Pilot
Pollution Prevention Assessment
for the
Laboratory for Energy and Health-Related Research (LEHR)

July 1999

Executive Summary

The P2 Assessment performed at the Laboratory for Energy and Health-Related Research (LEHR) was a pilot test of a methodology developed by DOE's Office of Pollution Prevention, EM-77. The P2 assessment methodology was developed to assist sites identify cost-saving and waste volume reduction opportunities during environmental cleanup.

The LEHR site was chosen for the pilot P2 assessment because it fit the criteria defined prior to the pilot study. The criteria included: 1) the site must have accurate and documented baseline waste forecasts and budget information, 2) the site project personnel must be available to assist in the assessment, 3) the assessment will not adversely effect the project schedule, and 4) the assessment could be completed and documented within a 3-4 month period. LEHR has quantifiable baseline waste volumes and costs for FY 1999 and FY 2000 which was needed in order to measure potential P2 accomplishments. The current life cycle cost estimate for the entire cleanup effort (including waste management and environmental restoration) is $40.8M for FY 1997 - 2004. The site also was chosen because project personnel were willing to host the pilot and were willing participants in the process.

The P2 assessment methodology included the use of a team of experts in particular areas of expertise drawn from across the DOE complex. The experts applied lessons learned from around the complex and their particular site to target their knowledge and innovative ideas and approaches to specific LEHR concerns. The experts were identified based upon the types of contaminants and issues associated with the LEHR cleanup project. The LEHR P2 expert team included members with expertise in the areas of waste management, material recycle/reuse, asset sales, residual radiological release standards, small laboratory decommissioning and remediation, innovative technologies, life cycle assessment, and pollution prevention/waste minimization.

The team focused the P2 assessment on near-term projects that would be started and/or completed within a two- to three-year time period. These included the Ra/Sr Treatment Area and the Western Dog Pens. The team also reviewed past practices implemented during the Southwest Trenches Removal Action and other building decommissioning activities and validated numerous approaches and actions taken by site project personnel and management which reduced waste volumes and/or provided reduced costs to the site. One practice in particular was noted during the P2 assessment which will save project costs. The use of a DOE-owned gamma spectrometer to survey for Ra-226 at one foot intervals during the Ra/Sr Area

Removal Action will minimize by segregation the amount of contaminated soils to be excavated and shipped for disposal. This particular approach was baselined into the Ra/Sr Area Removal Action Workplan by the site project personnel. The site has documented approximately $3.3M cost savings from implementing P2 actions over the past five years.

The following chart is a summary of the project-specific P2 opportunities identified by the P2 expert team in conjunction with the LEHR site project personnel during the onsite visit to LEHR.

LEHR Project-Specific P2 Opportunities
Summary Chart

P2 Opportunity	% LLW Volume Reduced from Baseline	Baseline Cost ($)	P2 Opportunity Cost ($)	Potential Cost Savings ($)
(1a) Clean Cobble/Gravel	78%	1,794K	906K	888K
(2) Segregate/decon Ra/Sr Area Concrete	90%	280K	174K	106K
(3) Segregate/decon WDP Concrete	73%	413K	329K	84K
(4) Segregate/decon WDP Asphalt	70%	420K	350K	70K

These P2 opportunities, if successfully implemented, could save the site approximately $1.1M over the remaining cleanup baseline of $25M. More importantly, the low level waste volumes destined for high cost LLW burial could be reduced by an estimated 2,900 cubic yards, or a reduction of 51 percent in site-wide estimated LLW volumes. It should be noted that the volume of sanitary waste may increase due to segregating and decontaminating the LLW cobble and gravel. Part of this sanitary waste may be reused onsite and may be disposed offsite at a sanitary landfill, at a greatly reduced disposal cost.

The opportunity with the most cost saving and implementable potential is the segregation and cleaning of the cobble and gravel from both the Western Dog Pens and the Ra/Sr Area. This alternative has the potential to reduce LLW volumes by 78 percent over the baseline LLW volume and save approximately $888 K in baseline costs. The LEHR site has agreed to perform a feasibility evaluation of this alternative. Phase I, the pilot study, will be funded by EM-77. Phase II, the free release evaluation, Phase III, alternative development for the Engineering

Evaluation and Cost Analysis (EE/CA), and Phase IV, Work Plan development will be performed by the site pending the successful results of Phase I. The pilot study will be completed within five months of funding authorization.

One cost-savings only opportunity (no waste reduction) was identified. Utilizing supersacks for transporting bulk shipments of LLW soil, concrete, and asphalt to a commercial disposal facility versus the use of B-25 boxes would save approximately $95K for an estimated 960 cubic yards of soil.

Each of the LEHR P2 opportunities was assessed using Oak Ridge National Laboratories qualified-version (versus quantified) of their life cycle analysis. The goals of the life cycle analysis are to help project managers understand the problems they may face during project implementation, construct decision alternatives to solve the problems, specify criteria (attributes) to judge the alternatives (opportunities), and make trade-offs among decision criteria and alternatives in order to ensure that all effects are considered when making decisions. The qualified analysis performed on the four LEHR P2 opportunities provided the site with data and decision criteria which can be the basis for a more detailed, quantified analysis if more detail is warranted. The four LEHR P2 opportunities were qualitatively evaluated on each of seven criteria; cost, environmental impacts, health and safety impacts, pollution prevention, schedule impacts, regulatory impacts, and local economic impacts. The results of the analysis was included in the report in graphical format for use when presenting to regulators and stakeholders.

This P2 assessment provided the LEHR site with the initial information necessary to perform a more quantified analysis of the identified P2 opportunities in order to determine the true life cycle cost of the P2 alternatives. It is recommended that the site do a more thorough evaluation of the alternatives and involve the stakeholders and regulators in the decision process. The most cost saving P2/WMin opportunities are primarily identified during project planning phases and in conjunction with waste forecasting activities.

In summary, the P2 assessment methodology should be applied to other sites in the DOE complex as a means of improving planned cleanup actions and maximizing efficiencies. The lessons learned from each site should be shared between all sites in an effort to improve the productivity of the DOE's massive cleanup program.

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1.0 Pollution Prevention Assessment Background

The DOE's Office of Pollution Prevention (EM-77) and the Office of Environmental Restoration (EM-40) have recognized the need to integrate pollution prevention and waste minimization (P2/WMin) into the remediation and decommissioning activities taking place across the DOE complex. The use of P2/WMin techniques can reduce the risks associated with waste management and reduce waste volumes and waste management costs. The reduction of waste volumes directly effects the project baseline costs and can assist the project manager to achieve efficiency goals and cost savings.

Over the last several years, EM-77 and EM-40 have developed numerous tools and resources to assist environmental restoration (ER) project managers and project teams in the effective integration of P2/WMin techniques into ER projects. The existing pollution prevention tools and resources have been geared towards administrative (guidance and training) and planning (case studies, guides, tracking, and technique listing) activities, but have not been directed at actual opportunity identification and implementation assistance. To move toward implementation, a pilot P2 assessment methodology was developed and funded by EM-77. The location for the pilot P2 assessment was chosen based upon several criteria including**:** 1) the site or project would have accurate and documented baseline waste forecast and budget information, 2) site project personnel were available to assist in the assessment, 3) the assessment would not adversely effect the project schedule, and 4) the assessment could be completed and documented within a 3 month period.

The P2 assessment methodology included the use of a team of experts in particular areas of expertise drawn from across the DOE complex. The experts applied lessons learned from around the complex to target their knowledge and innovative ideas and approaches on a site or project which has the potential for waste reduction. These experts were identified based upon the site specific concerns, contaminants, and issues being addressed in the assessment and on their personal application of techniques and technologies for resolving these issues.

