Low-Level Waste and Radiation Management

Program Overview

Program Description

Nuclear power plants face significant regulatory, economic, environmental, and public perception pressures with respect to low-level waste (LLW) management and personnel exposure to radiation. The safe processing, handling, and disposing of low-level waste requires a detailed familiarity with both technical and regulatory issues. Similarly, as regulatory limits on personnel exposure to radiation decrease, greater effort is needed to develop and demonstrate effective radiation protection and source-term reduction technologies.

The Low-Level Waste and Radiation Management Program investigates improvements to nuclear plant operational practices that can reduce risks associated with waste management and radiation exposure. The program develops guidelines and technologies for waste disposal volume reduction, dose and radiation field reduction, and nuclear plant decommissioning, resulting in lower electricity production costs, better informed regulatory oversight, and improved public perception. The program also develops technical guidance for early detection, mitigation, and remediation of groundwater contamination, an issue of increasing public concern and regulatory oversight.

Research Value

Effective management of low-level waste and radiation exposure enables nuclear plants to operate safely, cost-effectively, and with minimal risk to plant personnel, the public, and the environment. Research results are used by utility radwaste managers to develop strategies for minimizing waste generation and reducing handling and storage costs. Research results are used by radiation protection managers to minimize radiation fields and reduce activity generation. Low-Level Waste and Radiation Management Program participants gain access to the following:

- Technologies, assessments, and guidelines that can reduce solid and liquid waste volumes. LLW assessments, for example, have identified optimization recommendations valued at more than $75 million per year.
- New source-term reduction and radiation protection techniques that can reduce radiation dose. Source-term reduction studies have identified methods for reducing radiation fields by as much as 50% over five years.
- Technical guidance for risk-informed regulations in LLW, radiation protection, and groundwater protection that can address public safety and environmental stewardship concerns. Operational strategies for reducing the volume of Class B/C LLW could save the industry more than $27 million per year when fully implemented.

Approach

The Low-Level Waste and Radiation Management Program develops knowledge, guidance, and tools to reduce the risks and costs associated with waste management and radiation protection. The program also conducts plant assessments to provide expert support and to capture lessons learned that can be shared across the industry.

- Provide cost-effective, risk-based alternatives for waste disposal in the current environment of limited LLW site access (Barnwell closure).
- Develop guidelines and technologies for reducing waste volumes and worker radiation dose.
- Establish technical foundations for reduced regulatory burden in the area of radiation protection.
- Provide tools for improved public perception regarding groundwater protection programs.

Accomplishments

Electric Power Research Institute's (EPRI's) Low-Level Waste and Radiation Management Program supports industry efforts to reduce the costs and regulatory burdens associated with low-level waste, and to drive reductions in public, environmental, and personnel exposure to radiation. The Program develops and demonstrates innovative technologies, converts industry operating experience into practical guidelines, and explores alternative approaches for more effective LLW and radiation management.

- Developed and submitted for regulatory endorsement *On-Site LLW Storage Guidelines*, which will provide consistent, industry-driven guidance for operation of on-site LLW storage facilities (post Barnwell).
- Provided the technical basis for LLW concentration averaging, which would provide $36 million per year in industry cost savings upon implementation.
- Developed tools for implementing an effective, optimized groundwater monitoring and remediation program, including technical guidelines and supplemental site evaluations. Nuclear Regulatory Commission endorsement of the Electric Power Research Institute (EPRI) Guidelines would provide significant site relief.
- Identified and quantified source-term reduction methods to reduce station radiation fields by as much as 50% over five years, produced as part of EPRI's roles with respect to the industry's RP2020 Plan.

Current Year Activities

Low-Level Waste and Radiation Management Program R&D for 2010 will sustain progress toward lower-cost waste handling and disposal, reduced worker dose, and improved detection and monitoring of groundwater. Specific efforts will include the following:

- Develop the technical basis for regulatory changes to low-level waste classification criteria.
- Evaluate dose mitigation opportunities for Alloy 600 inspections and other high-dose emergent tasks.
- Implement EPRI groundwater protection guidelines and technologies. Provide site-specific implementation support for source-term reduction technical guidance being developed by the program.

Estimated 2010 Program Funding

$4.5 million

Program Manager

Sean Bushart, 650-855-2978, sbushart@epri.com

Summary of Projects

Project Number	Project Title	Description
P41.09.01.01	LLW Disposal Technology R&D Program	The Low Level Waste Disposal Technology R&D Program focus is to reduce the generation of Class B/C LLW requiring on-site storage, provide clear and concise industry guidance for the safe and regulatory compliant on-site storage of LLW, and where appropriate, provide technical justifications for changes to existing disposal regulations to expand the disposal options available to LLW generators.
P41.09.01.02	Advanced Techniques for LLW Management R&D Program	The Barnwell disposal site closure motivates utilities to minimize Class B and C waste. Very low concentration limits for specific nuclides often determine whether an entire waste volume exceeds the limit. In order to minimize Class B/C wastes, nuclide-specific removal technologies should be explored. This project proposes to evaluate three of these technologies.
P41.09.01.03	Supplemental Low Level Waste Program	The Low Level Waste Supplemental Program is comprised of a number of assessment activities designed to help plant personnel fully benefit from base research program results. The LLW Supplemental Program conducts plant assessments to provide expert support for implementation of EPRI guidance, tools, and technologies and to capture lessons learned that can be shared across the industry.
P41.09.01.03a	Media Evaluation/Water Characterization	Advanced analytical support, such as chemical characterization or media testing, allows the development of new and existing liquid treatment process optimization studies. Support currently available through this program includes advanced media testing with the EPRI Multi-Bed Test Unit (MBTU) and nuclide species chemical characterization.
P41.09.01.03b	On-Site Storage Assessment	To aid utilities in preparing for on-site storage of Class B/C LLW, EPRI can assess the readiness of nuclear plant on-site storage facilities and programs in comparison to EPRI and regulatory guidance. These assessments also can help utilities evaluate the application of Class B/C reduction strategies.
P41.09.01.03c	BC Reduction Assessment	EPRI has developed this assessment to aid members with assessing their application of Class B/C LLW reduction strategies in comparison to EPRI guidance and to assist members with reducing the personnel exposure associated with handling this waste stream.
P41.09.01.03d	Low Level Waste Assessment	This project consists of a detailed analysis of a nuclear site's solid or liquid LLW management program. The main objective is to optimize program performance while reducing costs.
P41.09.01.03e	LLW Technical Strategy Group	The project is a collaborative effort by the utility membership to manage the family of Waste Logic software codes and provide strategic direction for the management of LLW issues. Membership also provides utilities with direct access to on-site consulting time.
P41.09.01.04	Radiation Protection R&D Program	Dose reduction for cumulative and individual exposure tasks will be accomplished by developing a systematic method for evaluating the tasks and determining the optimum strategy for technology evaluation.
P41.09.01.05	Development of Radiation Control Techniques R&D Program	This program is a multi-year effort to collect all available radiation, chemistry, materials, and fuels data for both PWR and BWR plants and use this information to assess the benefits or disadvantages of technologies and operations strategies that affect ex-core dose rates.

