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Oak Ridge National Laboratory

Liquid & Gaseous Waste Treatment System Strategic Plan

August 2003

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OAK RIDGE NATIONAL LABORATORY
LIQUID AND GASEOUS WASTE TREATMENT SYSTEM (LGWTS)
STRATEGIC PLAN

August 2003

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http://eshtraining.ornl.gov/eshq/EPWS/EM_Program/pdfs/LGWTS_OIP/LGWTS_Strategic_Plan.pdf

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ACRONYMS AND ABBREVIATIONS

%	percent
ADS	activity data sheets
AFDCS	Active Facilities Data Collection System
Ag	silver
ALARA	as-low-as-reasonably-achievable
^{241}Am	americium-241
AMCL	Advanced Materials Characterization Laboratory
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
BJC	Bechtel Jacobs Company, LLC
BOD	biological oxygen demand
BNL	Brookhaven National Laboratory
Bq	becquerel
Bq/L	becquerels per liter
BVESTs	Bethel Valley Evaporator Service Tanks
Ci	curies
CEM	continuous emissions monitoring
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CH	contact-handled
CNMS	Center for Nanophase Materials Sciences
Cr	chromium
^{137}Cs	cesium-137
Cu	copper
DCG	derived concentration guide
D&D	decontaminate and decommission
DOE	U.S. Department of Energy
DOT	Department of Transportation
EM	Office of Environmental Management
EPA	Environmental Protection Agency
ES&H	environmental, safety, and health
ESH&Q	Environment, Safety, Health, & Quality Directorate
°F	degrees Fahrenheit
FEVA	Facility Environmental Vulnerability Assessment
FFA	Federal Facilities Agreement
F&O	Facilities & Operations Directorate
FRP	Facilities Revitalization Project
FTE	full-time equivalent

FWENC	Foster Wheeler Environmental Corporation
FY	fiscal year
GAC	granular activated carbon
gal	gallon
gal/month	gallons per month
gal/yr	gallons per year
GPE	general plant equipment project
gpm	gallons per minute
GPP	general plant project
^{3}H	tritium
HEPA	high efficiency particulate air
HFIR	High Flux Isotope Reactor
Hg	mercury
HOG	hot off-gas
IGPP	institutional general plant project
JIBS	Joint Institute for Biological Sciences
JICS	Joint Institute for Computational Sciences
JINS	Joint Institute for Neutron Sciences
kw	kilowatt
LGCF	Laboratory for Comparative and Functional Genomics
LGWTS	Liquid and Gaseous Waste Treatment System
LLW	low-level waste
LLLW	liquid low-level waste
m^{3}	cubic meter
mCi	millicuries
mgy	million gallons per year
mg/L	milligrams per liter
M&I	management and integrating
M&O	management and operating
mrem	millirem
mR/hr	milliroentgen per hour
MSRE	Molten Salt Reactor Experiment
MVSTs	Melton Valley Storage Tanks
nCi/ml	nanocuries per milliliter
NE	Office of Nuclear Energy, Science, and Technology
NPDES	National Pollutant Discharge Elimination System
NTS	Nevada Test Site
OIP	Operations Improvement Program
ORCAS	Oak Ridge Center for Advanced Studies
ORO	Oak Ridge Operations
ORNL	Oak Ridge National Laboratory

OSR	Operational Safety Requirement
Pb	lead
POTWs	publicly owned treatment works
ppm	parts per million
PNNL	Pacific Northwest National Laboratory
psig	pounds per square inch gauge
PVC	polyvinylchloride
PWTC	Process Waste Treatment Complex
RCRA	Resource Conservation and Recovery Act
R&D	research and development
REDC	Radiochemical Engineering Development Center
RH	remote-handled
RPM	Risk-Based Priority Model
SANS	Small-Angle Neutron Scattering
SBHE	special building hot exhaust
SBMS	Standards-Based Management System
SC	Office of Science
SHADES	shielded hot air drum evaporator system
SNS	Spallation Neutron Source
^{90}Sr	strontium-90
STP	Sewage Treatment Plant
SWSAs	Solid Waste Storage Areas
TCLP	toxic characteristics leaching procedure
TDEC	Tennessee Department of Environment and Conservation
^{229}Th	thorium-229
TSS	total suspended solids
TRU	transuranic
^{233}U	uranium-233
^{235}U	uranium-235
^{238}U	uranium-238
U.S.	United States of America
UT-B	UT-Battelle, LLC
WAC	waste acceptance criteria
WDC	wastewater discharge criteria
WIPP	Waste Isolation Pilot Plant
WPF	Waste Processing Facility
WWTU	wastewater treatment unit
Y-12	Y-12 National Security Complex
Zn	zinc

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EXECUTIVE SUMMARY

Oak Ridge National Laboratory (ORNL) is the nation's largest and most diverse energy research and development (R&D) institution in the U.S. Department of Energy (DOE) laboratory complex. To accomplish its mission of scientific research, ORNL staff is dependent upon the availability of a wide variety of facilities and equipment, including specialized experimental laboratories, user facilities, hot cells, and nuclear reactors, and their associated waste collection and treatment systems. Many of ORNL's physical facilities are quite old, and many are reaching the end of their safe operating life. The DOE Office of Science (SC) has implemented the "Laboratories of the 21st Century" initiative to accomplish full modernization of the laboratories managed by DOE-SC by 2012. UT-Battelle, LLC, (UT-B) the ORNL management and operating contractor for DOE-SC, has initiated the Facilities Revitalization Project to upgrade ORNL's research facilities and associated infrastructure by 2011 to support the DOE-SC initiative. Most of the waste treatment systems, particularly the waste collection systems, were installed in the 1950s and need to be modernized as the rest of the ORNL campus revitalization is conducted.

The *ORNL Liquid and Gaseous Waste Treatment System (LGWTS) Strategic Plan* provides a prioritized roadmap for the development of cost-effective and upgraded liquid and gaseous waste collection and treatment systems as a part of the revitalization effort to modernize ORNL into one of DOE's premier "21st Century Laboratories". Waste management activities at ORNL, with the exception of the sanitary/sewage waste system and industrial and storm water runoff, are currently managed by Bechtel Jacobs Company LLC (BJC), the DOE Office of Environmental Management (EM) management and integrating contractor. DOE-EM's mission is currently planned to end at the ORNL site when the Comprehensive Environmental Response, Compensation, and Liability Act Record of Decision requirements for Bethel and Melton Valleys have been implemented, which is expected to be in the 2015 timeframe. DOE-EM proposes to transfer responsibility for newly-generated waste management to DOE-SC prior to 2015. Final agreement between DOE-EM and DOE-SC on the transition dates for newly-generated waste and existing waste treatment systems (if needed to support the DOE-SC mission) has not been reached.

Studies associated with the development of this strategic plan considered the age, legacy contamination, size of the facilities for treatment of R&D waste, physical location, and operating costs of the existing treatment systems, and concluded that DOE should construct new liquid and gaseous waste collection and treatment facilities to support the long-term missions at ORNL. Figure E-1 is a plan view of the resulting "21st Century" waste systems. Existing liquid and gaseous waste treatment systems will be replaced with more efficient systems, specifically designed to treat R&D-generated waste, which will significantly reduce their operating costs. The new systems will also provide capabilities to solidify liquid low-level waste (LLLW) for disposal; a capability that the existing LLLW system does not provide.

The strategy is to construct and operate the proposed new liquid and gaseous waste management facilities by the end of 2010 to be consistent with UT-B's goal to revitalize ORNL's infrastructure by 2011 to meet the DOE-SC programmatic schedule for the "Laboratories of the 21st Century" initiative as outlined in the *ORNL Land and Facilities Plan*[1]. This timeframe is compatible with the DOE-EM remediation schedule for Bethel Valley, which is scheduled to begin in FY10. The strategy will allow DOE-EM to operate the existing waste treatment systems as needed for closure activities, and then cost-effectively decontaminate and decommission (D&D) the facilities. DOE-EM is more experienced with D&D, and cost savings can potentially be achieved if the remediation of the existing waste collection and treatment facilities is combined with other DOE-EM remediation activities through one integrated project.

[1] ORNL/TM-2002/1

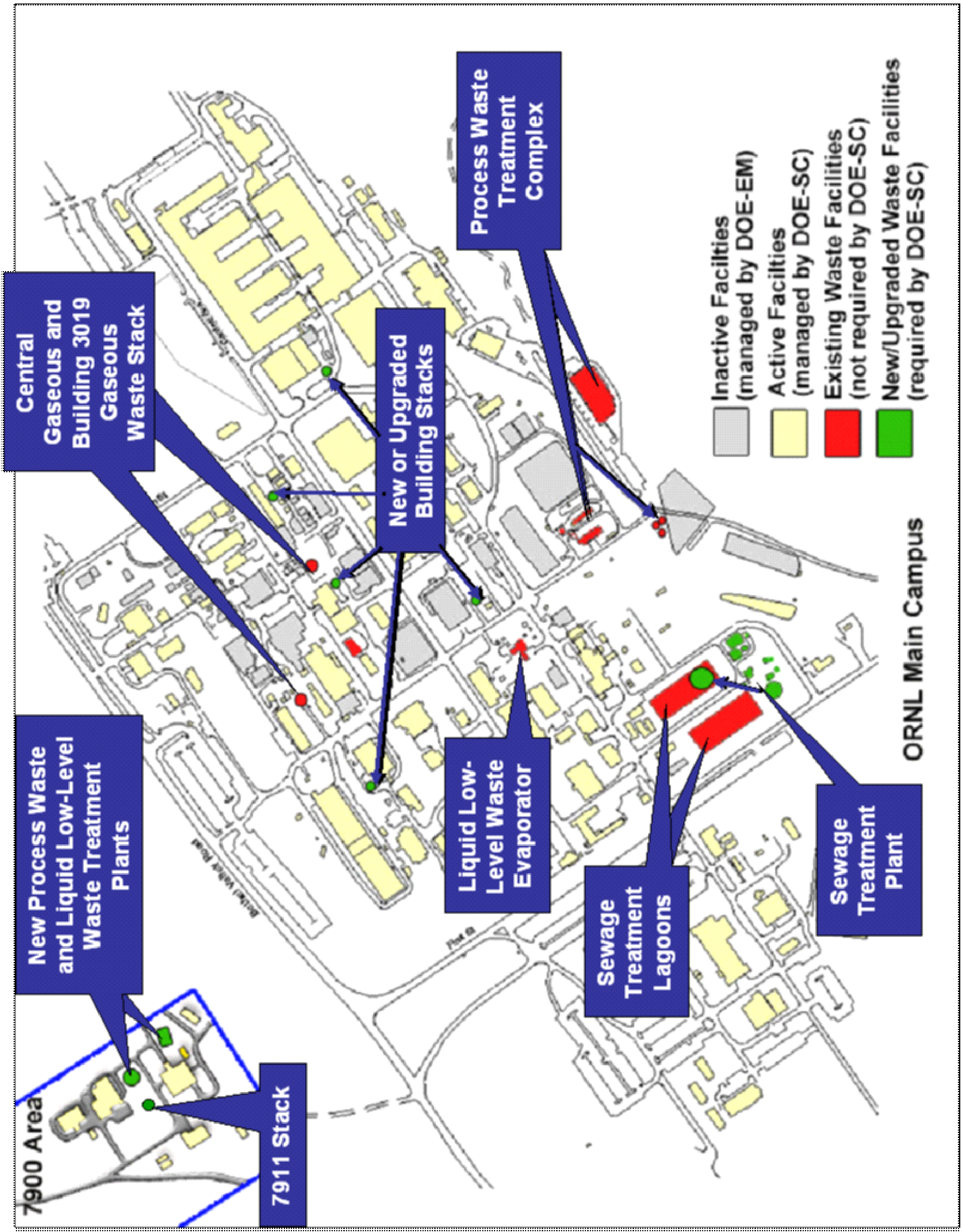


Figure E-1. Future ORNL waste management systems are located at generator sites and minimize underground collection piping.

The liquid and gaseous waste management strategy will consolidate new radioactive wastewater treatment systems in Melton Valley and eliminate the use of the aging centralized gaseous waste, process waste, and LLLW systems, which are primarily located in Bethel Valley on the ORNL Central Campus. Facilities to process newly-generated R&D waste, recommended in this strategic plan, are scoped to accommodate existing and new waste streams; such as those expected to be generated by the Spallation Neutron Source (SNS) and proposed Nuclear Initiative programs. Nuclear and radiological R&D facilities in Bethel Valley will have local gaseous waste handling systems and local LLLW collection systems. This will allow upgrades to be implemented on a building-by-building basis as hot cell consolidation activities and the ORNL Ten Year Site Plan evolve.

The *ORNL LGWTS Strategic Plan* supports pollution prevention goals by segregating hazardous wastes at the source of generation and reducing the volumes of generated liquid wastes. This strategic approach will reduce environmental, safety, and health (ES&H) related risks by eliminating the use of existing underground piping for wastewater collection (except for the sanitary/sewage waste system) and minimizing long-term storage of LLLW in underground storage tanks.

The strategy will be implemented primarily through a combination of DOE general plant projects (GPPs) and line item capital projects totaling $74.2 Million over nine years, as indicated in Figures E-2 and E-3. Expense funding totaling $4.7 Million is also needed to support these projects. The annual operating cost of the new, modernized liquid and gaseous waste collection and treatment facilities is estimated to be $5.2 Million per year. The annual operating and environmental monitoring costs for the current centralized liquid and gaseous waste treatment systems is approximately $19.3 Million per year. Therefore, the total cost avoidance for construction and a 30-year operating life, compared to the current system, would be $423 Million, or over $14 Million per year. The cost of the treatment system construction would be repaid in about 5.6 years. This return on investment does not reflect the cost avoidance for maintenance/modification that would be required to keep the existing systems operating for an additional 30 years, or the costs to D&D the existing system. The annual operating and environmental monitoring costs for the existing system also do not include costs for solidification and disposal of LLLW. If these costs were included in the above calculations, the construction costs would be repaid in less than 3 years. Clearly, continuing with “business-as-usual” will result in a higher costs than implementing the “modernization approach” proposed in this strategic plan.

The proposed schedule for the liquid and gaseous waste system capital projects was developed to:

- implement operations of waste management facilities designed to meet DOE-SC/UT-B R&D needs by no later than the end of FY10, in order to facilitate the D&D of the existing DOE-EM/BJC-managed waste management systems during DOE-EM remediation activities,
- implement new treatment capabilities as required to meet the research community’s needs,
- reduce impacts to the environment in the near term, and
- optimize the use of DOE resources by implementing projects with potential for near-term payback first.

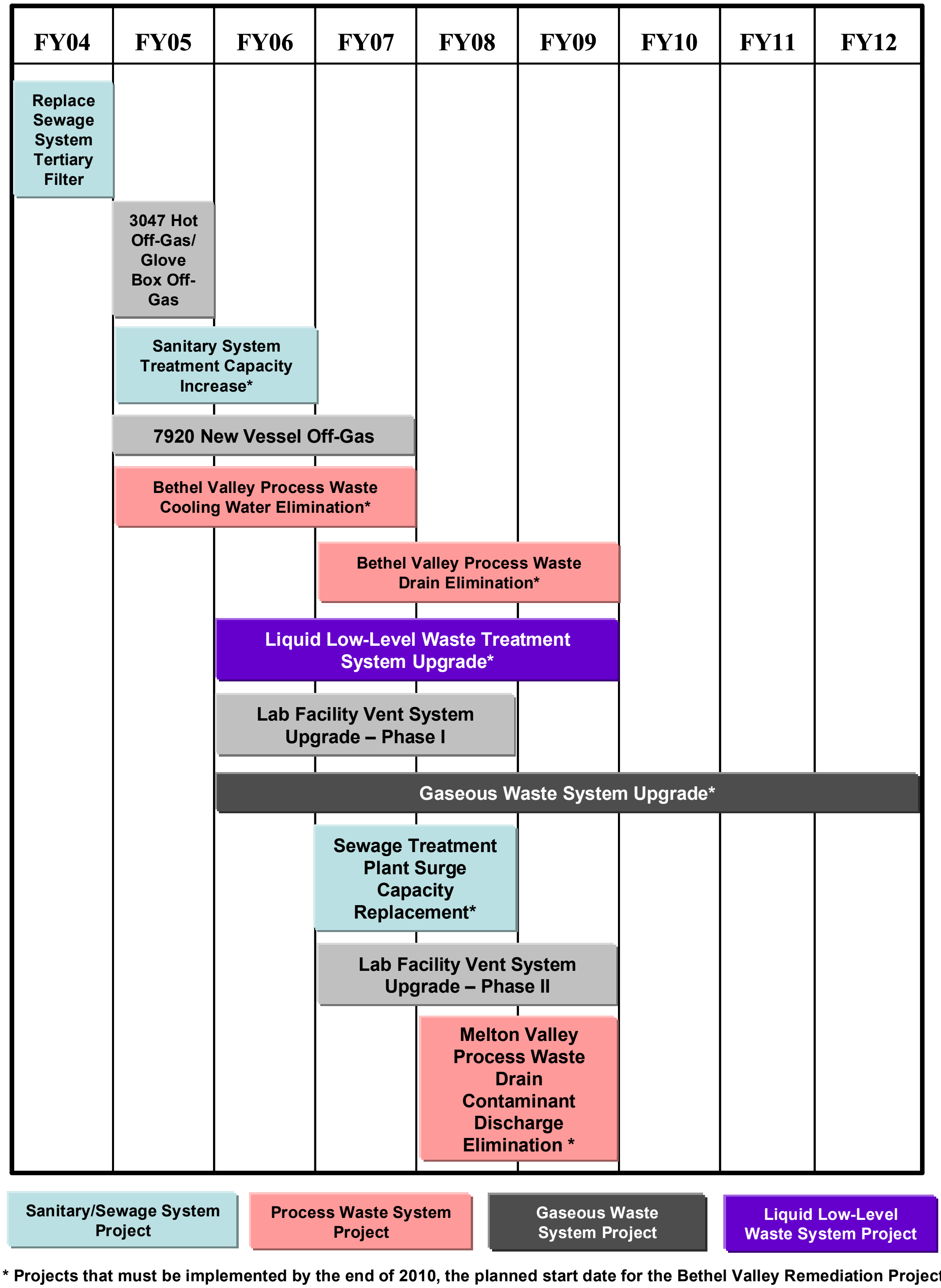
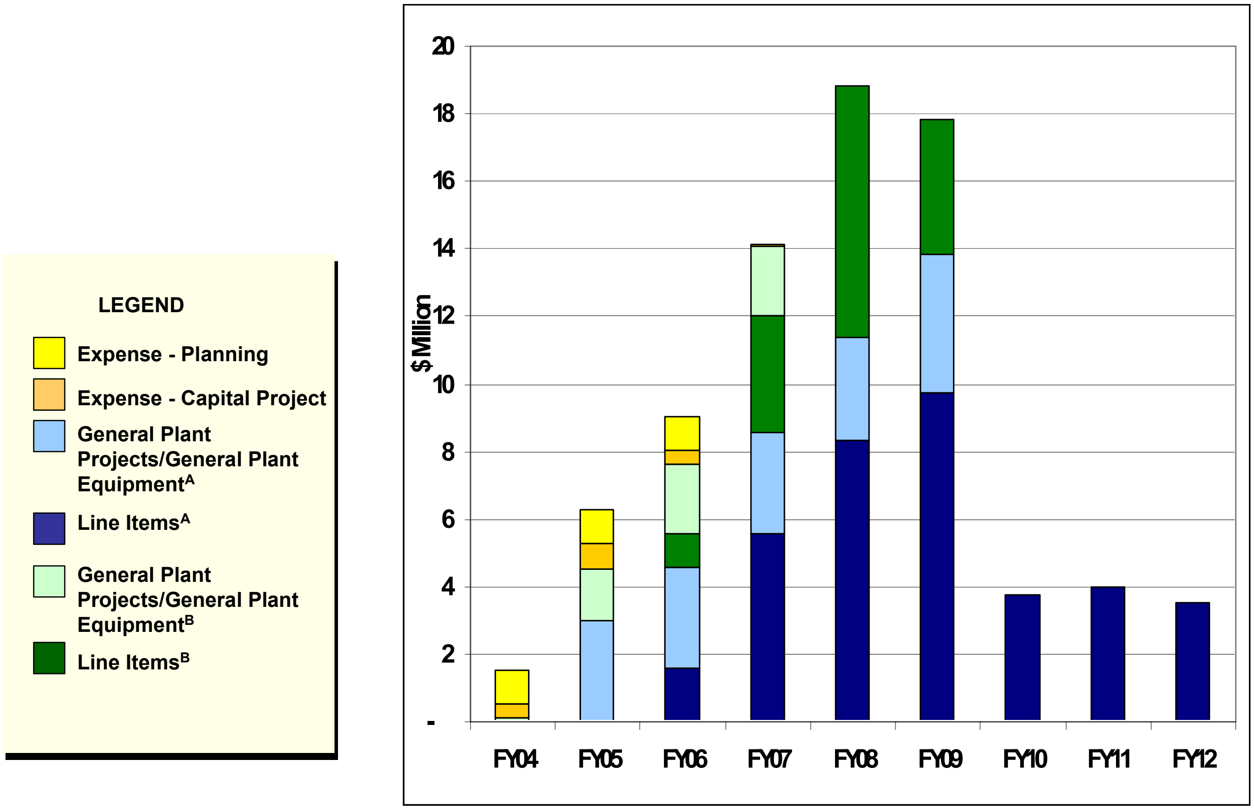


Figure E-2. Preliminary schedule for implementing the Oak Ridge National Laboratory Liquid and Gaseous Waste Treatment System Strategic Plan.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	Total
Expense - Planning	1.0	1.0	1.0	-	-	-	-	-	-	3.00
Expense - Capital Project	0.4	0.75	0.45	0.1	-	-	-	-	-	1.70
General Plant Projects/General Plant Equipment[A]		3.0	3.0	3.0	3.0	4.1	-	-	-	16.10
Line Items[A]	-	-	1.6	5.55	8.35	9.75	3.75	4.0	3.5	36.50
General Plant Projects/General Plant Equipment[B]	0.1	1.5	2.0	2.0	-	-	-	-	-	5.60
Line Items[B]	-	-	1.0	3.5	7.5	4.0	-	-	-	16.00
									GRAND TOTAL	78.90

A. Must be implemented by the end of 2010 to meet DOE-EM remediation schedule for existing treatment facilities

B. Must be implemented to upgrade existing facilities to continue operations for an additional 50 years.

Figure E-3. Estimated funding requirements to implement liquid and gaseous waste system modernization.

Following is a brief discussion about the proposed scope and schedule and for each waste system.

Sanitary/Sewage Waste System – The recommended sanitary/sewage waste system GPPs should be implemented immediately to accommodate consolidation of off-site ORNL staff to the main ORNL campus; increase the system's capacity to accommodate personnel growth; and prepare for the diversion of process wastewater to the system. The results of ongoing activities to reduce inleakage into the sanitary/sewage collection system will be used to refine the scope of these projects.

Process Waste System - Because UT-B's once-through cooling water and R&D waste accounts for 65% of the process wastewater flow, the process waste related GPPs should be implemented immediately to reduce the near-term Process Waste Treatment Complex costs and eliminate environmental vulnerabilities associated with the use of underground process waste system piping. The costs of operating the process waste system could be reduced in the near term if the inflow can be reduced enough to allow the system to be operated on a part-time basis rather than around-the-clock.

Gaseous Waste System - A line item capital project is proposed to replace the existing centralized gaseous waste system by the end of FY10, and to upgrade existing building stacks that are still needed by the end of FY12. In order to meet the DOE-EM remediation schedule, the gaseous waste system line item requires a conceptual design report in FY05 and design in FY06. Engineering evaluations needed to support the conceptual design reports must be implemented in FY04. They will include refining the scope of the project to reflect the outcome of ongoing hot cell consolidation activities and proposed ORNL Nuclear Initiative programs.

LLLW System - A line item capital project is proposed to replace the existing LLLW system, add pretreatment capabilities at select generator sites, and install new capabilities to solidify LLLW in preparation for disposal. In order to meet the DOE-EM remediation schedule, the LLLW system line item requires a conceptual design report in FY05 and design in FY06. Engineering evaluations and technical studies needed to support the conceptual design reports must be implemented in FY04. These requirements will depend on the development of the National Transuranic (TRU) Waste Program's waste acceptance criteria (WAC) for remote-handled (RH) TRU waste at the Waste Isolation Pilot Plant (WIPP), located in New Mexico; the outcome of ongoing hot cell consolidation activities; proposed ORNL Nuclear Initiative programs; and the updated SNS Waste Management Plan.

The FY03 analysis of the LLLW system identified a potential future unfunded vulnerability; there will be no capabilities at ORNL to process future newly-generated LLLW for disposal. The existing LLLW system only collects, concentrates, and stores LLLW. Foster Wheeler Environmental Corporation was awarded a DOE-EM contract to solidify and dispose of ORNL's existing inventory of stored LLLW and TRU wastes at the TRU Waste Processing Facility (WPF), which is scheduled to stop accepting newly generated LLLW in the FY05/FY06 timeframe. This *ORNL LGWTS Strategic Plan* develops an approach for addressing future LLLW generated by DOE-SC/UT-B by no later than FY10. However, a significant volume of LLLW could be generated by DOE-EM remediation activities and the DOE Office of Nuclear Energy, Science, and Technology (NE) uranium-233 processing activities through 2014. There is not an existing plan or funding in place to address processing these LLLW streams.

The *ORNL LGWTS Strategic Plan* defines efficient state-of-the-art facilities to support ORNL on a schedule that is compatible with DOE-SC mission needs. These new liquid and gaseous waste management facilities will be designed and sized to efficiently treat research-generated waste, minimize waste management operating costs, and reduce ES&H risks by minimizing the use of underground collection systems and long-term storage of LLLW in tanks. The new systems will be less expensive to operate than the existing DOE-EM-managed facilities, and construction costs will be repaid in approximately 5.6 years. The new LLLW system will also include the capability to routinely solidify LLLW in preparation for disposal.