During the Oakland Operations Office FY 1998 Year-End Review, the possibility of a pilot P2 assessment methodology to reduce waste disposal volumes and cut the proposed baseline costs at Laboratory for Energy and Health-Related Research (LEHR) was discussed. EM-77 and EM-40 personnel, DOE Oakland Operations Office personnel and DOE LEHR personnel agreed to support a limited pollution prevention assessment (considered a pilot) on the FY 1999 and FY 2000 baseline activities to formulate potential opportunities to reduce waste volumes and project costs. EM-77 agreed to fund the study and provide the LEHR site with a report of findings. The study was performed by a team of experts from across the DOE complex who are knowledgeable in the areas of concern at the LEHR site and in the conduct of the P2 assessment. This team of experts worked in cooperation/coordination with LEHR project personnel.

LEHR was chosen because it fit the criteria mentioned above and had a quantitative baseline for FY 1999 and 2000 which included waste volume forecasts and cost information. The site is moving towards an aggressive cleanup schedule and has definitive schedules and project plans to be evaluated by the team. LEHR's life cycle cost estimate for the entire cleanup effort (including waste management and environmental restoration) is $40.8 M for FY 1997 - 2004. The life cycle cost for the remaining years, FY 2000 - 2004, has been estimated at $25.3M[1]. This information provides a measurement for potential P2/WMin accomplishments. The LEHR site was also chosen because project personnel were willing to host the pilot and were helpful during the entire assessment process.

It is important to note that the pilot P2 assessment at LEHR was being used to test the methodology and ascertain whether it could be a valuable tool for use at other sites across the complex. The intent was to perform the assessment at LEHR and evaluate the concept and approach of the P2 assessment methodology and revise the methodology (as necessary) to create a useful tool for identifying pollution prevention techniques and practices for use at environmental restoration projects. While the focus of the pilot P2 assessment was towards piloting the P2 methodology *process,* it was anticipated that the team may identify cost-effective P2 opportunities at LEHR to provide alternatives to the existing baseline and validate current P2 practices being deployed at the site.

[1] Data provided by the Interim Data Management System (IDMS).

2.0 Key Pollution Prevention Regulatory Drivers

Figure 2-1 graphically depicts various drivers for practicing pollution prevention and waste minimization in routine, recurring operations. These regulatory drivers, to a large degree, can also be applicable to cleanup activities. Although there are no specific regulations that drive the inclusion of P2/WMin principles in cleanup and stabilization activities, DOE has chosen to create internal drivers for encouraging and rewarding the evaluation and implementation of waste reduction practices.

2.1 DOE's Strategic Plan

The highest level DOE document that discusses incorporating P2/WMin in cleanup activities is *DOE's Strategic Plan*. This Plan sets the goals, objectives, and strategies that will be implemented within DOE through the Annual Performance Plan, the budget, and the Performance Agreement with the President. Two objectives in the Strategic Plan deal with the application of P2/WMin to meet DOE goals.

The first P2 objective in the Plan states that DOE must "prevent future pollution." To accomplish this objective, the illustrative measure to "reduce waste generation from cleanup and stabilization activities by ten percent annually, beginning in Fiscal Year 1999" was established.

The second P2 objective in the Plan states that the DOE must "reduce life-cycle costs of cleanup." To accomplish this objective, the illustrative measure to "enhance performance, increase efficiency, and reduce costs by recycling and other waste minimization techniques" was established.

These measures provide the incentive for ER project managers to begin to evaluate and deploy technologies and techniques that will improve productivity and reduce the life-cycle costs of cleanup projects.

2.2 Accelerating Cleanup: Paths to Closure

DOE's *Accelerating Cleanup: Paths to Closure* is a management tool that forecasts, on a project-by-project level, the technical scope, cost, and schedule required to complete approximately 353 ER projects at 53 remaining cleanup sites across the complex. The life-cycle cost estimates provided in the document, for cleanup at these 53 sites, total $147 billion (1997

Federal Drivers	Pollution Prevention Act of 1990 Resource Conservation & Recovery Act (RCRA) Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) 1980 Clean Air Act/Clean Water Act Emergency Planning and Community Right-to-Know Act Energy Policy Act of 1992
Executive Orders	E.O. 12856 - P2 Strategy and Plans E.O. 12873 - Recycling and Energy Efficiency E.O. 13101 - Greening the Government Through Waste Prevention, Recycling and Federal Acquisition
DOE Orders	DOE Order 5400.1 - P2 Program Development DOE Order 435.1 - Radioactive Waste Management; In Draft

Figure 2-1 P2/WMin Regulatory Matrix

through 2070). By 2006, DOE intends to complete more than 90 percent of the cleanup activities. *Paths to Closure* provides critical information on technical activities, budgets, risks, and worker safety and health in order to inform the public about these issues and to provide them with the depth of understanding required to make cost-effective and sound decisions.

Paths to Closure provides a closure plan for each site that identifies the key technical and programmatic activities that must occur and the decisions that must be made before a site can be closed. Additionally, a Waste and Materials Disposition Map (flow chart) that describes each projected waste stream, the steps for processing and managing that waste, and where the waste is intended to be permanently disposed (if known) has been produced for each site. Although many of these projections will change due to the development of new technologies, more economical cleanup approaches, and changes in the interests of stakeholders and regulators associated with each site, the Waste Material and Disposition Maps can be utilized as pollution prevention tools. ER project managers and project teams can utilize the site specific waste material and Disposition Maps in identifying high priority projects that can be expected to generate large quantities of regulated wastes.

Paths to Closure also discusses the use of "Performance Enhancement Mechanisms" that will help DOE meet the programmatic challenges of accelerating cleanup while reducing costs. Pollution prevention has been identified as one of the mechanisms that will improve efficiencies by reducing waste volumes and associated disposal costs. Other mechanisms that improve efficiencies include technology deployment, integration, project sequencing, contract reform, and lessons learned. The aggressive application of pollution prevention techniques for cleanup projects is expected to provide streamlined approaches for managing wastes.

2.3 1996 Pollution Prevention Program Plan

One other document which includes pollution prevention requirements for cleanup and stabilization activities is the *1996 Pollution Prevention Program Plan*. This plan includes the DOE Secretarial goals to be achieved by December 31, 1999. The Secretarial Goal established for cleanup and stabilization activities states that for all operations, including cleanup and stabilization, 33 percent of the sanitary waste must be recycled. Progress toward this goal must be reported annually.

2.4 CERCLA and RCRA Drivers for P2/WMin in Cleanup Activities

It is important to note that pollution prevention and waste minimization should be a part of cleanup activities regulated under both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and under the Resource Conservation and Recovery Act (RCRA). CERCLA includes "reduction in the toxicity, mobility, or volume of a waste through treatment" as one of the nine criteria used to evaluate the acceptability of a response action. RCRA requires that hazardous waste generators have a program in place to reduce both the volume and the toxicity of hazardous wastes. These statutes provide drivers for sites regulated under CERCLA or under RCRA to employ P2/WMin during cleanup actions.

3.0 LEHR Pollution Prevention Expert Team Members

Based upon the types of activities being assessed and the contaminants and issues examined, a team of experts was assembled which provided expertise in these areas. Each team member provided unique and qualified knowledge in particular areas and created a dynamic mix of DOE complex experience.

The P2 Expert team members for the LEHR P2 assessment included:

- *Mr. Lee Bishop* - DOE Oak Ridge, Program Manager for DOE's Center of Excellence for Metals Recycle. Expertise includes material release criteria, applied health physics, analytical management, recycle/reuse, and waste management operations.

- *Mr. Steve Schmucker* - Project Manager at Battelle Columbus Laboratories Decommissioning Project (BCLDP). The BCLDP is a medium-scale laboratory decommissioning project with a small budget and similar waste issues to LEHR. Mr. Schmucker's expertise includes all aspects of waste management including sampling, packaging, handling, storage, certification, transportation and dispositioning. Acts as BCLDP's P2/WMin lead.

- *Mr. Shih-Yew (SY) Chen* - Manager in Risk and Waste Management for the Environmental Assessment of Argonne National laboratory. Expertise in residual radiological release standards and dose modeling and assessments.