Project Number	Project Title	Description
P41.09.01.06	Supplemental Radiation Management Program	The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel fully benefit from research program results. The program conducts plant assessments to provide expert support for implementation of EPRI guidance, tools and technologies, and to capture lessons learned that can be shared across the industry.
P41.09.01.06a	Scaffold Assessment: Scaffolding Management Program for Dose Reduction	The project consists of an on-site review of the plant's vertical access management program. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed.
P41.09.01.06b	ALARA Assessment: Direct Support of Radiation Protection Operations	This project provides an independent on-site assessment of the station's ALARA program. The comprehensive review performed under this program provides members with added assurance that ALARA issues are addressed prior to regulatory and industry assessments. Members implement assessment recommendations to reduce radioactivity source term and improve ALARA work planning.
P41.09.01.06c	Remote Monitoring Assessment	The project consists of a review of the RMT program practices and compares it to EPRI and industry best practices. Funding stations also will have access to the RMT User Group.
P41.09.01.06d	Radiation Source Term Assessment	To meet the NEI/EPRI/INPO RP 2020 objective of reducing radiation field source terms, this project offers a unit-specific assessment of the radiation field source term. Radiation field reduction is accomplished through an assessment of the plant materials, normal operations chemistry, core design, shutdown chemistry, and plant operations. Differences in PWR and BWR plants will be accounted for in the individual sites.
P41.09.01.06e	Exposure Reduction Assistance	The project combines on-site assessment of multiple station programs that affect site dose with facilitated benchmarking to produce short-term and long-term action plans for dramatically reducing station dose.
P41.09.01.06f	ALARA Users Group	The ALARA User Group provides an interactive forum for capturing, evaluating, and disseminating industry ALARA Program experience and technologies.
P41.09.01.06g	Large Component Replacement Exposure Management	In this project, EPRI will evaluate technologies that have been used for large component replacements and that have had beneficial impacts on cumulative exposure reduction.
P41.09.01.06h	Radiation Field Control Reduction in Carbon Steel Piping	Carbon steel piping is prone to activity pickup when in communication with the reactor coolant. This project will investigate the mechanisms of activity uptake in carbon steel piping and review methods for surface pretreatment. This project also will evaluate the impacts of hydrogen cycling on boiling water reactor (BWR) activity uptake.
P41.09.01.07	Groundwater Protection R&D Program	This project will evaluate and develop advanced technologies and methodologies for groundwater protection, monitoring, and remediation at nuclear power plants.
P41.09.01.08	Groundwater Supplemental Program	This project provides site-specific guidance and technical solutions for the implementation of groundwater protection programs and tritium management strategies developed through the EPRI Groundwater Protection Program.

Project Number	Project Title	Description
P41.09.01.08a	Groundwater Assessment	This project provides on-site and site-specific technical assessment and support for developing and implementing comprehensive groundwater monitoring and remediation programs at nuclear power plant sites.
P41.09.01.08b	Site Tritium/Water Management	The EPRI In-Plant Tritium and Water Management Model is an Excel-based tool that tracks tritium in plant systems from generation in the reactor coolant to transfer and storage in various plant systems and release.
P41.09.01.08c	Groundwater Monitoring and Remediation Technology Pilot Tests	EPRI expert on-site, site-specific technical support and assessment for the pilot test, evaluation, and deployment of advanced technologies for groundwater monitoring and remediation at nuclear power plant sites.

LLW Disposal Technology R&D Program (061432)

Key Research Question

Ninety percent of the U.S. industry lost access to Class B/C Low-Level Waste (LLW) disposal in June, 2008. The Electric Power Research Institute (EPRI) has developed a three-part strategy to address this issue: 1) Minimize the generation of Class B and C waste, 2) provide industry guidance for on-site storage of waste, and 3) examine alternatives to existing disposal regulations. The program will provide immediate benefits as well as support a long-term strategy based on regulatory action.

Approach

In 2007, EPRI published the *Waste Class B/C Reduction Guide* (1015115) to assist plant personnel with identifying methods to reduce the generation of Waste Class B and C LLW. In 2008 and 2009, EPRI issued the *Guidelines for Operating an Interim On-Site Low Level Radioactive Waste Storage Facility, Revision 1* (1018644) and the *Low Level Waste On Site Storage Operating Guideline - Supplemental Information Manual* (1018651) to aid plant personnel with the implementation of on-site LLW storage. In addition, EPRI published the *Proposed Modification to the NRC Branch Technical Position on Concentration Averaging and Encapsulation (BTP), Technical Basis and Consequence Analysis* (1016761) to provide the technical basis for proposed modifications to the BTP that the Nuclear Regulatory Commission (NRC) is currently considering. The proposed modifications would allow broader blending of compatible waste types and evaluate classification alternatives that could be adopted to permit greater flexibility in the classification of low-level waste, but would not violate the performance objectives of 10CFR61.

In 2010, EPRI will focus resources on examining alternatives to existing disposal regulations and to minimize the accumulation of B and C wastes on-site. EPRI will evaluate the use of 10CFR61.58 to allow for an alternative disposal criterion based on site-specific hydro-geological characteristics and end land use scenarios. The model evaluation will be conducted to determine the feasibility of an alternative disposal model and its impact on plant operating procedures. The model evaluation will be based on a conceptual design or reference facility to determine maximum average concentrations for performance limiting radionuclides, to determine protection level based on current stream profiles, and to identify and evaluate appropriate intruder scenarios. Impacts of regulatory changes as they relate to public health risk, collateral impacts, implementation challenges, and industry costs/benefits will be considered. In addition, EPRI will continue to provide technical support as the NRC considers proposed changes to the BTP and will investigate media management strategies and guidance for on-site storage of LLW.

Impact

- Reduced generation of Class B/C LLW requiring on-site storage.
- Avoided potential new rule making regarding on-site storage of LLW.
  - The *On-Site Storage Guidelines* were reviewed and endorsed by the NRC as "providing an acceptable method for recordkeeping, determining waste forms and waste containers and monitoring and inspecting the interim long-term storage of LLRW". This effort provides concise guidance to plant operators on how to operate their interim storage facilities in compliance with regulatory expectations.
- Provided technical basis for modification of the BTP to allow broader blending of compatible waste. If adopted, these changes will favorably increase the volume of waste that is classified as Class A and reduce the amount that is Class B or C.
- Expanded disposal options for the nuclear industry through more clearly established protection requirements.
- (Future) Provide technical justification for regulatory relief to the concentration limits defined in 10CFR61 based on existing knowledge of performance assessment technology and realistic dose-pathways of existing disposal facilities. For classification controlling nuclides (C-14 and Ni-63), this could have up to a factor of an 800 increase in the concentration limits for Class A disposal.

How to Apply Results

Program results are used by radwaste managers in developing strategies for minimizing the generation of Class B/C waste. Members also can apply technical guidance to ensure compliance with regulatory concerns regarding interim waste storage. Long-term research results will provide regulatory relief of current waste classification and disposal limitations.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
10CFR61.58 Alternative Disposal Criteria Model: Model evaluation of the use of 10CFR61.58 to allow for an alternative disposal criterion based on site-specific hydro-geological characteristics and end land use scenarios.	12/21/10	Technical Report
LLW On Site Storage Operating Guideline, Revision 2: Update to the *On Site Storage Operating Guideline* to include expanded guidance for outside storage and relevant industry experience with interim storage and waste forms.	12/21/10	Technical Report

Advanced Techniques for LLW Management R&D Program (061433)

Key Research Question

The recent closure of Barnwell has motivated the need to minimize Class B and C waste. Specialized media and other operations continue to be a developing field, as the need to reduce Class B and C waste has led to the cost-effective development of nuclide-specific separation methods. For example, there are three potential candidates for Cs-137 removal including the Electric Power Research Institute (EPRI) MagMolecules technology. The EPRI MagMolecules process bench-scale development, funded under the technology innovation program, is scheduled to be completed in 2009 and will be ready for scale-up testing under realistic plant conditions for comparison with other selective and traditional media. The 2010 work will continue investigation and development of these technologies.

Approach

This project will evaluate the use of nuclide-specific media by treating plant-generated liquid radioactive waste in a series of test columns. The tests will look to evaluate the absolute removal with varying chemistry conditions, as well as a relative removal efficiency as compared to other media types.

Impact

- Reduced solid B/C radioactive waste generation.
- Application of vendor and utility resources to investigate first-of-a-kind technologies at lower overall costs.
- Availability of an advanced liquid radwaste treatment technology that is new to the industry.