1. INTRODUCTION

Excellence in Laboratory operations is one of the three key goals of the Oak Ridge National Laboratory (ORNL) Agenda. That goal will be met through comprehensive upgrades of facilities and operational approaches over the next few years. Many of ORNL's physical facilities, including the liquid and gaseous waste collection and treatment systems, are quite old, and are reaching the end of their safe operating life. The condition of research facilities and supporting infrastructure, including the waste handling facilities, is a key environmental, safety and health (ES&H) concern. The existing infrastructure will add considerably to the overhead costs of research due to increased maintenance and operating costs as these facilities continue to age. The Liquid Gaseous Waste Treatment System (LGWTS) Re-engineering Project is a UT-Battelle, LLC (UT-B) Operations Improvement Program (OIP) project that was undertaken to develop a plan for upgrading the ORNL liquid and gaseous waste systems to support ORNL's research mission.

1.1 DEFINITIONS

The definitions of waste management terms used in this document, and included in Table 1-1, were taken from the ORNL Environmental Management System, which is maintained by UT-B on the ORNL Standards-Based Management System (SBMS).

Table 1-1. Definition of waste management terms used in the *ORNL Liquid and Gaseous Waste Treatment System Strategic Plan*.

Term	Definition
incidental process wastewater	Non-radiological and/or pretreated research-generated process wastewater that meets the UT-B process wastewater discharge criteria.
liquid low-level waste	Aqueous liquid waste containing radionuclide constituents at the concentrations described in the ORNL Waste Acceptance Criteria for LLLW (i.e., maximum total radionuclide concentration of the ingestion dose equivalent of 2×10^{10} Becquerels per liter {Bq/L} of strontium-90).
major source	A point source with a potential to discharge radioactive airborne emissions, which would result in an effective dose equivalent to any member of the public greater than or equal to 0.1 mrem.
minor source	A point source with a potential to discharge radioactive airborne emissions, which would result in an effective dose equivalent to any member of the public of less than 0.1 mrem.
non-radioactive process wastewater	Wastewater with no radionuclide constituents or with radionuclide constituents below the concentrations described in the ORNL waste acceptance criteria for the Process Waste Treatment Complex Building 3608 (non-radioactive process wastewater treatment plant) (i.e., less than the derived concentration guide levels of radioactivity).
process wastewater	Aqueous liquid wastewater containing radionuclide and/or metal or organic pollutant constituents as described in ORNL Waste Acceptance Criteria for the ORNL Process Waste Treatment Complex.
radioactive process wastewater	Wastewater with radionuclide constituents above the concentrations described in the ORNL Waste Acceptance Criteria for the Process Waste Treatment Complex Building 3544 (i.e., a maximum total radiological concentration of the ingestion dose equivalent of 1×10^4 Bq/L of strontium-90).
sanitary wastewater	Aqueous liquid wastewaters containing biodegradable constituents (e.g., from restrooms, food preparation, and laundry facilities).
transuranic (TRU) waste	Radioactive waste containing more than 100 nanocuries (3,700 Bq) of alpha-emitting transuranic isotopes per gram of waste at the time of assay, with half-lives greater than 20 years, except for: 1) High-level radioactive waste; 2) Waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the *Title 40 Code of Federal Regulations, Part 191* (*40 CFR Part 191)* disposal regulations; or 3) Waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with *10 CFR Part 61*.
Wastewater discharge criteria	Waste disposal criteria defined by UT-B for discharge of wastewaters into ORNL waste drain systems.

1.2 OVERVIEW OF CONTRACTORS AT ORNL AND ASSOCIATED RESPONSIBILITIES

ORNL is a multipurpose laboratory, which receives research funding from the U.S. Department of Energy (DOE) Office of Science (SC), as well as other DOE Offices and government agencies. DOE-SC is the landlord for ORNL and has the responsibility for facility operations. UT-B is the DOE-SC management and operating (M&O) contractor for ORNL. UT-B has responsibility for Bethel Valley and Melton Valley sites and surrounding areas, with the exception of facilities and activities managed by the DOE Office of Environmental Management (EM) prime contractors. Bechtel Jacobs Company LLC (BJC) is the management and integrating (M&I) contractor for DOE-EM remediation activities. Foster Wheeler Environmental Company (FWENC) is the contractor for the DOE-EM funded Transuranic (TRU) Waste Processing Facility (WPF), which is being constructed to process ORNL's legacy TRU wastes, including legacy liquid low-level waste (LLLW). Beginning in fiscal year 2004 (FY04), the DOE Office of Nuclear Energy, Science and Technology (NE) will begin managing the 3019A complex. DOE-NE is in the process of establishing a separate contract for a contractor to process uranium-233 (^{233}U) stored in Building 3019A.

UT-B manages ORNL's active research and development (R&D) facilities, and is responsible for the sanitary/sewage waste system, coal yard runoff, and storm water runoff. BJC is responsible for operating the remaining liquid and gaseous waste systems, storing and transporting solid waste (except for hazardous waste), remediating contaminated soils and groundwater, and decontaminating and decommissioning (D&D) inactive contaminated facilities. FWENC is responsible for the construction and operation of the temporary TRU WPF and will process/treat legacy TRU solid waste and the existing inventory of legacy LLLW (and associated TRU sludge) stored in the Melton Valley Storage Tanks (MVSTs) system for disposal. UT-B and the selected DOE-NE contractor for the 3019A complex are responsible for characterizing, packaging, and certifying their solid waste.

The DOE-EM mission is currently planned to end at the ORNL site when the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision requirements have been implemented for Melton and Bethel Valleys, which is expected to be in the 2015 timeframe. DOE-EM proposes to transfer responsibility for newly-generated waste management to DOE-SC prior to 2015. Final agreement between DOE-EM and DOE-SC on the transition dates for newly-generated waste and the existing facilities has not been reached. The *ORNL Liquid and Gaseous Waste Treatment System (LGWTS) Strategic Plan* recommends that DOE implement new liquid and gaseous waste treatment facilities to treat research-generated waste by the end of FY10. DOE-EM should maintain responsibility for the D&D of existing liquid and gaseous waste treatment facilities after they have served in accomplishing DOE-EM's closure plan. DOE-EM is more experienced with D&D activities, and there are potential cost-savings if the remediation of these waste collection and treatment facilities is combined with other DOE-EM remediation activities.

1.3 WHAT THIS STRATEGIC PLAN INCLUDES

Revitalization of the ORNL campus is a key initiative of UT-B. The *ORNL LGWTS Strategic Plan* supports the revitalization effort by providing a roadmap for the development of cost-effective and upgraded liquid and gaseous waste collection and treatment systems for DOE-SC research facilities. This plan covers the collection and treatment systems for gaseous waste, process waste, LLLW, and sanitary/sewage waste. It does not cover solid waste or concentrated hazardous and mixed chemical wastes from research laboratories that are currently collected in containers for treatment and disposal.

The *ORNL LGWTS Strategic Plan* identifies the waste management facilities needed to support the DOE-SC mission for the next 50 years. The following sections provide details of this strategic plan for upgrading/replacing ORNL's liquid and gaseous waste collection and treatment systems, which will

- help avoid or significantly reduce costs and ES&H risks associated with the continued operation of the aged, central liquid and gaseous treatment facilities;
- reduce the likelihood of environmental releases by eliminating the use of the aged, underground LLLW and process waste collection system piping;
- respond to ORNL's expected future programmatic mission activities;
- establish safe and efficient liquid and gaseous waste systems for the Laboratory's strategic facilities; and
- identify funding requirements to accomplish these objectives.

The *ORNL LGWTS Strategic Plan* provides:

- a brief overview of the LGWTS Re-engineering Project established to develop this prioritized strategic plan (Chapter 2);
- an assessment of the current and future waste generation rates at ORNL (Chapter 3);
- a summary of benchmarking studies conducted to support the LGTWS strategy (Chapter 4);
- a review of the current and planned waste collection and treatment facilities (Chapter 5);
- the proposed strategic plan for upgrading ORNL's liquid and gaseous waste collection and treatment systems (Chapter 6);
- the preliminary cost and schedule estimates for completing the proposed strategy (Chapter 7); and
- conclusions and recommendations of the strategic planning exercise (Chapter 8).

Supporting documentation is provided in the appendices of this document. This strategic plan is a living document that is expected to be revised based on future studies and actions. Updates will be included in the future ORNL Ten Year Plan.

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2. PROJECT SCOPE AND PLANNING PROCESS

To accomplish the goal of developing upgraded liquid and gaseous waste handling systems at ORNL that are needed to support a fully modernized "Laboratory of the 21st Century", UT-B implemented the LGWTS Re-engineering Project. This project is being conducted in FY03 - FY04 with funding from the ORNL OIP. The Associate Laboratory Director for Facilities and Operations (F&O) is responsible for the LGWTS Re-engineering Project, and for eventual construction of the new facilities described in this plan. The ORNL Environmental Management Program (Legacy), which is part of the Environment, Safety, Health, and Quality (ESH&Q) Directorate and the Environmental Protection and Waste Services Division, provided the supporting leadership and was responsible for management of all activities performed within the scope of the LGWTS Re-engineering Project in FY03.

2.1. COMPREHENSIVE PLANNING PROCESS

A comprehensive planning process was employed in the development of the *ORNL LGWTS Strategic Plan*. That process was initiated with a review of the *ORNL Institutional Plan*[2], *ORNL Strategic Facilities Plan*[3], *ORNL Land and Facilities Plan*[4], *Facility Environmental Vulnerability Assessment*[5], and supporting documents. Meetings were held with ORNL managers to validate program directions and needs in each of the Laboratory's primary research mission areas, as well as to obtain input on Laboratory priorities on support functions to be provided by the new waste facilities. The waste collection systems needed to support the new research facilities described in the *ORNL Land and Facilities Plan* were included in the planning activities. The need for existing facilities that would be maintained long-term was also reviewed, particularly the hot cell consolidation planning activities. The near-term needs for facilities planned for D&D were also considered. Pollution prevention and process wastewater minimization plans for near-term reduction of vulnerabilities associated with the continued use of the ORNL process wastewater system[6] were included. The age, physical condition, capacity, and costs associated with maintaining and operating the existing waste collection and treatment systems were also evaluated. The decision-making process included review and evaluation of proposed plans by subject matter experts, including representatives from the ESH&Q and F&O Directorates, research divisions, program managers, and the Facilities Revitalization Project (FRP). These results formed the nucleus around which the *ORNL LGWTS Strategic Plan* was developed.

2.2. RISK-BASED MANAGEMENT AND PRIORITIZATION

ORNL uses a formal Risk-Based Priority Model (RPM) to prioritize all landlord operations, ES&H, and infrastructure projects from a risk-based management perspective. A modified version of this process was used to guide the LGWTS Re-engineering Project. The LGWTS Re-engineering Project team used the risk prioritization methodology to identify requirements for waste treatment systems at ORNL for the next 50 years (Table 2-1). These values are based on LGWTS re-engineering priorities, and benefits summarized in Figure 2-1.

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[2] ORNL/PPA-2002/2
[3] ORNL/TM-2000/238
[4] ORNL/TM-2002/1
[5] ORNL/TM-2001/123
[6] *Process Wastewater Minimization at Oak Ridge National Laboratory (ORNL): Reducing Vulnerabilities Associated with the Continued Use of the ORNL Process Wastewater System*, Wes Goddard, et al., September 2002.

The project team assessed each waste system in six risk/impact categories, including:

- The combined public and site safety and health category includes potential adverse impacts to health and safety for both the off-site and on-site populations.
- The regulatory compliance category includes failures to comply with laws, regulations, compliance agreements, DOE orders, and Executive orders that could adversely affect the confidence of DOE and other agencies in the ability of ORNL to operate, while protecting the public, workers, and the environment.
- The impact to ORNL mission category includes performance-based requirements, potential losses to ORNL's capital investments or loss of fee, or an opportunity for cost savings or improved program development.
- The cost-effective risk management category includes potential accidental losses to a facility's capital investment (buildings, equipment) or an existing opportunity for cost savings, such as infrastructure upgrades, management systems upgrades, or improved program development.
- The environmental protection category includes potential adverse impacts on natural resources, such as air, water, land, or wildlife.
- The schedule requirements category includes the timing for new waste treatment capabilities needed to accommodate new programmatic and/or facility consolidation activities, and decommissioning of existing facilities as a part of DOE-EM remediation activities.

Table 2-1. Initial risk-based prioritization was used to identify the requirements for ORNL LGWTS re-engineering.

Risk/Impact Categories and Initial Assessment

Waste Type	Safety & Health	Regulatory Compliance	Impact to ORNL Mission	Cost-Effective Risk Management	Environmental Protection	Schedule Requirements
Gaseous	H	M	H	M	M	M
Process	L	M	L	H	M	M
LLLW	M	L	M	M	L	H
Sanitary	L	M	L	M	L	M
Cooling Water	L	L	L	M	L	L

H = High risk/impact **M = Medium risk/impact** **L = Low risk/impact**

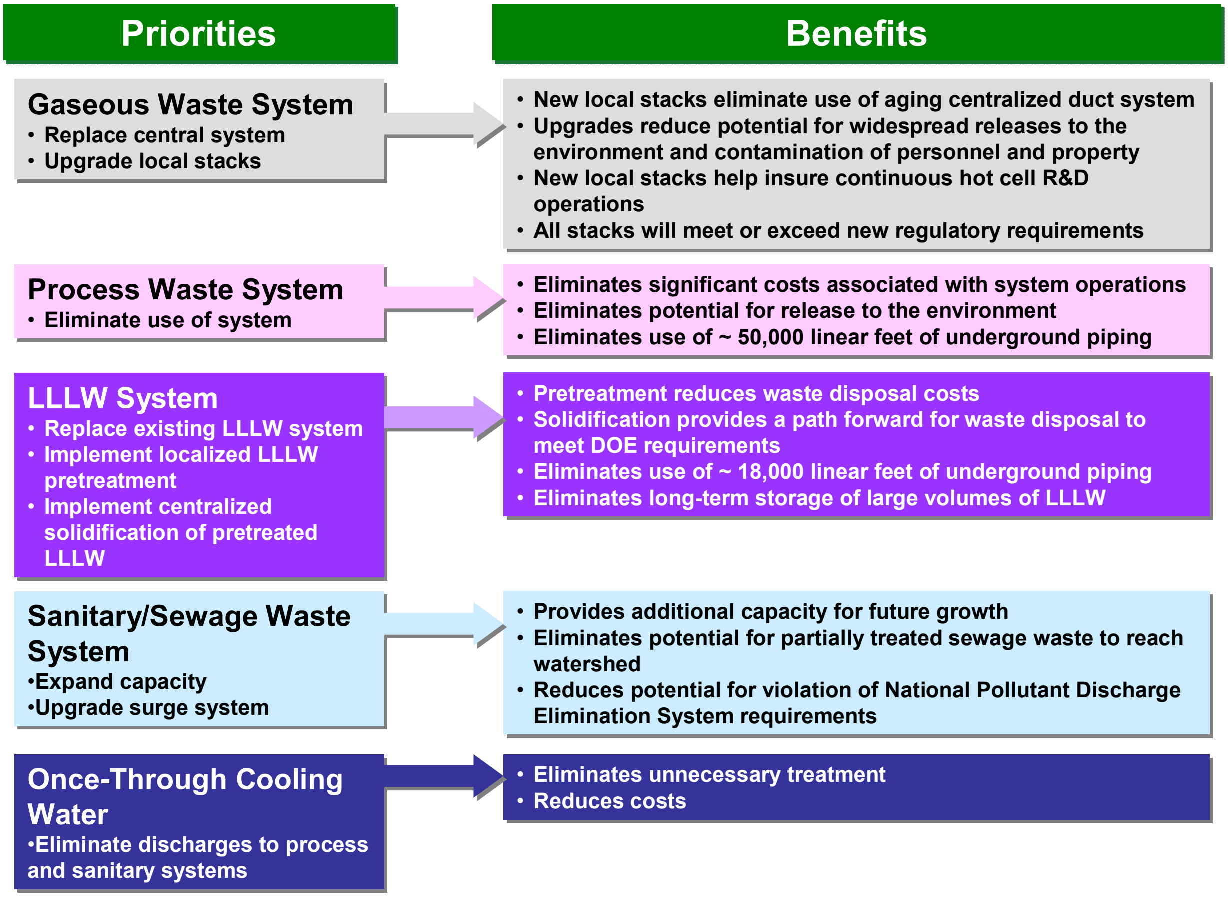

Figure 2-1. ORNL liquid and gaseous waste treatment system re-engineering priorities and benefits.

Once the waste system requirements were identified, the project team developed capital project scopes and funding requirements to implement the LGWTS re-engineering strategy. Activity data sheets (ADSs) were developed for each capital project, which contain the scope, schedule, cost estimate, and management information necessary for ORNL organizations to support planning and provide input to the budget process. The ADSs were submitted to the ORNL Capital Assets Program, where ORNL senior management rank the projects within the overall ORNL capital assets program using the RPM. Resource allocations are determined by supporting the highest-ranking activities within target funding levels. Resource planning and allocation are done on the basis of programs essential for compliance, fulfillment of ORNL missions, and assurance of the safety and well being of ORNL personnel, the public, and the environment. The ORNL Leadership Team and the DOE Oak Ridge Site Office review and approve proposed overhead-funded and capital projects. Details of the resulting projects defined to implement the waste management strategy are contained in Chapter 7 of this document.

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3. CURRENT AND FUTURE WASTE GENERATION

The *ORNL LGWTS Strategic Plan* covers the collection and treatment systems for gaseous waste, process waste, LLLW, and sanitary/sewage waste. This report does not generally cover solid waste or concentrated hazardous and mixed chemical wastes that are currently collected from research laboratories in containers for treatment and off-site disposal. Nor does it cover "minor" gaseous waste sources, which are typically discharged from local ventilation systems. This plan does consider the specific interfaces between the liquid, gaseous, and solid waste systems. The impacts of LLLW treatment on secondary solid waste requiring disposal were also evaluated. Summaries of current and estimated future ORNL liquid and gaseous waste generation volumes are provided in this chapter. More detailed information is provided in the appendices of this document.

3.1 CURRENT LIQUID WASTE GENERATION

ORNL generates a total of 895 million gallons per year (mgy) of wastewater (Figure 3-1).

- Once-through cooling water accounts for the largest volume, with 635 mgy discharged via storm drains directly to the environment through permitted and monitored National Pollutant Discharge Elimination System (NPDES) discharge points. Additional once-through cooling water is discharged to the process and sanitary/sewage waste systems, which is included in the annual volumes for these systems.
- The second largest volume of wastewater at ORNL is attributed to the process waste system, which generates 165 mgy of process wastewater annually (Figure 3-2). Process wastewater consists primarily of once-through cooling water, laboratory sink waste, and groundwater. Process waste is treated at the ORNL Process Wastewater Treatment Complex (PWTC) and discharged to White Oak Creek.
- The annual volume of sanitary/sewage wastewater at ORNL is 80 mgy (Figure 3-3), which is generated from restrooms, kitchens, janitorial sinks, and non-radiological laundry facilities. This waste is treated at the ORNL Sewage Treatment Plant (STP) and discharged to White Oak Creek.
- Treated runoff from the coal yard area accounts for 15 mgy of the total annual volume of liquid waste at ORNL. It is treated at the coal yard runoff treatment facility and discharged to White Oak Creek.
- The annual LLLW volume at ORNL is 0.17 mgy (169,000 gallons per year {gal/yr}) (Figure 3-4), which consists of remote-handled (RH) and contact-handled (CH) liquid wastes from laboratories, hot cells, remediation activities, and other waste treatment systems. LLLW is concentrated by evaporation and stored in large, double-contained tanks for future solidification and disposal at the Nevada Test Site (NTS) and/or the Waste Isolation Pilot Plant (WIPP).

DOE-SC/UT-B managed facilities currently generate approximately:

- ***99% of the sanitary/sewage waste,***
- ***65% of the process waste,***
- ***10% of the LLLW, and***
- ***65% of the gaseous waste.***

Depending on the outcome of DOE-EM/BJC remediation activities, by 2015 ORNL research activities, managed by DOE-SC/UT-B, will generate essentially:

- ***100% of the sanitary/sewage waste,***
- ***20% of the process waste,***
- ***50% - 100% of the LLLW, and***
- ***100% of the gaseous waste.***

Sanitary/sewage waste generation rates will be greater due to projected staffing increases. Other waste streams are expected to decrease due to additional pollution prevention measures and completion of DOE-EM remediation activities.

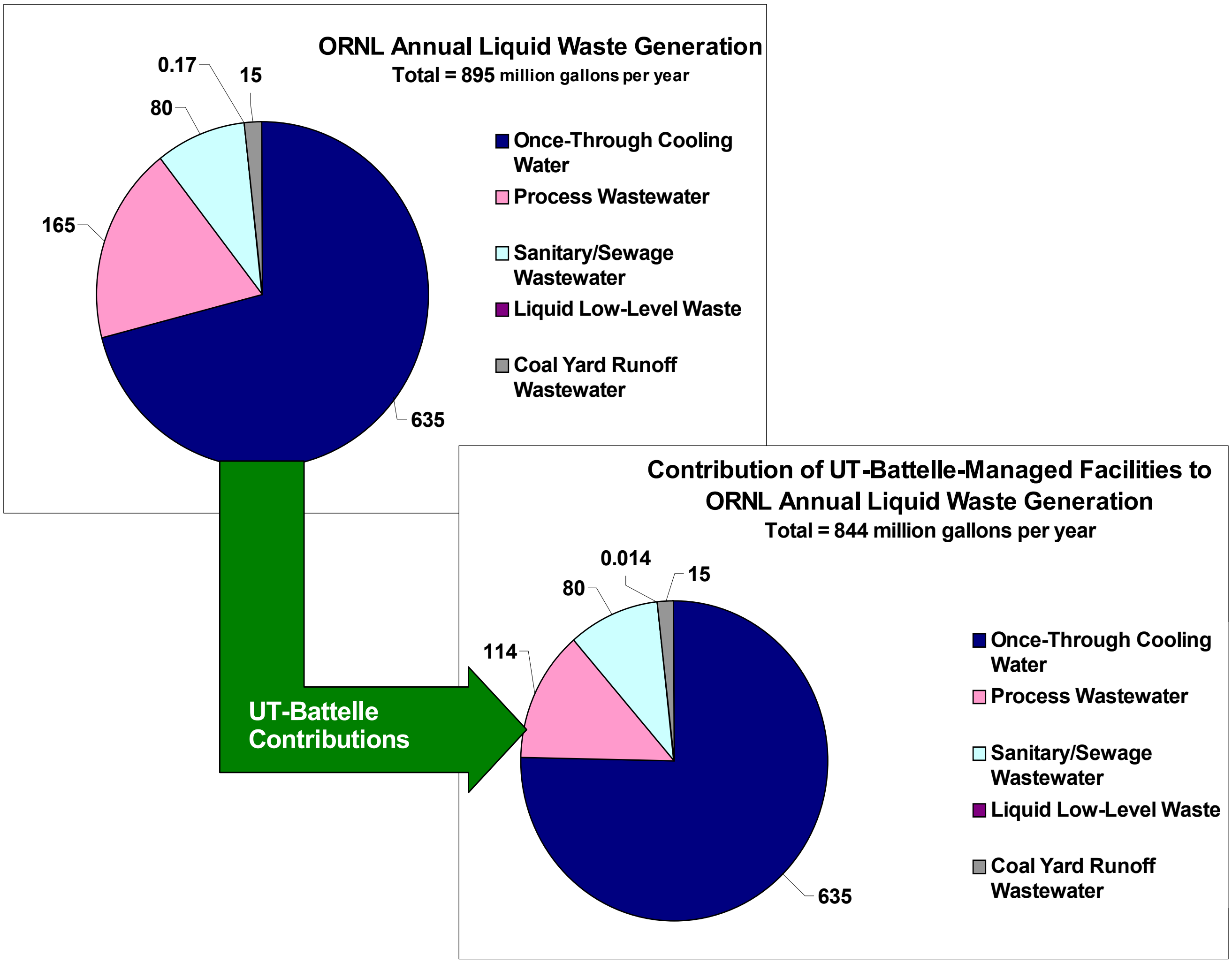

Figure 3-1. Total ORNL annual liquid waste generation and DOE-SC/UT-B contributions to the total.

3.2 CURRENT GASEOUS WASTE GENERATION

A significant portion of ORNL's gaseous waste is discharged through the central 3039 stack. The UT-B contribution to the central system is approximately 65% of the total gaseous waste generation (Figure 3-5). UT-B also discharges to two local stacks:

- Stack 2026 serves the Radioactive Materials Analytical Laboratory located in Building 2026.
- Stack 7911 serves the Melton Valley complex, primarily the Radiochemical Engineering Development Center (REDC) located in Buildings 7920 and 7930, and the High Flux Isotope Reactor (HFIR) located in Building 7900.

Building 3019A, the Radiochemical Development Facility, has its own local stack and is also connected to the central system. The Molten Salt Reactor Experiment (MSRE) facility has its own stack (stack 7503). Long-term upgrades for these stacks were not considered in this study because the facilities are expected to be shut down by 2014.

3.3 ESTIMATED FUTURE LIQUID AND GASEOUS WASTE GENERATION

Future liquid and gaseous waste generation rates were estimated by taking into consideration the following plans and activities.

- ORNL's major research initiatives in neutron sciences, complex biological systems, terascale computing and simulation science, energy and environmental systems, advanced materials, nuclear energy, and national security.
- FRP consolidation plans to move approximately 500 personnel from various off-site locations into facilities located at the ORNL Central Campus between FY03 and FY05, as well as the occupation of the new East Campus, West Campus, and Spallation Neutron Source (SNS) site facilities.
- Waste services needed for non-strategic facilities as they are transitioned into long-term surveillance and maintenance ("cheap-to-keep") while awaiting disposition. The "cheap-to-keep" process will place facilities in a safe shutdown condition with minimum services. Nuclear and radiological facilities may require negative pressure ventilation provided by gaseous waste systems and continued liquid waste collection, such as contaminated groundwater collection in building sumps. The actual required services will be determined on a case-by-case basis through safety analyses.
- DOE-EM remediation plans to clean up contaminated groundwater and soil and treat legacy waste for off-site disposal.
- Over 20 new facilities were proposed during FY03 FRP planning activities, including facilities for homeland security, sensor systems, and a fuel cell center.

The following major activities impact future liquid and gaseous waste treatment needs.

