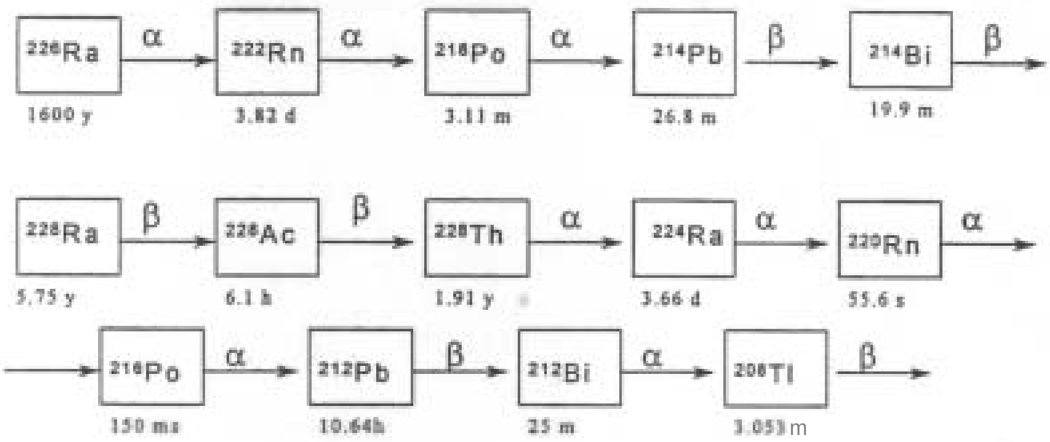

Figure 1 Simplified decay series for Ra^{226} and Ra^{228} showing half lives and decay products important to analysis by gamma spectroscopy (taken from DOE report 13223-2).

the cooperation from a number of state and private companies to collect data.

Characterization of NORM

Characterization of NORM in oil and gas industry equipment and wastes was an early thrust of the NORM program. The primary NORM agents are: 1) Ra^{226} & Ra^{228} precipitated as scale on tubing and equipment, 2) sludge and sands with isotopes of radium, thorium and uranium precipitated in equipment, 3) radon gas emitted from radium-contaminated materials and soils, 4) deposits of lead, Pb^{210} on the interior of pipes from the transmission of natural gas, 5) produced waters. Following the identification of the types of NORM contamination through surveys and testing, programs were initiated for development of standardized procedures, more extensive sampling, development of technologies for identification and disposal of NORM, and a comparison of existing state regulations.

Field Studies – Databases and Sampling

A brief summary of field studies funded by DOE's NORM program in Texas, Louisiana, Mississippi, Michigan, and Colorado which have implemented NORM regulations with varying requirements follows

A DOE and Mississippi database project to study NORM wastes in Mississippi provided for development of sample collection procedures and maintenance of database records to document handling, collection, and analysis of oil field brines from 225 wells representing several different producing zones and 61 fields in Mississippi. The samples are being used to study the mobility of NORM and concentrations of uranium, thorium and radium in the environment. This is one of the first studies to include analysis of the isotopic composition of thorium, in oil field wastes. The goal of the project in Mississippi was to contribute data for making environmental policy decisions at the state level. Preliminary results indicate that the amounts of radioactivity leached from scale and sludge samples was very low, no apparent correlation was found between soil type and leachability of radioactive materials, and that the amounts of NORM going into solution was negligible.

Prior to turning the National Petroleum Reserve #3 at Teapot Dome, Wyoming over to private industry, a survey of NORM distribution and concentration was made at the site. A preliminary gamma survey of the site was conducted to identify potential areas of NORM concentration. Two areas were identified and soil samples were taken from these and tested for Ra^{226},

Ra^{228}, K^{40}, and radon emanation. The areas identified were associated with water flooding and produced-water discharge. Both areas at the site were found to have less NORM concentrations than the amount degreed by states (Louisiana and Texas) which have set NORM regulations.