How to Apply Results

Members will have a report describing the efficacy of nuclide-specific removal technologies, including plant demonstration experience with actual plant waste.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Summary of EPRI Advanced Liquid Radioactive Waste Technology Demonstrations: This report would summarize development and evaluation status of the Electric Power Research Institute (EPRI) liquid radioactive waste processing technologies and provide commentary about the recommended implementation strategy for advanced technology demonstrations.	12/31/10	Technical Report

Supplemental Low Level Waste Program (052332)

Key Research Question

Nuclear power plants face significant regulatory, economic, environmental, and public perception pressures with respect to low-level waste (LLW) management. The safe processing, handling, and disposing of low-level waste requires a detailed familiarity with both technical and regulatory issues. Electric Power Research Institute's (EPRI's) LLW Base Research Program investigates improvements to nuclear plant operational practices that can reduce risks associated with waste management. The LLW Supplemental Program conducts plant assessments to provide expert support and to capture lessons learned that can be shared across the industry.

Approach

The **Low Level Waste Supplemental Program** is comprised of a number of assessment activities designed to help plant personnel gain the full benefit of base research results. EPRI understands that the implementation of guidance, technologies, and strategies that are produced by the LLW Base Research Program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant."

Most assessment activities provide an on-site evaluation of the application of research results, technology development, industry experience, and industry best practices. The assessment provides expert evaluation of those items that represent the largest potential benefit to the site. It also documents a site-specific review of the application of guidance and research and identifies potential gaps that, if closed, could provide economic, performance, and/or regulatory margin benefits. **LLW assessments, for example, have identified optimization recommendations valued at more than $75 million per year. Operational strategies for reducing volume of Class B/C LLW could save the industry more than $27 million per year when fully implemented.**

Impact

- Optimized LLW management program performance
- Improved regulatory margin through independent evaluation of site implementation of the on-site storage guidelines
- Reduced costs due to reduced generation of Class B and C waste
- Improved effluent program performance
- Cost savings due to reduced media generation
- Cost savings due to reduced dry active waste generation
- Improved program performance through advanced technology applications
- Evaluation of site implementation of guidance documents

How to Apply Results

Members participate with an industry expert during an on-site assessment. The area of focus is determined by the assessment activity selected. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI LLW Program guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report details the strengths and gaps associated with program implementation and prioritizes recommendations and potential benefits. Later, generic results and lessons learned may be compiled in program reports for industry use.

Media Evaluation/Water Characterization (053296)

Key Research Question

The nuclear power industry is continually driving toward minimization of liquid radioactive waste releases. Several stations have achieved annual releases of less than 1 curie (0.027 MBq). For stations to remain competitive while under budget constraints, a greater understanding of both the waste and the system performance is required.

Approach

Advanced analytical support allows the development of new and existing liquid treatment process optimization studies. This program offers two options: advanced media testing with the Electric Power Research Institute (EPRI) Multi-Bed Test Unit (MBTU) and nuclide species chemical characterization:

- Advanced media testing evaluates new media and process flow configurations using a plant’s waste streams. Cost/performance predictions can be made from the results.
- Chemical characterization of waste streams allows plants to determine the insoluble (colloidal) and soluble nuclide composition of the plant’s waste stream during both normal operations and outages.

Impact

Liquid radioactive waste systems need to be optimized for maximum purification of normal operations and outage water. This project allows the radwaste engineer to determine optimum loading strategies without generating large volumes of waste or acquiring personnel dose by experimenting with a full-scale system. Benefits include the following:

- Cost savings through process optimization and reduced media usage
- Ability to achieve effluent goals
- Evaluation of various treatment strategies at minimal cost •
- Lower Class B/C waste generation by directing liquid waste to treatment when mandatory

How to Apply Results

Members have access to two project options:

Option 1: Advanced media testing (EPRI MBTU)

- Review of the current media processing configuration
- Testing of alternative media and/or configurations
- Testing of chemical injection methods
- Two weeks of on-site testing (split between normal operations and outage)
- Final report of results
- Cost-benefit analysis of the recommendation implementation using Waste Logic™ software

Option 2: Nuclide species chemical characterization

- Review of radwaste chemistry data, operations, and process
- Two weeks of on-site testing (split between normal operations and outage)
- Final report of results
- Process optimization recommendations based upon the nuclide species composition

On-Site Storage Assessment (062788)

Key Research Question

As of July 2008, the Barnwell waste disposal facility no longer accepts waste from outside the Atlantic Compact, which includes South Carolina, Connecticut, and New Jersey. As a result, 80% of commercial U.S. nuclear plants must now store Class B/C waste on-site. This challenge requires a multi-faceted response encompassing waste volume minimization, efficient on-site storage program design, and regulatory-informed procedures.

The Electric Power Research Institute (EPRI) has developed a series of reports covering all aspects of on-site storage, including waste minimization techniques, interim on-site storage guidelines, and regulatory compliance to aid utilities in addressing this issue.

Approach

The On-Site Storage Assessment project is designed to help plant personnel fully benefit from base research program results. EPRI understands that the implementation of guidance, technologies, and strategies that are produced by the base low-level waste (LLW) research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

In the assessment, EPRI experts will review the plant's current Class B/C waste management and on-site storage program and compare it to EPRI guidance, regulatory guidance, storage facility condition, and waste minimization and processing options. The collected information will be analyzed to develop a confidential comprehensive report proposing site-specific recommendations such as modified filter resin management practices and optimized mixing/packaging of wastes. The project aim is to identify changes that could be implemented to reduce the volume of Class B/C LLW that is generated, thereby reducing the cost and liability associated with the on-site storage of these waste streams and reducing the long-term costs associated with the eventual disposal of this material.

Impact

EPRI's *On-Site Storage Operating Guidelines* have been reviewed and endorsed by the Nuclear Regulatory Commission (NRC). On-site storage programs that are implemented in accordance with this guidance are expected to be regulatory compliant. This assessment provides an independent third-party review to help utilities self-identify any challenges that may exist and provides recommendations for addressing those challenges. Since most stations have limited experience with actual implementation of on-site storage, this project is designed to increase the utility's confidence that the station's on-site storage programs are regulatory compliant and to identify any areas that may need improvement.

This assessment also provides a review of the station's implementation of Waste Class B/C reduction strategies. Class B/C waste has the highest-cost LLW stream, long-term disposal costs estimated at $4000 to more than $10,000 per cubic foot. In the meantime, with no disposal pathway available, all Class BC LLW must be stored on-site. Implementation of on-site storage recommendations is expected to reduce or eliminate the operational costs and liability associated with on-site storage and to reduce or eliminate the future disposal costs associated with this high-dollar waste stream. Recommendations that result in a 10 cubic foot reduction in the generation of Class B/C low-level waste would more than pay back the cost of the assessment.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI LLW program guidance, technologies, and tools to the plant's advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

BC Reduction Assessment

Key Research Question

Class B/C low-level waste (LLW) continues to be the most expensive, highly active waste that is generated and handled on a routine basis in a commercial nuclear plant. This waste stream can represent a significant challenge in terms of solid waste volumes, program costs, staff resources, and cumulative radiation exposure performance.

Further exacerbating this issue for many stations is the 2008 access restriction to the State of South Carolina Barnwell LLW disposal site, resulting in interim on-site storage of Class B/C wastes. Some stations have opted for, or are evaluating, alternative Class B/C waste disposition options such as off-site volume reduction with transfer of title or processes that modify the waste package activity concentration. While these options may mitigate all or part of the on-site storage challenge for those stations, the options can result in substantial cost increases relative to already high historical values. Additionally, regardless of the option that is chosen, the on-site handling and packaging activities represent a high-dose activity.

Therefore, any improvement to media performance, handling, packaging, and disposition should result in reduced volumes, cost, and related personnel exposure.

Approach

The **BC Reduction Assessment** is designed to help plant personnel fully benefit from base research program results. The Electric Power Research Institute (EPRI) understands that the implementation of guidance, technologies, and strategies that are produced by the base LLW research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

In the assessment, EPRI experts will review the plant's current Class B/C waste management and associated personnel exposure and compare it to EPRI guidance. Operational practices and considerations are taken into account. The collected information will be analyzed to develop a confidential, comprehensive report proposing site-specific recommendations such as modified filter resin management practices and optimized mixing/packaging of wastes. The project aim is to identify changes that could be implemented to reduce the volume of Class B/C LLW that is generated, thereby reducing the cost and liability associated with the final disposition of this material.