- Consolidation of off-site personnel to the main ORNL site and increased personnel due to growing research initiatives suggest that the capacity of the ORNL sewage treatment plant needs to be increased.
- Once-through cooling water presently accounts for 60% of the process wastewater (90% of the UT-B contribution) and 10% of the sanitary wastewater. Elimination of once-through cooling water from wastewater treatment systems will reduce waste management costs and open up alternative, less-costly treatment options for the remaining process wastewaters.
- The SNS and growth in research programs, including the Plutonium-238 Supply Program, reactor technology R&D, advanced materials science, fusion energy systems and materials, space power systems, and medical and isotope production will be the most significant contributors to the gaseous waste, process waste, and LLLW systems in the future. The SNS is an accelerator-based, next-generation neutron scattering facility that is under construction at ORNL. The project is scheduled for completion in June 2006, and it is projected to be the largest new source of LLLW and a significant source of radioactive process wastewater for the foreseeable future. Present estimates for SNS waste generation[7] are 91,000 gal/yr of LLLW (82% of the future UT-B generation), and 1.4 mgy of process wastewater (15% of the future UT-B generation). Once-through cooling water, which will be discharged to the storm drain is

[7] *Spallation Neutron Source Preliminary Waste Management Plan*, SNS 102030000-TR002-R01, Steven Trotter and Joe DeVore, June 2002.

estimated to be a maximum of 16 mgy. These estimates will be updated in the SNS Waste Management Plan due in the summer of FY04.

- Current activities at the Radiochemical Development Facility (Building 3019A) involve storage of ^{233}U that generates a minimal amount of waste. DOE-NE is seeking a private sector contractor to process ORNL's inventory of ^{233}U to extract thorium-229 (^{229}Th). Further processing will produce actinium-225 and bismuth-213 for medical applications. These activities are comparable to those currently performed at the REDC, the largest current generator of LLLW contaminants at ORNL, and have the potential to generate significant amounts of LLLW from FY06 through FY14. Actual waste generation rates for Radiochemical Development Facility processing will not be available until the DOE-NE contract has been awarded.
- D&D of inactive facilities managed by BJC will eliminate DOE-EM's use of the gaseous waste system, except for possible operation of the LLLW evaporator. The volume of contaminated wastewater generated by DOE-EM in the future will depend upon the actions taken during Bethel Valley remediation; scheduled to begin in approximately FY10. BJC is conducting an engineering study[8], which will be completed in FY04 to provide data needed to define the remediation activities that will occur under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) closure. If minimum action is taken to remediate contaminated soils, groundwater plumes, and existing waste treatment facilities, DOE-EM could continue to generate their present levels of process waste (contaminated groundwater). Significant remediation and/or new treatment systems for select groundwater streams could totally eliminate their use of the PWTC. Depending upon changes implemented for the gaseous and process waste systems, DOE-EM is expected to generate between zero to two-thirds of their existing LLLW streams.

The current and future generation rates for each system are shown in Figures 3-2 through 3-5. Future generation rates are equivalent to the estimated FY15 generation, when DOE-EM remediation and Radiochemical Development Facility (Building 3019A) ^{233}U processing are scheduled to be completed. The future generation rates assume:

- once-through cooling water is essentially eliminated from the process and sanitary/sewage waste systems,
- some waste streams presently treated at the PWTC are diverted to the sanitary/sewage system, and
- DOE-EM discontinues use of the existing treatment plants.

The strategic plan for LGWTS re-engineering, described in Chapter 6, was developed to address these future waste streams and generation rates. Plans for new facilities will be incorporated by UT-B into the future ORNL Ten Year Site Plan planning effort, which is due to be completed in the summer of 2004. Detailed waste management plans for these initiatives will be completed after this date, but it is expected that the waste treatment systems proposed in this report will accommodate their needs.

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[8] *Engineering Study Work Plan for Groundwater Actions in Bethel Valley, Oak Ridge, Tennessee*, DOE/OR/01-2035&D2, March 2003.

Once-through cooling water flow will be essentially eliminated from the process waste system by 2008, which will reduce the overall process wastewater volume by 60%, and the UT-B contribution by 90%.

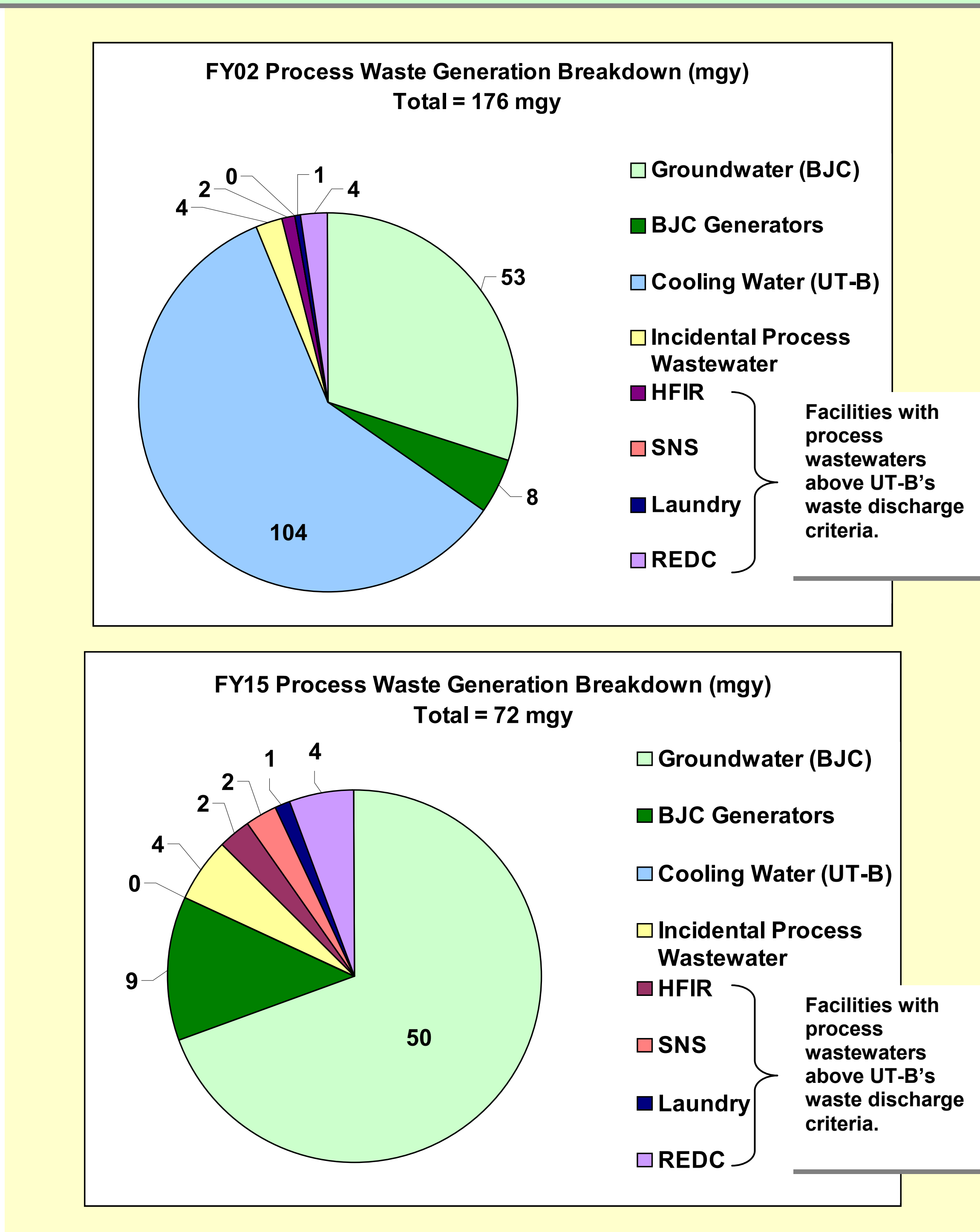
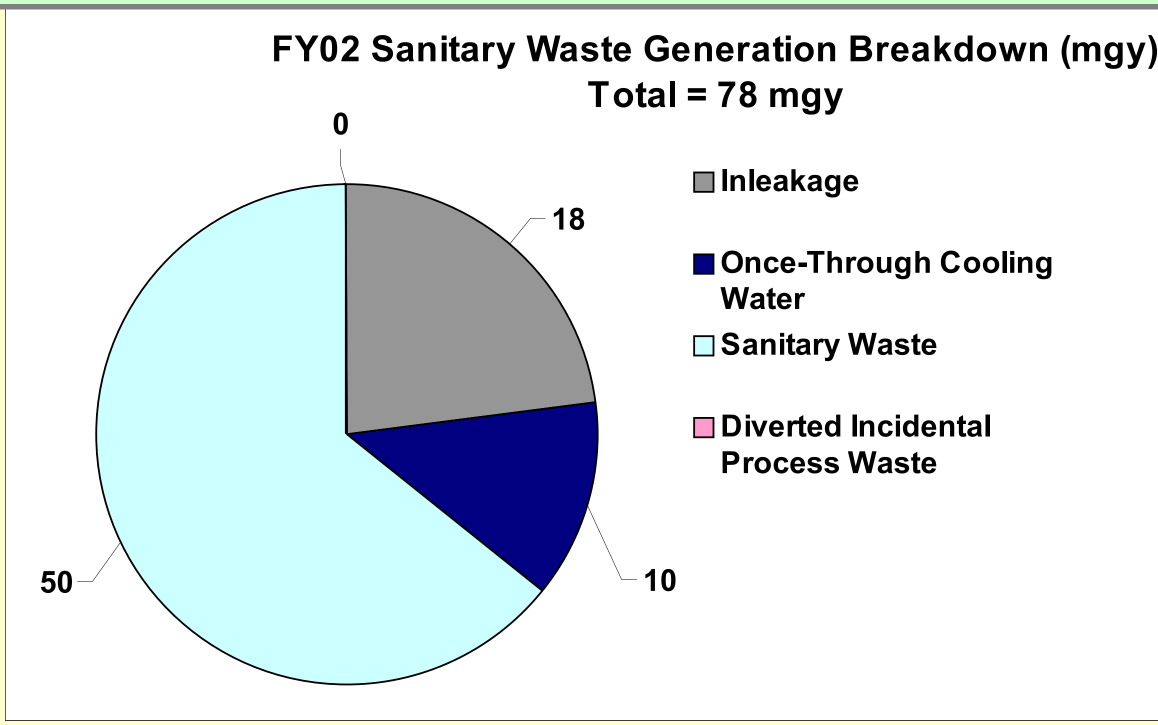


Figure 3-2. Current and estimated future process wastewater generation at ORNL.

Sanitary waste generation increases due to the consolidation of existing staff to the main ORNL campus, long-term growth, and diversion of incidental process waste to the system.



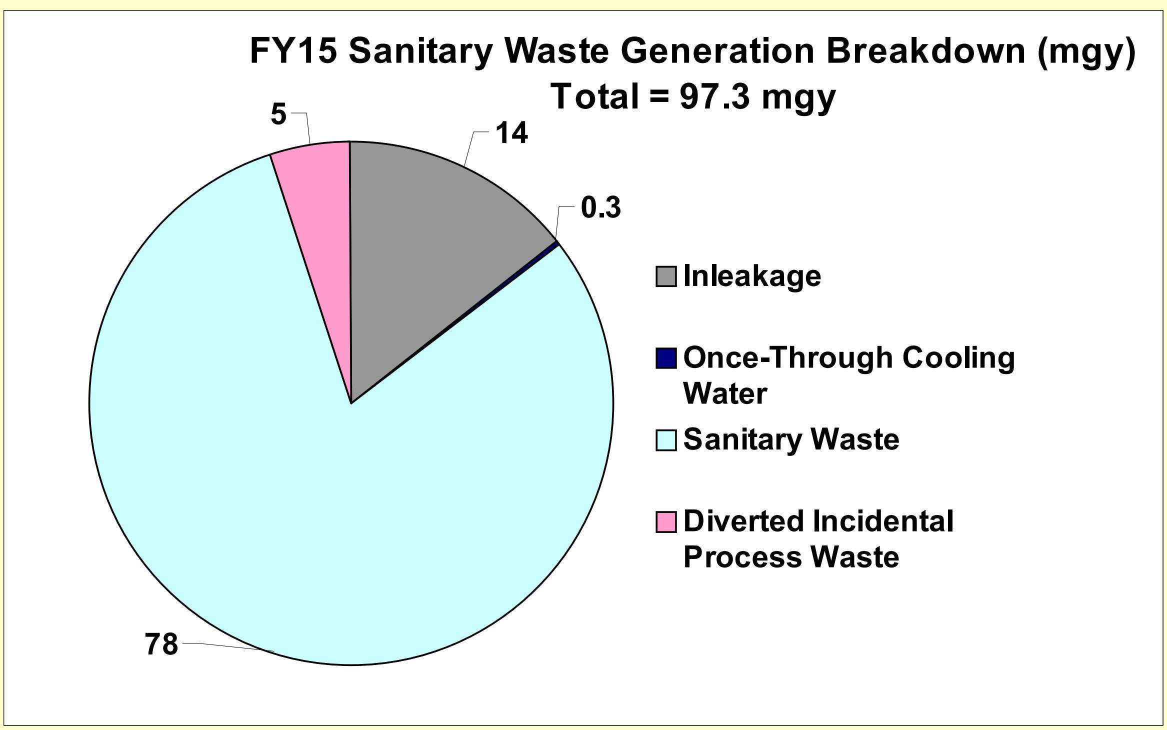


Figure 3-3. Current and estimated future sanitary waste generation at ORNL.

If BJC eliminates their LLLW operations by FY15, the SNS and REDC will be the major LLLW generators, generating over 90% of ORNL's LLLW.

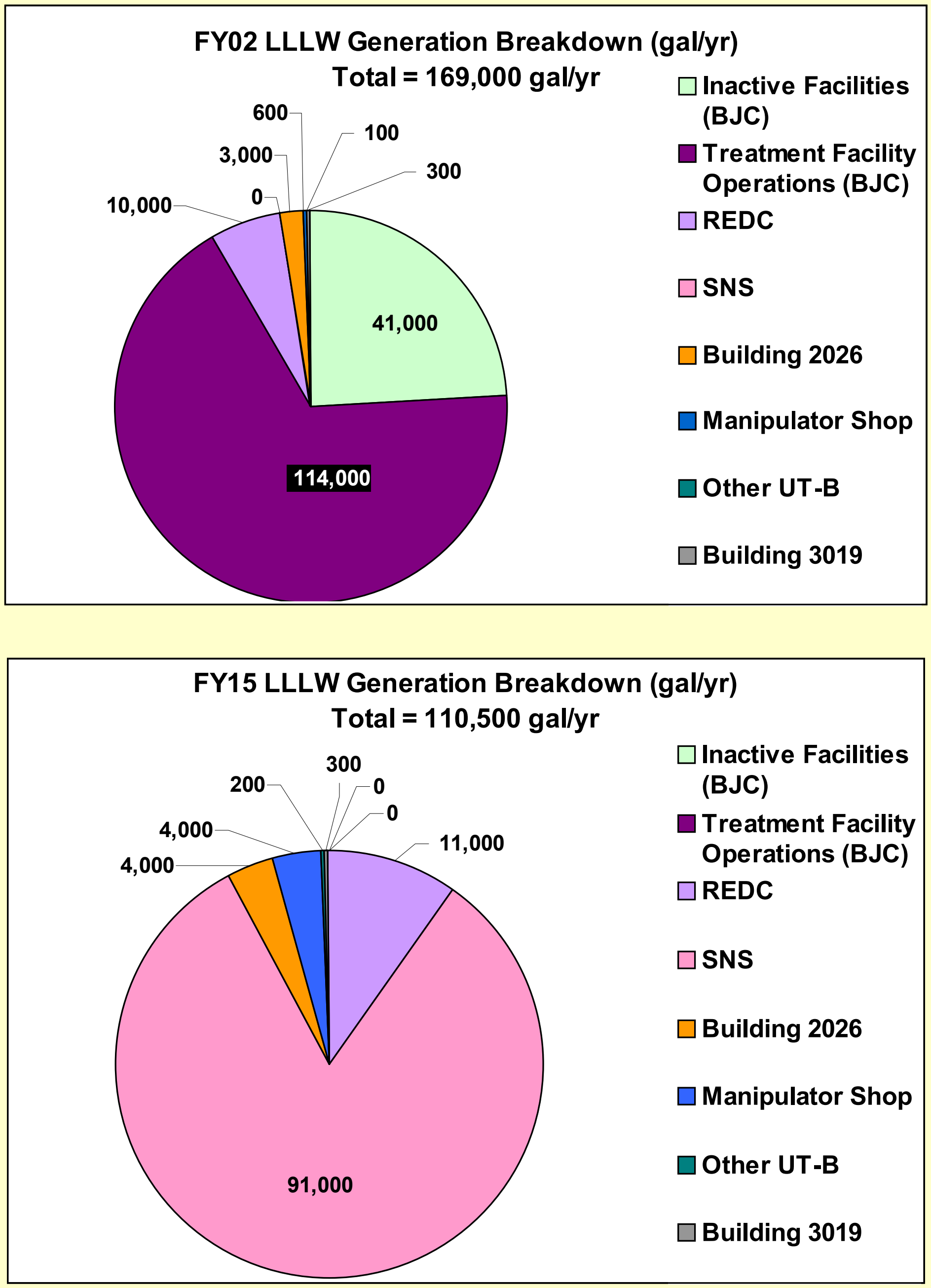
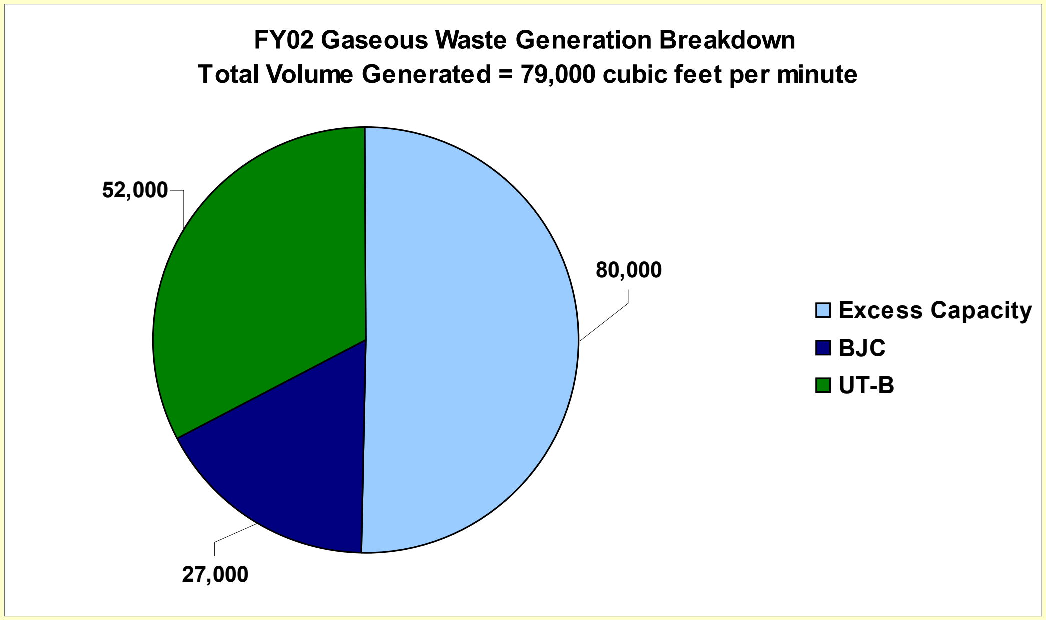


Figure 3-4. Current and estimated future LLLW generation at ORNL.

Only one-third of the central gaseous system capacity will be utilized in FY15 once DOE-EM/BJC remediation activities are completed.



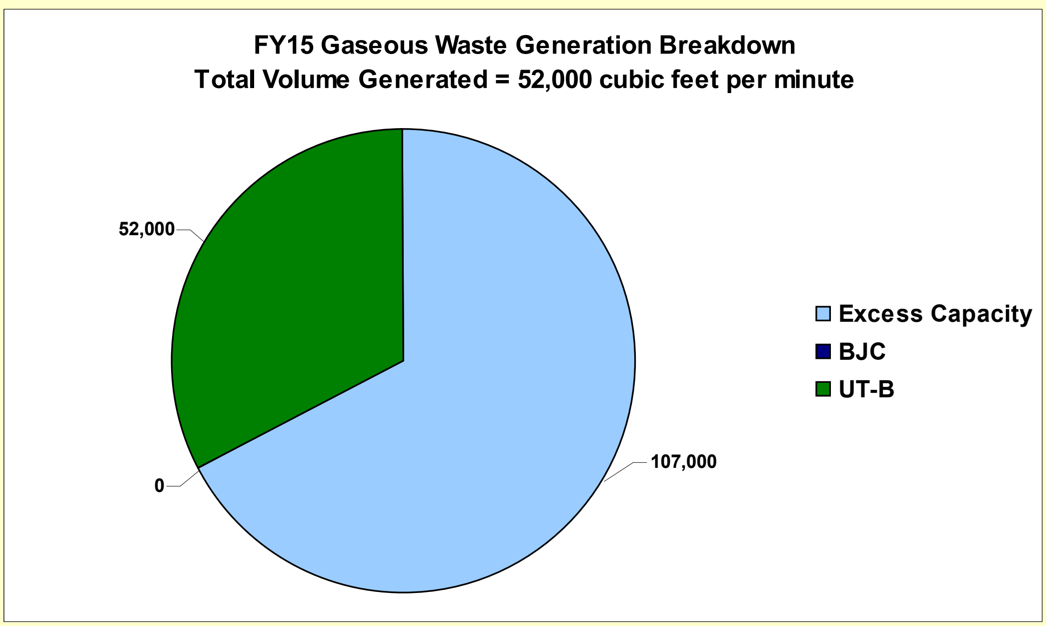


Figure 3-5. Current and estimated future gaseous waste generation at ORNL.

4. LIQUID AND GASEOUS WASTE SYSTEM BENCHMARKING STUDIES

The liquid and gaseous waste collection and treatment systems at several large facilities with similar waste management challenges were benchmarked during the LGWTS Re-engineering Project. They include:

- Brookhaven National Laboratory (BNL),
- Argonne National Laboratory (ANL) West,
- Pacific Northwest National Laboratory (PNNL),
- Theragenics in Georgia (an industrial radiological laboratory),
- BWXT in Virginia (an industrial radiological laboratory), and
- the Y-12 National Security Complex (Y-12), a DOE manufacturing facility.

The information gained from benchmarking activities was considered in developing the strategy for future ORNL waste treatment systems.

4.1 PROCESS WASTEWATER

All sites follow ORNL's practice of segregating hazardous chemicals, concentrated radiological wastewaters, and/or mixed waste at the source of generation. All sites discharge chemical rinse water, neutralized acids and bases, buffer solutions, and dilute radioactive waste to centralized process wastewater treatment facilities. The Y-12 site routinely trucks process wastewater (see section 4.1.3). All other sites routinely collect process wastewater in underground piping and treat the waste in centralized facilities.

4.1.1 Nonradiological Process Wastewater

Approximately half the benchmarked sites treat their nonradiological process wastewater in industrial wastewater treatment facilities similar to the ORNL PWTC (described in Appendix B) to remove organics and/or heavy metals prior to discharge to the environment. The other half sends their waste to publicly-owned treatment works (POTWs) sanitary systems. BNL is the only benchmarked site that operates a DOE-owned sanitary/sewage wastewater treatment plant that only serves the DOE site, like ORNL does. BNL allows nonradiological wastes, as well as wastewaters containing low levels of radioactivity from shutdown reactors, accelerators, and remediation projects, to discharge in the sanitary sewer.

All sites allow generators to rinse chemical bottles, wash laboratory glassware, and discharge non-Resource Conservation and Recovery Act (RCRA) solvents, neutralized acids and bases, and buffer solutions through the laboratory drain/piping system to the treatment facilities as a part of normal operations. Typical concentrations for laboratory discharges are given in Table 4-1. Additional chemicals can be discharged after review by environmental/waste management personnel. All facilities control the composition of waste entering the treatment plants using administrative controls, real-time monitoring in the collection system, and/or quarterly analytical sampling. Their systems are operated with in-line, real-time monitors for pH and conductivity (and radioactivity at BNL) in the collection systems. They collect waste in local collection tanks or discharge directly to the treatment facilities. In the latter case, they have the capability at the generator facility, or at the head-works of the treatment facility, to divert to tanks or lagoons if on-line monitors alarm.

Table 4-1. Selected process wastewater discharge limits at benchmarked facilities.

Contaminant	ORNL UT-B Laboratory Waste Discharge Criteria[1] (mg/L)	ORNL PWTC Waste Acceptance Criteria[2] (mg/L)	BNL Laboratory Waste Discharge Criteria[2] (mg/L)	PNNL Treatment Plant Waste Acceptance Criteria[3] (mg/L)
Cadmium	0.0011	0.01	-	0.32
Chromium	0.1	3.3	-	1.74
Copper	0.0118	0.1	0.15	1.30
Lead	0.0032	30.0	0.019	0.37
Cyanide	0.046	0.2	0.1	-

1. Based on "free-release" model to restrict discharge of contaminants to pipes of unknown or unverified integrity. (*Process Wastewater Minimization at Oak Ridge National Laboratory (ORNL) Reducing Vulnerabilities Associated with the Continued Use of the ORNL Process Wastewater System*, September 2002.)
2. Based on capability of treatment plant to meet regulatory requirements.
3. Based on maximum values that the Publicly Owned Treatment Works will accept from PNNL at the plant boundary. Discharge limits for PNNL generators are determined by environmental/waste management staff on a case-by-case basis.

A key factor in determining how process wastewaters are managed and disposed of at various sites is how the wastewater treatment facility is regulated by RCRA. If one assumes that process wastewaters will at times be hazardous and, therefore, RCRA-regulated at the point of generation, it is critical to know how RCRA applies to the wastewater treatment plant. POTWs, such as those owned by municipalities, have an exemption from RCRA. The POTWs issues pretreatment permits to regulated discharges to assure compliance with all requirements. PNNL discharges to a POTWs in the City of Richland, Washington. Tank-based treatment systems may qualify for RCRA's wastewater treatment unit (WWTU) exclusion wherein certain RCRA requirements are subverted to the Clean Water Act to achieve environmental protection goals. Currently, ORNL process wastewater generators discharge to a tank-based system subject to the WWTU exclusion. BNL has neither a POTWs nor a tank-based wastewater treatment system, so any hazardous wastewaters must be managed as hazardous waste and sent to a RCRA-permitted facility.