- *Mr. Mike Morris* - Project Manager for the Center of Life Cycle Cost Analysis at Oak Ridge National laboratory. Expertise includes life cycle assessment, innovative technology demonstrations and mixed waste treatments.

- *Ms. Lisa Allmon-Burns* - Project Manager for IT Corporation, Contractor for EM-44 and EM-77 and an expert in the area of P2 in environmental restoration and waste minimization deployment. Acted as Team Lead and Assessment Coordinator.

Site personnel involved in the P2 assessment offered invaluable expertise. These individuals are listed below.

- *Ms. Susan Fields* - DOE Project Manager for the LEHR site. Susan joined DOE in 1994 bringing her experience gained from managing cleanup activities at 100 sites for the USEPA as a Region 4 On-Scene Coordinator and a National Environmental Response Team Member.

- *Mr. Salem Attiga* - Principal with Environmental Management Services (EMS). Salem was the LEHR Project manager from 1990 to 1996. Salem provided valuable experience and information regarding past and future P2/WMin opportunities at LEHR.

- *Ms. Dawn Mitchell-Munso* - Program Manager with Environmental management Services. Dawn has been a key member of the LEHR project since 1990. Dawn provided excellent LEHR site background information and numerous ideas and suggestions that were essential to the completion of the assessment.

- *Mr. Bill Schaal* - Project Manager for IT Corporation at the LEHR Site. Bill has been involved in the LEHR site activities since 1995. Bill assisted the P2 Assessment Team effort by providing information about past facility and current restoration practices as well as verifying cost data.

4.0 LEHR Site Background

The Laboratory for Energy Health-Related Research (LEHR) site is a 15 acre area located on the University of California, Davis South Campus. The site is currently undergoing remediation and demolition activities. The mission of the LEHR environmental restoration program is to clean up the facilities and site in a safe and cost-effective manner and to a condition that would permit transfer of ownership of the LEHR facility to the University of California, Davis for unrestricted use.

LEHR was established in 1958 at University of California, Davis as a DOE research facility. The DOE funded research at LEHR focused on the health effects from chronic internal exposures to radionuclides, primarily Strontium-90 (Sr-90) and Radium-226 (Ra-226) using beagles to simulate radiation effects on humans. In a separate, but related project, research animals were exposed to external gamma radiation to advance knowledge of the effect of this type of radiation on development of cancers such as Leukemia. DOE funded research involving the use of small amounts of Plutonium-241 (Pu-241), Thorium-228 (Th-228) and other radioisotopes.

The research facility was closed in 1988. University of California, Davis conducts some research in labs previously operated by DOE. In May of 1994, as a result of groundwater contamination detected during a preliminary investigation and the potential threat of contamination to public health and the environment, the U.S. EPA placed LEHR on the National Priority List (NPL).

The DOE, EPA, and the State of California are still negotiating a Federal Facility Agreement for site restoration. Specific interim or removal actions are being implemented before the ROD.

In June 1997, DOE and University of California, Davis signed an MOA whereby DOE will be responsible for cleanup activities at four areas within the site, specifically, the Southwest Trenches, the Radium/Strontium Treatment Systems, the Domestic Septic Tanks and the Eastern and Western Dog Pens. University of California, Davis will be responsible for cleanup activities at the three landfills, the southern and eastern burial trenches and groundwater contamination, which extends offsite to the east.

4.1 Site Description

The land is owned by University of California, Davis and leased to DOE. All structures at the LEHR site are owned by DOE. On-site facilities consist of 15 buildings, including two animal hospitals, waste storage facilities, laboratory and support buildings, hundreds of outdoor concrete pad dog areas, 18 underground septic and treatment tanks and several sources and standards. Two inactive landfill units occupy about six acres of the LEHR site. A third landfill unit used in the 1960's is located on University of California, Davis property east of the LEHR site. Several low level radioactive waste burial trenches exist where commingled waste generated by the University of California, Davis campus and LEHR were buried according to regulations that were in effect at the time.

The University of California, Davis long range plan is to continue to use the site as a research facility for research and teaching. No residential use is planned. Refer to the LEHR Facility Map on page 11.

4.2 Site Contamination

During the 30-year operation of the LEHR facility, a variety of wastes were generated, stored, and/or disposed onsite. These wastes included radioactive, biological, chemical, municipal, and laboratory debris.

4.3 Past Site P2 Activities

LEHR has continually integrated P2/WMin techniques and cost savings initiatives into the sites cleanup effort. The following is a list of examples where P2/WMin provided the site with waste volume reductions and substantial cost savings:

- Transferred two radioactive sources (Co-60 and Sr-90) offsite for reuse,
- Reduced the volume of D&D wastes (contaminated animal cages) by 50% by utilizing a shredder and compactor prior to disposal,
- Contracted the services of a commercial supercompactor for additional D&D wastes, including a ten ton tanker trailer,
- Reused an onsite building as a waste staging facility,
- Used asbestos waste as void space filler in LLW containers to avoid Class 1 landfill costs, and
- Streamlined the D&D approach by eliminating more than 80% of unnecessary characterization and assessment work.
- Preparing to ship approximately 30,000 pounds of metal to a recycling vendor.

These activities have saved the site ~ $3.3M over the past five years.

Map - LEHR Facilities, UC Davis, California

5.0 LEHR Pollution Prevention Assessment Focus Areas

The LEHR P2 assessment was focused on near-term projects that would be started and/or completed within a two to three year time period. The project baseline documents were reviewed and with the approval of DOE Oakland and the DOE LEHR Project manager, the following activities were the focus of the P2 assessment.

FY 1999 Baseline Site Activities
Several activities were tentatively planned for spring/summer 1999.

- Mobilize and complete site preparation for the Area 1 Ra/Sr Treatment Systems Removal Action.

- Perform confirmatory sampling and analysis.

- Complete Area II Removal Action (i.e., Ra-226 and Sr-90 system underground treatment tanks, Sr-90 leachfield). Materials that will be generated during this removal action include water from numerous tanks, sludge from one tank, concrete, soil, and carbon steel pipe with lead joints.

- Remove 11 Ra/Sr tanks and piping systems (part of Imhoff Treatment System). Only one tank has some sludge - possibly moved to FY 2000

- Complete Area 1 Removal Action (i.e., Ra-226 system three dry wells, seepage trench, and distribution box and domestic septic tank number 2). Materials that will be generated during this activity include concrete, gravel, rock, soil, sand, carbon steel pipe, vitrified clay pipe, and wood.

- Excavate and remove Domestic Septic tank No. 2 located in Ra/Sr Area.

- Backfill excavated areas.

FY 2000 Baseline Site Activities - may be pushed to FY 2001 due to funding constraints.
The assessment team reviewed the following removal action activities scheduled for FY 2000.

- Implement the selected removal action alternative for the western dog pens and the domestic septic tanks number 3 and 6 as specified in the EE/CA.

- Perform confirmatory sampling and analysis at the western dog pens and domestic septic tanks number 3 and 6.

- Backfill excavations in the dog pens and domestic septic tanks, as needed.

Additional Issues/Activities Examined

- Off-site disposal of approximately 1,000 cubic yards of LLW soil and debris (soil may have sharps which may need to be screened prior to disposal). The soil and debris was removed from the southwest trench area and stored in the western dog pen area.

- Evaluation of options for the disposition of (presumed volumetrically contaminated) concrete and asphalt with re-bar from past decommissioning activities. This material is currently stored in the Cobalt-60 storage area. Concrete from the removal of the Ra/Sr tanks and the concrete from the curbing around the western dog pens was evaluated for potential release/reuse or volume reduction.

- Evaluation of onsite treatment technologies for 39 cubic meters of mixed waste soil - not mixed under RCRA although some may be a California listed waste. The soil is contaminated with chlordane and Ra-226 and could be shipped as a combined LLW to Envirocare with no treatment needed. Evaluation of 268 cubic meters of potential hazardous waste (soils contaminated with chlordane) removed from the southwest trenches excavation and stored in the western dog pen area.