Impact

This assessment provides a review of the station's implementation of Waste Class B/C reduction strategies. Class B/C waste is the highest-cost LLW stream, with long-term disposal costs estimated at $4000 to more than $10,000 per cubic foot. Implementation of recommendations from the B/C assessment is expected to reduce or eliminate the operational costs and liability associated with on-site storage and to reduce or eliminate the future disposal costs associated with this high-dollar waste stream. Recommendations that result in a 10 cubic foot reduction in the generation of Class B/C low-level waste would more than pay back the cost of the assessment.

Additionally, because of the high activity of this waste stream, reduced generation of this waste stream and optimization of handling and packaging strategies offer significant opportunities for reductions in personnel exposure. An additional benefit is a reduction in the liabilities associated with conveyance of radioactive materials on public roads.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI LLW Program guidance, technologies, and tools to the plant's advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

Low Level Waste Assessment (049409)

Key Research Question

All commercial nuclear power plants generate both liquid and solid low-level radioactive wastes. Management of these waste streams must consider technical and economic aspects associated with processing, handling, storing, and disposition. Liquid low-level waster (LLW) assessments evaluate the station's processing volumes, effluent quality, and associated media generation to highlight strengths and to identify recommendations to optimize the program performance while reducing costs. Solid LLW assessments focus on the generation, handling, processing, packaging, storage, and disposal of solid LLW. The main objective is to identify practices that minimize the generation of the waste and/or favorably impact the economics associated with its handling, storage, and/or disposal.

Approach

The Low Level Waste Assessment project is designed to help plant personnel fully benefit from base research program results. The Electric Power Research Institute (EPRI) understands that the implementation of guidance, technologies, and strategies that are produced by the base LLW research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

EPRI has developed a comprehensive assessment of LLW management strategies through the evaluation of more than 80 U.S. and international LLW management programs. In this assessment, members participate with an industry expert during a five-day on-site evaluation of the plant's current solid or liquid LLW

management program. The information is analyzed off-site and used to develop a comprehensive report that identifies station strengths and recommendations for program improvements.

Impact

This program has been highly successful in driving cost savings and LLW generation reductions across the industry. Average annual savings and volume reduction results for dry active waste (DAW) assessments performed since 1993 are $1.3 million and 3074 m^3 per unit for boiling water reactors (BWRs) and $722,000 and 1739 m^3 for pressurized water reactors (PWRs). Significant cost savings and volume reduction also are being achieved for plants performing second (continuous improvement) LLW assessments. Recent corporate-wide assessments have identified and documented more than $1 million in cost savings for a three-site corporate group.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI LLW program guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

LLW Technical Strategy Group (004514)

Key Research Question

The industry recognizes the high cost and complexity of radioactive waste processing, storage, and disposal. In response to these concerns, the Electric Power Research Institute (EPRI) developed a family of codes called Waste Logic™ to optimize low-level waste (LLW) management. The Waste Logic User Group (WLUG) and LLW Technical Strategy Group (TSG) supports this family of codes through code performance feedback, updates, detailed training, and consulting.

Approach

The Technical Strategy Group provides a forum for advising on technical issues regarding the strategic management of LLW. Members of the WLUG receive annual on-site expert technical consulting as part of their membership. This consulting time is typically used for continuous improvement of LLW program management strategies and for analysis of special projects. Periodic conference calls are used to keep membership apprised of emerging issues and to solicit input on addressing these same issues. On-site consultation topics are scheduled with individual members.

Impact

Participation in the Waste Logic User Group provides expert support to utilities in loading their data in the Waste Logic codes, maintaining the software, and evaluating new or special projects.

On-site consulting time is provided through on-site installation sessions at each utility site. This session gives members the opportunity to have their site-specific data entered into the code by experts, saving members significantly more money than they spend on their user-group membership fee.

TSG members also may apply their dues to support specific plant or corporate project requests. Fleet strategies for LLW management are frequently evaluated with this support.

How to Apply Results

On-site consultation time is used to ensure EPRI guidance is applied to addressing emerging and critical plant-specific LLW management issues.

Radiation Protection R&D Program (061424)

Key Research Question

The Electric Power Research Institute (EPRI), the Nuclear Energy Institute (NEI), and the Institute of Nuclear Power Operations (INPO) have collaboratively developed the RP2020 initiative with the stated goal of making radiation exposure a non-issue in nuclear power plants by the year 2020. EPRI has been tasked with seeking existing or new radiation protection technologies to reduce the cumulative exposure associated with high-dose tasks.

Approach

A five-step approach is planned: 1) survey the industry to determine which jobs have the highest cumulative and individual exposures, 2) reach out to other EPRI programs and vendors to identify the detailed tasks associated with the high-dose jobs, 3) organize the jobs and rank them for feasibility to reduce dose through technology implementation, 4) identify technologies that can be useful for reducing the time, distance, or shielding requirements for each of the high-dose tasks, and 5) identify and implement the technologies at host utilities.

Impact

The industry has been challenged to meet the INPO 5-year dose goals because of necessary material inspections and mitigation strategies. There is a wide range in the as-low-as-reasonably-achievable (ALARA) performance of these actions based on the early planning and implementation of ALARA strategies. Early involvement with these tasks can significantly reduce cumulative and individual exposures.

How to Apply Results

The results of the proposed method to prioritize tasks and implement individual plant demonstrations will provide members with resources such as technology identification, engineering qualifications of the technologies, and implementation lessons-learned.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Selection of Radiation Protection Technologies for High Dose Reduction: This project will implement the first two phases of the radiation protection technologies program. The industry will be surveyed for high individual and cumulative dose tasks, and the tasks will be prioritized according to dose impact and feasibility for dose reduction through implementation of technologies. Early task and technology suggestions will be presented.	12/31/10	Technical Report

Development of Radiation Control Techniques R&D Program (052350)

Key Research Question

In 2003, in response to a negative trend in cumulative exposure at nuclear power plants, the Electric Power Research Institute (EPRI), the Nuclear Energy Institute (NEI), and the Institute of Nuclear Power Operations (INPO) collaboratively developed the RP2020 Initiative. The Initiative's main goal is to promote radiation protection fundamentals, leading to reduced dose and essentially "taking radiation off the table" as an industry metric. Radiation exposure analysis and new radiation control techniques are needed to identify and mitigate the causes underlying the negative trend.

Approach

The EPRI Source Term Reduction Program is a multi-year project developed to investigate the causes for differences observed in boiling water reactor (BWR) and pressurized water reactor (PWR) shutdown dose rates and crud burst peaks and recommend strategies for reducing radiation source term. The 2010 project plan focuses on two areas: revision of the Cobalt *Reduction Guidelines* and recommendations for source-term reduction based on the results of plant benchmarking and technology analysis from the PWR Chemistry Monitoring and Assessment Database, Steam Generator Degradation Database, Fuel Reliability Database, and Standard Radiation Monitoring Program. Recommendations will address procedures to minimize ex-core contamination and sequences for technology implementation to reduce source-term generation over the life of the plant.

Impact

- Reduce/manage crud burst peaks
- Lower radiation fields
- Improve fuel performance (less crud on fuel leads to fewer failures)
- Reduce low-level waste generation

How to Apply Results

BWR members will use the cobalt quantification results to identify potential cobalt sources and implement the lessons learned from newly developed shutdown activity quantification results. Plant data benchmarking will be applied to understand the impacts of in-core vessel components. PWR members will be able to identify their plants according to the recommended grouping and implement recommendations to minimize radiation fields and reduce activity generation.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Cobalt Reduction Guidelines: Revision of the *Cobalt Reduction Guidelines*, an industry catalog of various elemental cobalt sources in boiling water reactor (BWR) and pressurized water reactor (PWR) plants.	12/31/10	Technical Report

Supplemental Radiation Management Program (052353)

Key Research Question

Nuclear power plants face significant regulatory, economic, environmental, and public perception pressures with respect to personnel exposure to radiation. As regulatory limits and industry goals associated with personnel exposure to radiation become more challenging, greater effort is needed to develop and demonstrate effective radiation protection and source-term reduction. Electric Power Research Institute's (EPRI's) Radiation Management (RM) Base Research Program investigates improvements to nuclear plant operational practices that can improve performance associated with management of radiation exposure.