4.1.2 Radiologically-Contaminated Contact-Handled (CH) Process Wastewater

Sites using publicly owned sanitary/sewage systems (all except BNL) pretreat radioactive wastewater in facilities similar to ORNL's PWTC with unit operations to remove radionuclides, organics, and/or heavy metals before discharge to the environment. They consider the liability for discharge of radioactive waste directly to a publicly-owned sanitary system to be too high. BNL treats dilute radioactive wastewaters at their DOE-owned sanitary treatment plant.

PNNL evaluated sending small quantities of radionuclides to the City of Richland sanitary sewer, but they did not implement the practice because the additional analysis and paperwork were not considered economical. Local tank collection and routine hauling of wastewater to centralized treatment systems or off-site facilities is considered impractical for all but very small sites.

4.1.3 Process Wastewater Trucking

Y-12, managed and operated by BWXT Y-12, is the only benchmarked site that routinely transports wastewater via tanker truck. Y-12 has trucked most of its wastewater for many years, so it was evaluated as a benchmark for trucking process wastewater at ORNL. Major sources of wastewater at Y-12 include the waste from remote sites, such as the new solid waste disposal cell in Bear Creek Valley; groundwater from old burial grounds; and process wastewater from the main plant production facilities. Total wastewater volume currently averages 4 mgy (7.6 gallons per minute {gpm}). The transported volume, which occurs during actual working hours, is about 33 gpm. The transportation contractor has a fleet of 5 tractors and 43 tankers, which cost approximately $4 Million. Two drivers and one supervisor, who also handle scheduling and U.S. Department of Transportation (DOT) paperwork, spend part of their time hauling wastewater. The tankers are loaded by BWXT personnel, and the drivers typically do not wait while tankers are being filled. Routine DOT-required inspection of the tankers requires about a 0.3 full-time equivalent (FTE) employee. Typically BWXT Y-12 makes 3 to 4 trips per day to transport wastewater. During the 20-plus years that wastewater has been routinely hauled at Y-12, two tankers have been damaged: one in a vehicle accident and the other by freezing water inside the tanker causing expansion damage.

4.2 RADIOLOGICALLY-CONTAMINATED REMOTE-HANDLED (RH) WASTEWATER (LIQUID LOW-LEVEL WASTE {LLLW} AT ORNL)

BNL does not generate this type of waste and was not included in the evaluations. All other sites treat or pretreat RH hot cell waste at the site of generation. Industrial sites treat liquid waste in hot cells and generate solid waste forms for disposal at off-site commercial disposal facilities. PNNL installed a tank collection system for this waste at the hot cell facilities, which is transferred by tanker truck to centralized Hanford waste treatment facilities. These facilities are similar to ORNL systems. The DOE-EM contractor has not completed the tanker truck unloading station on the Hanford site, and the PNNL generators are presently treating all liquid waste in the hot cells for disposal as solid waste.

At ANL-West, LLLW streams are pretreated at the generator site to remove the major radiological and hazardous components. The streams are then treated in a centralized treatment facility where the LLLW is dried to a salt cake in shielded hot air drum evaporator (SHADE) systems (Figure 4-1). Six parallel SHADE systems (30-gallon drums inside 55-gallon drums with a concrete-filled annulus) treat an average of 16,000 gal/yr of waste, and generate thirty-six 55-gallon drums a year of solid low-level waste (LLW) for disposal.

Neither ANL West or PNNL evaluated the impacts of labor-intensive source treatment and disposal of several secondary solid waste streams for many buildings prior to implementing local treatment requirements. They recommend doing life-cycle analyses before adopting local treatment or pretreatment strategies for RH-liquid wastes.

4.3 GASEOUS WASTE

None of the benchmarked sites operate centralized gaseous waste systems, as ORNL presently does. Facilities generally have local treatment systems designed for the specific building operations. In-cell chemical scrubbers are installed for chemical processes, if necessary. Most building ventilation air and hot cell off-gas are routed through high efficiency particulate air (HEPA) filters located within the buildings and discharged to local stacks, which do not have chemical scrubbers.

4.4 ONCE-THROUGH COOLING WATER

All sites, except PNNL, segregate once-through cooling water and discharge it to the storm sewer. PNNL presently discharges some once-through cooling water to the City of Richland sanitary sewer, but is in the process of installing recirculating systems, where economically feasible, to reduce the load on the treatment plant.

4.5 APPLICABILITY OF BENCHMARKING STUDIES TO ORNL

ORNL's practice of segregating hazardous chemicals and mixed waste at the source of generation should continue. ORNL should minimize the use of underground pipelines by locating new waste treatment facilities at or near the site of generation. Implementing real-time treatment and disposal capabilities for waste would minimize the inventory of waste stored at the generator site and in centralized storage facilities. ANL-West's practice of pretreating LLLW prior to discharge to centralized treatment facilities should be evaluated. New ORNL waste treatment facilities should be sized and designed for efficient treatment of R&D waste. Incidental or pretreated process wastewater should be considered for treatment through the ORNL sanitary/sewage system.

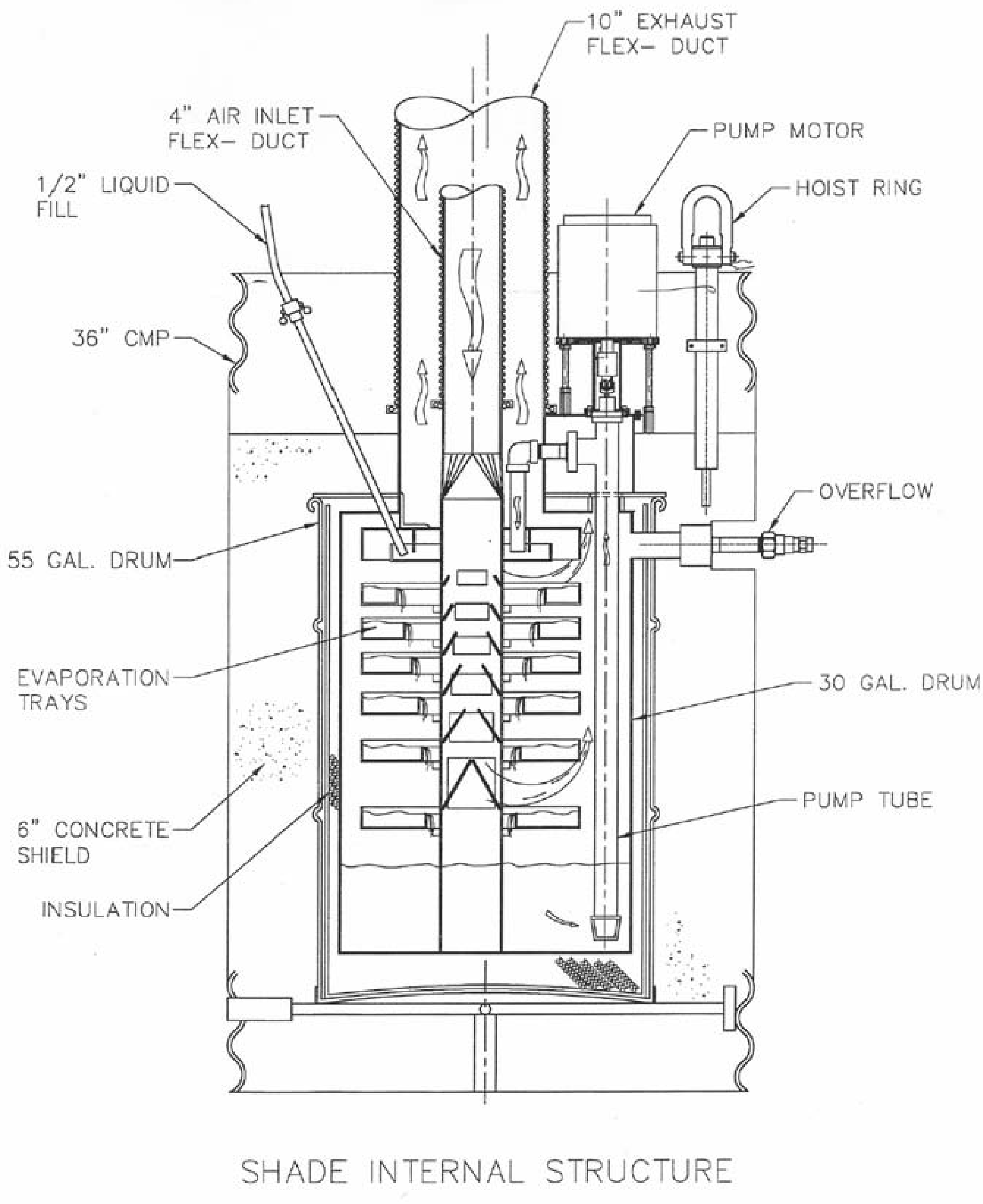


Figure 4-1. Diagram of the ANL-West's SHADE system internal structure.

5. WASTE SYSTEM DESCRIPTIONS AND EVALUATIONS

This *ORNL LGWTS Strategic Plan* covers the waste collection and treatment systems for gaseous waste, process waste, LLLW, and sanitary/sewage waste, which are described in this chapter. Critical issues that affect waste management strategic planning are also summarized in this chapter.

The existing radiological waste treatment facilities are highly interconnected, requiring strategic planning for the system as a single unit. Examples of these interconnections are provided below.

- ***The Process Waste Treatment Complex, Building 3544 generates 40% of ORNL's concentrated LLLW, which is stored in MVSTs system for future treatment and disposal.***
- ***The gaseous waste scrubber system generates 30% of the LLLW collected for treatment by the LLLW evaporator.***
- ***The LLLW evaporator overheads produce 10% of "process-generated" process wastewater treated at the Process Waste Treatment Complex.***
- ***Inleakage into the gaseous waste collection system generates 3 to 6 million gallons per year of process wastewater.***

5.1 SYSTEMS OVERVIEW

The ORNL liquid and gaseous waste collection and treatment systems were primarily constructed between 1950 and 1989, and they have had significant upgrades over the years. The collection piping is the most vulnerable part of the systems; some portions have not been upgraded since installation. The treatment facilities are generally structurally sound, and can be expected to operate through DOE-EM Melton Valley and Bethel Valley remediation schedules with routine maintenance of equipment. However, none of the collection systems or treatment facilities can be expected to operate for an additional fifty years without significant upgrades or replacements. Table 5-1 summarizes the construction dates and life expectancy of ORNL's waste collection and treatment systems, and the DOE prime contractor responsible for their management and operation. These systems are aging and must be upgraded or replaced to meet long-term needs. Replacement, rather than upgrade of the facilities, is the preferred option considering their age, legacy contamination, inappropriate size of facilities for treatment of only R&D wastes, physical location (generally far away from generator buildings), and operating costs. Detailed descriptions of the existing ORNL wastewater collection and treatment systems, and technical evaluations of their capabilities to support long-term DOE-SC waste management needs are provided in the appendices of this document.

Table 5-1. ORNL liquid and gaseous waste treatment systems construction dates and life expectancy.

Waste System	Current Responsible DOE Prime Contractor	Construction/Modification Dates		Life Expectancy	
		Collection System	Treatment Facilities	Collection System	Treatment Facilities
Gaseous Waste	BJC	1950s	1950 - 1997	1980s	1980 - 2027
Process Waste	BJC	1950s – 1989	1975 - 1989	1980s - 2017	2005 - 2019
Liquid Low-Level Waste Collection/ Storage	BJC	1980 – 1997	1965 - 1994	2010 - 2024	1995 - 2024
Transuranic Waste Processing Facility (for legacy waste)	FWENC	-	2003	-	2018 (Operation ends in approximately 2008)
Sanitary/Sewage Waste	UT-B	1943 – 2003	1985	1973 - 2033	2010

BJC = Bechtel Jacobs Company LLC FWENC = Foster Wheeler Environmental Corporation UT-B = UT-Battelle, LLC

ORNL's underground collection systems are the oldest and most vulnerable portions of the waste systems. Much of the underground collection piping for the gaseous, sanitary, and process waste systems was installed in the 1940s and 1950s. The existing waste collection systems include miles of underground piping, which connects generator facilities in both Bethel Valley and Melton Valley to centralized treatment facilities located in the ORNL Central Campus (Figures 5-1 and 5-2).

No upgrades have been made on the underground concrete ducts serving the gaseous waste system since installation. The integrity of all underground gaseous ductwork is a vulnerability, and they must be upgraded or replaced if operated long term. An evaluation of the potential for release of contaminants through the gaseous waste system, primarily through the central stack, was performed in FY02. Schedules for HEPA filter replacements were reviewed to reduce the likelihood of releases through the central stack.

Most of the underground piping in the sanitary and process waste systems have been replaced or have had liners installed to improve their integrity. However, short runs of piping from generator facilities to the first connections with the central collection system (e.g., manholes or service laterals) have not been upgraded. Near-term vulnerabilities associated with the use of the process waste collection piping have been minimized by pollution prevention activities to reduce waste generation, and the establishment of more stringent process wastewater discharge criteria by UT-B. Similar waste management practices may be imposed by UT-B in the future for the sanitary/sewage waste system.

Most of the underground collection piping for the LLLW system was installed or significantly upgraded since the 1980s to provide double containment and leak detection. The integrity of the system is presently good, but upgrades will be required if it remains in service for another 50 years.

Due to their age, legacy contamination, inappropriate size, and location, existing radiological waste treatment systems will not be suitable for treating only R&D waste after DOE-EM remediation activities end. By FY15, the annual R&D waste generation rates will be:

- ***3% of the existing Process Waste Treatment Complex capacity***
- ***less than 1% of the existing LLLW system capacity***
- ***less than 33% of the existing central gaseous waste system capacity.***

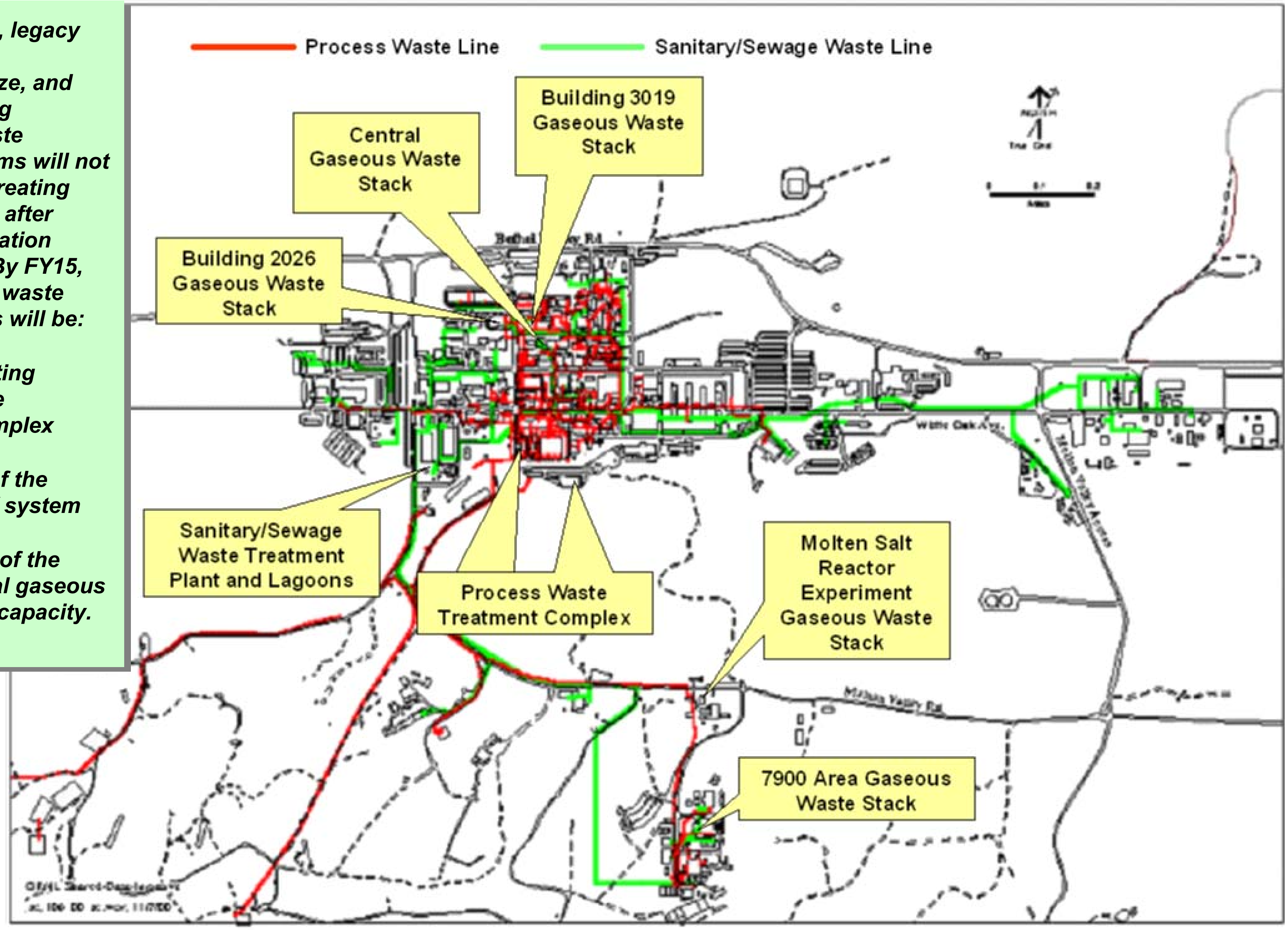


Figure 5-1. Existing ORNL gaseous, process, and sanitary/sewage collection and treatment systems.

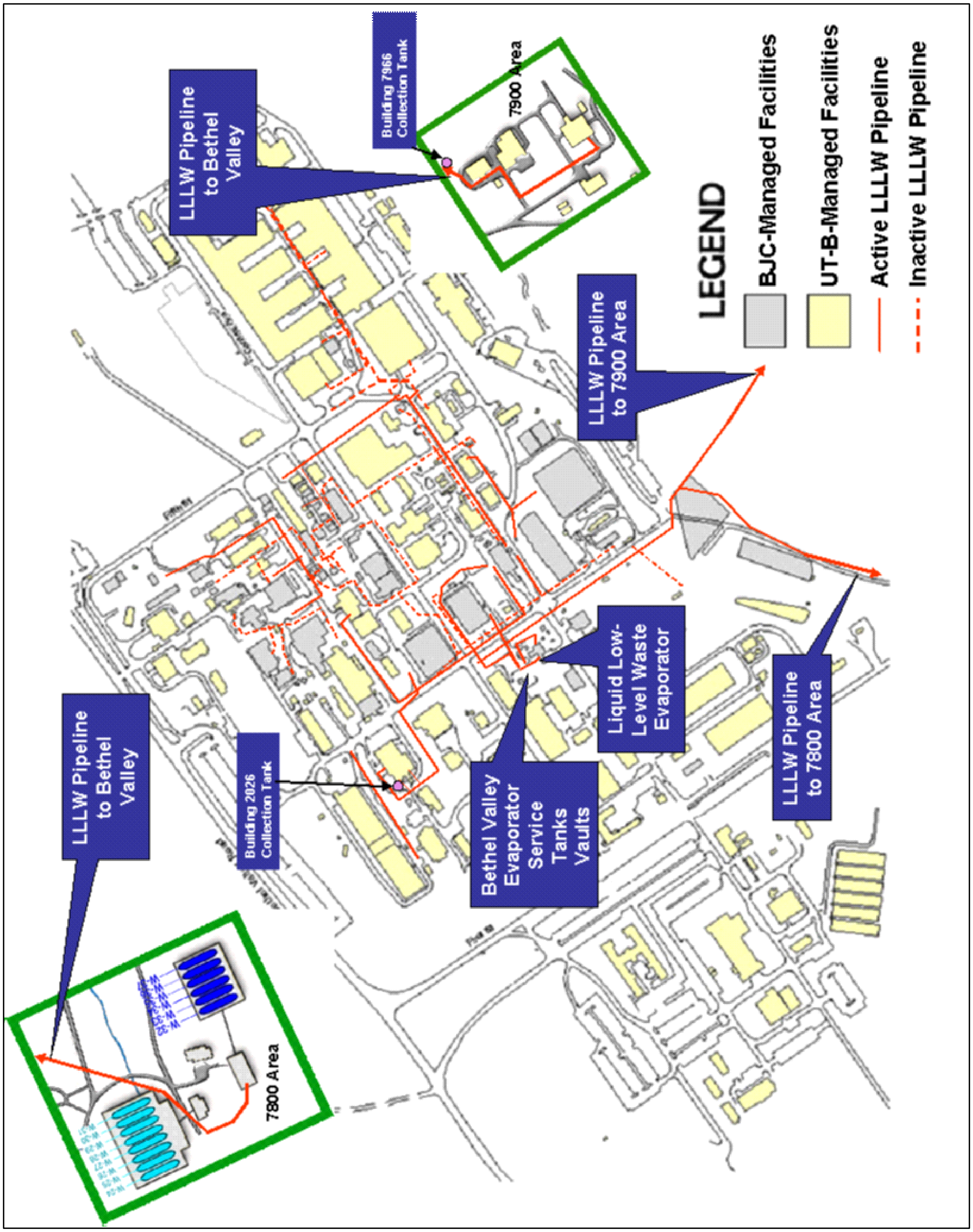


Figure 5-2. Existing LLLW collection and treatment systems.

5.2 SANITARY/SEWAGE SYSTEM

The sanitary/sewage system collects and treats sanitary waste from ORNL facilities, small amounts of biodegradable chemicals, and other wastes meeting the STP waste acceptance criteria (WAC).

5.2.1 Critical Sanitary/Sewage System Infrastructure Issues

The ORNL STP (Figure 5-3) is currently 18-years old and will reach its design life in 2010. In addition, the *ORNL Land and Facilities Plan*[9] recommended that construction of the SNS, East Campus additions, and West Campus additions will require an addition to the STP and related portions of the sanitary/sewage collection system. Continued facility planning in FY03 identified 20 new facilities needed for future ORNL missions. Strategic liquid waste treatment planning calls for treating research-generated incidental and/or pre-treated process wastewater at the STP before FY10. Increased wastewater load from new facilities and diverted incidental process wastewater will introduce new flows in excess of what the current plant is designed to treat.

Figure 5-3. The Sewage Treatment Plant (STP), is located in Building 2521 just east of First Street and south of the sewage treatment lagoons.

At the present time, the STP can not handle the total flow during periods of heavy rain, so part of the influent is diverted into two clay-lined lagoons (Figure 5-4), and is then processed during periods of lower flow. Occasionally during periods of heavy rainfall, the inflow exceeds the capacity of the STP and the lagoons, and partially treated wastewater must be discharged directly to White Oak Creek. In 2002, partial treatment during periods of heavy rainfall resulted in five NPDES permit noncompliances. Permit violations are likely to occur more frequently as more waste is added to the system, unless the capacity of the system is increased. Efforts should also continue to reduce inleakage to the sanitary/sewage collection system.

Figure 5-4. One of two sewage treatment lagoons located south of White Oak Avenue.

The detection of radioactivity in the STP sludge and lagoon sediment indicates that there is infiltration of contaminated groundwater and/or legacy contamination in the collection piping. The most likely source of contamination is from groundwater inleakage from the 3000 area of the ORNL Central Campus. As

[9] ORNL/TM-2002/1

more definite long-term plans for this part of the plant are developed, actions may be required to reduce the levels of radioactive contaminants entering the sanitary/sewage system.

5.2.2 Technical Assessments for Future Sanitary/Sewage Wastewater Treatment Needs

In order to identify options to eliminate use of the aging process waste system, the STP capabilities for removing radionuclides, metals, and organics were evaluated. The metals and metallic radionuclide removal efficiency at the STP is approximately 90%, very similar to that of the PWTC. Evaluation of UT-B-generated process wastewater indicates that the STP could adequately remove the contaminants, and the STP liquid effluent and sludge compositions would not change significantly. Although the STP could adequately process these waste streams, current UT-B waste management practices would require removing the radionuclides and most of the metals from process wastewater prior to discharge to the underground collection system to reduce environmental risks if leaks in the piping occur. Wastewater discharge criteria may be imposed by UT-B on the sanitary/sewage waste system in the future, similar to the existing process wastewater discharge criteria. It is expected that the incremental impact to the generators should be minimal.

The sludge generated at the STP is radiologically contaminated. It was previously trucked to the City of Oak Ridge STP and landfarmed after being combined with sludge from the City of Oak Ridge STP. Currently, the City of Oak Ridge has suspended accepting the ORNL sewage sludge, so the sludge is being packaged for future disposal as low-level waste (LLW) at Envirocare of Utah, Inc. Sewage sludge would have to meet City of Oak Ridge acceptance criteria for mercury, lead, and radiological contamination if disposal by landfarming is resumed. Technical analyses indicate that treatment of incidental process wastewater at the STP will have a minimal impact on the sludge composition.

A modification to the NPDES permit and regulatory approval would be required in order to discharge and treat process wastewater in the sanitary/sewage system. Permit modifications will require a two- to five-year lead-time. A renewal application was submitted in 2001 for a 5-year renewal of the existing permit; it is still pending. Therefore, initial steps to obtain regulatory approval for proposed changes at the STP should begin in FY04.

Analysis of the regulations indicates that engineering and administrative control modifications will be required before process wastewater can be accepted into the sanitary/sewage system. The existing sanitary/sewage wastewater collection lagoons will need to be replaced with collection tanks, and administrative controls will probably be very similar to those presently in place for use of the process waste system.

5.3 PROCESS WASTE SYSTEM

The ORNL PWTC consists of two facilities:

- Building 3544 (used for radiological wastewater treatment) was built in 1975 with upgrades made in 1996 (Figure 5-5).
- Building 3608 (used for nonradiological wastewater treatment) was constructed in 1989 (Figure 5-6).

The process waste system accepts wastewater from laboratories, contaminated groundwater, and other waste treatment systems that have a maximum total radiological concentration of the ingestion dose equivalent of 1 x 10^4 Becquerel per liter (Bq/L) strontium-90 (^{90}Sr). The system is designed to treat wastewater similar to an industrial metal finishing facility with additional capability to remove radioactivity.

Figure 5-5. Building 3544 is part of the PWTC located north of White Oak Creek, and is used to treat radiologically contaminated process wastewater.

Figure 5-6. Building 3608 and the associated tanks are part of the PWTC located south of White Oak Creek, and are used to treat nonradiological process wastewater.