- Evaluation of disposal options (land application versus offsite disposal) for 900 **cubic** yards of nitrate-contaminated soil. Onsite insitu bioremediation is feasible and would negate the need for disposal.

6.0 Results/Opportunities

The LEHR site visit was performed on March 24 - 26, 1999. Training on P2/WMin applications to environmental restoration activities was provided on the first morning to approximately 10 site ER personnel and 5 DOE Oakland personnel.

The remainder of the site assessment was spent on the waste steam review and assessment of the facility. Each of the baseline site activities discussed in Section 4.0 were reviewed and the waste forecasts assessed for P2/WMin opportunities. P2/WMin opportunities were not found for every site baseline activity. Several baseline activities were simply validated as being the best practice in terms of P2/WMin. Four project-specific opportunities were identified which affect particular projects and one cost savings only opportunity. The opportunities were recommended for more detailed evaluations after an initial screening by the assessment team and site personnel. The following sections discuss these opportunities.

Each P2 opportunity was evaluated against the LEHR baseline activity using a qualified-approach to the life cycle analysis methodology developed by Oak Ridge National Laboratory (ORNL). It is important to remember that the life cycle analysis is a decision making tool and is meant to assist project managers in making reasonable and defensible decisions. While an attempt was made to include all potential costs and other criteria such as health and safety, environmental impacts, schedule impacts, regulatory requirements, pollution prevention, and local economic impacts, the site staff will need to perform a more quantified analysis and explore these opportunities thoroughly before making a final decision to implement the P2/WMin action. Consultation with local stakeholders may also be needed.

6.1 Project-Specific P2 Opportunities

The project-specific opportunities are listed below in order of greatest volume reduction and cost savings achieved. They will be discussed in greater detail in section 6.4.

1a) Remove, segregate, and tumble/grind/clean low level waste gravel from the western dog pens and cobble/gravel from the Ra/Sr Area for reuse onsite ~ $888 K total cost savings for combined approach.

1b) Remove, segregate, and tumble/grind/clean low-level waste gravel from the western dog pens only for reuse onsite ~ $810 K cost savings for this opportunity only.

2) Remove, segregate, and decontaminate by scabbling the low level waste concrete from the Ra/Sr Area for disposal as clean rubble versus disposal as low level waste ~ $106 K cost savings.

3) Remove, segregate, and decontaminate by scabbling low-level waste concrete from the western dog pens for disposal as clean rubble versus disposal as low-level waste ~ $84 K cost savings.

4) Remove, segregate, and decontaminate by scabbling low-level waste asphalt from the western dog pens for disposal as clean rubble versus disposal as low-level waste ~ $70 K cost savings.

LEHR Project-Specific P2 Opportunities
Summary Chart

P2 Opportunity	% LLW Volume Reduced from Baseline	Baseline Cost ($)	P2 Opportunity Cost ($)	Potential Cost Savings ($)
(1a) Clean Cobble/Gravel	78%	1,794K	906K	888K
(2) Segregate/decon Ra/Sr Area Concrete	90%	280K	174K	106K
(3) Segregate/decon WDP Concrete	73%	413K	329K	84K
(4) Segregate/decon WDP Asphalt	70%	420K	350K	70K

Total potential cost savings from the project-specific P2 opportunities only (1 - 4) is estimated at $1.1 M. Total low-level waste volume reductions are estimated at 2,900 cubic yards. The volume of sanitary waste may increase due to segregating and decontaminating LLW. Part of the sanitary waste will be reused onsite and some disposed of offsite at a sanitary landfill, at a greatly reduced disposal cost.

6.2 Cost Savings Only Opportunity

1) Use "supersacks" for transporting bulk shipments of low level waste soil, concrete and asphalt to a commercial disposal facility versus the use of B-25 boxes. This potential opportunity was not evaluated against a baseline activity and does not appear in the preliminary life-cycle analysis tables, although an attached cost estimate shows a substantial cost savings per cubic yard shipped ~ $95 K cost savings over B-25 boxes for an estimated 960 cubic yards of soil.

6.3 Validated Best Practice Activities and Additional P2/WMin Evaluations/Ideas Not Selected or Requiring Further Evaluations

1. The LEHR baseline activity for the Ra/Sr Area LLW soils (estimated at ~ 1,617 cubic yards ex situ) and the Western Dog Pens LLW soils (estimated at ~ 240 cubic yards ex situ) were evaluated for potential P2/WMin actions and were found to be employing best management practices which will minimize the amount of contaminated soils to be removed. The site plans on utilizing a DOE-owned gamma spectrometer to survey for Ra-226 at one foot intervals in order to segregate out clean from contaminated soils and minimize the amount of soils excavated and shipped for disposal. It was suggested that half-foot intervals be evaluated for potential use, increasing the precision of excavation.

2. The site has a listing of numerous radioactive sources and standards stored at the site which could be reused. The list has been publicized by LEHR staff in several national laboratory exchange lists and will continue to be advertised to laboratories for potential reuse. The assessment team has also provided the list to other laboratories and DOE sites which may need the materials. This will continue to be monitored for acceptance.

3. The 300 cubic yards of chlordane contaminated soil from the Southwest Trenches Removal Action was evaluated for alternative innovative treatment technologies to the baselined incineration alternative. One idea investigated was the use of a new patented bioremediation technology called the Xenorem Process which would remediate soils contaminated with chlorinated pesticides. The technology incorporates the use of cyclic anaerobic and aerobic bioremediation of the chlorinated pesticide contaminants and uses indigenous bacteria and readily available natural amendments to remove over 95% of the chlordane. A field pilot test was conducted at a site in Florida and treated concentrations of 48 mg/kg chlordane to 2.3 mg/kg. At issue is the concentration of mercury in the soil and the low cleanup goal of ~ 0.5 ppm. An estimate for a bench-scale test of the Xenorem technology was calculated at ~ $12,000 to determine if the chlordane and mercury would be addressed and the cleanup goals met. The full-scale treatment for 300 cubic yards of soil was estimated at ~ $ 88,000. This does not include the cost of obtaining an air permit. The Xenorem process is still an option, as is the thermal desorption process which the site is investigating. The Xenorem bioremediation approach would allow the soil to remain in place. Both of these technology options should be assessed against the baseline incineration approach which has a baseline estimate of ~ $400K for the RCRA and non-RCRA soils. The site will need to perform further evaluations.

4. The 900 cubic yards of nitrate-impacted soil was not currently in the sites baseline and was not evaluated for potential P2/WMin actions. The site is currently investigating and negotiating with the state regulators regarding the potential of leaving the nitrate soils in place (land-application scenario). This would be a best management practice and eliminates the need to treat and dispose of the waste offsite.

5. The concrete and asphalt chunks (with rebar) stored in the Co-60 storage yard, which was generated from past decommissioning activities, was evaluated for potential P2/WMin opportunities. Due to the small size of the chunks and the potential for breakage into

smaller size pieces, the chance of being able to scabble and remove any areas of contamination would be extremely difficult. The team felt the best opportunity for this waste was to rubbleize for packaging purposes and dispose at a LLW disposal facility. If the site develops a volumetric release protocol, this waste could be scanned after rubbleizing and possibly be reused onsite as fill material.

6.4 Detailed Description of Opportunities

The following section includes descriptions of the potential P2 opportunities, cost savings achievable, and potential waste volumes to be reduced. Flow diagrams for the baseline approach (supplied by the LEHR site) and P2 alternative approach are included in this section as well as the cost comparison tables. Key assumptions for the baseline approach can be found in Appendix B. Key assumptions for the P2 alternative approach are included in the narratives.

Clean for Reuse the LLW Cobble/Gravel from the Western Dog Pens and the Ra/Sr Area - Combined Approach

BASELINE APPROACH: The ~ 2,386 cubic yards (ex situ) of LLW gravel and cobble/gravel from the Western Dog Pens Removal Action (2,156 cubic yards) and the Ra/Sr Treatment Area Removal Action (230 cubic yards) was baselined to be removed, bulk/packaged and disposed as LLW debris at a commercial LLW disposal facility. The baseline approach for both areas is the most schedule efficient but generates an excessive amount of LLW, it is also expensive, see Figure 1.