Approach

The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel gain the full benefit of the base research program results. EPRI understands that the implementation of guidance, technologies, and strategies that are produced by the base RM research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant."

The RM Supplemental Program conducts plant assessments to provide expert support and to capture lessons learned that can be shared across the industry. Most assessment activities provide an on-site evaluation of the application of research results, technology development, industry experience, and industry best practices. The assessment provides expert evaluation of those items that represent the largest potential benefit to the site. It also documents a site-specific review of the application of guidance and research and identifies potential gaps that, if closed, could provide economic, performance, and/or regulatory margin benefits.

Impact

- Reduced personnel exposure
- Reduced radiation fields
- In-depth assessment of source term with benchmark relative to industry
- Reduced source term
- Reduced outage dose, duration, and costs
- Enhanced technologies for remote monitoring of personnel
- Improved integrated station goals and focus

How to Apply Results

Members participate with an industry expert during an on-site assessment. The area of focus is determined by the assessment activity selected. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI RM Program guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

Scaffold Assessment: Scaffolding Management Program for Dose Reduction (057063)

Key Research Question

Aggressive industry goals to minimize station dose are challenging to meet in the life extension environment. Industry data continue to identify the management of vertical access programs as a consistent significant contributor to high personnel exposure at a majority of plants. In 2004, the Electric Power Research Institute (EPRI) published an industry best practices and guidance document, *Scaffolding Program Management for Dose Reduction*. EPRI has used this document to develop a comprehensive assessment of scaffolding program management strategies.

Approach

The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel gain the full benefit of the base research program results. EPRI understands that the implementation of guidance, technologies, and strategies that are produced by the base RM research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development R&D program products and reports.

In this assessment, members participate with an industry expert during a four-day, on-site, independent review of the plant’s current vertical access program. The site-specific data are analyzed off-site and used to define current program performance, identify opportunities for improvement, and to benchmark the station’s performance relative to similar stations. The methodology focuses on "practical" elements and includes an assessment of the integration and effectiveness of the overall organization.

Impact

Successful implementation of an effective scaffolding management program can have significant impact on the station's dose performance, which in turn can impact Institute of Nuclear Power Operations (INPO) Plant Evaluations and Nuclear Regulatory Commission (NRC) inspection results.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply EPRI guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

ALARA Assessment: Direct Support of Radiation Protection Operations (053248)

Key Research Question

Nuclear power plants face significant regulatory, economic, environmental, and public perception pressures with respect to personnel exposure to radiation. As regulatory limits and industry goals associated with personnel exposure to radiation become more challenging, the importance of an effective nuclear plant as-low-as-reasonably-achievable (ALARA) program becomes even more important.

Approach

Electric Power Research Institute's (EPRI's) Radiation Management (RM) Research Program investigates improvements to nuclear plant operational practices that can improve performance associated with management of radiation exposure. The ALARA Assessment helps a nuclear plant evaluate the effectiveness of its program and identify recommendations for program improvements that can lead to lower station dose. Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

EPRI has developed an assessment approach that provides a comprehensive review of a plant's current ALARA program in a consistent and meaningful manner. During the five-day on-site assessment, a two-person team works closely with key plant staff to assess the application of ALARA in the daily activities of the plant. The information is analyzed off site and used to develop a comprehensive report that summarizes the program's strengths and status using EPRI and industry exposure management databases. The approach uses a series of established "filters" to identify relevant criteria from various sources, including EPRI technology, information system of occupational exposure (ISOE) databases, and industry "good practices." To date, the EPRI methodology has been used to evaluate the ALARA programs at 16 sites.

Impact

- Assess ALARA application during daily plant activities
- Summarize the status of the ALARA program and benchmark its effectiveness against the EPRI ALARA database
- Identify strengths of the plant's ALARA program
- Identify and prioritize potential improvements to the plant's ALARA program

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply guidance, technologies, and tools to the plant's best advantage. The comprehensive review performed under this program provides members with added assurance that ALARA issues are addressed prior to regulatory and industry

assessments. Members implement assessment recommendations to reduce radioactivity source term and improve ALARA work planning.

After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

Remote Monitoring Assessment (057040)

Key Research Question

As stations seek to upgrade their existing remote monitoring capability, many will have to assess their existing hardware, software, and data transmission needs. This assessment will form the basis for near-term and long-range expansion for this technology in terms of hardware, software, and transmission capability requirements. The programmatic implementation of remote monitoring technology (RMT) also is crucial to its successful use at the station.

Approach

The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel fully benefit from base research program results. The Electric Power Research Institute (EPRI) understands that the implementation of guidance, technologies, and strategies that are produced by the base RM research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

EPRI has published industry guidelines on the field implementation of remote monitoring. These guidelines can be used as a standard with which to assess a station’s RMT program. Each funder of this program will work with the EPRI project manager to determine the specific focus of the assessment. In general, a site visit will be performed by two industry experts to evaluate and determine or define the plant needs for RMT based on goals established by the plant or corporate program.

Impact

Implementation of remote monitoring technologies provides the station with improved personnel monitoring while reducing the associated dose to radiation protection technicians. The project aids the implementation process by providing station personnel state-of-the-art feedback, industry best practices, and lessons learned associated with the planning process. Remote monitoring often provides benefits beyond the immediate benefit to the radiation protection department, including positive impacts on outage control and monitoring of field work.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

Radiation Source Term Assessment (066341)

Key Research Question

To meet the Electric Power Research Institute (EPRI)/Nuclear Energy Institute (NEI)/Institute of Nuclear Power Operations (INPO) Radiation Protection 2020 objective of reducing radiation fields and collective dose, nuclear plants are considering a variety of options targeting source-term reduction. This project offers a unit-specific assessment of the radiation field source term through an assessment of the plant materials, normal operations chemistry, core design, shutdown chemistry, and plant operations. Differences in pressurized water reactor (PWR) and boiling water reactor (BWR) plants will be accounted for in the individual sites.

Approach

- This project entails a three-day site visit to evaluate a plant's source-term reduction potential by performing the following tasks:
- Evaluate the material and operational status of each unit and, when possible, benchmark their performance to units of similar design.
- Evaluate the normal operations chemistry program for source-term quantification.
- Review the radiation monitoring strategy and provide program suggestions.
- Review the radiation monitoring program for effectiveness in historical trending of system piping.
- Review plant chemistry controls related to shutdown, operational, and startup chemistry to achieve reduction in personnel exposure, possible improvement opportunities with chemistry, and potential improvement in costs.
- Review the plant’s strategic water chemistry plan to improve the station’s chemistry and dose goals.

Impact

The Radiation Protection (RP) 2020 Initiative seeks to reduce cumulative radiation exposure by reducing radiation source term throughout the plant. The Radiation Source Term Assessment will provide the plant with recommendations to reduce radiation fields as quickly and economically as possible.

How to Apply Results

The plant will receive a report that identifies the source-term reduction status of the plant with respect to the rest of the industry and provides recommendations for an optimum path toward radiation field reduction.

Exposure Reduction Assistance (068278)

Key Research Question

Aggressive industry goals to minimize station dose are difficult to meet in the aging plant environment. Developing an effective station management strategy that integrates the optimal exposure reduction attributes from multiple programs to reduce station dose is challenging. Finally, competing goals and priorities, resource limitations, and staff turnover increase this challenge. The Electric Power Research Institute (EPRI) has the data, experience, and knowledge to accurately assess the collective impact that individual aspects of related plant programs have on station dose.