5.3.1 Critical Process Waste System Infrastructure Issues

The integrity of the process waste system collection piping from generator buildings to connecting manholes is a vulnerability. There have been few upgrades to the piping between the facilities and the first manholes for the collection system since construction. Leaks have been detected in this type of pipe over the years, and it is likely that some of the remaining clay pipe is leaking. The *Facility Environmental Vulnerability Assessment*[10] identified vulnerabilities associated with the use of this portion of the process waste collection system and recommended reducing UT-B facility discharges to the process waste system drains. As a result of the *Facility Environmental Vulnerability Assessment*, UT-B established wastewater discharge criteria for the process waste system.

The PWTC has undergone a number of upgrades over the past 10 years, which have significantly improved the integrity and process durability; however, the treatment facilities will need significant upgrade or replacement if they are considered for treatment of R&D-generated waste for the next 50 years. The facilities are significantly oversized for treating only the projected levels of R&D generated process wastewater for DOE-SC/UT-B managed facilities. The nominal treatment capacity of the PWTC is 400 mgy, while the annual wastewater generation rate from future R&D activities is expected to be less than 15 mgy.

[10] ORNL/TM-2001/123

5.3.2 Technical Assessments for Future Process Wastewater Treatment Needs

Four ORNL facilities are expected to produce wastewater that is above the process wastewater discharge criteria implemented by UT-B in FY02, including the: HFIR, REDC, SNS, and ORNL radiological laundry. Options were evaluated for treating these waste streams (approximately 9 mgy) prior to discharge to the environment, and include the following.

- A small, dedicated wastewater treatment system containing a specialty ion exchange resin was selected as the least expensive and most efficient method for treating future SNS, HFIR, and REDC process wastewater. This new system should be located near the REDC and HFIR, where the bulk of the process waste above the wastewater discharge criteria will be generated. SNS waste would be trucked by tanker to this site.
- Because of the detergent and particulates in the ORNL radiological laundry wastewater, it will not be easily treated for radionuclide removal by any existing or proposed treatment system, unless it is significantly diluted with other wastewater prior to treatment. The volumes of HFIR, REDC, and SNS process waste will not dilute the laundry process waste enough to allow treatment at the proposed treatment system identified above. Since the laundry is a batch process, three options could be considered for further analysis:
    - trucking to the STP if the waste meets future STP WAC,
    - direct solidification at the site of generation, or
    - contracting laundry operations to an off-site vendor.

It is recommended that process wastewater meeting the UT-B process wastewater discharge criteria (approximately 4 mgy) be treated at the ORNL STP. Technical analysis of the STP's capability for treating this waste stream is covered in section 5.2.2

5.4 LLLW SYSTEM

LLLW system facilities are located throughout ORNL, including:

- LLLW collection/storage tanks, which are located near generator facilities;
- the LLLW Evaporator Facility (Building 2531), which is located near Third Street and White Oak Avenue in the ORNL Central Campus (Figure 5-7), and includes five 50,000-gallon (gal) double-contained LLLW collection/storage tanks, which are known as the Bethel Valley Evaporator Service Tanks (BVESTs); and
- the Melton Valley Storage Tanks (MVSTs) system, which is located Melton Valley, and includes eight 50,000-gal tanks and six 100,000-gal tanks.

The LLLW system collects, neutralizes, concentrates, and stores aqueous radioactive waste solutions for future solidification and disposal. The waste is collected from "hot" sinks and drains in research laboratories, radiochemical pilot plants, nuclear reactor facilities, and other waste treatment systems. The LLLW system WAC administratively limits the wastes that can be added to the LLLW system to a maximum total radionuclide concentration of the ingestion dose equivalent of 2×10^{10} Bq/L ^{90}Sr.

Figure 5-7. Building 2531 is the LLLW Evaporator Facility, which contains 2 evaporators for LLLW.

FWENC has a fixed-price, unit-rate contract with DOE-EM to treat ORNL legacy LLLW (including newly generated LLLW produced through the FY05/FY06 timeframe). Wastes will be treated at the TRU WPF being constructed in Melton Valley, just west of the MVSTs system. New Category II nuclear hot cell facilities, specifically designed to treat large volumes of legacy waste over a short time period, have been constructed in the TRU WPF. Wastes treated at the TRU WPF will be dispositioned at the NTS and WIPP. The TRU WPF is expected to operate through approximately FY08, and will be D&D'd in approximately FY11. These dates are not final, however, as changes in waste stream priorities and other external forces (e.g., the WIPP RH-TRU WAC), could significantly impact the schedule.

5.4.1 Critical LLLW System Infrastructure Issues

The LLLW generation rates have been estimated through FY14, when DOE-EM remediation activities and DOE-NE processing of ^{233}U at Building 3019A are expected to be completed. After completion of the solidification and disposal of the existing inventory of legacy LLLW at the TRU WPD, and the facility's D&D, there will be no facility available to process newly-generated LLLW for disposal. If the TRU WPF stops accepting LLLW in the FY05/FY06 timeframe, as presently scheduled, as much as 300,000 gal of concentrated LLLW could accumulate in the MVSTs system by FY14. Only 30,000 gal (10%) of this concentrated LLLW will have resulted from direct processing of UT-B R&D waste. In the near-term, actions must be taken to address treatment of LLLW, which is expected to accumulate in the MVSTS system through FY14. Additional actions must be taken to provide new LLLW collection and treatment systems designed for R&D-generated LLLW waste over the next 50 years.

5.4.2 Technical Assessments for Future LLLW Treatment Needs

New treatment facilities for R&D-generated LLLW must be installed to meet DOE's requirement that all generated wastes have a path for disposal. The TRU WPF is not a viable long-term treatment option for LLLW solidification since it only has a 15-year design life and is oversized for R&D needs. The TRU WPF is sized to treat 58,500 gallons per month (gal/month) of LLLW, and the future production rate of evaporated LLLW is expected to be 240 gal/month. Similarly, the BJC-managed LLLW collection/storage system is oversized for DOE-SC/UT-B R&D needs. The total storage capacity in the BVESTs/MVSTs system is 1,070,000 gal (based on the Operational Safety Requirement (OSR) limits)[11]. It will take approximately 300 years to fill these tanks to 80% capacity with R&D-generated LLLW. New treatment capabilities should be put in place as soon as possible, since plans call for the TRU WPF to stop accepting newly-generated LLLW for treatment in the FY05/FY06 timeframe and stop processing LLLW in approximately FY08.

[11] *Liquid and Gaseous Waste Operations Project Annual Operations Report CY2001*, DFS/LGWO/RPT/2002-1, April 2002, Duratek Federal Services, page 159.

The ANL-West treatment concept (See Chapter 4) was evaluated for treatment of newly-generated LLLW. ANL-West LLLW streams are pretreated at the generator site to remove the major radiological and hazardous components, which are disposed of as solid waste. The resulting liquid waste streams are dried to a salt cake in the disposable SHADE systems located in a centralized treatment facility. In the future, SNS is projected to generate 91,000 gal/yr of LLLW, and all other generators are projected to produce 19,000 gal/yr. With the exception of SNS LLLW, R&D-generated LLLW streams could probably be processed in a centralized treatment system using a SHADE-type solidification system without pre-concentration. If SNS waste was evaporated and concentrated by a factor of approximately 60 prior to entering the centralized SHADE-type system along with other R&D generated LLLW, it is estimated that 20,000 gal/yr of LLLW from ORNL would be processed in the solidification equipment. Centralized LLLW treatment would generate approximately 300 gal/yr of solid RH-TRU waste, which would require disposal at the WIPP, primarily due to LLLW input from the REDC.

If REDC LLLW was pretreated at the source of generation to remove TRU waste and cesium-137 (^{137}Cs), the new, centralized LLLW solidification facility (described in the previous paragraph) would require less shielding, and therefore, would be less expensive to construct. The solid waste forms exiting this centralized LLLW treatment system would also be low-activity LLW that could be disposed of at the NTS. Pretreatment of REDC waste was investigated in the 1990s, but several problems arose.

Additional technical analysis will be required to:

- Reevaluate the SNS waste treatment options after the SNS Waste Management Plan is updated in FY04,
- develop a REDC LLLW pretreatment system,
- determine disposal options for the pretreated waste residuals, and
- design the centralized LLLW treatment system for processing the pretreated REDC LLLW and all other LLLW streams generated at ORNL.

5.5 GASEOUS WASTE SYSTEM

This plan covers major stack systems at ORNL. It does not include minor gaseous sources, which are often vented through facility roofs. ORNL has one central stack system that serves several facilities (Figure 5-8). The UT-B managed facilities connected to the central gaseous waste system include:

- 3025 cell ventilation,
- 3027 cell ventilation,
- 3047 cell ventilation and off-gas,
- 3525 cell ventilation,
- 4501 cell ventilation and off-gas,
- 4505 off-gas, and
- 4500 North off-gas.

Figure 5-8. Above ground ducts connect into the central gaseous waste system stack, which is located in the ORNL Central Campus.

The process off-gas exhaust represents low-volume, potentially high-activity gaseous waste from process vessels or other sensitive areas where the concentration of radioactivity may be routine and highly concentrated. The cell ventilation exhaust is comprised of high-volume, low-activity gaseous waste from enclosed areas such as containment areas and hot cells.

ORNL has several local stacks that typically serve a single building. Local stacks serve Buildings 2026, 3019A, and the MSRE. Stack 7911 serves Buildings 7900, 7920, 7930. The MSRE and Building 3019 stacks should be shutdown by FY14 and were not included in this study.

5.5.1 Critical Gaseous Waste System Infrastructure Issues

The 50-year old central gaseous waste treatment system, including the above-ground ductwork in the general vicinity of the central 3039 stack, was upgraded in the 1980s. The central gaseous waste treatment system is oversized for ORNL's future R&D missions. Approximately half of the system's capacity is currently being used. In the future, use is expected to drop to less than 30% of system capacity. Balancing the airflow in the system is tricky, and the airflow will become more difficult to balance as BJC remediates facilities and UT-B hot cell consolidations occur. The central system should be replaced with a system that is tailored to meet ORNL's future gaseous waste flow requirements and treatment needs.

The central gaseous waste collection system's underground ducts are over 50 years old. Visual inspections of the ducts were performed in the 1980s and 1990's and indicated:

- deterioration of most duct joints,
- tree roots growing into the piping, and
- groundwater and/or rainwater inleakage into contaminated ductwork.

Figures 5-9 and 5-10 show deterioration of ORNL's gaseous waste system ductwork. Readings of 50 milliroentgen per hour (mR/hr) were noted in the 3500-area ducts, and the 4500-area ductwork was likely contaminated with TRU radionuclides. The assessment indicated that groundwater or rain water is likely leaking into the ducts, and contaminated wastewater is likely leaking out of the ducts. The inspectors recommended structural integrity assessments and repairs to eliminate inleakage[12, 13, 14, 15], but neither have been performed. The inleakage is increasing over time, and it has become hard to maintain airflow requirements in some research buildings during periods of heavy rain. This ductwork must be significantly upgraded or replaced if it is to be used in the future.

The ORNL stacks were designed to meet regulatory standards for a major source at the time of construction. The new American National Standards Institute (ANSI) standard, ANSI N13.1-1999, requires continuous stack monitors for major sources and verification that uniform sampling occurs. When "major modifications" are made to a system, such as significantly changing the amount of radioactive material in the building, the existing stacks will need to be upgraded to meet the new

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[12] *Evaluation Report Structural Integrity of Concrete Ducts 3500 Area of ORNL*, Report 87052, April 1988, Lee Wan & Associates.

[13] *Evaluation Report Methods of Upgrading Joints in Concrete Ducts 3500 Area of ORNL*, Report 87051, April 1988, Lee Wan & Associates

[14] *Assessment Report Structural Integrity of Concrete Ducts ORNL*, Report 87033, July1988, Lee Wan & Associates.

[15] *Evaluation Report Methods of Upgrading Joints in Concrete Ducts ORNL*, Report 87027, July 1988, Lee Wan & Associates

regulations. The 2026 stack, which serves Building 2026, and the 7911 stack, which serves the REDC and HFIR are 20 and 40 years old, respectively. These stacks will likely need significant upgrade or replacement to meet the new ANSI standards over the next several years.

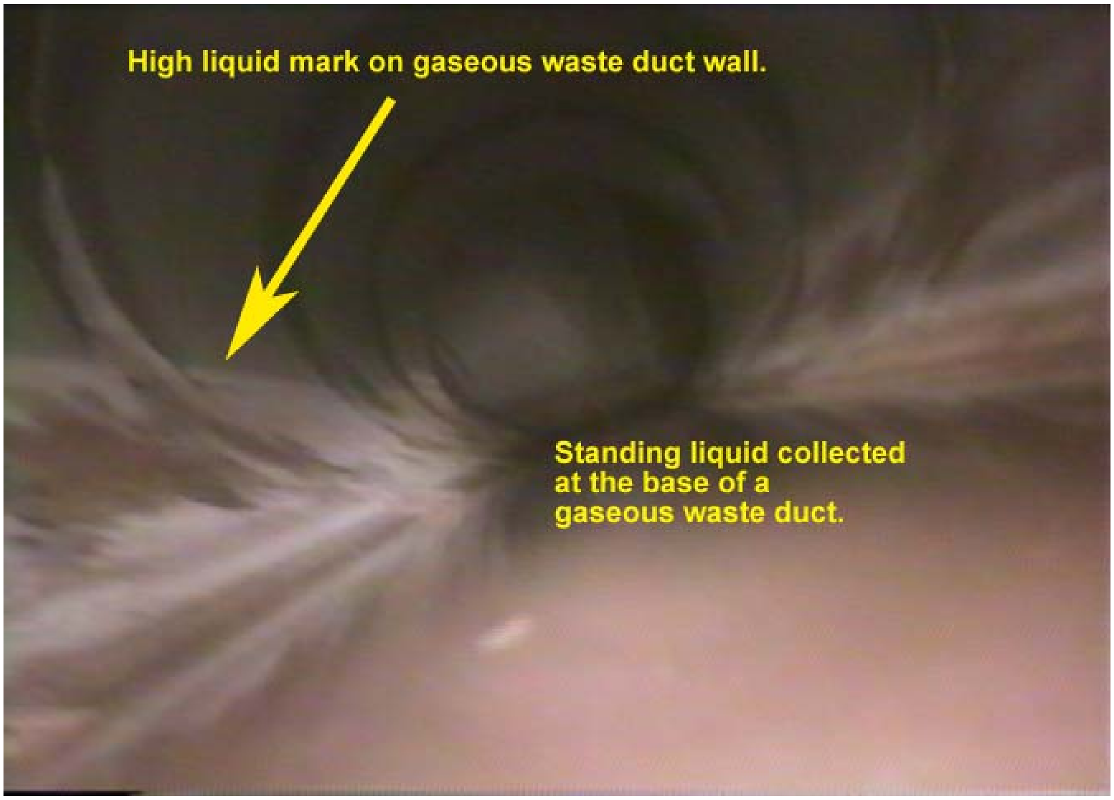

Figure 5-9. Inleakage into the ORNL gaseous waste system ductwork was found during a 1996 video inspection.

5.5.2 Technical Assessments for Future Gaseous Waste Treatment Needs

Order-of-magnitude feasibility studies were performed to evaluate the comparative cost of replacing the centralized gaseous waste system with another centralized system, or installing local systems designed for each building's needs. Results indicate that four to five local treatment facilities could be built for the cost of replacing the central system. Preliminary analyses indicate that it may be less expensive and technically favorable to replace the centralized system with local building stacks and treatment capabilities.

Additional engineering evaluations should be performed after decisions on ORNL hot cell consolidation activities are completed to determine:

- how many facilities actually need treatment upgrades in the future,
- which buildings will contain enough inventory of radioactive material to require regulation as major sources, and
- the total life cycle costs, including D&D costs, for modifying the existing system, compared to replacing the system with a new central system or local building systems.

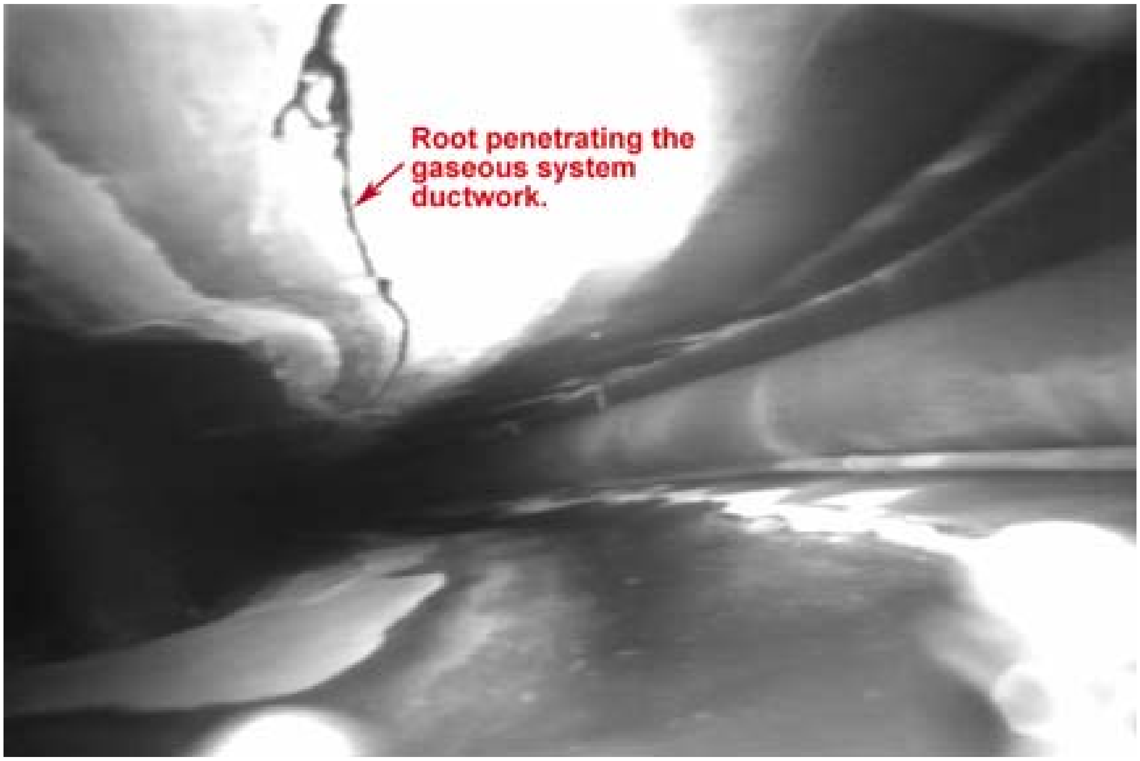

Figure 5-10. A root was found penetrating the gaseous waste system ductwork during a 1986 video inspection.

5.6 ONCE-THROUGH COOLING WATER

The ORNL Land and Facilities Plan[16] identified wide spread use of once-through cooling water and the need to dechlorinate those flows as a critical infrastructure condition. The chemical used to dechlorinate the water is a toxin and an oxygen scavenger. The report recommended that ORNL pursue installation of recirculating cooling systems to eliminate the once-through cooling water flows to the process and sanitary/sewage waste systems as a pollution prevention measure. The impact of eliminating once-through cooling water was evaluated as a part the LGWTS strategic planning effort.

5.6.1 Technical Assessments for Future Once-Through Cooling Water Treatment Needs

The Tennessee Department of Environment and Conservation (TDEC) includes once-through cooling water in the calculation of baseline flow (a minimum flow rate needed for protection of fish and aquatic life to calculate NPDES permit limits). Removing once-through cooling water from the existing process and sanitary/sewage waste treatment systems, by elimination or diversion to the storm water drain system, has a positive impact on the aquatic life base flow and should be pursued. However, reducing the once-through cooling water discharging to White Oak Creek via storm drains could make it more difficult for treatment plant effluents to meet NPDES permit limits. Therefore, these impacts must be evaluated before once-through cooling water flows discharging directly to storm drains are eliminated.

[16] ORNL/TM-2002/1

5.7 GROUNDWATER TREATMENT SYSTEMS

BJC currently collects 53 mgy of contaminated groundwater for treatment at the PWTC where contaminants (primarily mercury, cesium, and strontium) are removed from the groundwater.

5.7.1 Future Melton Valley Groundwater Treatment System

BJC is building a new facility to treat contaminated groundwater generated during Melton Valley remediation activities. The facility is being designed for a 20-year life, and is expected to cost $1.75 Million for construction and $900,000 for annual operating costs[17]. The Melton Valley groundwater treatment system will remove contaminants from collected groundwater at Solid Waste Storage Areas (SWSAs) 4, 5, and 6; Seeps C and D; and the Seepage Pits and Trenches. The volume of collected groundwater is initially expected to be 32-42 mgy, and this is expected to gradually decrease to about 4 mgy. The proposed treatment train consists of filtration, air stripping, activated carbon, and zeolite adsorption to remove volatile organic compounds and strontium/cesium. If metals removal is required, a membrane treatment system will be installed. The treated effluent will be discharged to White Oak Creek.

5.7.2 Future Bethel Valley Groundwater Treatment System

An engineering study[18] will be completed in FY04 to provide data needed to define the remediation activities that will occur during the DOE-EM Bethel Valley clean up. If contaminated Bethel Valley groundwater must be treated long-term, as assumed in the current DOE-EM life cycle baseline, mercury, cesium, and strontium will most likely need to be removed prior to discharge into the environment. These can be removed at the existing PWTC, the new Melton Valley Groundwater Treatment System, or new treatment system(s) in Bethel Valley, such as local treatments systems at the site of generation.

5.7.2.1 Technical Assessments for Future Groundwater Treatment Needs

If the PWTC is to be operated long-term for the treatment of contaminated groundwater, portions of the system will need to be replaced due to facility age. The PWTC ion exchange system generates 40% of the annual LLLW stored in the MVSTs system. Analysis of the PWTC shows that this stream could be eliminated by replacing the two existing ion exchange systems (one for strontium removal and one for cesium removal) with a single zeolite system designed to remove both cesium and strontium. The loaded zeolite would be disposed of as solid waste, thereby eliminating the LLLW stream generated at the PWTC. Use of zeolite ion exchange would also eliminate the need for water softening prior to the existing ion exchange system. The upgrade would not only eliminate the LLLW, it would also reduce the amount of secondary solid waste (softener sludge plus zeolite) generated at the PWTC by 40%. Following the upgrade, groundwater could possibly be discharged to White Oak Creek without additional treatment. The ORNL STP could remove organic contaminants, if necessary, assuming plant capacity is available.

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[17] Personal communications with Frank Carter of Bechtel Jacobs Company LLC.

[18] *Engineering Study Work Plan for Groundwater Actions in Bethel Valley, Oak Ridge, Tennessee*, DOE/OR/01-2035&D2, March 2003.

6. ORNL LIQUID & GASEOUS WASTE TREATMENT SYSTEM (LGWTS) STRATEGIC PLAN

6.1 VISION AND GOALS

This chapter of the *ORNL LGWTS Strategic Plan* outlines the recommended approach for providing cost-effective, upgraded waste collection and treatment systems to accomplish the goal of modernizing ORNL into one of DOE's premier "21st Century Laboratories" within the modernization schedule outlined in the *ORNL Land and Facilities Plan*[19]. The *ORNL LGWTS Strategic Plan* incorporates technologies and strategies from benchmarked facilities and pollution prevention programs to provide safe, economic, and efficient liquid and gaseous waste systems for ORNL's expected future programmatic mission, activities, and facilities.

The ORNL LGWTS Strategic Plan recommends a cost-effective approach for liquid and gaseous waste management to support modernizing ORNL. The plan recommends developing and putting into service new systems specifically designed to treat R&D waste at the lower flow rates expected to result from implementing DOE-EM remediation and DOE-SC pollution prevention programs. The plan calls for:

- ***installing local gaseous waste treatment systems at the site of generation;***
- ***constructing LLLW and process waste treatment systems in Melton Valley near major generators;***
- ***treating incidental process wastewater at the ORNL Sewage Treatment Plant;***
- ***increasing the capacity of the sanitary/sewage; and***
- ***reducing once-through cooling water discharges.***

This approach will minimize ES&H risks by eliminating the use of all existing underground collection piping, except for the sanitary/sewage waste system, and minimizing use of LLLW underground storage tanks and pipelines. The existing DOE-EM managed systems will remain available for remediation activities conducted as part of the CERCLA closure projects.

6.2 STRATEGIC DRIVERS

The ORNL process waste, gaseous waste, and LLLW systems are currently managed by BJC, DOE-EM's managing and integrating contractor. DOE-EM proposes to transfer responsibility for management of newly-generated waste to DOE-SC prior to 2015. DOE-EM and DOE-SC have not reached a final agreement on the transition dates for newly-generated waste and the existing waste systems. These systems will be inappropriate for treatment of future R&D wastes, because of their age, legacy contamination, inappropriate size of the facilities for treatment of only R&D waste, location, and operating costs. DOE-EM/BJC should continue to operate the ORNL waste management facilities needed to support DOE-EM/BJC remediation activities in Bethel and Melton Valleys, and then D&D these facilities once these remediation activities are complete. DOE-EM is experienced in facility D&D and should be able to achieve cost savings by combining these D&D activities with other DOE-EM remediation activities.

New facilities tailored to treat R&D-generated waste should be constructed and operated by DOE, and should be designed to:

- cost-effectively support DOE-SC's mission for the next 50 years,
- disconnect DOE-SC/UT-B-managed research facilities from the existing DOE-EM/BJC-managed waste management facilities by the end of FY10 (the start of the Bethel Valley remediation), and
- meet new regulatory requirements.

System-specific drivers are noted in the system descriptions in Chapter 5 and in the following sections.

[19] ORNL/TM-2002/1

6.3 STRATEGIC PLAN FOR SANITARY/SEWAGE WASTE

6.3.1 System-Specific Drivers

- The ORNL STP will reach its design life in 2010.
- The construction of additional ORNL facilities to accommodate ORNL missions and staff will introduce new sanitary/sewage flows in excess of what the current STP can treat.
- The strategic plan for ORNL process wastewater calls for treating R&D-generated incidental process wastewater at the STP, which will also increase the flow rate through the plant and change the design criteria (to a tank-based system).

6.3.2 Recommended Strategy for the ORNL Sanitary/Sewage Waste System

In the near-term, efforts to reduce inflow to the sanitary/sewage waste system by eliminating once-through cooling water and minimizing inleakage into the collection piping should be continued. Opportunities to reduce inflow by replacing older toilets with low-flow fixtures should be further investigated.