The potential of radon emanation from NORM-contaminated oil field pipe scale, soils, and sediments was analyzed in a separate study. A widespread gamma survey performed in 1989 (American Petroleum Institute) which covered twenty states and three offshore areas was used as the basis to identify potential sites for sample collection. Samples were collected form Oklahoma, Michigan, Kentucky, Illinois, Texas, and Wyoming. Radon emanation is defined as the fraction of the total radon contained in a material that is released and free to migrate into a gas phase where it may pose a potential health risk. The range of Rn^{222} emanation was from 4% in Texas to 14% in Michigan and Kentucky. These ranges were all less than published radon emanation from uranium mill tailings, and all contaminated materials could be disposed of under existing regulations in most of the states.

Field sampling in Michigan had the dual purpose of identifying NORM-contaminated areas and developing technologies for cost-effective surveys, sampling and testing of potential NORM sites. The Michigan test site was an oil pipe and equipment yard with long-term accumulation of oil field wastes. Previous remediation efforts had identified and isolated some radioactive oil field and equipment wastes. One cost-reduction measure tested was on-site analysis of samples compared to sending samples to laboratories for analysis. This proved effective both in cost outlay and in reduce man hours by combining the sampling and remediation tasks in one field effort.

Field Studies - Technologies for Identification of NORM Contaminated Wastes

The Michigan Adaptive Sampling and Analysis Program (ASAP) tested three real-time data collection technologies: 1) gamma radiation detection walkover site survey using a Global Positioning System (GPS), 2) in-situ High Purity Germanium spectroscopy for quantitative isotopic measurements, and 3) sodium iodide–based direct measurement (RadInSoil) developed specifically for NORM work. All the technologies were successful, and in-situ analysis greatly reduced the per sample analytical costs. The on-site sampling and analysis procedures improved documentation, and ultimately led to better remediation by better delineation of soils not in compliance. The GPS gamma survey was found to work best when only one radium(isotope either Ra^{226} or Ra^{228}) was present in NORM wastes. Ra^{226} is the more typical isotope in soils and scales because Ra^{228} has a very short half-life.

Field Studies – Technologies for NORM Disposal

Several technologies for treatment and disposal of NORM wastes were tested in states, which allowed for NORM disposal. Results and recommendations could prove beneficial to other states, which are reviewing options for NORM disposal regulations.

Landspreading of NORM wastes is a method which relies on spreading oil-field-contaminated waste over the soil surface to allow the hydrocarbon component of the wastes to degrade. Most states have laws governing landspreading practices to protect against environmental contamination, although most states currently prohibit hazardous wastes. This study was conducted in Colorado, where landspreading of oil field waste is permitted when the final concentrations in the soil are reduced to less than 1,000 ppm total petroleum hydrocarbons in sensitive areas and less than 10,000 ppm in all other areas. Recommendations on the specifications for landspreading to meet these requirements provide valuable data to states, which may wish to consider this method of disposal. Techniques include use of earth-moving equipment to spread hydrocarbon materials as thinly as possible to enhance biodegradation, disking the shallow soils after spreading to increase surface area

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exposure, and spraying the soil surface with water or fertilizers to increase biodegradation.

Michigan law permits disposal of non-hazardous wastes (NOW) in landfills. A study to determine the cost-effective alternatives for NORM disposal in landfills has produced recommendations on the specific number of layers and thickness of layers of sediments and gravels above and below, placement of NORM wastes as seen in **Figure 2**. Recommendations on acceptable analysis and distances from other types of land use such as industrial, agriculture, recreational and residential were made. The Michigan study found that landfill disposal of NORM wastes could be one of the most cost-effective disposal options for states to approve either by regulation or special permit.