ALTERNATIVE P2 APPROACH: The alternative P2 approach for the LLW gravel and cobble wastestream is to clean the material and render it non-contaminated and capable of reuse either onsite or transferred to an offsite vendor or public works project. This approach combines the two wastestreams (2,156 cubic yards of gravel from the Western Dog Pens and 230 cubic yards of a gravel/cobble mixture from the Ra/Sr Treatment Area). Figure 2 and Table 1 shows this alternative for the Western Dog Pens gravel only, but by combining the two wastestreams a higher cost savings can be achieved and offsets the capital cost. See Figure 3 and Table 2.

A simple combination of sorting out the hot spots and tumble/grinding the sorted material in a concrete mixer or like apparatus should render the material below background levels and capable of being released for onsite reuse as backfill or offsite release as a road bed base material.

This alternative approach is based upon the assumption that any radioactive contamination left on the cobble/gravel after years of weathering is firmly attached to the surface and relatively

Figure 1

Figure 2

Table 1

Figure 3

Table 2

non-soluble. Therefore, simple grinding in a tumbler/grinder configuration should remove the surficially-fixed contamination remaining in the gravel after hot spot removal which can then be captured through filtration in a neutral water solution. The capital purchase of the equipment for the Ra/Sr Area gravel/cobble alone would not be cost effective due to the limited quantity of material. Therefore, it is recommended that both the Ra/Sr Area cobble/gravel and the Western Dog Pen gravel be processed in the same manner to offset the capital costs.

The use of the tumbler/grinder initially increases the labor costs onsite but it provides a dramatic decrease in the total waste volume (~78%) with a tremendous cost savings due to the reduction in LLW disposal costs. The estimated cost savings when compared to the baseline is approximately $888 K (49%) savings including capital costs. The key assumptions for the alternative are as follows:

- Any liquids generated could be reused after filtering and ultimately will meet the NPDES permit at UC Davis for discharge or can be evaporated without undesired impact to the atmosphere, human health, or the environment.
- Bench-scale tests validate the conclusion regarding the behavior of the contamination associated with the gravel.
- An excess concrete mixer or similar equipment and screening plant can be located within the DOE complex and is provided as government-furnished equipment.
- The stakeholders agree with the alternative approach.
- Work is performed in a manner consistent with ALARA principles.
- Onsite treatment permit can be obtained within a period that accommodates schedule or is determined to be unnecessary.

Decontaminate Concrete from Ra/Sr Treatment Area for Disposal as Clean Rubble

BASELINE APPROACH: The baseline approach for the ~ 336 cubic yards of LLW concrete from the Ra/Sr Treatment Area Removal Action is to excavate the material with a hydraulic breaker to crush the concrete to one inch chunks and bulk package the waste for disposal as LLW debris at a commercial LLW disposal facility (Figure 4).

ALTERNATIVE P2 APPROACH: The P2 alternative approach uses scabbling and segregation to reduce the amount of contaminated concrete destined for LLW disposal. Since an estimated

Figure 4

100 percent of the interior surfaces of the Ra/Sr treatment tanks have come into contact with contaminated material, it is assumed that it is 100 percent contaminated. After removing a uniform 3/4 of an inch of the internal concrete surface during the initial decontamination, a radiological survey will be performed. Special attention will be necessary for areas where cracks may have been found in the concrete wall. Additional removal of concrete along the crack line with a jackhammer or mechanical chisel will be required. Spray paint will be used to delineate contaminated areas from non-contaminated areas. It is assumed that 25% of the surface area will need to be re-scabbled. The scabbled concrete would need to be staged for HEPA vacuuming to remove loose particles from all exposed surfaces prior to smear survey/direct frisk for radiological free release. The low-level concrete waste from the scabbler and the concrete that may fail radiological free release is estimated to be approximately 34 cubic yards. Additional costs per cubic yard have been factored in to offset increased costs of confined space entry, setup of scaffolding and a HEPA ventilation system.

It is assumed the same level of effort/funding per cubic yard included in the baseline approach for sampling, analysis, designating and profiling will stay about the same, because the overall volume of the waste would remain constant. The only difference is the segregation of radiological from non-radiological. Profiling costs could be minimized by combing and averaging the waste streams from the first scabble and the second scabbling event.

The clean concrete would not be stored since the estimated cost of transportation and disposal at a demolition landfill should not be a significant cost. The clean concrete would be accumulated in 1 yard supersacks, which cost about $20 each. When approximately 18 supersacks have been accumulated, a roll-off box would be loaded and transported to an offsite demolition landfill. This would minimize per-day roll-off box rental fees. The shipping costs would be reduced since the clean waste would not have the cost of labor to mark, label, and manifest the waste as is required when handling and shipping LLW. The transportation costs will also be less since the demolition landfill would be relatively close to the LEHR site, and a non-specialized carrier would be utilized (Figure 5, Table 3).

Cost savings are estimated to be ~ $100K. A 90 percent volume reduction in LLW could be achieved.

Figure 5

Table 3

Decontaminate Concrete from Western Dog Pens for Disposal as Clean Rubble

BASELINE APPROACH: The baseline approach for the ~ 525 cubic yards of LLW concrete from the Western Dog Pen Removal Action is to excavate and grind the concrete into 1-2 inch pieces and bulk package the waste for disposal as LLW debris at a commercial LLW disposal facility (Figure 6).

ALTERNATIVE P2 APPROACH: The P2 alternative approach for the contaminated concrete uses scabbling and segregation to reduce the amount of contaminated concrete destined for LLW disposal. An additional step to the baseline radiological survey would be to identify areas as radiologically-contaminated with spray paint. During the radiological survey, special attention would need to be given to any cracks in the concrete. During the removal phase, the spray-painted contaminated areas would need to be severed from the clean areas with a jack hammer or concrete saw. It is assumed that approximately 50 cubic yards of the concrete would be too small to re-survey and would be disposed as LLW at this point.

Using one equipment operator, one laborer and one rad tech, the clean concrete would need to be staged for HEPA vacuuming to remove loose particulate from all exposed surfaces prior to smear survey/direct frisk for radiological free release. A containment area with HEPA ventilation would probably be needed for scabbling of the contaminated concrete. The scabbled concrete would need to be staged for HEPA vacuuming to remove loose particulate from all exposed surfaces prior to smear survey/direct frisk for radiological free release. The low-level concrete waste from the scabbler and the concrete that may fail radiological free release is estimated to be approximately 80 cubic yards.

It is assumed the same level of effort/funding per cubic yard included in the base in the areas of sampling, analysis, designating and profiling will stay about the same, because the overall volume of the waste would remain constant, only segregated radiological from non-radiological.

The clean concrete would not be stored since at the estimated cost of transportation and disposal at a demolition landfill should not be a significant cost. The clean concrete would be accumulated in one cubic yard super sacks, which cost about $20 each. When approximately 18 supersacks have been accumulated, a roll-off box would be loaded and hauled away. This would minimize per-day roll-off box rental fees. The shipping costs would also be reduced since the clean waste would not have the labor costs spent marking, labeling and manifesting shipments such as LLW. The transportation costs will be less since the demolition landfill would be

Figure 6

relatively close to the LEHR site, and non-specialized carrier could be utilized (Figure 7, Table 4).

Cost savings are estimated at ~ $84K. A 73 percent volume reduction in LLW could be achieved.

Decontaminate Asphalt from the Western Dog Pens for Disposal as Clean Rubble

BASELINE APPROACH: The baseline approach for the ~ 546 cubic yards of LLW asphalt from the Western Dog Pen Removal Action is to excavate and grind the asphalt into 1-2 inch pieces and bulk package the waste for disposal as LLW debris at a commercial LLW disposal facility (Figure 8).