In the long-term, the strategic plan for the ORNL sanitary/sewage systems includes:

- adding an extended aeration basin to the existing STP to accommodate the increased wastewater load for the next ten years;
- replacing the clay-lined lagoons with tanks to allow treatment of incidental process wastewater; and
- ultimately replacing the current STP. Evaluations will be performed to select optimal methods for long-term replacement of the existing sanitary/sewage waste system when the ORNL Ten Year Site Plan provides more detailed information on future facilities and personnel estimates.

Planning should begin in FY04 for capital projects and permit modifications necessary for treating R&D-generated incidental process wastewater at the STP.

Radioactivity in the STP sludge indicates that there is infiltration of contaminated groundwater and/or legacy contamination in the collection piping. The most likely source of contamination is from groundwater inleakage from the 3000 area of the ORNL Central Campus. As long-term plans for this part of the plant are developed by UT-B, actions may be required to reduce the radioactive waste entering the sanitary/sewage system, including rehabilitation of small-diameter pipelines between the buildings and the main collector trunk lines.

6.4 STRATEGIC PLAN FOR PROCESS WASTE

6.4.1 System-Specific Drivers

- Replacements will be needed for the PWTC treatment facilities to extend their operability for 50 years.
- The PWTC treatment facilities are significantly oversized for future R&D waste treatment needs; future generation rates will be 3% of the existing system design capacity.
- The integrity of the 50-year-old collection piping is a vulnerability, particularly between the research facilities and the central collection manholes.

6.4.2 Recommended Long-Term Strategy for the ORNL Process Waste System

Eliminate the use of the PWTC by the end of FY10 by:

- eliminating and/or rerouting once-through cooling water to the storm drain system;
- rerouting incidental process wastewater to the sanitary/sewage waste system, with local pretreatment as required; and
- constructing and operating a new process waste treatment system in Melton Valley, near the HFIR and REDC, for the treatment of radioactive process wastewater generated at the HFIR, REDC, and SNS. SNS waste will be trucked to the treatment facility.

It is recommended that the ORNL radioactive laundry wastewater be processed by:

- trucking the wastewater to the ORNL STP,
- solidifying the wastewater at the source of generation, or
- outsourcing the laundry wastewater to an off-site facility.

These recommendations should be implemented as soon as possible, since they have the potential for major cost savings. The current operating costs for the PWTC are $11.3 Million per year. The operating costs of the new treatment systems are expected to be $1.4 Million per year above the present costs for the sanitary/sewage waste system.

6.5 STRATEGIC PLAN FOR LLLW

6.5.1 System-Specific Drivers

- The current ORNL LLLW system only concentrates and stores LLLW; it does not provide capabilities to routinely treat waste to a solid form suitable for disposal.
- DOE-EM awarded a private-sector contract to solidify legacy LLLW at the TRU WPF, but it will not provide long-term capabilities to solidify newly-generated LLLW.
- The TRU WPF is presently scheduled to stop accepting newly-generated waste, including R&D waste, in the FY05/FY06 timeframe and shut down the LLLW treatment capabilities toward the end of FY08.

6.5.2 Recommended Long-Term Strategy for the LLLW System

It is recommended that new treatment capabilities be implemented to convert R&D-generated LLLW into solid waste forms as soon as possible. New collection/treatment facilities will be designed to reduce the risks and operating costs associated with the handling of highly-radioactive LLLW by treating the most hazardous components at the source of generation, minimizing the use of underground pipelines and storage tanks, and minimizing the inventory of liquid waste within the system by implementing real-time treatment and disposal processes.

The strategic plan for newly generated LLLW is outlined below:

- TRU and high-gamma-activity LLLW will be treated at the point of generation at the REDC to produce small volumes of solid RH-TRU and RH-LLW for disposal at WIPP and NTS, respectively.
- The effluent from REDC pretreatment will be added to the lower activity LLLW from other R&D activities and solidified in new facilities designed for real-time processing of waste for disposal at NTS. These facilities will be located in Melton Valley near the REDC and the relocated Manipulator Shop.
- LLLW from Bethel Valley (SNS and Building 2026) will be trucked to the new LLLW treatment facilities. For all other generators that produce small quantities of LLLW, the LLLW will be bottled for transport to the new facilities.
- SNS waste will also be evaluated for pretreatment.

Engineering analyses and technical studies needed to support implementation of the strategy should be initiated in FY04 to support the design of capital projects. These include evaluation of REDC pretreatment options, review of the revised SNS Waste Management Plan, and technical studies to design the LLLW solidification system. The ORNL LGWTS Strategic Plan will implement new capabilities to treat newly-generated R&D waste by the end of FY10. DOE must provide capabilities to treat LLLW, which will accumulate in the MVSTs system from approximately FY06 through FY14 when DOE-EM remediation activities and DOE-NE ^{233}U processing at the 3019A complex end (estimated to be up to 300,000 gal).

6.6 STRATEGIC PLAN FOR GASEOUS WASTE

6.6.1 System Specific Drivers

- Much of the centralized gaseous waste system is 50 years old, and significant portions of the system, particularly the concrete collection ducts, have structural integrity issues.
- The system is significantly oversized for long-term R&D needs; projected future flow rates are one third of the existing capacity.
- New ANSI N13.1-1999 standards will eventually require that the existing systems be upgraded/replaced to meet new dispersion and sampling criteria.

6.6.2 Recommended Long-Term Strategy for the ORNL Gaseous Waste System

- Discontinue use of the centralized gaseous waste system as soon as possible, but no later than FY10.
- Replace the existing, aged, centralized treatment system in Bethel Valley with new local treatment systems for strategic DOE-SC facilities. This will include new stacks for major sources, local roof ventilation systems for minor sources, and putting non-strategic facilities in safe shutdown. The local stacks will be specifically designed for the research needs of each building. Facilities presently discharging to the central stack include Buildings 3025E, 3525, 3047, 4501, 4505, and 4500 North. The upgrades that will be implemented for each building will be determined by on-going hot cell consolidation activities and the ORNL Ten Year Site Plan, which will be updated in FY04.
- Upgrade the two local building stacks (2026 and 7911) to meet the new ANSI standards and programmatic needs for the next 50 years by the end of FY12.

6.7 STRATEGIC PLAN FOR ONCE-THROUGH COOLING WATER

Once-through cooling water accounts for a significant portion of the present flows to White Oak Creek through discharges from storm sewers and the process and sanitary/sewage waste systems. Once-through cooling water discharges to the process and sanitary/sewage systems will be minimized since it unnecessarily increases the load on these treatment plants. In the near-term, this will be accomplished by eliminating 37 mgy and diverting 77 mgy of once-through cooling water to the storm drain system. Over the long-term, much of the cooling system equipment will be replaced with new, recirculating-type systems to eliminate the once-through cooling water discharges. Since the chemical used to dechlorinate once-through cooling water prior to discharge to storm drains is a toxin and an oxygen scavenger, the installation of recirculating cooling water systems to reduce/eliminate the flows discharged to the storm system will be undertaken as a pollution prevention measure. However, eliminating too much once-through cooling water discharging directly to storm drains could have a negative impact on the wastewater treatment facilities' ability to meet NPDES permit requirements. Detailed evaluations of these impacts must be performed before these projects are implemented.

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7. PRELIMINARY COST AND SCHEDULE

Completing the vision for ORNL's "21st Century" waste treatment systems will require significant investment of both operating and capital funds. The process for identifying these resources is summarized in Chapter 2, and a summary of the proposed project schedules and costs is given in this chapter. Traditional DOE-funded operating expense and capital projects, including GPPs, general plant equipment projects (GPEs), institutional general plant projects (IGPPs), and line items, were considered, as well as alternative funding options, such as private-sector construction of new waste treatment facilities. Alternative funding options did not appear viable upon preliminary investigations (see Appendix A, section 4.2; Appendix B, section 4.4; and Appendix C, section 4.1). Therefore, all projects were scoped as traditional DOE-funded capital projects.

7.1 SUMMARY OF ESTIMATED COSTS AND SCHEDULE

The ORNL liquid and gaseous waste system upgrade strategy will be implemented through the capital projects listed in Table 7-1, which total $74.2 Million over nine years. As noted in Table 7-1, these costs include $52.6 Million for projects required to replace the existing DOE-EM/BJC-managed centralized liquid and gaseous waste treatment facilities, and $21.6 Million for projects to upgrade existing equipment located in generator facilities, which will continue to be used for the foreseeable future. The ongoing Building 1506 Renovation Project, which is an FY03-FY04 IGPP, and the Surplus Facility Clean Out, Deactivation and Demolition expense project, eliminate once-through cooling water presently discharging to the process and sanitary/sewage systems from Buildings 1506, 2018, 2019, and 2024. Additional project scopes and capital funding required to implement the *ORNL LGWTS Strategic Plan* are included in Table 7-1. Expense funding of $100,000 for each GPP, GPE, and IGPP, as well as $250,000 in expense funding for each line item, are needed one year prior to project initiation. An additional $3 Million of expense funding is needed in FY04 - FY06 for continued strategic planning, engineering evaluations, and treatability studies to support the planning of the capital projects. Therefore, the cost for implementing the *ORNL LGWTS Strategic Plan* is $79 Million.

For comparison purposes, the annual operating and environmental monitoring costs for the proposed new liquid and gaseous waste collection and treatment systems were estimated relative to the costs for the existing centralized treatment systems. Costs associated with the portions of the ORNL waste systems that are not expected to be significantly impacted by the ORNL LGWTS strategy were not included in these estimates (e.g., most generator facilities; the Building 2029, 7911, 3019, and 7503 stack operations; and UT-B environmental compliance staff time for preparing permit applications).

The annual costs of the existing and future waste treatment systems are given in Table 7-2. The costs for operating existing waste treatment systems were obtained from the current facility managers. The methodology for estimating the future operating costs are given in the Appendix F. These include the costs for operating the collection systems and treatment facilities, regulatory monitoring, and disposing of secondary solid waste. The costs are currently borne by:

- UT-B for operating the sanitary/sewage waste system;
- BJC for operating the gaseous and process waste treatment and collection systems, and the LLLW collection/storage system; and
- UT-B for the NPDES permit monitoring for the STP and the PWTC, and the NESHAPs gaseous stack monitoring costs.

The annual operating and environmental monitoring costs for the existing centralized liquid and gaseous waste treatment systems are approximately $19.3 Million per year, as shown in Table 7-2. The proposed new systems will have estimated operating and environmental monitoring costs of $ 5.2 Million per year. Therefore, the total cost avoidance for the construction and a 30-year operating life for the new systems, as compared to the current systems would be $423 Million, or over $14 Million per year. At this rate, the cost of the treatment systems construction would be repaid in about 5.6 years. The return on investment calculations do not reflect costs for maintenance or modifications that would be required to keep the existing DOE-EM/BJC-managed liquid and gaseous waste systems operating for an additional 30 years, nor does it include closure or D&D. The existing systems costs do not include costs for solidification and disposal of concentrated LLLW stored in the MVSTs system, since these capabilities for newly-generated waste do not presently exist. If these additional costs were included in the above return-on-investment calculations, the construction costs of the new facilities would likely be paid back in less than three years.

The operating costs are essentially fixed for the gaseous and LLLW systems. Therefore, the cost reductions for waste management at ORNL will not be realized by DOE until they are completely shut down. Since operating costs for the proposed new systems designed for R&D waste treatment would be significantly less than the existing systems, these new systems should become operational no later than the end of FY10, to allow DOE-EM to close the existing facilities during the Bethel Valley and Melton Valley remediation activities. The costs of operating the process waste system could be reduced in the near-term if the flow to the plant can be reduced enough to allow the system to be operated on a part-time basis rather than around-the-clock. Because UT-B's once-through cooling water and R&D wastewater accounts for 65% of the process wastewater flow, the sanitary/sewage system and process waste system related GPPs, described in Table 7-1, should be implemented immediately, in order to reduce the near-term process waste treatment plant costs. The project schedules listed in Table 7-1 were developed to accomplish these objectives.

ADSs were developed for each of the capital projects listed in Table 7-1 for ranking by ORNL senior management. These projects were ranked along with all other capital project requests, using the RPM described in Chapter 2. The seven capital projects replacing the existing liquid and gaseous waste treatment systems before the end of FY10, to accommodate DOE-EM remediation schedules, were ranked very high in the overall ORNL capital assets program ranking. The remaining projects were ranked lower, and their schedules may change from the dates identified in Table 7-1 as the ORNL Leadership Team and DOE continue the funding approval process for capital projects.

Table 7-1. Proposed *ORNL LGWTS Strategic Plan* capital projects and associated funding requirements and schedules.

Project Title (Capital Project Type) and Project Description	Proposed Schedule	Proposed Funding Requirements
Sanitary/Sewage System Projects		
Replace Tertiary Filter at the Sewage Treatment Plant (GPE)[1] - Replaces sand filter with continuous back flush unit for existing extended aeration unit.	FY04	$125,000
Sanitary System Treatment Capacity Increase (GPP)[1,2] - Adds extended aeration unit to existing STP.	FY05 - FY06	$ 4.08 Million
Sewage Treatment Plant Surge Capacity Replacement (GPP)[2] - Replaces two existing clay-lined lagoons with a 1 million-gal collection tank and closes lagoons in-place.	FY07 - FY08	$ 4.32 Million
Process Waste System Projects		
Bethel Valley Process Waste Cooling Water Elimination (GPP)[2] - Eliminates once-through cooling water from the process waste and sanitary/sewage systems by eliminating sources and/or rerouting once-through cooling water to the storm drains.	FY05 - FY07	$ 2 Million
Bethel Valley Process Waste Drain Elimination (GPP)[2] - Reroutes Bethel Valley process wastewater drains to the sanitary/sewage waste system.	FY07 - FY09	$ 4 Million
Melton Valley Process Waste Drain Contaminant Discharge Elimination (GPP)[2] - Constructs process waste treatment system near HFIR and REDC to treat radiological process wastewater for discharge to Melton Creek. - Implements truck transfer for SNS process wastewater.	FY08 - FY09	$ 1.71 Million
Liquid Low Level Waste Project		
ORNL Liquid Low-Level Waste Treatment (Line Item) [1,2] - Implements source treatment to remove high gamma and TRU elements from REDC LLLW. - Constructs a centralized treatment facility in Melton Valley to solidify LLLW for disposal at the NTS. - Implements truck transfers for SNS and other Bethel Valley LLLW generators.	FY06 - FY09	$ 9.5 Million
Gaseous Waste System Projects		
Upgrade Hot Off-Gas/Glovebox Off-Gas System in Building 3047 (GPP)[1] - Replaces Building 3047 hot off-gas and glove-box off-gas systems components.	FY05	$500,000
Install New Vessel Off-Gas Scrubber System in 7920 (GPP)[1] - Replaces Building 7920 vessel off-gas scrubber.	FY05 - FY07	$ 5 Million
ORNL Gaseous Waste System Upgrade (Line Item) [1, 2] - Removes Buildings 3525, 3025E, 3047, 4501, 4505, and 4500N from central gaseous waste system; installs local stacks or roof ventilation systems, or disconnects existing ventilation system (Actual facility scope to be determined by the outcome of Hot Cell Consolidation activities and the *ORNL Ten Year Site Plan*) ($17 Million). - Upgrades 2026 and 7911 stacks serving Building 2026, REDC, and HFIR to meet new American National Standards Institute standards ($10 Million).	FY06 - FY12	$ 27 Million
Laboratory Facility Vent System Upgrade – Phase I (Line Item)[1] - Modernizes ventilation and exhaust systems inside ten ORNL facilities. - A portion of this line item compliments the ORNL Gaseous Waste System Upgrade Line Item above, by upgrading portions of the gaseous waste collection system located inside generator buildings (i.e., Building 2026E cell off-gas and vessel off-gas systems).	FY06 - FY08	$ 7.5 Million
Laboratory Facility Vent System Upgrade – Phase II (Line Item)[1] - Modernizes ventilation and exhaust systems inside ten ORNL facilities. - A portion of this line item compliments the ORNL Gaseous Waste System Upgrade Line Item above, by upgrading portions of the gaseous waste collection system located inside generator buildings (i.e., Building 7920 vessel and cell off-gas systems, compressors, and filter pits and Building 4501 cell off-gas and vessel off-gas exhaust ductwork).	FY07 - FY09	$ 8.5 Million

1. Project implements upgrades to the existing facility and/or adds new treatment capabilities, which are needed to continue operations for the next 50 years.
2. Project implements waste treatment systems to replace existing DOE-EM/BJC managed waste treatment facilities.

Table 7-2. Estimated costs for operating and monitoring existing and proposed ORNL liquid and gaseous waste treatment facilities.

	Annual Costs ($ Million)						Annual Cost Savings/ Avoidance ($ Million)
	Existing Systems			New Systems			
Waste System	Facility Operations	Regulatory Monitoring	Total	Facility Operations	Regulatory Monitoring	Total	
Sanitary/ Sewage	0.5	0.5	1	0.6	0.6	1.2	(.2)[1]
Process Waste	11.0	0.3	11.3	1.1	0.3	1.4	9.9
LLLW Collection and Storage	4.8	0	4.8	0.8	0	0.8	4.0
LLLW Solidification[2]	Not Available	0	Not Available	0.8	0	0.8	(0.8)
Gaseous Waste	1.6	0.6	2.2	0.3	0.7	1.0	1.2
Total	**17.9**	**1.4**	**19.3**	**3.6**	**1.6**	**5.2**	**14.1**

1. Sanitary/sewage waste system costs are expected to increase due to additional maintenance costs associated with the additional of a second treatment unit and additional environmental monitoring costs associated with treating incidental process wastewater.
2. The current LLLW system does not provide for solidification and disposal of LLLW. The new LLLW treatment facilities will provide these additional capabilities.

8. CONCLUSIONS AND RECOMMENDATIONS

Various infrastructure systems, including waste management systems, are located at ORNL and operate to support research activities. Similar to the research facilities themselves, these infrastructure systems are in various stages of deterioration due to age. These infrastructure systems are critical to the mission of ORNL and must receive equal attention in revitalization planning. The *ORNL LGWTS Strategic Plan* proposes to revitalize ORNL's liquid and gaseous waste management systems to support the objectives of the DOE-SC "Laboratories of the 21st Century" modernization initiative. This plan will enable revitalization of ORNL's waste management systems to sustain ORNL as a world-class research institute. Implementing this plan will require a collaborative effort from the DOE-SC and UT-B team in a number of areas, which are recommended in this Chapter.

Anticipated DOE decisions and actions needed:

1. Support and promote construction of new waste management facilities at ORNL that optimize DOE resources and provide attainable paybacks.
2. Define DOE-EM's work scope in a logical flow consistent with implementing operation of the proposed new waste treatment facilities.
3. Support D&D of existing DOE-EM-managed waste treatment facilities by DOE-EM as part of the Melton Valley and Bethel Valley closure projects.
4. Implement project(s) to treat LLLW accumulated in the MVSTs system through FY14. Bethel Valley remediation and Building 3019A ^{233}U processing are scheduled to be completed by FY14, and projects should be in place no later than FY14 to treat R&D-generated LLLW by other means.

UT-B will be challenged with:

1. Supporting the expense and capital projects described in this strategic plan to meet ORNL modernization and EM remediation schedules.
2. Defining and cost-effectively implementing the plan's tasks.
3. Developing the strategy for the ORNL Nuclear Initiative, which will define many of the long-term waste management needs at ORNL.

In FY03, UT-B OIP funded and implemented the LGWTS Re-engineering Project to define the strategy outlined in this plan for upgrading ORNL's liquid and gaseous waste systems. In FY04, engineering evaluations needed to support the implementation of this strategy will continue, and planning will begin for the capital projects defined in Chapter 7.

Several ongoing and future efforts will impact the *ORNL LGWTS Strategic Plan* and may result in future modifications, including:

- ORNL Facilities Revitalization planning for 2006 - 2011;
- hot cell consolidation activities, and the long-term plan for the ORNL Nuclear Initiative;
- DOE-EM's CERCLA contaminated soil, groundwater, and facilities clean up in Bethel Valley;
- DOE-NE's private sector contract, to be awarded later this year, for processing ^{233}U at the Radiochemical Development Facility (Building 3019A);
- DOE's National TRU Program's development of the WAC for RH-TRU waste, and acceptance of this waste for disposal;
- development of detailed waste management plans for the SNS; and
- effectiveness of ongoing projects to reduce infiltration into the STP collection system.

This strategic plan is a living document that is subject to change based on future studies and actions. Progress on the liquid and gaseous waste management system's revitalization schedule will be documented in the *ORNL Ten Year Site Plan,* as well as changes in the scope or direction for the revitalization of ORNL's liquid and gaseous waste managements systems.

APPENDIX A – SANITARY/SEWAGE WASTE SYSTEM

1. SANITARY/SEWAGE SYSTEM DESCRIPTION

1.1 SANITARY/SEWAGE COLLECTION SYSTEM

The Oak Ridge National Laboratory (ORNL) sanitary/sewage collection system consists of over 32,000 feet of clay, cast iron, and polyvinylchloride (PVC) pipe ranging in size from 4 to 12 inches. Access to the collection system is obtained through 194 brick and concrete manholes. The system itself has grown as ORNL has grown. The oldest parts of the system, located roughly between First Street and Fifth Street, were constructed in 1943 when ORNL was initially built, and consist primarily of vitreous clay pipe with packed joints and manholes constructed entirely of brick. The rest of the collection system was constructed as ORNL grew and developed. The construction methods used in these areas reflect the construction practices used when they were built, with some collection lines constructed from vitreous clay, concrete, cast iron, and PVC. Manhole construction also reflects this diversity, as some are built entirely from brick, others are part brick and part concrete, some are poured-in-place concrete, and the newer manholes reflect the current practice of using precast units.

In the early 1980s, a leak test was performed on the sanitary/sewage collection system. The survey was used as the basis for several general plant projects (GPPs) in the mid-1980s, which were directed at lessening infiltration into the system. During 1984 and 1985, approximately 60% of the sanitary/sewage collection lines 6 inches in diameter and larger were rehabilitated using a then-new process called "Insituform". The "Insituform" process installs a new, joint-free liner inside the existing pipe, creating a slick, leak-free system. The success of this effort was immediate, with daily average flows falling from about 175 gallons per minute (gpm) to 110 gpm; however, within a year the volumes began to slowly increase. Investigation of the problem indicated that the groundwater flow, which previously had been entering the pipe through open joints, cracks, and breaks, was now flowing along the outside of the pipe and entering the system either through the manholes or through sections of pipe that had not been lined.

Because of the groundwater inleakage problem and other weaknesses identified in the sewage collection system, a line item project to upgrade the sanitary/sewage collection system was initiated in the late 1980's and funded in 1993. This project successfully upgraded most of rest of the collection system by

- installing cured-in-place lining in all sewer lines 6 inches and larger,
- sealing all manholes with a polyurethane, and
- making other improvements.

There are only a few short sections of the main collector lines, as well as the individual building service laterals, that could not be rehabilitated. There are approximately 150 buildings that are tied into the sanitary/sewage collection system, with up to 50 linear feet of piping per building that has not been rehabilitated. Therefore, there is 5,000 to 7,500 linear feet of piping that may need upgrades in the future.

Smoke testing of the sanitary/sewage collection system was conducted during the summer of 2001 to determine possible problem areas and potential sources of infiltration and other unauthorized inflows. A number of areas where infiltration could possibly occur were identified. Most of these were broken or missing clean-out plugs, but there are a few areas where it appears a line may be broken that could allow rainfall or runoff to enter the collection system. Repairs are being made, with the goal of eliminating all of the deficiencies by the end of 2003.

1.2 SEWAGE TREATMENT PLANT

The ORNL Sewage Treatment Plant (STP), built in 1985, is an extended aeration, package unit, with a nominal treatment capacity of 300,000 gallons per day (gal/day) (208 gpm). The STP consists of

- an aeration chamber, where organics and ammonia in the wastewater are oxidized,
- a clarifier, where solids are removed from the effluent, and
- a digester, where the excess sludge is stabilized.

The effluent is filtered and then disinfected with ozone to kill bacteria prior to discharge to White Oak Creek. The digested sludge (150,000 gallons per year {gal/yr}) was previously trucked to the City of Oak Ridge STP, combined with sludge from the City of Oak Ridge STP and then landfarmed. Currently, the City of Oak Ridge has suspended accepting the ORNL sludge, so the sludge is dried to a damp solid (30,000 gal/yr) and packaged in B-25 boxes for future disposal as solid low-level waste (LLW) at Envirocare of Utah, Inc.

The STP is 18 years old and will reach its design life in 2010. The facility is in good condition and should last for several years if properly maintained. No upgrades are required to meet current or projected National Pollutant Discharge Elimination System (NPDES) discharge permits.

2. SANITARY/SEWAGE WASTE GENERATION ESTIMATES

In 2002, the flow rate at the ORNL STP NPDES discharge point averaged 150 gpm, while the flow measured at the STP averaged 127 gpm. Sanitary inputs to the STP are expected to increase due to consolidation of personnel to the main ORNL campus and occupation of the new facilities planned for the East Campus, West Campus, and Spallation Neutron Source (SNS) site. Future sanitary waste generation was estimated annually between fiscal year 2004 (FY04) and FY08 for:

- 25% reduction of infiltration to the STP collection system in FY03,
- elimination of 10.2 mgy of once-through cooling water from the STP inflow by FY07,
- 475 employees moving from leased facilities to the main ORNL site in FY04 and FY05,
- additional animal sewage due to occupation of the Laboratory for Comparative and Functional Genomics in FY04,
- up to 700 guests per day visiting the new East Campus buildings beginning in FY05, and
- 700 additional employees and/or guests at the SNS site in the Center for Nanophase Materials Sciences, Joint Institute for Neutron Sciences, and SNS between FY06 and FY08.

Annual personnel growth beyond FY08 was estimated at 2% per year. The estimated annual sanitary waste generation rates are summarized in Figure A-1.