Disposal in salt caverns is being evaluated in Texas. Salt caverns formed by dissolution mining have been used for petroleum storage for years. The Argonne National Laboratory studied the feasibility of disposal of NOW and NORM-contaminated wastes in salt caverns. Thick-bedded or domal deposits of salts are found in 15 states (AL, AZ, CO, KS, LA, MI, MS, NM, NY, ND, OH, OK, PA, TX, and UT), so the potential for disposal is widespread. Salt caverns can be formed as a by-product of salt mining or purposefully for storage or waste disposal. Hydrocarbon waste being considered for salt cavern are those which do not qualify for Class II injection well disposal because of the presence of solids. The wastes contain drilling fluids, drill cuttings, completion and stimulation waste, produced sand, tank bottoms and contaminated soil. Disposal technologies involve grinding the sediment and mixing with water to inject a slurry into the top of the salt cavern and allowing materials to precipitate. The cavern should be completely filled before sealing. Long-term monitoring and risk assessment for each site is neces-

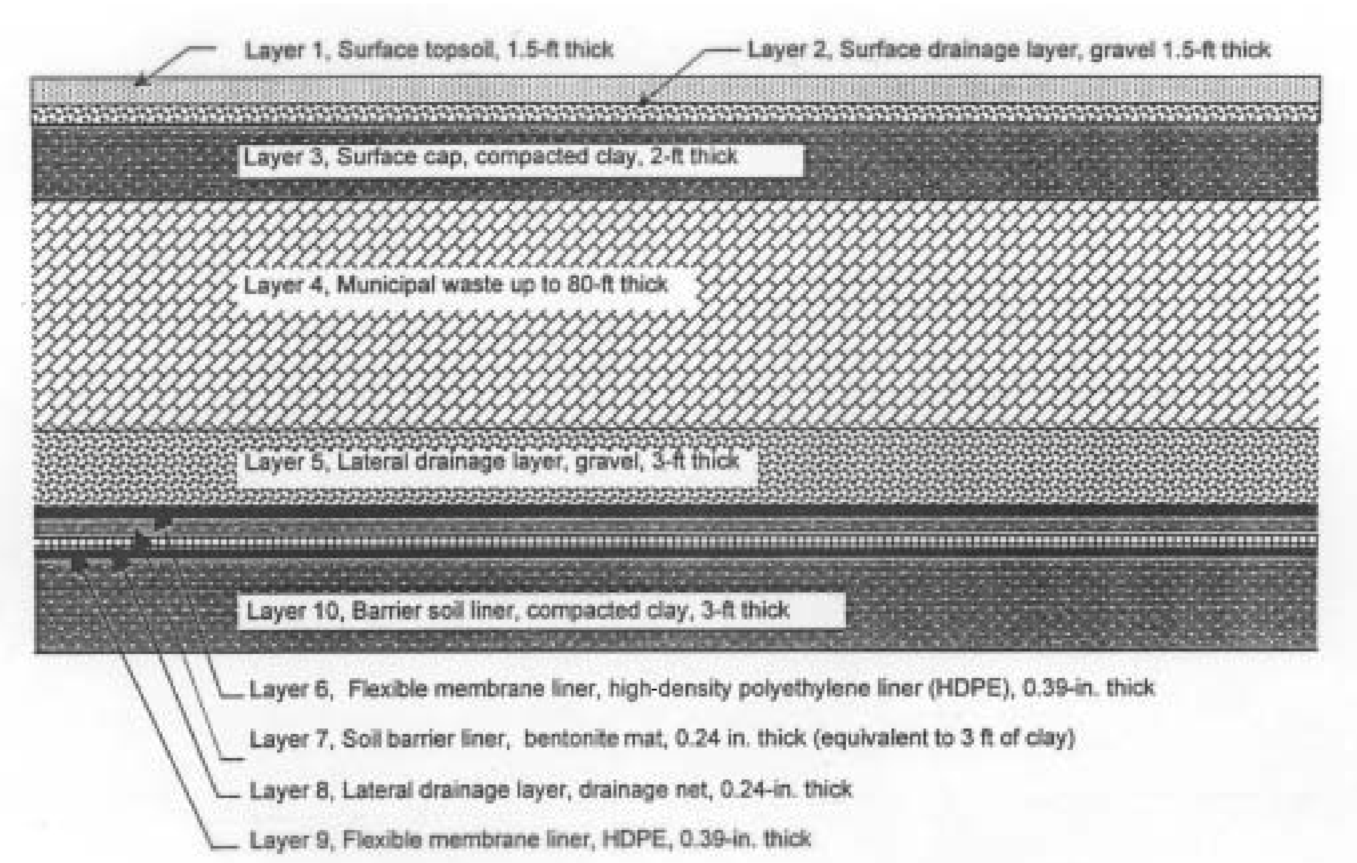

Figure 2 Landfill Design (taken from DOE/W-31-109-ENG-38-8)

sary. Currently only Texas is certified by EPA for commercial salt cavern disposal of NOW waste. New Mexico has also applied for certification. If disposal of NORM waste is approved by EPA and state governments, disposal operators in Texas estimate the cost would be around $150 bbl, which is competitive with current NORM disposal methods.

A project is currently under study to demonstrate the feasibility of mobile equipment to treat tank bottoms. The process would remove the oil, and water, dissolve the radionuclides from the oil and reinject the produced water. A bench-scale demonstration has been completed, and a pilot demonstration is being initiated.

IOGCC Website