Approach

The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel gain the full benefit of the base research program results. EPRI understands that the implementation of guidance, technologies, and strategies that are produced by the base Radiation Management (RM) research program can be done more quickly and effectively with on-site and site-specific assistance. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

This project consists of a comprehensive multi-phase assessment of a plant's As Low as Reasonably Achievable (ALARA), Chemistry, Source Term, Fuels, and System or Plant Decontamination Programs. The assessment is performed in three phases. During the on-site assessment phase, the plant's ALARA, Chemistry, Source Term, Fuels, and System or Plant Decontamination Programs are evaluated to identify program strengths and challenges and to gauge the effectiveness of individual programs. The benchmarking phase is coordinated by EPRI experts through selection and preparation of host facilities, assistance with data queries, collection, results analysis, and identification of the lessons learned most applicable to the station. The Action Plan Development Phase uses the results of the Assessment and Benchmarking Phases to assist the plant with development of an integrated action plan that outlines short- and long-term actions, technical justifications, and expected benefits.

Impact

This program uses EPRI's proven expertise and industry insight to assist plants with developing an aligned strategic approach for improving station dose. The program also provides a unique opportunity for ensuing exposure performance success and can impact INPO evaluations, Nuclear Regulatory Commission (NRC) inspections, and American Nuclear Insurers (ANI) liability premiums.

How to Apply Results

Members participate with an industry expert during the on-site assessment. The process helps plant personnel gain insights about their plant-specific performance and how to apply guidance, technologies, and tools to the plant's best advantage. After the assessment, a confidential site-specific report that details the strengths and gaps associated with the program implementation is developed. Prioritized recommendations and potential benefits are highlighted. Later, generic results and lessons learned may be compiled in program reports for industry use.

ALARA Users Group (044401)

Key Research Question

The industry's annual collective radiation exposure continues to trend down with few exceptions. Cumulative exposure and exposure estimating are used by the Nuclear Regulatory Commission (NRC) and other industry organizations to assess the health of radiation protection programs. Aggressive industry goals to further minimize station dose are challenging to meet in the life extension environment, yet utilities are obligated to minimize the impact of ionizing radiation on plant personnel.

Approach

The Radiation Management Supplemental Program is comprised of a number of assessment activities designed to help plant personnel fully benefit from base research program results. The Electric Power Research Institute (EPRI) understands that the implementation of guidance, technologies, and strategies that are produced by the base Radiation Management (RM) research program can be done more quickly and effectively with assistance. The ALARA User Group is designed to enhance the technology transfer between EPRI and member utilities. The supplemental offerings are designed to help the plants "take the research off the shelf and put it into the plant." Generic results and lessons learned will be used in base research and development (R&D) program products and reports.

The ALARA User Group provides an interactive forum to assist members with realizing the maximum benefit from EPRI ALARA technology, industry lessons learned, and emerging issues. The User Group focuses on best practices, advanced technologies, the most efficient implementation options, and cost-effective sustainable ALARA program success.

Impact

Plants that have implemented relevant EPRI technology in the ALARA area have realized significant benefits in personnel exposure control. EPRI's radiation field control technologies provide a menu of techniques to reduce out-of-core shutdown radiation fields, and continuing development of worker risk minimization techniques target increased worker productivity. The ALARA User Group provides an important opportunity for ensuing exposure performance success that, in turn, can impact INPO evaluations, NRC inspections, and ANI liability premiums.

How to Apply Results

Members sponsor annual meetings and workshops that address key ALARA issues and have access to ALARA User Group industry experience databases and reports. The goals of the ALRA User Group are to provide a forum to address technical ALARA issues and to provide assistance with implementing worker risk-minimization techniques.

Large Component Replacement Exposure Management (061031)

Key Research Question

Utilities are obligated by law to minimize the impact of ionizing radiation on plant personnel and the general public. Large component replacements add to the cumulative exposure for the plant outage, and with each new experience, industry feedback can assist in reducing the dose associated with the work.

Approach

The 2010 occupational dose goals established by the Institute of Nuclear Power Operations for boiling water reactors (BWR) and pressurized water reactors (PWR) have elevated interest in detailed as-low-as-reasonably-achievable (ALARA) planning. Several innovative technologies have been developed that could be useful to reduce radiation exposure or radiation fields. In this project, the Electric Power Research Institute (EPRI) will evaluate technologies that have been used for large component replacements and that have had beneficial impacts on cumulative exposure reduction.

Impact

The project is flexible in design and can be customized by the funders. Actual reports produced will be determined by the total amount of supplemental funding received. Project funders will be able to provide input into the project topics. Potential topics include the following:

- **Steam generator replacement experiences:** A report on steam generator (SG) replacement innovations including dose saved per SG, duration, and the observed effects of source-term mitigation treatment (for example, electropolishing of the SG channel head bowl).
- **Reactor pressure vessel head replacement:** Previous EPRI reports have documented dose experiences with reactor pressure vessel (RPV) head replacements. Techniques implemented for recent RPV head replacements will be studied.
- **BWR steam dryer replacements:** Some domestic and international BWR plants have replaced steam dryers, and several novel methods for handling, storing, and segmenting the large component have been developed.

How to Apply Results

Technical reports issued through this project will

- identify potential technologies to minimize the dose impacts of large component replacements,
- state the radiation exposure benefits of technologies or innovations, and
- document procedures or technologies for these projects.

Radiation Field Control Reduction in Carbon Steel Piping

Key Research Question

Boiling water reactor (BWR) reactor water cleanup (RWCU) systems often have carbon steel piping between the reactor vessel and the cleanup system, and CANada Deuterium Uranium (CANDU) feeder tubes also use carbon steel. There have been several reports from BWR utilities that the carbon steel piping has incorporated a substantial amount of radioactivity, which has resulted in high dose rates, as has been observed in the CANDU plants. The RWCU system and feeder tubes often require maintenance, and the high-radiation fields cause significant personnel dose.

Approach

This project will investigate the activity incorporation of cobalt-60 and other nuclides into carbon steel, study the impact of hydrogen cycling on activity uptake, and review options for surface pretreatment or other methods to reduce radiation fields. Specific tasks include the following:

- Survey BWR and CANDU plants for carbon steel piping that is in communication with the reactor coolant and poses significant as-low-as-reasonably-achievable (ALARA) impact.
- Perform a literature review of methods to reduce corrosion (and activity pickup) of carbon steel.
- Develop an experimental plan for investigating activity pickup in carbon steel, and test the pretreatment methods and hydrogen cycling for impact on activity pickup.
- Seek candidate plants to perform recommended loop tests.

Impact

The RP 2020 Initiative seeks to reduce cumulative radiation exposure by reducing radiation source term in areas where frequent maintenance is required. This project seeks to reduce radiation fields in the RWCU system and other areas where carbon steel piping is used. If a suitable method for treating carbon steel is found, the research also may impact pressurized water reactor (PWR) systems that have carbon steel piping.

How to Apply Results

- A technical update with an experimental plan for investigating carbon steel activity uptake.
- A technical report with the results of the proposed loop tests.

Groundwater Protection R&D Program (068229)

Key Research Question

Leaks and spills from nuclear power plant operations have the potential to impact site groundwater throughout the life of the plant. Experiences at decommissioning and operating nuclear power plants show that although there is little to no public risk from the leaks, the fact that they represent unplanned discharges has resulted in damage to the industry's credibility with the public. In 2007 the U.S. nuclear industry committed to a the Groundwater Protection Initiative [NEI 07-07] to implement groundwater monitoring programs at all nuclear power plant sites.

Decommissioning plants have spent millions of dollars in the characterization and mitigation of contaminants (for example, tritium) from groundwater and soils due to minor leaks from spent-fuel pools, transfer lines, and liquid storage tanks. Operating plants have experienced similar leaks. These experiences have required significant amounts of time and resources to investigate the extent and magnitude of groundwater contamination to assure that the public health and safety was being maintained. As utilities are implementing groundwater protection programs at their sites they are encountering new challenges and lessons learned related to groundwater contamination.