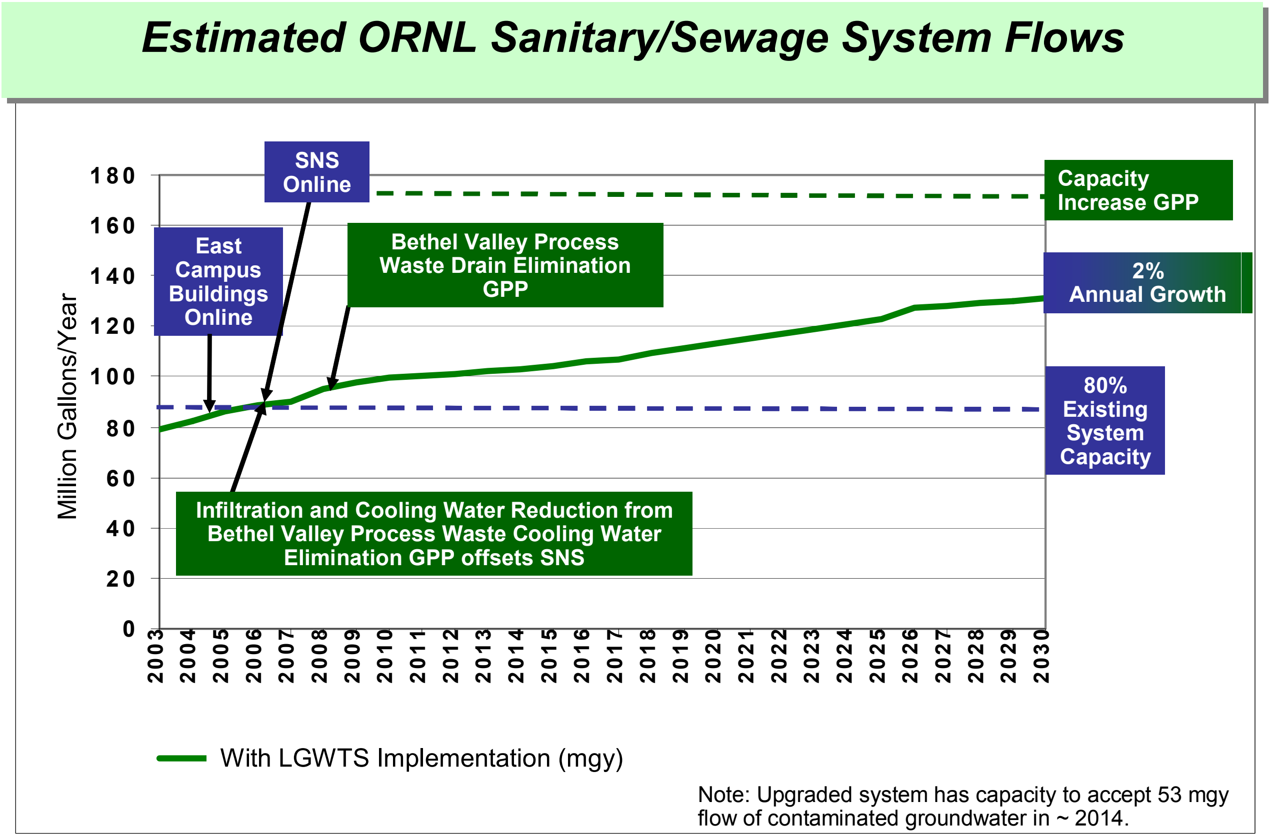

Figure A-1. Summary of ORNL sanitary/sewage waste contributions.

3. SANITARY/SEWAGE SYSTEM RE-ENGINEERING EVALUATIONS

3.1 SANITARY/SEWAGE SYSTEM CAPACITY EVALUATIONS

In 2002, the flow rate at the ORNL STP NPDES discharge point averaged 150 gpm, while the flow measured at the STP averaged 127 gpm. The flow rate is strongly affected by rainfall, with a base flow of 115 gpm and an average increase of 44 gpm for each inch of rain. Most of the larger collection lines have been "insituformed" in the past, but inleakage into the system is still significant. Efforts are continuing to identify and fix any problem areas. Currently, the STP can not handle the total flow rate during periods of heavy rain, so part of the influent is diverted into two clay-lined ponds and then processed during periods of lower flow. A couple of times a year, during periods of heavy rain, the lagoons can not handle the influent and partially treated wastewater is discharged directly to White Oak Creek. There were five NPDES permit noncompliances in calendar year 2002, due to the discharge of partially treated sanitary wastewater during periods of heavy rain.

Figure A-2 shows the average flow through the ORNL STP, total rainfall, and ORNL population for the past ten years. The ORNL population shown is the sum of the full-time and temporary employees, plus half the number of part-time employees, and one-tenth of the badged non-employees. This is a somewhat arbitrary estimate of the average number of people utilizing the sanitary/sewage system each year. Using different factors changes the absolute numbers, but does not significantly change the trend. Data were not readily available to distinguish between personnel working on-site and using the ORNL sanitary system versus those located off-site. It was assumed that the ratio did not change significantly over this time

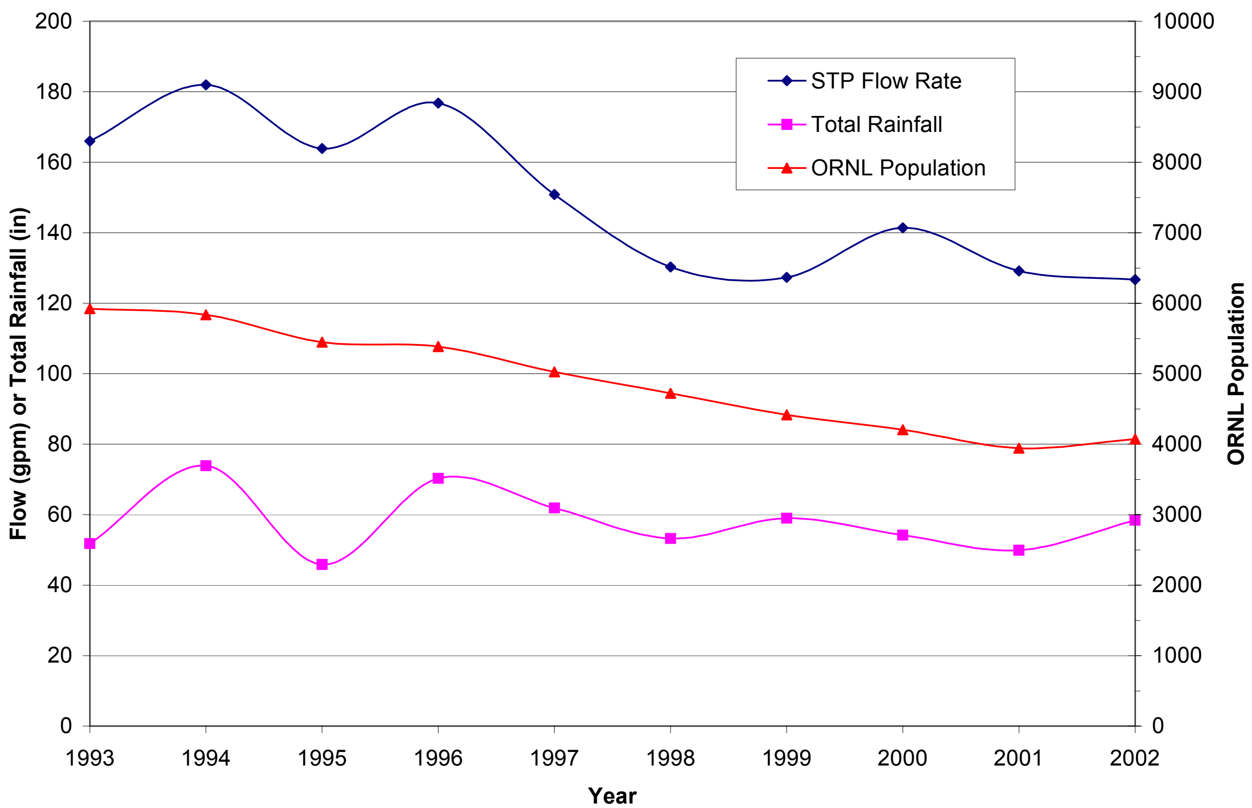

Figure A-2. Summary of ORNL STP flow, total yearly rainfall, and ORNL population.

period. The graph shows the strong effect of rainfall and population on the yearly flows through the ORNL STP.

Efforts are underway to reduce the amount of infiltration into the sanitary/sewage collection system, which was estimated to be an average of 35 gpm in 2002. A survey of once-through cooling water inputs to the sanitary/sewage system indicated that 20 gpm of once-through cooling water is discharged to the system. Projects are being planned to remove 19.4 gpm (see Appendix B, section 4.1 {Bethel Valley Process Waste Cooling Water Elimination GPP}) from the sanitary/sewage system. Removing this clean water from the sanitary/sewage system could reduce the average flow through the STP to 130 gpm. Even if these actions are successful, an increase in the sanitary/sewage treatment capacity will likely be required to treat new sanitary/sewage wastewater. As the construction of new buildings are completed and employees currently located off-site move back to the ORNL campus, flow to the ORNL STP is expected to steadily increase for the foreseeable future, although new low-flow fixtures in these buildings will limit the increase. The capacity increase will also be required to allow diversion of incidental process wastewater to the STP. Figure A-1 shows the expected flows to the STP over time.

3.2 SANITARY/SEWAGE SYSTEM TREATMENT EVALUATIONS

The NPDES permit for the ORNL STP has limits for biological oxygen demand (BOD), total suspended solids (TSS), ammonia, oil and grease, pH, dissolved oxygen, residual chlorine, fecal coliform, and aquatic toxicity. Levels of cadmium (Cd), mercury (Hg), silver (Ag), and cyanide (CN) must be reported, but do not currently have limits. Composite samples of the effluent from the ORNL STP are collected three times a week, and then combined and analyzed once a month for NPDES compliance. The average

STP contaminant concentrations for metals, cyanide, and radionuclides for calendar year 2002 are shown in Table A-1.

Table A-1. Contaminant concentrations in STP effluent.

Contaminant	Concentration	Units
Silver	<0.0002	mg/L
Cadmium	<0.0005	mg/L
Copper	0.0050	mg/L
Mercury	<0.0002	mg/L
Lead	0.0021	mg/L
Uranium	0.0002	mg/L
Zinc	0.0332	mg/L
Cyanide	<0.0005	mg/L
Gross Alpha	1.32	pCi/L
Gross Beta	265	pCi/L
Strontium-90	117	pCi/L
Cobalt-60	2.5	pCi/L
Cesium-137	8.9	pCi/L

The influent to the ORNL STP is not routinely monitored, so the long-term concentration of metals and other contaminants entering the STP is not known. Composite samples of the influent were collected from February 28, 2003, to March 28, 2003, and analyzed for total and soluble metals. Four weekly composites and then three daily composites were collected. A sub-sample of the effluent samples that are routinely collected for compliance monitoring was also analyzed using the same techniques. The results are shown in Table A-2.

Table A-2. Metals concentrations in ORNL STP influent during March 2003.

Metal	Copper (mg/L)	Lead (mg/L)	Zinc (mg /L)
Influent – Total			
Average	0.085	0.044	0.231
Maximum	0.223	0.111	0.529
Minimum	0.023	0.01	0.109
Number of Detects	7	7	7
Influent – Soluble			
Average	0.033	0.004[A]	0.043[A]
Maximum	0.06	0.019	0.183
Minimum	0.01	<0.005	<0.04
Number of Detects	7	1	1
Effluent - Total			
Maximum	<0.007	<0.005	<0.04
% Removal	>92	>89	>83

A. Average is calculated using a value of half the detection limit for samples below the limit

Copper (Cu), lead (Pb), and zinc (Zn) were consistently present in the influent, mostly as particulates. All of the effluent samples were below the detection limits for the heavy metals. There was considerable variation in the metal concentrations, with the weekly composite sample for March 7 - 14, 2003, showing the highest total concentrations for all three metals, and the sample for February 28 - March 7, 2003, showing the highest soluble metal concentrations. Possible sources of the metals include mop waters from shops (metal dust and particulates) and corrosion from piping (low levels of dissolved metals).

Literature data show that typical removal efficiencies for dissolved metals range from 41% for nickel (Ni) to 86% for Cu. The results for metals removal at the ORNL STP are higher than the literature values, but this is likely a result of the high proportion of insoluble metals in the influent. Quantitative data are not available for radionuclide removal by sewage treatment plants, but metallic radionuclides should show similar results to the other metals, while strontium (Sr) and cesium (Cs) would probably concentrate less. The metals concentrations in the STP influent are similar to those measured in ORNL process wastewater. The metals removal at the STP is also similar to that measured at the Process Waste Treatment Complex, Building 3608.

Each batch of sludge from the ORNL STP is characterized for disposal. Average concentrations of measured contaminants in liquid sludge from the digester are shown in Table A-3 for samples from 1998 through 2000. The highest concentrations are for Cu, Pb, and Zn, which is consistent with the influent data. Table A-4 shows the concentrations of leachable metals, using the toxic characteristics leaching procedure (TCLP) procedure, from the dried sludge. The volume reduction factor for the amount of sludge produced versus the influent wastewater treated is 513 for the liquid sludge from the digester and 2,570 for the dried sludge. For an average metals removal of 90%, the metals in the STP influent would be concentrated by a factor of 462 in the liquid sludge and by a factor of 2,313 in the dried sludge. The very low levels of metals in the TCLP leachate, compared to the concentrations in the liquid sludge, show that the metals are tightly bound in the sludge and do not readily leach.

An estimate of the influent metal concentrations that would be required to produce the measured metal concentrations in the sludge can be calculated from the volume reduction factor and the metals removal data. These results are shown in Table A-5, assuming 90% to 99% metals removal (typical efficiency ranges) in the STP, and compared to the measured influent concentrations.

The required influent concentrations to produce the measured metal concentrations in the sludge are much higher than those measured for the influent samples. There was significant variation in the influent sample results during the time period that samples were taken, so much higher influent concentrations could have occurred at other times. The metals in the sludge represent a long-term accumulation of the metals entering the STP.

The STP data were used to evaluate the STP capabilities for removing radionuclides, metals, and organics in order to identify options to eliminate use of the aging Process Waste Treatment Complex (PWTC). The metals removal efficiency at the ORNL STP is approximately 90%, very similar to that of the PWTC. Metallic radionuclides will have similar removal efficiencies. Sr and Cs are removed, but not as efficiently as metallic compounds.

Table A-3. Contaminant concentrations in digester sludge from the ORNL STP.

Contaminant	Concentration	Units
Silver	30.7	mg/kg
Cadmium	3.81	mg/kg
Copper	503	mg/kg
Mercury	13.5	mg/kg
Lead	622	mg/kg
Uranium	8.01	mg/kg
Zinc	1573	mg/kg
Gross Alpha	49,000	pCi/kg
Gross Beta	504,000	pCi/kg
Strontium-90	106,000	pCi/kg
Cobalt-60	32,600	pCi/kg
Cesium-137	128,000	pCi/kg

Table A-4. TCLP metal concentrations in dried sludge from the ORNL STP.

Contaminant	Concentration (mg/L)	Resource Conservation and Recovery Act (RCRA) Limit (mg/L)
Arsenic	0.075	5.0
Silver	<0.01	0.2
Cadmium	<0.02	1.0
Chromium	<0.1	5.0
Mercury	<0.01	0.2
Lead	0.04	5.0
Selenium	<0.01	1.0

Evaluation of the UT-Battelle, LLC (UT-B) process wastewater being considered for treatment, indicates that the ORNL STP could adequately remove the contaminants, and the STP liquid effluent and sludge compositions would not be significantly effected. Current UT-B management practices would require removing radionuclides and most of the metals from process wastewater prior to discharge to the sanitary collection system. If contaminated groundwater were to be treated in the sanitary system in the future, Hg, Cs, and Sr would need to be removed from selected portions of the main plant area prior to discharge into the system.

In addition to pretreatment of some waste streams, a modification to the NPDES permit would be required in order to discharge process waste into the ORNL sanitary/sewage system. Permit modifications will require a two- to five-year lead-time. A renewal application was submitted in 2001 for a 5-year extension of the existing permit; it is still pending.

Table A-5. Calculated influent metals concentrations required to produce sludge concentrations.

Contaminant	Calculated Influent Concentrations (mg/L)		Measured Concentration (mg/L)
	For 90% Removal	For 99% Removal	
Silver	0.066	0.060	<0.004
Cadmium	0.008	0.008	<0.002
Copper	1.090	0.991	0.085
Lead	1.348	1.266	0.044
Zinc	3.406	3.097	0.231

Options for permit modifications include:

- meeting the Resource Conservation and Recovery Act (RCRA) wastewater treatment unit exclusion for the sewage treatment system similar to the PWTC's, or
- taking advantage of the RCRA mixture rules and exception to the prohibition on dilution of characteristic-only wastes (where suitable and appropriate treatment is conducted).

Analysis of the regulations indicates that engineering and administrative controls will be required for both options. Engineering controls include:

- replacement of the lagoons at the STP with tanks, or
- installation of tanks at each generator site.

Administrative controls for the first option are expected to be similar to those presently in place for the sanitary and process waste systems. Administrative controls and sampling/monitoring requirements for the second option would be much more extensive. The second option has two additional disadvantages:

- anything less than "perfect implementation" would likely result in RCRA violations, and
- bypassing the treatment system, which presently occurs a couple of times each year during weather related surges, is prohibited by the NPDES permit. Increasing the STP capacity would eliminate this problem.

Therefore, replacement of the ORNL STP lagoons and increasing the plant capacity is the preferred alternative.

4. PROPOSED SCOPES AND COST ESTIMATES FOR SANITARY/SEWAGE WASTE SYSTEM PROJECTS

Conceptual level engineering cost estimates were obtained for the following capital projects, which are listed in Chapter 7 of the *ORNL Liquid and Gaseous Waste Treatment System Strategic Plan*.

4.1 EVALUATED SANITARY/SEWAGE WASTE SYSTEM CAPITAL PROJECTS

4.1.1 Sewage Treatment Plant Surge Capacity Replacement (GPP)

The ORNL sanitary/sewage collection system currently uses two lagoons to store excess wastewater during heavy rains. In order to use the sanitary/sewage system for treating process wastewater, the collection system must be compliant with the RCRA, which requires a tank-based system. The lagoons will be replaced with a one-million-gallon tank. The primary location for situating the new tank is at the east lagoon, following the removal of the sludge from the lagoon. It will be necessary to keep using the west lagoon during construction of the tank, so the timing for remediating the lagoons and building the tank is critical for using this location. The secondary location for the tank is on the site of the old coal yard, just south of the ORNL steam plant and east of the STP.

A cost estimate was prepared for a painted carbon steel, open top tank, with aeration to provide oxygen and maintain movement that is 90 feet in diameter and 22 feet high. The storage tank foundation would be a concrete mat on engineered fill. The existing pumps will be upgraded to supply the required head for pumping wastewater into the tank, and a new air compressor will be installed. The estimated cost is $3.32 Million and includes a 20% contingency factor. Title I and II design are assumed to take 4 months, and construction is estimated to take 6 months. The cost estimate assumed that the tank sub-base foundation preparation would be constructed with the lagoon remedation project and was included in the above estimate. In-place closure of the lagoons is assumed, and the project team estimated the cost of the lagoon closure to be $1 Million.

4.1.2 Sewage Treatment Plant Capacity Increase (GPP)

In order to accommodate increased sanitary/sewage waste flows from increased ORNL population and diversion of process wastewater to the sanitary/sewage system, the treatment capacity of the ORNL STP must be increased. Maximum flexibility will be achieved by installing a unit similar to the existing extended aeration plant. The new unit would be located just west of the existing STP and have a rated capacity of 300,000 gal/day. The new unit will be approximately 50 feet in diameter and sit on a ring wall foundation filled with compacted sand. It is assumed that the existing ozone generator, chemical tanks, and chemical feed systems are of sufficient size for both the existing and new equipment. The estimated cost is $4.08 Million and includes a 21% contingency factor. Title I and II design are assumed to take 6 months, and construction is estimate to take 9 months.

4.2 ALTERNATIVE SANITARY/SEWAGE WASTE SYSTEM CAPITAL FUNDING CONSIDERATIONS

The option of converting the ORNL STP into a Publicly Owned Treatment Works (POTW) was considered. Under this scenario, the City of Oak Ridge would take over operation of the plant and use City financing for upgrades to meet ORNL's future sanitary waste management needs. The option was not pursued because it did not appear viable for the City of Oak Ridge to take over operating the plant as long as it generates radioactively contaminated sludge.

APPENDIX B – PROCESS WASTE SYSTEM

1. PROCESS WASTE SYSTEM DESCRIPTION

1.1 PROCESS WASTE COLLECTION SYSTEM

The Oak Ridge National Laboratory (ORNL) process waste collection system consists of a network of underground pipes. Process wastewater in Bethel Valley flows from generator facilities to a pumping station for transfer to the Process Waste Treatment Complex (PWTC). There is about 36,000 linear feet of process waste piping in Bethel Valley and 19,000 linear feet in Melton Valley. Materials of construction include vitreous clay (oldest piping), steel, and polyvinylchloride (PVC). Vitreous clay piping (4,800 linear feet) serves some active facilities (including 1,300 linear feet from the 4500 area). ORNL has installed 25,300 feet of carbon steel and PVC piping (33% in Bethel Valley, and 66% in Melton Valley) since 1987.

The process waste collection system in Melton Valley consists of underground piping connected to four 100,000-gallon storage tanks which began operation in 1989. The wastewater is pH adjusted before entering these tanks and is then pumped to the PWTC through one of three 6,800-foot long, carbon steel transfer pipelines that were installed in 1989. At strategic points throughout the collection system, manholes are equipped with beta-gamma radiation monitors, pH monitors, and flow monitors that are continuously monitored.

Upgrades to the process waste system were performed several years ago to line the main trunk lines between the major manholes and the PWTC using the “insituform” process. Almost 8,400 linear feet of older pipe was “insituformed” to reduce inleakage, but a few sections of older pipe in the 3000 area, which were known to collect contaminated groundwater, were purposely not “insituformed” to allow continued removal of contamination from the soil. In Bethel Valley, almost 7,000 linear feet of piping is connected to inactive facilities. There have been few upgrades to the piping between these facilities and the first process waste system manholes.

1.2 PROCESS WASTE TREATMENT SYSTEM

The PWTC consists of Building 3608 (formerly the Nonradiological Wastewater Treatment Plant) and Building 3544 (formerly the Process Waste Treatment Plant). Building 3608 is designed to treat and discharge nonradiological process wastewater generated at ORNL to levels of pollutants acceptable under restrictions imposed by the effluent limits in the National Pollutant Discharge Elimination System (NPDES) permit, and according to the regulations established by the U.S. Environmental Protection Agency (EPA), the Department of Energy (DOE), and the State of Tennessee. Building 3544 treats radiologically-contaminated process wastewater, and is optimized to remove strontium-90 (^{90}Sr). Effluent from Building 3544 is sent to Building 3608 for treatment of nonradiological contaminants prior to discharge.

Building 3544 was built in 1975. The building is structurally sound. The concrete floors were recoated and the roof replaced in the mid-1990s. Nondestructive analysis of the ion-exchange columns and major tanks has shown that the equipment is in good condition. With proper maintenance of the building and equipment, the facility should continue to function for some time. Building 3608 was built in 1989, and its appearance has not changed significantly. The facility should continue to function for many years. However, neither facility can function for another 50 years without significant upgrade or replacement.

The nonradiological treatment process at Building 3608 consists of filtration, air stripping, granular activated carbon (GAC) adsorption, and pH adjustment, to remove heavy metals and organics from the wastewater. Sources of feed to the plant's nonradiological treatment process include drainage from various laboratories, once-through cooling water, aqueous streams from several radiochemical processing plants and reactor operations, plus the Building 3544 effluent.

Radiologically contaminated process wastewater is treated in Building 3544 by precipitation, filtration, and ion exchange. The first two of these treatment processes, together called head-end treatment, utilize conventional water treatment equipment; specifically, a static in-line pipe mixer, a sludge-blanket type precipitator clarifier, and pressure filters. Ferric sulfate is added as a flocculant, the pH is adjusted with sodium hydroxide to 11.5 to precipitate calcium and magnesium, and an organic polymer is added to help the solids settle. The precipitation operation was relocated to Building 3608 in late 1996, utilizing an existing but unused precipitator clarifier, to provide an additional throughput capacity for Building 3544. The existing precipitation equipment at Building 3544 is maintained in stand-by. The ion-exchange equipment uses a strong-acid resin to remove ^{90}Sr. A zeolite resin treatment system is also available to treat wastewater for removal of cesium (Cs) during periods of high Cs concentration in the plant influent. Influent to Building 3544 includes drainage and once-through cooling water from radiological laboratories, wastewater from the High Flux Isotope Reactor (HFIR), and contaminated groundwater.

2. PROCESS WASTEWATER GENERATION

Assessment of the present and projected future waste generation rates for liquid and gaseous waste at ORNL were performed to support the waste treatment strategic planning efforts. A detailed analysis of the UT-Battelle, LLC (UT-B) generated process wastewater at ORNL was undertaken, particularly focusing on the 4500 area where UT-B generates essentially all of the streams. These nonradiological wastewaters are treated at Building 3608. The results of the analyses are shown in Table B-1. The data were obtained through generator interviews for once-through cooling water and routine generator estimates provided through the ORNL Standards-Based Management System (SBMS), Environmental Management System Subject Area: Managing Wastewater. The measured flow rates were obtained from manhole monitoring data collected from January 2002 through May 2003. The estimated flow rates are within the accuracy of the monitoring equipment for the 4500 area, where only UT-B wastewater is collected. Mass balances for the Central and West Campuses could not be completed because manhole-monitoring data is not available for much of the system in these areas, and many manholes intentionally collect contaminated groundwater and rainwater for treatment (see Table B-3). The measured flow within the collection system (270,271 gallons per day {gal/day}) accounts for only 65% of the total wastewater treated in the PWTC.

Table B-1. Estimated UT-B process wastewater generation.

		Estimated Flow Rates (gallons per day)					
Manhole/ Building	**Measured Flow Rate (gallons per day)**	**Total**	**Non-Cooling Water**	**Research & Development Waste**	**Cooling Water**	**Other**	**Definition of "Other" and/or Comments**
Areas with manhole monitoring							
Manhole 240							
Building 2026	86	21	21	21	0	0	
Manhole 179							
Building 5500		4,335	15	15	4,320	0	
Building 5505		12,081	30	30	12,051	0	
Building 5510		0	0	0	0	0	
Manhole Totals	18,720	16,416	45	45	16,371	0	
Manhole 178							
Manhole 179		16,416	45	45	16,371	0	
Building 4500N, Wing 5		354	354	354	0	0	
Manhole Totals	20,160	16,770	399	399	16,371	0	
Manhole 172							
Manhole 178		16,770	399	399	16,371	0	
Building 4500N, Wings 3 and 4		8,316	36	36	8,280	0	
Building 4500S, Wings 3 and 4		61,494	300	300	61,194	0	
Manhole Totals	60,480	86,580	735	735	85,845	0	

Table B-1. Estimated UT-B process wastewater generation - continued.