As a source of information to the public, DOE and the Interstate Oil and Gas Compact Commission IOGCC) are developing a Website to disseminate data. An overview of the NORM program and existing NORM regulations will be available. A section on frequently asked questions will be set up to respond to questions on NORM projects: where they are located, when regulatory changes are made and what the costs for different methods will be. IOGCC will also sponsor a program called HELP for states which don't have NORM regulations. Data will be compiled and available on existing regulations and proposed regulations in all states.

References

Data presented on the DOE's NORM disposal projects are available in a series of reports. Contact Herb Tiedemann, DOE, National Petroleum Technology Office, P.O. Box 3628, Tulsa, OK 74101 for copies of the following:

Characterization of NORM in Oil & Gas Wastes:
DOE/13223-1 and –2

Characterization of NORM at NPR#3 site:
DOE/5AC304

Salt Cavern Disposal:
DOE/W-31-109-ENG-38-4 & -6 & -7

Landspreading:
DOE/W-31-109-ENG-38-5

Landfills:
DOE/W-31-109-ENG-38-8Adaptive

Sampling:
DOE/W-31-109-ENG-38-9

Bibliography of NORM papers:
DOE/W-31-109-ENG-38-1

EYE *On Environment*
features oil and gas related projects implemented through DOE's oil and gas environmental research program.

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DOE Receives Brownfields Voluntary Redevelopment Certification

By Viola Rawn-Schatzinger,
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On December 7, 1999 Bob Gee, the Department of Energy's (DOE) Assistant Secretary for Fossil Energy accepted a Certificate of Completion from the Oklahoma Department of Environmental Quality (DEQ) in Bartlesville, Oklahoma. When DOE announced it would close and divest its petroleum research laboratory in Bartlesville, Oklahoma by November 1998, it became one of the first sites to be included in Oklahoma's Brownfields Voluntary Redevelopment Program.

Scott Thompson of Oklahoma's Department of Environmental Quality certified the successful completion of the National Institute for Petroleum and Energy Research (NIPER) site cleanup. Thompson stated in the ceremony, "The NIPER facility is a perfect example of what the Brownfields Program is all about. We've taken a very serviceable facility, cleaned it up, and reduced the environmental liability concerns to ensure its continued productive use."