ALTERNATIVE P2 APPROACH: The P2 alternative approach for the contaminated asphalt uses scabbling and segregation to reduce the amount of contaminated asphalt destined for LLW disposal. An additional step to the baseline rad survey phase would be to spray areas identified as rad-contaminated, with special attention to any cracks in the asphalt. During the removal phase, the contaminated areas would need to be severed from the clean areas with a jack hammer or concrete saw. It is assumed approximately 50 cubic yards of the asphalt would be too small to resurvey and wasted at this step.

Using one equipment operator, one laborer and one rad tech, the clean asphalt would need to be staged for HEPA vacuuming to remove loose particulate from all exposed surfaces prior to smear survey/ direct frisk for radiological free release. A containment area with HEPA ventilation would probably be needed for scabbling of the contaminated asphalt. The scabbled asphalt would need to be staged for HEPA vacuuming to remove loose particulate from all exposed surfaces prior to smear survey/ direct frisk for radiological free release. The low-level asphalt waste from the scabbler and the asphalt that may fail radiological free release is estimated to be approximately 114 cubic yards.

It is assumed the same level of effort/funding per cubic yard included in the base in the areas of sampling, analysis, designating and profiling will stay about the same, because the overall volume of the waste would remain constant, only segregated radiological from non-radiological.

The clean asphalt would not be stored since at the estimated cost of transportation and disposal at a demolition landfill should not be a significant cost. The clean asphalt would be accumulated in one cubic yard super sacks, which cost about $20 each. When approximately 18 supersacks have

Figure 7

Table 4

Figure 8

been accumulated, a roll-off box would be loaded and hauled away. This would minimize per-day roll-off box rental fees. The shipping costs would be reduced since the clean waste would not have labor costs spent marking, labeling and manifesting shipments such as LLW. The transportation costs will be less since the demolition landfill would be relatively close to the LEHR site, and non-specialized carrier could be utilized (Figure 9, Table 5).

Cost savings are estimated at ~ $76K. A 70 percent volume reduction in LLW could be achieved.

Use of "Supersacks" for the Bulk Shipment of Low Level Waste Soil, Concrete, and Asphalt

The baseline approach for packaging waste at the LEHR site is typically B-25 boxes. This opportunity is not a P2/WMin opportunity as it does not decrease waste volumes, but merely a cost savings opportunity for the site to investigate. The team felt that it should be mentioned in this report.

Cost savings (not waste volume reduction) could be achieved with the use of 3' x 3' x 3' woven poly supersacks for the packaging of soil, concrete and asphalt from the LEHR site. These supersacks are loaded onto lined, tarped dump trailers for disposal at Envirocare. This configuration would meet DOT packaging requirements for limited quantity, radioactive material and/or DOT exempt, which should be a majority of volume generated during LEHR remediation activities. It is estimated that approximately $74/yd can be saved on packaging, marking and labeling costs alone. This is based on the estimated $350/box to obtain and certify used B-25's from the Savannah River site.

For an estimated 960 cubic yards of soil to be generated from the Ra/Sr Treatment Area and Western Dog Pens, the total cost savings would be approximately $95,000. This cost saving measure could also be applied to contaminated asphalt and concrete.

One of the concerns would be the outside storage of these semi-permeable supersacks. Tarping the bags determined to contain a limited amount of radioactive material should pose no greater risk than the soil currently tarped inside the Western Dog Pen area. Soils from areas determined or suspect to contain of higher levels of radioactive contamination could be loaded directly into B-25 boxes or into supersacks first and over packed into B-25's until ready to ship (Figure 10, Table 6).

Figure 9

Table 5

Figure 10

Table 6

6.5 Preliminary Life Cycle Analysis of Pollution Prevention Opportunities

The Oak Ridge National Laboratory Life Cycle Analysis (LCA) approach has its foundation in the field of decision analysis. The goals are to help project managers understand the problems they face, construct decision alternatives to solve the problems, specify criteria (attributes) to judge decision alternatives, and make trade-offs among decision alternatives and criteria to arrive at reasonable and defensible decisions. The LCA approach considers each of the alternatives on each of the relevant attributes in order to ensure that all effects are considered when making decisions and reduce the likelihood of unintended consequences.

DOE program managers and project teams do not have the time or resources to conduct exhaustive data collection and assessment efforts to evaluate all potential alternatives over all decision criteria related to P2/WMin. The LCA provides a practical and streamlined yet analytically structured approach to deal with these problems. The decision-aiding approach needs to meet the following criteria:

- **Cost Effectiveness**. Data needed for the LCA must be straightforward to collect and the collection efforts must not require undue time or money. The process must be systematic and easily implemented.

- **Comprehensiveness of Decision Factors**. The LCA needs to encompass a range of decision factors to allow decision makers to understand the complex content of their decisions.

- **Defensible Results**. The outputs of the system must be replicable.

- **Standardization**. The approach must be standardized so that cross site/program comparisons are possible.

The LEHR P2 assessment team utilized the basic elements of this approach to analyze the five project-specific P2 alternatives identified during the site visit. The analysis performed on the LEHR P2 alternatives cannot be categorized as a **comprehensive** LCA, but more of a preliminary screening of the P2 alternatives or a qualified analysis, not a quantified analysis. This initial screening approach provides the LEHR site with data and decision criteria which can be the basis for a more detailed, quantified analysis if more detail is warranted. This preliminary, qualified analysis provides information and back-up case studies for discussions with stakeholders and regulators.

Many factors influence P2/WMin decisions. For the LEHR P2 alternatives, seven decision criteria were identified as having key importance at the LEHR site. These criteria are: cost;

environmental impacts; health and safety impacts; pollution prevention; schedule; regulatory requirements, and local economic impacts.

Each P2/WMin alternatives identified in the LEHR assessment was qualitatively evaluated on these seven criteria and an attribute table was developed. Each row in the attribute table refers to a proposed alternative, in the case of LEHR these are**:** No Action, Base Case, and P2 Alternative. The cells in the table represent initial, qualified assessments of how well each alternative meets each of the seven criterion. For each main criterion other than cost, a qualified assessment was made on a five-point scale, from best to worst.

Definitions for each criterion and how it was evaluated for this P2 assessment are addressed below.

Cost - The purpose of this criterion is to communicate to decision-makers the economic costs to the site associated with a particular alternative. This is not evaluated, just the straight implementation cost to the site is stated.

Environmental Impacts - The purpose of this criterion is to capture potential consequences an alternative may have upon the environment. These consequences may extend beyond the DOE site in question, for example to include impacts associated with loss of landfill space. The only environmental impact not included in the purview of this criterion is that associated with pollution prevention, as described below. The approach to operationalizing this criterion is to specify five subcriteria. Specifically, an alternative will be assessed as to its consequences upon: greenhouse gas (GHG) emissions; air quality; drinking water quality; land use; and biodiversity. Assessments are made for the several subcriteria over the same scale and are then aggregated into assessments for the main criterion.

Health and Safety Impacts- The purpose of this criterion is to capture the risk to public and worker health and safety directly attributable to an alternative. This criterion will be operationalized as expected number of fatalities in the exposed population of public and workers attributable to an alternative. This includes the risk to the total exposed population, from both radiological and non-radiological causes (e.g., chemical exposure, transportation accidents, and occupational accidents). For the LEHR assessment, this was evaluated in terms of potential risk to the onsite workers or local public. No quantified risk assessments were performed.   One piece of information was needed to make this assessment [over the scale] (exceed the acceptable crireria?) for expected fatalities.

Pollution Prevention- The purpose of this criterion is to estimate the amount of material disposed of in the environment. This includes all waste types. This may also include unique or special pollution prevention consequences of alternatives, such as energy conservation. Two pieces of information were needed to make this assessment [over the scale]; reduced waste generation and reduced waste generation of a regulatory waste.

Schedule Impacts- The purpose of this criterion is to capture the relationships between an alternative and the established site schedule. One piece of information was needed to make this assessment [over the scale], meets the baseline schedule or not.