Regulations and policies related to groundwater protection are being developed by the NRC for operating, decommissioning, and new nuclear power plants. 10CFR20.1406 "Minimization of Contamination" makes groundwater protection mandatory for newly licensed nuclear power plants. Upcoming decommissioning rulemaking stipulates minimization of groundwater contamination and remediation of contamination during operation as key cost savings and environmental protection actions for decommissioning.

Approach

EPRI's Groundwater Protection Project provides members with advanced strategies and technologies for improved management of situations involving radiologically contaminated groundwater. This project develops technical guidance for implementing site-specific groundwater monitoring programs geared toward mitigation, early detection, and remediation of groundwater contamination. Implementing these programs will enhance site knowledge and increase confidence and accuracy in communications with stakeholders.

Advanced and cost-effective technologies for the early detection, monitoring, and remediation of groundwater contamination will be developed and demonstrated for the nuclear industry. Methods and technologies for evaluating and preventing the failure of systems, structures, and components containing radioactive liquids will be explored for proactive action against groundwater contamination. EPRI also collaborates with and technically supports the NEI and NRC in developing policies related to groundwater protection.

Impact

By taking proactive action against groundwater contamination, utilities will be able to allay stakeholder concerns about environmental protection. By implementing site-specific groundwater protection programs and the best technologies available for groundwater protection at nuclear power plants, utilities will be able to optimize costs and reduce waste due to groundwater monitoring and remediation:

- Improve relationship with communities, government, and the regulatory agency about the industry’s commitment to public radiation safety and environment protection
- Cost savings at the decommissioning stage due to preemptive action during the operating stage
- Cost savings due to advanced and efficient monitoring and remediation technologies
- Cost savings due to prevention of radioactive liquid leakage to the environment

How to Apply Results

Members can implement site-specific groundwater protection programs using the guidance provided in the EPRI Groundwater Protection Guidelines (1015118.) Members can apply the technologies that are developed and demonstrated by EPRI at their plant sites. EPRI provides site specific technical support to utilities for applying both the Guidelines and advanced technologies through the EPRI Groundwater Characterization and Protection Assistance Program. Members can interact with fellow groundwater protection colleagues and share lessons learned, experiences, good practices, and technologies at the annual EPRI Groundwater Protection Workshop.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Review of EPRI Groundwater Protection Guidelines: The EPRI Groundwater Protection Guidelines is a living document that is updated and revised as new technologies, best practices, and lessons are developed. In 2009, two years from the original publication date of 2007, EPRI and the Guidelines Committee will review the Guidelines and industry experiences and technologies. In 2010 the results of this review and the decision to revise the Guidelines will be published.	09/30/10	Technical Update

Product Title & Description	Planned Completion Date	Product Type
MANAGES for Nuclear Power Plants: MANAGES is an EPRI Environment Group software for management of groundwater and soil monitoring data. The EPRI Nuclear Groundwater Protection Program will collaborate with the EPRI Environment Group to develop radionuclide data management capabilities to MANAGES.	12/31/10	Software

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
EPRI Groundwater Protection Guidelines for Nuclear Power Plants, Rev. 1: If required based on the 2009-2010 review of the Rev. 0 of the EPRI Groundwater Protection Guidelines, the Guidelines will be revised to reflect current industry best practices, lessons learned, and advanced technologies. A special emphasis on systems, structures, and component (SSC) evaluation will provide utilities with enhanced guidance for evaluating and mitigating leaks and spills from SSCs.	06/30/11	Technical Report
Technology Demonstration Experience Reports: EPRI will support and facilitate the demonstration of groundwater monitoring and remediation technologies at nuclear power plant sites. The results of these demonstration projects will be documented in EPRI Technical Updates.	12/31/11	Technical Update
Remedial Option Analysis Module (ROAM) for Nuclear Power Plants: The Remedial Option Analysis Module (ROAM) is an EPRI Environment Group software tool for modeling groundwater remediation options. The Groundwater Protection Program will collaborate with the Environment Group to develop radionuclide modeling capabilities for ROAM.	12/31/12	Software

Groundwater Supplemental Program

Key Research Question

Throughout nuclear power plant operation, leaks and spill of radioactive liquids from systems, structures, and components (SSCs) and routine operations can lead to groundwater contamination. Although not a safety or public health concern, such groundwater contamination can incite regulatory and stakeholder concerns about environmental protection and impact plant operation and decommissioning from schedule, waste generation, and cost perspectives.

In 2006 the entire U.S. nuclear industry committed to the NSIAC Groundwater Protection Initiative and set new standards for on-site groundwater monitoring program implementation, proactive groundwater contamination prevention, and timely reporting of groundwater contamination findings.

Groundwater Protection is an issue for new plant design and construction, operation, and decommissioning as well. 10CFR20.1406 "Minimization of Contamination" stipulates that new licensees must take into account the minimization of environmental contamination into the design, construction, and operation of new nuclear power plants. New decommissioning regulations and regulatory guidance under development by the U.S. NRC will require all operating plants to evaluate the impact of any contamination event on decommissioning waste generation, schedule, and cost and take any action necessary during operation to decrease any potential impacts.

Approach

Through the base Groundwater Protection and Decommissioning Technology program, EPRI has developed and maintains a suite of Groundwater Protection Projects, including the *EPRI Groundwater Protection Guidelines for Nuclear Power Plants* (1015118) and Advanced Technologies for Groundwater Protection. The Groundwater Supplemental Program is a suite of site-specific and collaborative research projects that provide members with tailored guidance, solutions, and direct technical support for developing and implementing groundwater protection programs at nuclear power plant sites.

Groundwater protection professionals expert in plant operations, radiological impacts on the environment, groundwater monitoring, and groundwater remediation work directly with plant groundwater protection personnel to provide them with step by step guidance for implementing a groundwater protection program, implementing advanced groundwater protection technologies, and tritium management programs. Generic lessons learned and operating experience from these projects will be fed into the Base program to improve the collective nuclear industry knowledge about groundwater protection and associated technologies.

Impact

The Groundwater Protection Supplemental Program will provide members with the guidance and solutions needed to implement optimized groundwater protection programs tailored to the characteristics of their own plant and sites:

- Cost savings realized from expert implementation of site-specific groundwater protection monitoring programs.
- Optimized groundwater remediation solutions tailored to the needs and objectives of each site and site stakeholders.
- Understanding of plant-specific tritium generation and tritium inventory and development of commensurate effluent management program.
- Evaluation of advanced technologies against site-specific hydrogeological conditions and criteria.

How to Apply Results

Groundwater protection experts will provide confidential site-specific action items, guidance, and recommendations for developing, implementing, and enhancing groundwater protection and tritium management programs at member sites. The groundwater protection manager should work with site management and related groups (e.g. maintenance, engineering, environment, operations, etc.) to evaluate and implement each action item or recommendation.

Groundwater Assessment (062510)

Key Research Question

Throughout nuclear power plant operation, leaks and spill of radioactive liquids from systems, structures, and components (SSCs) and routine operations can lead to groundwater contamination. In 2006 the entire nuclear industry committed to the NSIAC Groundwater Protection Initiative and set new standards for on-site groundwater monitoring program implementation, proactive groundwater contamination prevention, and timely reporting of groundwater contamination findings. EPRI developed a suite of Groundwater Protection Projects, including the *EPRI Groundwater Protection Guidelines for Nuclear Power Plants* (1015118) and Advanced Technologies for Groundwater Protection, to provide technical support to the industry fulfill its commitments to the Initiative.

A comprehensive Groundwater Protection Program involves a complete understanding of a site's hydrogeology, the evaluation of any existing and potential contamination sources (i.e. work practices, systems, structures, and components), mitigation or remediation of any pre-existing contamination, installation of a network of monitoring wells, sampling and analyzing groundwater and soils, and drawing technically sound conclusions based on this monitoring program. A Groundwater Protection Program should

be tailored to the site specific programs of a site; this optimization will ensure that the appropriate level of protection is applied to the site's risk of contamination.