As a step towards turning over the NIPER site to a non-profit organization, DOE undertook the environmental cleanup of the NIPER site, and to meet specifications entered the Brownfields Program. In 1999 the U.S. Environmental Protection Agency approved Oklahoma's application to run its own Brownfields Program. The Brownfields Program was developed to eliminate developers' fear of liability for costly, time-consuming cleanup of contamination for which they may not be responsible. Financial institutions may hesitate to issue loans on properties where unexpected cleanup costs could exceed the property value. With the certification of completion, DOE can turn the NIPER site over to a new owner, and the new owner is free of liability for any contamination that occurred prior to taking over the site.

NIPER Site Involves Many Partners

The NIPER site was the DOE's Bartlesville Project Office from 1983 till 1998, and was first established as a Federal petroleum research station and laboratory in 1918. A short history of the site indicates its importance to the petroleum industry and the oil economy of the United States.

- 1917 George Keeler donated the land to the City of Bartlesville.
- 1917 Bartlesville donated the site to the federal government for the first petroleum research facility in the country.
- 1919–1983 The Petroleum Station was run by the Bureau of Mines and several other government agencies. Key research included oil field safety, water flooding, WWII aviation fuel, and refinery technologies.
- 1983–1993 DOE privatized the research facility and turned it over to IITRI to operate under a Cooperative Agreement. Key research included imaging, chemical and microbial, thermal dynamics development, enhanced oil recovery demonstrations, and fuels testing.
- 1993–1998 DOE authorized BDM to operate the facility under an M&O contract to add flexibility to the Petroleum Research Program.
- 1996 DOE began environmental cleanup of the NIPER site.
- 1997 DOE offices for the National Oil Program moved to Tulsa as the National Petroleum Technology Office (NPTO).
- 1998 DOE closed NIPER site, and began process of turning the site back to the City of Bartlesville.
- 1998 The Delaware Tribe moved into the DOE main building, east, as Tribal Headquarters.
- 1999 Environmental cleanup completed. Oklahoma DEQ certifies the NIPER site.
- 1999 DOE announced legislation that authorizes transfer of the site to the City of Bartlesville.

- 2000 Main building, west, will become home of the Jane Phillips Hospital Free Clinic.

December 7, 1999 Ceremony

On hand for the ceremony representing the DOE were Bob Gee, DOE's Assistant Secretary for Fossil Energy; Bill Lawson, Director of the National Petroleum Technology Office, and David Alleman, NPTO's Environmental Technology Manager. **Figure 1** shows personnel at the December 7 ceremony. Mr. Gee announced that in addition to turning the site over to the city for community use, the DOE donated more than $2 million worth of scientific and computer equipment to area school systems. Scott Thompson represented the Oklahoma Department of Environmental Quality. Bartlesville's Mayor, Ron Nikkel and Jim Fram, President of the Bartlesville Development Corporation, acknowledged the pending transfer of the NIPER site to the city. Dee Ketchum, Chief of the Delaware Tribe, thanked DOE and the City of Bartlesville for use of the buildings for Tribal Headquarters for the 10,000 member Delaware Tribe. Bartlesville plans to use the main building, west, as the site for the Jane Phillips Hospital Free Clinic.

Figure 1 Left to Right, Dee Ketchum, Delaware Tribal Chief; Bob Gee, DOE Assistant Secretary of Fossil Energy, Ron Nikkel, Mayor of Bartlesville; Bill Lawson, Director of DOE's NPTO.

Calendar

APRIL 4–6, 2000

International Hazardous Material Spills Conference–www.nrt.org/hazmat2000, April 4-6, 2000, St. Louis, MO.

APRIL 19, 2000

AAPG Annual Convention–Division of Environmental Geosciences Luncheon; Speaker, Chip Groat, Director, U.S. Geological Survey, "Job opportunities in environmental geosciences and the USGS' role in environmental issues"; April 19, 2000, New Orleans, LA.

SEPTEMBER 20–22, 2000

Oil Spill 2000 International Conference–Oil & Hydrocarbon Spills, Modeling, Analysis & Control; September 20–22, 2000, Las Palmas de Gran Canaria, Spain; e-mail s/walsh@wessex.ac.uk.

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