Regulatory Impacts- The purpose of this criterion is to evaluate if there are regulatory issues that must be addressed. One piece of information was needed to make this assessment **[**over the scale**]**, meets current regulatory requirements

Local Economic Impacts- The purpose of this criterion is to capture the ability of an alternative to contribute to local and site jobs. The baseline approach will be to evaluate the number of jobs to be created and/or retained in the community that can be attributed to the alternative. One piece of information was needed to make this assessment **[**over the scale**]**, jobs.

The following section includes attribute tables for each P2 alternative as well as an analysis chart identifying why each alternative was given a particular rating.

Combined LLW Gravel/Cobble from Western Dog Pens and Ra/Sr Area Analysis Chart

Criterion	No Action	Base Case	Alternative
Cost	$0	$1,794K	$906K
Pollution Prevention Impact	No waste generated	Generates LLW	78% waste volume reduction in LLW
Health and Safety Impact	Least exposure/least accidents	More risk of transportation accidents	May have more worker exposure to contamination and equipment
Environmental Impact -air -drinking water -land use -biodiversity	Leaves some contamination in place, may limit land use scenarios	Fills up LLW disposal facilities	May increase NPDES discharge. Creates nominal volume of waste for sanitary landfill rather than significant LLW
Schedule	Easily meets schedule	Meets schedule	May impact schedule
Programmatic Regulatory Requirements	Does not meet regulatory requirements at this time	Meets regulatory requirements	May need to develop radiological release protocol
Local Economic Impacts	No work required except monitoring	No additional cost over that estimated for establishing the baseline	Requires increased upfront planning and local onsite work, this is offset by disposal cost savings

analysis chart

Ra/Sr Treatment Area LLW Concrete
Analysis Chart

Criterion	No Action	Base Case	Alternative
Cost	$0	$280K	$174K
Pollution Prevention Impact	No waste generated	Generates LLW	90% waste volume reduction in LLW
Health and Safety Impact	Least exposure/least accidents	More risk of transportation accidents	More worker exposure, confined space entry
Environmental Impact -air -drinking water -land use -biodiversity	Leaves some contamination in place, may limit land use scenarios	Fills up LLW disposal facilities	Scabbling may increase air emissions; Creates nominal volume of waste for sanitary landfill rather than significant LLW
Schedule	Easily meets schedule	Meets schedule	May impact schedule
Programmatic Regulatory Requirements	Does not meet regulatory requirements at this time	Meets regulatory requirements	May need to develop radiological release protocol
Local Economic Impacts	No work required except monitoring	No additional cost over that estimated for establishing the baseline	Requires increased upfront planning and local onsite work, this is offset by disposal cost savings

analysis chart

Western Dog Pens: LLW Concrete
Analysis Chart

Criterion	No Action	Base Case	Alternative
Cost	$0	$413K	$329K
Pollution Prevention Impact	No waste generated	Generates LLW	73% waste volume reduction in LLW
Health and Safety Impact	Least exposure/least accidents	More risk of transportation accidents	More worker exposure to contamination and equipment
Environmental Impact -air -drinking water -land use -biodiversity	Leaves some contamination in place, may limit land use scenarios	Fills up LLW disposal facilities	Scabbling may increase air emissions; Creates nominal volume of waste for sanitary landfill rather than significant LLW
Schedule	Easily meets schedule	Meets schedule	May impact schedule
Programmatic Regulatory Requirements	Does not meet regulatory requirements at this time	Meets regulatory requirements	Need to develop radiological release protocol
Local Economic Impacts	No work required except monitoring	No additional cost over that estimated for establishing the baseline	Requires increased upfront planning and local onsite work, this is offset by disposal cost savings

analysis chart

Western Dog Pens: LLW Asphalt
Analysis Chart

Criterion	No Action	Base Case	Alternative
Cost	$0	$420K	$350K
Pollution Prevention Impact	No waste generated	Generates LLW	70% waste volume reduction in LLW
Health and Safety Impact	Least exposure/least accidents	More risk of transportation accidents	More worker exposure to contamination and equipment
Environmental Impact -air -drinking water -land use -biodiversity	Leaves some contamination in place, may limit land use scenarios	Fills up LLW disposal facilities	Scabbling may increase air emissions; creates nominal volume of waste for sanitary landfill rather than significant LLW
Schedule	Easily meets schedule	Meets schedule	May impact schedule
Programmatic Regulatory Requirements	Does not meet regulatory requirements at this time	Meets regulatory requirements	Need to develop radiological release protocol
Local Economic Impacts	No work required except monitoring	No additional cost over that estimated for establishing the baseline	Requires increased upfront planning and local onsite work, this is offset by disposal cost savings

analysis chart

7.0 Conclusions and Path Forward

The P2 assessment methodology implemented at the LEHR site was successfully piloted and identified several cost-saving P2/WMin alternatives to the site baseline activities. The P2 assessment team also validated several activities planned at LEHR as best practices in terms of P2/WMin, including the incremental screening and segregating of soil during site Removal Actions.

The P2/WMin alternatives identified during the assessment, if successfully implemented, could save the site approximately \$1.1M over the remaining cleanup baseline of \$25M. More importantly for waste minimization purposes, the low level waste volumes destined for high cost LLW burial could be reduced by an estimated 2,900 cubic yards, or a reduction of 51 percent in LLW volumes (per ex situ LLW volumes forecasted for the baseline activities evaluated, including soils at ~ 5,650 cubic yards).

The opportunity with the most cost saving and implementable potential is the segregating and cleaning of the cobble and gravel from both the Western Dog Pens and the Ra/Sr Area. This alternative has the potential to reduce LLW volumes by 78% over the baseline LLW volume and save approximately \$888 K in baseline costs. The LEHR site has agreed to perform a feasibility evaluation of this alternative. Phase I, the pilot study, will be funded by EM-77. Phase II, the free release evaluation, Phase III, alternative development for the Engineering Evaluation and Cost Analysis (EE/CA), and Phase IV, Work Plan development will be performed by the site pending the successful results of Phase I. The pilot study will be completed within five months of funding authorization.

It should be noted that the LEHR site had previously identified and implemented other P2/WMin opportunities over the last five years which has saved the site over \$3.3M. Site personnel continue to evaluate and implement waste reducing and cost saving ideas as part of best business practices.

The P2 assessment methodology implemented at LEHR provided a hands-on process for the site personnel and expert team members to follow while discussing and evaluating site cleanup activities and waste volumes. Often, the aggressive application of waste reduction practices are overlooked when determining the means of remediating a contaminated site and, just as often, the associated reduction in the overall project costs are overlooked. Providing a formalized method to assess potential P2/WMin practices during the cleanup activities may help other sites reduce baseline costs and reduce cleanup schedules.

The process of flow charting the material/waste flow, per cleanup activity and including the forecasted waste volumes was an excellent exercise for the project teams to undertake. During the LEHR site assessment, this step in the methodology appeared to be the most helpful and useful to the project team. This step provided the visual connection for the project personnel between what happens in the field and the resulting waste generation. The brainstorming of ideas and the discussions that ensued during this exercise provided the most relevant and original P2/WMin alternatives.

This P2 assessment provided the LEHR site with the initial information necessary to perform a more quantified analysis of the identified P2 opportunities in order to determine the true life cycle cost of the P2 alternatives. It is recommended that the site do a more thorough evaluation of the alternatives and involve the stakeholders and regulators in the decision process. The most cost saving P2/WMin opportunities are primarily identified during project planning phases and in conjunction with waste forecasting activities.

The P2 assessment methodology should be applied to other sites in the DOE complex as a means of improving planned cleanup actions and maximizing efficiencies. The lessons learned from each site should be shared between all sites in an effort to improve the productivity of the DOE's massive cleanup program.

Appendix A

Pollution Prevention Assessment Methodology

Pollution Prevention Assessment Methodology

The assessment methodology consists of three phases:

- Training site environmental personnel (ER project managers and project teams) on the applications of P2/WMin to cleanup activities,
- Identifying and formulating an expert team and performing the assessment, and
- Writing a final report on the potential opportunities to reduce project wastes and costs.