Approach

The EPRI Groundwater Assessment provides member site-specific technical support for implementing a comprehensive and optimized groundwater protection program at a nuclear power plant site based on the *EPRI Groundwater Protection Guidelines*. Two experts visit the site for one week to conduct an initial assessment of the groundwater protection program scenario and status of the host plant site. The EPRI Team will meet with plant personnel engaged in assessing the status and significance of any groundwater contamination and assemble information related to the investigation of groundwater contamination. The team will gather information needed to identify potential groundwater contamination sources and pathways and develop a “preliminary” understanding of the groundwater hydrology and any existing groundwater protection program. Following the site visit, the team will analyze the information and develop a Plant Specific Guidance Report based on the specific objectives of the site.

The assessment can be tailored for any phase of a plant’s groundwater protection plan implementation: new plant development, operating plants without a monitoring program in place, operating plants with a monitoring program in place, and decommissioning plants. All assessments are independent reviews of site groundwater monitoring program based on the *EPRI Groundwater Protection Guidelines for Nuclear Power Plants* (1015118). The Guidelines, developed in collaboration with utility groundwater protection experts, provides a graded approach to implementing groundwater protection programs at nuclear power plant sites.

Impact

Graded and optimized groundwater protection programs tailored to plant and site specific characteristics and objectives can provide the following benefits:

- Environmental protection for the life of the plant.
- Reduced impact on decommissioning site-release process (e.g. cost, waste generation, etc.)
- Comprehensive groundwater protection alleviates public and regulatory concerns related to environmental protection.
- Implementation of operating lessons learned and experiences to new plant construction and operation.
- Cost and other resource (e.g. staff labor) optimization inherent to a tailored program.

How to Apply Results

Each member will receive a site-specific report containing observations and recommendations for their plant groundwater protection program. These recommendations can be applied by plant site groundwater protection teams with the support of plant management and in collaboration with other groups (e.g. engineering, maintenance, chemistry, etc.)

Site Tritium/Water Management (063964)

Key Research Question

Tritium management has become a significant issue for the industry. Although the tritium concentrations in both routine plant effluents and inadvertent leaks or spills are not health or safety concerns, regulators and stakeholders have raised concerns about the general impact of radionuclides in the groundwater and environment. To address this concern, nuclear power plants have implemented several strategies to manage tritium in effluents – chiefly through the U.S. nuclear industry's Groundwater Protection Initiative. Also, of new nuclear power plants are required to implement provisions to minimize environmental contamination. One such provision may be to minimize effluents or design plant systems for 100% recycle of water to facilitate siting and reduce environmental impact. In response to industry concerns, the EPRI Low Level Waste Program developed the In-Plant Tritium and Water Management Model to predict the generation and in-plant distribution of liquid and gaseous tritium throughout normal operations and during shutdown and startup. An

understanding of tritium concentrations in plant systems will allow the nuclear plant operator to develop tritium management strategies to minimize tritium concentrations in plant effluents and to assess the impact of inadvertent leaks or spills on the environment.

Approach

The EPRI In-Plant Tritium and Water Management Model is an Excel based tool that tracks tritium in plant systems from generation in the reactor coolant to transfer and storage in various plant systems and release. The generation of tritium in the reactor core is calculated from the reactivity of the core and the concentrations of boron and lithium in the coolant. Transfers of water from the reactor core and throughout plant systems are recorded in the spreadsheet. The spreadsheet code calculates the concentrations of tritium in each transfer and the accumulation of tritium in each plant system. The user can model the actual and "what-if" tritium inventories in their plant systems to develop water transfer strategies that control the concentration of tritium in certain systems or in the plant effluents.

The EPRI In-Plant Tritium and Water Management Model is a site-specific tool that models the systems and components of each user plant. EPRI will customize and calibrate the model based on the plant's characteristics (site chemistry and tritium) and history of water transfers between systems. Based on the history of water transfers, EPRI will provide an initial assessment and recommendations for the optimization of the water management strategies. EPRI staff will train the plant staff on the use of the model in an on-site training session.

Impact

As liquid radioactive releases continue to decrease, tritium inventory management is being watched more closely. Plants striving for first quartile liquid radioactive waste release goals are finding that the only way to achieve optimum performance is a detailed accounting of water movements during normal operations and outages. This Model provides plant liquid radwaste personnel with the tool to track such tritium and water movements. The EPRI In-Plant Tritium and Water Management Model will allow the user to understand the impact of water transfers within systems on in-plant tritium concentrations for the following objectives:

- Develop informed strategies for minimizing tritium concentrations in plant systems and effluents through simple changes in water transfer practices (e.g. release of effluents during low tritium periods.)
- Evaluate various advanced and cost-effective tritium reduction or tritium management strategies and technologies optimized to real plant tritium concentrations.
- Evaluate the impact of zero-release (or 100% recycle) on in-plant tritium concentrations for new and operating plants.

How to Apply Results

The user can use the results of the EPRI In-Plant Tritium and Water Management Model to optimize water transfer between plant systems. The user can directly impact the concentrations of tritium in plant systems and in plant effluents by moving, storing, or releasing water at high or low tritium periods. In addition, the Tritium Management Model has been shown to be a useful tool for diagnosing transfer mismatch by noting unreasonable tritium concentrations in tanks in communication with the primary coolant. One site used the model to demonstrate that significant volume of non-radioactive equipment drain water was sent to liquid radwaste.

Groundwater Monitoring and Remediation Technology Pilot Tests

Key Research Question

Recent industry events have shown that inadvertent leaks and spills from site operations can impact site and off-site groundwater concentrations. Although tritium (and other radionuclide) concentrations arising from any inadvertent leaks or spills do not pose a safety or health risk to site staff or stakeholders, these events have raised regulatory and stakeholder concerns. To better manage the risk for such events, the U.S. nuclear power industry committed to the Groundwater Protection Initiative, through which nuclear power plants must implement an on-site groundwater protection program. The U.S. Nuclear Regulatory Commission also has proposed rulemaking to strengthen requirements for on-site groundwater characterization and remediation during operation to reduce the impact on site decommissioning costs and waste generation.

Approach

To assist industry in meeting the criteria of the Groundwater Protection Initiative and forthcoming monitoring and remediation regulations, EPRI assessed the current state of technologies for radionuclide groundwater monitoring and remediation. Several technologies stood out with potential for application at nuclear power plant sites. Through this project, EPRI will collaborate with nuclear power plants to pilot test, evaluate, and implement these advanced groundwater monitoring and remediation technologies at their sites.

EPRI will develop pilot test procedures, evaluation criteria and provide on-site support for the deployment and evaluation of the chosen technology. The technology will be evaluated against the site's hydrogeology and groundwater protection goals to assess whether the technology is best suited for the site. Evaluation criteria may include such considerations as: cost, robustness of the technology, ease of deployment, staffing requirements, and the performance of the technology (i.e. monitoring or remediation results.) EPRI will develop a site-specific report documenting the pilot test of the technology, the results of the evaluation, and recommendations for further technology deployment. The generic and non-site specific results of the pilot test will be incorporated into a report be available to all EPRI members to increase the general nuclear industry knowledge about groundwater monitoring and remediation technologies.

Impact

Currently, groundwater monitoring and remediation technologies have been best developed for non-nuclear industries and non-radionuclide contaminants. Through the base R&D program, EPRI has identified several technologies of these technologies that may be successfully implemented at nuclear power plant sites. These technologies must be demonstrated and evaluated to determine whether they are well suited for implementation at nuclear power plants of if they require further development and optimization. The successful implementation of advanced technologies for groundwater monitoring and remediation at a nuclear power plant site may lead to:

- Cost savings related to technology capital costs and staffing requirements for deployment and maintenance.
- Reduced waste generation from optimized groundwater sampling and remediation procedures
- Improved monitoring and remediation performance through: improved detection of radionuclide contaminants or improved remediation efficiency.

How to Apply Results

EPRI will develop a site-specific report documenting the pilot test of a technology, the results of the evaluation, and recommendations for further deployment of the technology. The member can use these results to decide whether to and how to further deploy the technology at the nuclear power plant site.