Figure 1 is a flow diagram of the steps in the P2 Assessment Methodology. Each step in the flow diagram will be briefly discussed below.

Step 1 - Select Site or Activity with Established Baseline Costs

Site selection was discussed previously and is extremely important to the deployment of the methodology. Actual project selection is just as important. The more discrete and focused the cleanup project, the more chance for success in identifying and deploying an opportunity. The availability of forecasted waste volumes, waste types, and cost data is essential. Without this information, it is impossible to track and measure the success of a P2/WMin action on the projects baseline. Fiscal year baseline data on waste volume and project costs are reviewed for accuracy and completeness by the site project personnel. A final attribute is the acceptance of the assessment by the project manager and all the personnel involved in the selected cleanup project. Their help is critical in defining the assessment limits, the baseline and cost data, providing site-specific data, and addressing any questions the expert team may have during the course of the assessment. Their willingness to work with the expert team and is essential to the success of the DOE's expert team approach.

Step 2 - Determine/Define Waste Streams, Volumes, and Forecasted Disposition Costs and Review for Accuracy

This step has been discussed briefly in Step 1 and must be done in order to track and measure the effect a P2/WMin action has on a projects waste volume and baseline cost and provides a benchmark for assessing potential P2 opportunities. This step also provides the expert team with the waste stream data needed to begin the assessment process.

Step 3 - Select Team Members with Expertise in Areas of Concern

The expert team approach was developed by DOE to utilize experts from across the complex to assist ER project managers and teams with innovative ideas and approaches used at other DOE sites with similar problems. Each site or project has very specific contaminants and waste matrices to deal with during cleanup projects as well as site specific policy, regulatory, logistical, and administrative concerns. This must be taken into account when selecting experts for the team. The LEHR expert team was selected based upon the residual radioactivity concerns (volumetric contamination) of concrete, asphalt, and soils as well as, concerns for the treatment of chlordane contaminated soils. The LEHR site also had Ra-226 and Sr-90 issues which were fairly specific for that site. The experts were selected based upon the project needs and the acceptance of the expert team member by DOE and site personnel.

Step 4 - Site Provides Baseline Activity Flow Diagrams

The project manager **was** asked for brief and simple material process flow diagrams for each forecasted waste stream generated by the project (this includes the forecasted waste stream volume, baseline cost for that waste stream, and disposition alternative chosen as well as the path from the point of generation to final disposition). The flow diagrams were used during the actual site visit/assessment as a starting point for the opportunity identification.

Step 5 - Gather Preliminary Site Information

The next step was to assemble project information. Information gathered may include: project waste volume estimates and baseline cost data, work plans, schedules and milestones, technical baseline documents such as risk assessments, RI/FS reports, cleanup criteria, facility end use reports, stakeholder meetings/comments, residual radioactivity analysis, etc. Basically, whatever background data available on the project was assembled and transmitted to the expert team members.

A series of conference calls between the expert team members, DOE HQ and site personnel were conducted prior to the site visits to clarify issues and ask any questions prior to the assessment.

Step 6 - Tailor Training

This step involved the modification of existing training modules for ER personnel based upon information gathered in Step 5. The training modules "P2/WMin Training Modules for ER Personnel" developed by EM-40 were the basis for each training session. The two modules (one for project managers and one for project teams) were used and tailored to the LEHR site. The training was combined into one session, at the request of site personnel. The training was modified to include the specific sites interests, cleanup phase, current and upcoming projects, site cleanup criteria, site end use, disposal costs, site contaminants and waste streams. Site-specific waste management issues were addressed individually in the training sessions.

Step 7 - Conduct Training; Perform Onsite Assessment

The assessment began with an initial screening of alternatives utilizing the activity baseline flow diagrams (for each project waste stream) generated by the project personnel prior to the visit. Using the site FY baseline waste stream data and the activity flow diagrams, the team and the site personnel evaluated each project waste stream for alternatives to the projected baseline action. A chart was developed for each project waste stream which included: waste stream, forecasted waste volume, baseline cost, waste type, baseline activity, the potential P2/WMin opportunity, schedule or milestone impacts, and any actions or challenges associated with the activity. The team, as well as site personnel, brainstormed ideas/opportunities and discussed feasibility.

Step 8 - Identify Potential P2/WMin Opportunities

The opportunities termed "feasible" were split between the team members (based upon area of expertise) for more extensive evaluations.

Step 9 - Research/Collect Additional Information/Refine Assumptions/Draw Flow Diagrams

Following the site visit, the team members performed more detailed feasibility analysis of the selected opportunities and developed a material flow diagram (mirroring the baseline flow diagrams) for the opportunity. The opportunity flow diagram included the waste stream, the baseline waste volume, and the material flow based upon the alternative to the baseline. Each box in the flow diagram included what happens during that step and the expected impact on the waste volume. Cost data (unit and total cost) was plugged in to the steps in the flow diagram based upon the costs used in the baseline flow diagrams in order to compare the alternatives by unit costs and total waste generation. All assumptions for each opportunity were clearly defined. The opportunity flow diagrams also included waste volume reduced and baseline cost reduction, where appropriate.

Step 10 - Evaluate Opportunities

After the team members developed the opportunity flow diagrams and the anticipated cost reduction, a simple, qualified analysis or preliminary life-cycle analysis (LCA) was performed on the opportunity to determine if the opportunity was worth pursuing**.** The preliminary LCA also was done to compare the alternatives (the baseline versus the opportunity) and select a preferred alternative (which may be the baseline activity).

The LCA approach helps people understand the problems they face, construct decision alternatives to solve the problem, specify criteria (attributes) to judge decision alternatives, and make trade-offs among decision alternatives and criteria to arrive at reasonable and defensible decisions. The LCA approach considered each of the alternatives and each relevant attribute in order to ensure that all effects are considered to make decisions and reduce the likelihood of unintended consequences. Specific evaluation criteria for the LCA will included: total cost to the government (project and program), environmental impacts, health and safety impacts, pollution prevention, schedule impacts, regulatory requirements, and local economic impacts (the number of jobs to be created and/or retained in the community that can be attributed to the alternative).

In performing the qualified LCA analysis, the basic principle used in determining the appropriate level of the evaluation effort was that the resources expended should be commensurate with the value of the information in supporting a management decision. Team members, as well as the site personnel supplied information needed to support the preliminary analysis. The end result of the qualified analysis was an attribute table showing which alternative (no action, baseline

approach, or P2 alternative) is best or worst within each evaluation criterion, supported by cost tables, flow diagrams, and decision comments.
The preliminary LCA was performed using a modified approach of the LCA Analysis developed by the Oak Ridge National Laboratory. A true (quantified and qualified) LCA may need to be performed on each alternative if the site decides to pursue the implementation of an alternative.

Step 11 - Write Report

The final P2 assessment report was written and includes the material flow diagrams for both the baseline activity as well as the alternative. The preliminary life-cycle analysis including qualitative attribute analysis, will be presented in a matrix format which is easily interpretable. The alternatives to the baseline activity are expressed so that specific attributes will be easily identified as being either positively or negatively affected.

The report also includes any case studies from other DOE sites which are relevant to the alternative as well as performance data, cost of implementation, waste reduced, cost avoided etc, from the implementation of the activity.

Step 12 - Assist Site with Proof-of-Concept, if Needed

The final report also includes a simple implementation plan for the deployment of the selected alternatives. The implementation plan will lays out a path forward for each alternative with steps identified for the project managers. If an alternative needs a "proof of principle" study performed to determine feasibility, the report also specifies a path forward to investigate such a study such as, technology contact person, issues to be addresses, amount of waste needed to perform the study, cost, time needed for the study, and a schedule.

The above 12 steps were executed during the LEHR Site P2 Assessment. The results will be presented in the following sections.

Appendix B

LEHR Pollution Prevention Baseline Data