		Estimated Flow Rates (gallons per day)					
Manhole/ Building	**Measured Flow Rate (gallons per day)**	**Total**	**Non-Cooling Water**	**Research & Development Waste**	**Cooling Water**	**Other**	**Definition of "Other" and/or Comments**
Areas with manhole monitoring - Continued							
Manhole 171							
Manhole 172		86,508	664	664	85,845	0	
Building 4500N, Wings 1 and 2		3,093	76	76	3,017	0	
Building 4500S, Wings 1 and 2		17,074	82	82	16,993	0	
Manhole Totals	92,160	106,675	822	822	105,855	0	
Manhole 190							
Manhole 171		106,748	894	894	105,855	0	Non-research & development (R&D) sources are piped to Manhole 190. Manhole monitoring data was adjusted for inaccurate measurements (25 gpm) obtained during part of the monitoring period.
Building 4501		3,265	25	25	3,240	0	
Building 4505		1,374	6	6	1,368	0	
Building 4508		54,805	11	11	54,795	0	
Building 4515		71,233	0	0	71,233	0	
Manhole Totals	**218,698**	**237,425**	**936**	**936**	**236,491**	**0**	
Manhole 112							
Building 3003		7	7	6	0	1	Eyewash; safety shower
Building 3080		0	0	0	0	0	
Building 3114		1	1	1	0	0	
Manhole Totals	7,439	8	8	7	0	1	Non-R&D sources are piped to Manhole 112 (see Table B-3)
Manhole 114							
Manhole 112		8	8	7	0	1	
Building 3047		1	1	1	0	0	
Manhole Totals	16,886	9	9	8	0	1	Non-R&D sources are piped to Manhole 114 (see Table B-3)

Table B-1. Estimated UT-B process wastewater generation - continued.

		Estimated Flow Rates (gallons per day)					
Manhole/ Building	**Measured Flow Rate (gallons per day)**	**Total**	**Non-Cooling Water**	**Research & Development Waste**	**Cooling Water**	**Other**	**Definition of "Other" and/or Comments**
Areas with manhole monitoring - Continued							
Manhole 149							
Building 3025E		5,860	100	97	5,760	3	Spill containment (Condensed Matter Sciences Division)
Building 3025M		5,852	50	50	5,802	0	1st floor water fountain
Building 3150		14,436	36	34	14,400	1	Eyewash
Building 3525		0	0	0	0	0	
Manhole Totals	19,807	26,148	186	181	25,962	4	Non-R&D sources are piped to Manhole149
F-2017/2018 tanks							
Building 7900		104	104	16	0	88	HVAC
Building 7903		1	1	1	0	0	
Manhole Totals	4,215	105	105	17	0	88	Non-R&D sources are piped to F-2017/2018
F-2019/2020 tanks							
Buildings 7920/ 7930	10,579	296	296	296	0	0	Non-R&D sources are piped to F-2019/2020
Other areas with limited monitoring							
1500 Area							
Building 1504		2	2	2	0	0	
Building 1505		8,858	13	13	8,845	0	
Building 1506		1,442	1	1	1,441	0	
Totals	not available	10,302	16	16	10,286	0	
2000 Area							
Building 2019		9,792	0	0	9,792	0	May not go to process waste system
Totals	not available	9,792	0	0	9,792	0	
Miscellaneous facilities with limited monitoring							
Building 2523		1,440	1,440	1,440	0	0	
Building 2528		33	33	33	0	0	
Building 3019A		331	331	2	0	329	Condensate
Building 3137		1,329	33	33	1,296	0	
Building 3144		1	1	1	0	0	

Table B-1. Estimated UT-B process wastewater generation - continued.

		Estimated Flow Rates (gallons per day)					
Manhole/ Building	**Measured Flow Rate (gallons per day)**	**Total**	**Non-Cooling Water**	**Research & Development Waste**	**Cooling Water**	**Other**	**Definition of "Other" and/or Comments**
Facilities with drain/pipeline connections reporting no process waste							
Building 1503		0	0	0	0	0	active drains
Building 2500		0	0	0	0	0	flow configuration issues
Building 2519		0	0	0	0	0	flow configuration issues
Building 3012		0	0	0	0	0	active drains
Building 3017		0	0	0	0	0	active drains
Building 3034		0	0	0	0	0	active drains
Building 3044		0	0	0	0	0	flow configuration issues
Building 3074		0	0	0	0	0	flow configuration issues
Building 3503		0	0	0	0	0	active drains
Building 3504		0	0	0	0	0	active drains
Building 3587		0	0	0	0	0	flow configuration issues
Building 3597		0	0	0	0	0	flow configuration/ ownership issues
Building 5510A		0	0	0	0	0	active drains
Building 7911A		0	0	0	0	0	active drains
Building 7913		0	0	0	0	0	active drains
Facilities with all process drains capped, plugged, or clogged							
Building 2000		0	0	0	0	0	drains plugged
Building 2001		0	0	0	0	0	drains plugged
Building 3013		0	0	0	0	0	drain plugged
Building 3036		0	0	0	0	0	drains capped
Building 3508		0	0	0	0	0	drains plugged
Building 3550		0	0	0	0	0	drains plugged
Building 3592		0	0	0	0	0	drains plugged
Building 7932		0	0	0	0	0	drain clogged
Total	**270,271**	**287,232**	**3,407**	**2,984**	**283,827**	**422**	

Analysis of the data indicates that approximately 90% of the UT-B generated process wastewater is once-through cooling water. The *ORNL Liquid and Gaseous Waste Treatment System (LGWTS) Strategic Plan* calls for elimination of this stream from the treatment system by FY07. The location of the once-through cooling water sources was determined during a 12 month study ending in June 2003. The data is provided in Table B-2.

Table B-2. Sources of once-through cooling water discharging to the process waste system.

Total for all sources of once-through cooling water from all ORNL facilities = 103,596,518 gallons per year.		
Location	**Equipment**	**Cooling Water (gallons per year {gal/yr})**
Building 1505 Total = 3,228,559 gal/yr		
Penthouse	Penthouse Water Distiller	131,400
Room 142	Laser or X-ray	149,760
Room 173	Microscope	525,600
Room 173	Carbon Sputter Coater	3,120
Rm 175	X-ray	3,640
Room 207	Barnstead Water Distiller	9
Room 267	SOXHLET Water Distiller	6,920
Room 267	S-VAP Water Distiller	6,920
Room 371	Mega-pure Water Distiller	6,290
Room 377	Autoclave	292,500
	400-Ton Marley tower blowdown	2,102,400
Building 1506 Total = 525,965 gal/yr		
	Chambers 15-19 lighting canopies	525,600
Room 111	Kodak Processor	365
Building 2019 Total = 3,574,080 gal/yr		
	Lumonics HyperEX-400 Excimer Laser	525,600
	Questek Model 2640 Excimer Laser	788,400
	Lambda LPX 301i Excimer Laser	788,400
	Turbo pump	525,600
	Turbo pump	525,600
	Intensified Diode array and an intensified camera system	210,240
	Intensified Diode array and an intensified camera system	210,240
Building 3025E Total = 2,102,400 gal/yr		
	4 turbo pumps	1,051,200
	2 turbo pumps	1,051,200
Building 3025M Total =2,118,000 gal/yr		
304	5-Ton WC, Computer Room	2,102,400
	water fountain	15,600
Building 3137 Total = 473,040 gal/yr		
	Haskeris Water cooled coolers	157,680
	Haskeris Water cooled coolers	157,680
	Neslab Water cooled coolers	157,680
Building 3150 Total = 5,256,000 gal/yr		
	Condensate cooling	5,256,000

Table B-2. Sources of once-through cooling water discharging to the process waste system – continued.

Location	Equipment	Cooling Water (gallons per year {gal/yr})
Building 4501 Total = 1,182,600 gal/yr		
Room 110A	Scanning Microscope	131,400
Room 106	California Hood	262,800
Room 113	Diffusion Pump (3)	788,400
Basement	Fuller Vacuum Pump #4505-01200	
Building 4505 Total = 499,320 gal/yr		
3rd Floor	Amsco Sterilizer	78,840
Shop 4505	Welder	210,240
3rd Floor	Fermantation Unit	210,240
Building 4515 Total = 26,000,000 gal/yr (Equipment discharges to building sump[1])		
L102	Multi-axis Grinder (Reservoir)	200
L103	Vigor Creep Feed Grinder (Reservoir)	300
L104	Lindberg Furnace (350 hours per year)	504,000
L104	Infiltration Furnace (1,500 hours per year)	2,430,000
L105	RF Generator (2,600 hours per year)	4,212,000
L105	RF Furnace (8,700 hours per year)	7,308,000
L105	Mellon Furnace (4,300 hours per year)	4,902,000
L106	RF Generator (350 hours per year)	504,000
L106	Therm Craft Furnace (6,000 hours per year)	8,640,000
L107	Small Infiltration Furnace (1,000 hours per year)	1,620,000
L108	Astro Furnace (100 hours per year)	114,000
L108	RF Generator Flanges (1,500 HRS/YR)	2,160,000
L108	OXIDATION FURNACE (1500 hours per year)	2,160,000
L109	Theta Dilatometer (8,700 hours per year)	5,934,000
L113	Xpert North Wall (8,700 hours per year)	12,528,000
L113	Scintag South Wall (4,300 hours per year)	5,934,000
L205	Laser Flash (2,500 hours per year)	4,050,000
L224	MFR Furnace (2,500 hours per year)	4,050,000
	350-Ton Marley blowdown	1,314,000

Table B-2. Sources of once-through cooling water discharging to the process waste system – continued.

Location	Equipment	Cooling Water (gallons per year {gal/yr})
Building 4508 Total = 20,000,000 gal/yr (Equipment discharges to building sump[1])		
139	901 Bres	5,990,400
139	6kW microwave	748,800
139	3 Kw microwave	374,400
139	Astro 1	748,800
139	Astro 2	374,400
136	Diamond saw	3,120
136	Diamond sander	3,120
247	Lindberg tube furnace	74,880
247	CM box furnace	74,880
247	Attritor Mill	18,720
251	Attritor Mill	18,720
251	CM tube furnace	74,880
265C	Brew hot press	5,391,360
265C	Astro hot press	224,640
265C	Thermal tech hot press	8,985,600
265C	Lindberg tube furnace	224,640
139A	Diffusion Pump for SEM	262,080
139A	Activation Furnace	2,620,800
244	Fox 300 and 304	187,200
139	Furnace #15	1,728,000
139	Furnace #16	1,728,000
139	IPS Furnace	1,728,000
139	Hot Press	0
139	CUI Furnace	1,728,000
139	Thermal Cycling Heat Exchange	786,240
139	Heat Sink Tester	2,880
235 Area	Equipment 1	262,080
235 Area	Equipment 2	1,179,360
235 Area	Equipment 3	393,120
235 Area	Equipment 4	131,040
224	AVS Furnace	10,483,200
242	Coating furnace	1,560,000
	5-Ton, WC, Room 250	2,522,880
	5-Ton, WC, Room 250	2,522,880
Building 5500 Total = 1,576,800 gal/yr (Equipment discharges to building sump)		
	Laser	1,576,800

Table B-2. Sources of once-through cooling water discharging to the process waste system – continued.

Location	Equipment	Cooling Water (gallons per year {gal/yr})
Building 5505 Total = 4,398,509 gal/yr		
1, 39	vacuum pump (4)	2,102,400
9	Diffusion Pumps (2)	525,600
9	Turbo pump	525,600
1	water cooled Haskris cooling furnace	525,600
1	Dark room developer runs continuously	525,600
15	Turbo pump has fan and water cooled	749
21	Laser cooling	43,200
corridor #4	Wtr cooled Haskris serial number H-009008	49,920
corridor #4	Wtr cooled haskris serial number H-A2635	49,920
corridor #4	Wtr cooled Thermo NESLAB model HX-150	49,920
Building 4500 North, Wing 1 & 2 Total = 1,101,120 gal/yr		
B21	Water Distiller	24,960
C17	Water Distiller	24,960
attic wing 1	water still	131,400
attic wing 2	water still	131,400
D17		262,800
115	diffusion pump	525,600
Building 4500 North, Wing 3 & 4 Total = 3,022,200 gal/yr		
attic wing 3	water still	131,400
F17		262,800
F21	cryopump	2,628,000

Table B-2. Sources of once-through cooling water discharging to the process waste system – continued.

Location	Equipment	Cooling Water (gallons per year {gal/yr))
Building 4500 South, Wings 1 & 2 Total = 6,202,267 gal/yr		
A161	Ion miller	1,051,200
B247	Furnace	525,600
B251	Furnace	525,600
C-147	Argon-ion Laser, (Sabre 15)	124,800
C-147	Nd; TAG Laser (Continuum)	49,920
C-147	Film Growth Chamber (Seki Corp)	14,976
C-151	Argon ion laser (I-100)	449,280
C-151	Nd; TAG Laser (Coherent Inifity)	149,760
C155	Coherent Ar ion laser (Innova 300 FReD)	249,600
C155	Coherent Kr ion laser (Innova 300)	262,080
C260		1,388
D147	Argon laser (Innova)	360,000
D147	Argon laser (Sabre)	168,000
D155	Coherent Ar ion laser (Innova 90-5)	411,840
D-163	"QTOF micro" mass spectrometer	80,995
R261		49,920
S261		32,947
T-5	Cryopump Compressor (APD Manufacturer, model MK! HC-4)	1,576,800
S-119	Spectrum laser system SL-450 ND-Yag	39,562
various	water fountains @ S261, A278, A176, S161, T22	78,000
Building 4500 South, Wings 3 & 5 Total = 22,335,658 gal/yr		
E-55	Auto Clave (small)	780
F151	Magnestir	52,560
G159	Diffusion pump	5,256,000
G159	Diffusion pump	5,256,000
G159	Cryo-pump	5,256,000
G-49	Chiller	5,256,000
H-159	Diffusion pump	224,640
H-163	Argon ion laser	34,560
R-127	Evaporator CVE301	277,517
R-127	Evaporator, CVE 301EB	305,899
R-127	ICCD, Princeton Instruments ICCD-576S	4,118
R-127	Krypton Laser, Innova 70	197,808
R-127	Argon-ion Laser, Spectra-Physics 2550	197,808
R227		1,388
R227		694
S235		13,886

1. Estimated flows for individual pieces of equipment and sump flows do not agree (Equipment flows are generator estimates and sump flows were single point measurements). Sump data was used for estimating building flows.

Of the remaining research and development (R&D) generated streams, the Radiochemical Engineering Development Center (REDC), High Flux Isotope Reactor (HFIR), Spallation Neutron Source (SNS), and the ORNL radiological laundry generate approximately 9 mgy of process waste annually. These streams are expected to exceed the UT-B process wastewater discharge criteria and will require additional treatment. It is assumed that this process wastewater can be discharged directly to the environment after treatment. Incidental process wastewater below the UT-B waste discharge criteria is being considered for diversion to the ORNL Sewage Treatment Plant (STP). Table B-1 indicates that this amounted to 2,984 gallons per day (approximately 1 mgy) in 2002. However, there are inaccuracies in the flow monitoring data (up to 20%) and the mass balance for the 3000 area has not been completed. Therefore, the amount of incidental wastewater that could be diverted to the sanitary system was estimated to be 4 to 5 mgy for strategic planning purposes. The estimated annual process waste generation rates during and after implementation *ORNL LGWTS Strategic Plan* are summarized in Figure B-1.

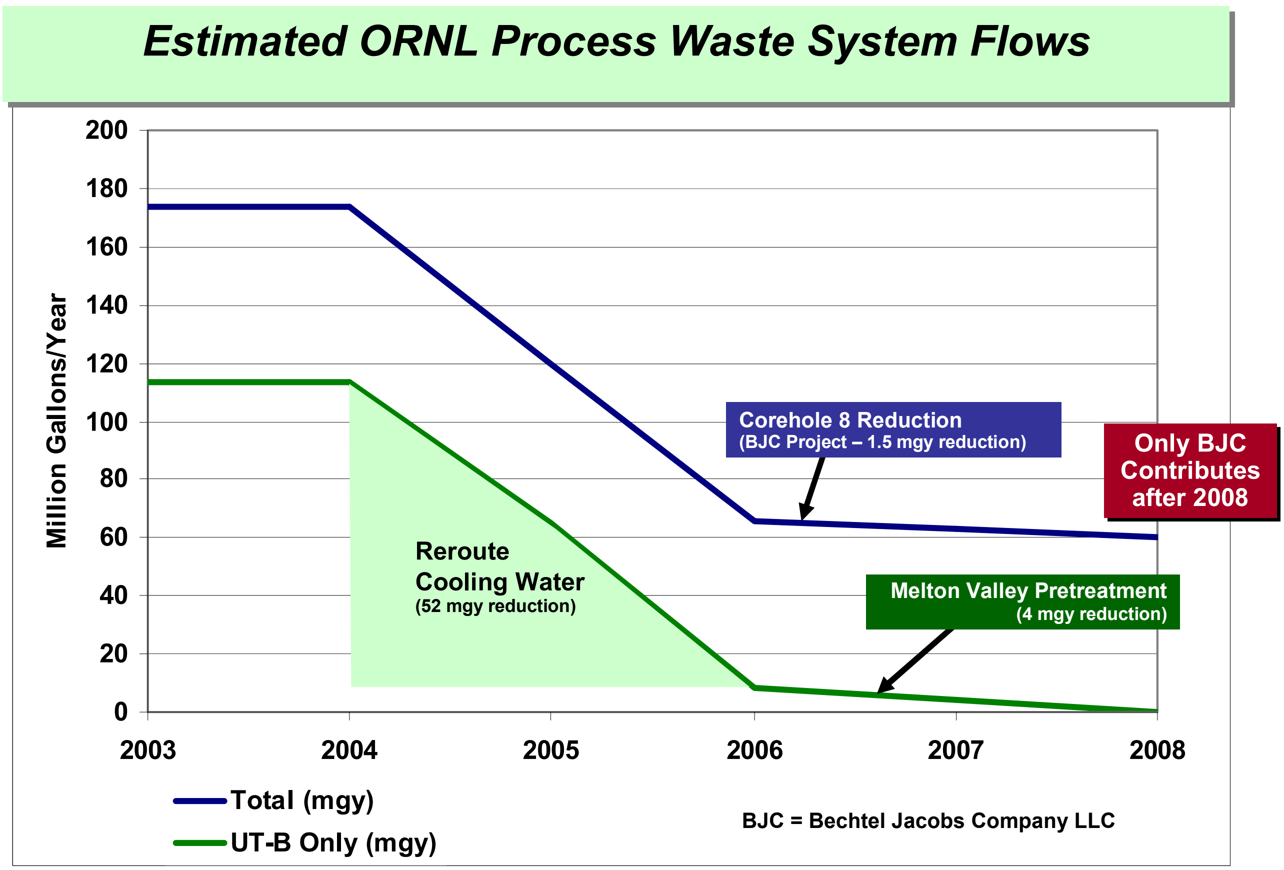

Figure B-1. Estimated process waste flows during and after implementation of the *ORNL LGWTS Strategic Plan.*

3. PROCESS WASTE SYSTEM RE-ENGINEERING EVALUATIONS

3.1 PROCESS WASTE SYSTEM FLOWS AND CAPACITY EVALUATIONS

The PWTC facilities are significantly oversized for treating R&D-generated process wastewater. The nominal treatment capacity of the PWTC is 400 million gallons per year (mgy), while the annual wastewater generation rate from R&D activities is expected to be less than 15 mgy in the future.

3.1.1 Nonradiological Process Wastewater

The largest source of nonradiological process wastewater is from the 4500 area, which flows through manhole-190. The wastewater is continuously monitored for radionuclides and activity and diverted to PWTC, Building 3544 if levels are too high. The nonradiological process wastewater is sent to either the metals or nonmetals collections tanks at Building 3608, depending on the pH of the water. If the pH is <6.0 or >12.0 the water is sent to the metals tank, otherwise it flows to the nonmetals tank. Previous work has shown that the process wastewater with a pH between 6 and 12 does not contain significant amounts of dissolved metals. The nonradiological effluent from Building 3544 is Building 3608's second largest process wastes stream, which is piped directly to the nonmetals tank at Building 3608. Other sources include nonradiological process wastewater from the Environmental Science complex located in the West Campus, and from the process wastewater collection tanks in Melton Valley. The metals tank in Building 3608 also receives backwash water from the filters and granular activated carbon (GAC) columns at Building 3608.

The measured flow at manhole-190 averaged 184 gallons per minute (gpm) in 2002, and the rate does not vary with rainfall, indicating little, if any, infiltration into this portion of the process wastewater system. The discharge from Building 3544 to Building 3608 averages 152 gpm. The effluent flow rate from PWTC, Building 3608 averaged 309 gpm in 2002, which is less than the measured flows entering Building 3608. Recent evidence suggests that the flow readings for manhole-190 are about 25 gpm too high due to a calibration error. The nonradiological process wastewater from the REDC in Melton Valley, which has an average flow rate of 5.2 gpm, contains very low concentrations of metals and is pumped to the nonmetals tank at Building 3608. The flow from the Environmental Science complex is pumped to the nonmetals tank in Building 3608, but the flow rate is not measured.

Once-through cooling water is estimated to contribute about 104 mgy (197 gpm) to the process waste system, or almost two-thirds of the total flow (see Table B-2). Projects are being developed to identify and eliminate the sources of once-through cooling water to the process waste system. If all of the identified sources of once-through cooling water were eliminated, the average process wastewater flow rate through the PWTC would be reduced to 110 - 130 gpm. Of this total flow, UT-B will contribute <15 gpm (or 15%).

3.1.2 Radiological Process Waste Water

The radiological process wastewater flow to Building 3544 averages 152 gpm and is strongly influenced by rainfall. The baseline flow rate averages 122 gpm, with an increase of 51 gpm for each inch of rain. Rain water from contaminated pads and groundwater from secondary-containment vaults and dry wells enters the system. Flow rate data is available from a number of manhole monitors in the upper reaches of the radiological process wastewater drain system in ORNL's Central and West Campuses**.** Table B-3 shows a summary of the flow data for these manholes for January through March of 2003. Manholes 112 and 114 and the Tank Farm show increased flow for several days after a major rain, while manhole 234 returns to normal flow the next day after the rain stops.

Table B-3. Flow rates for manholes in the radiological process wastewater system.

Manhole	Areas Served	Base Flow (gpm)	Rainfall Increase (gpm/inch of rain)
112	3000 Reactor Area; UT-B managed buildings include 3012, 3044, 3003, and 3114	1.4	27
114	Building 3047 plus flow from manhole-112	5.5	47
234	Buildings 3028 to 3034, 3038, and 3047	9.2	10.6
Tank Farm	North and South Tank Farm Wet Wells	26	71
149	Buildings 3025, 3026, 3150, and 3525	11	negligible
229	Buildings 3503 and 3508	3.6	negligible
235	Building 3525	13	negligible
243	2531Complex	2.1	negligible

3.2 PROCESS WASTEWATER TREATMENT EVALUATIONS

The strategic planning activities for the ORNL liquid and gaseous waste treatment systems evaluated options to treat process wastewater, which exceeds the UT-B process wastewater discharge criteria in local tailored facilities (see Section 3.3, of this appendix) and treatment of incidental process wastewater at the STP (see Appendix A).

3.2.1 Nonradiological Process Wastewater Treatment

The nonradiological process wastewater entering PWTC, Building 3608 contains very low levels of metals and organics. The influent concentrations are not routinely measured, but monthly samples were taken and analyzed in 1997 and 1998. Table B-4 shows the average metal concentrations in the influent to the nonmetals tank, the effluent concentrations at the NPDES discharge point, metal removal efficiencies, and the maximum daily limits for metals in the NPDES permit for PWTC, Building 3608. The wastewater from the nonmetals tank is treated by filtration, air stripping and GAC adsorption. These processes are designed to remove particulates and organics, but filtration and GAC will also remove some metals. Very low concentrations of organics, such as methylene chloride and chloroform, were occasionally detected in the influent to the nonmetals tank.

Table B-4. Metals concentrations in feed and effluent at Building 3608, and daily NPDES limits.

	Concentration (mg/L)			
Contaminant	Nonmetals Tank Influent	Effluent	Removal (%)	NPDES Limit
Arsenic	<0.05	0.0015	<97	0.14
Cadmium	<0.003	0.0001 6	<95	0.034
Chromium	<0.01	0.0017	<89	0.44
Copper	0.029	0.0057	80	0.11
Lead	0.090	0.0016	98	0.69
Mercury	0.001	<0.000 2	>80	0.0003
Nickle	<0.05	0.0014	<97	3.98
Selenium	<0.05	0.0025	<95	0.01
Silver	0.010	0.0001 7	98	0.008
Zinc	0.330	0.046	86	0.95

The Building 3608 metals tank wastewater is precipitated at a pH of 10.5 and clarified before it joins the nonmetals tank water. The flow rate of the metals tank wastewater is very low, averaging 8 gpm, with most of the wastewater coming from backwashing the filters and GAC columns. Flow diversions from manhole-190 to the metals tank are rare. Most of the contaminants in the metals tank were originally present in the non-metals wastewater as particulates, which were collected on the filters and backwashed into the metals tank. Table B-5 shows the metals concentrations in the metals-tank wastewater and in the effluent from the clarifier, and also shows the metals removal efficiencies. The precipitation process removes 56 – 90% of the silver (Ag), copper (Cu), chromium (Cr), mercury (Hg), lead (Pb), and zinc (Zn) from the metals-tank wastewater. The removal efficiencies are relatively low because of the very low concentrations in the influent wastewater.

Table B-5. Metals concentrations in the Building 3608 metals tank influent and clarifier effluent.

Contaminant	Concentration (mg/L)		
	Metals Tank Influent	Clarifier Effluent	Removal (%)
Arsenic	<0.05	<0.05	>0
Cadmium	<0.003	<0.003	>0
Chromium	0.023	0.01	56
Copper	0.570	0.15	74
Lead	0.233	0.09	61
Mercury	0.007	0.0007	90
Nickle	0.051	<0.04	>20
Selenium	<0.05	<0.05	>0
Silver	0.025	0.01	60
Zinc	1.196	0.33	73

3.2.2 Radiological Process Wastewater Treatment

The radiological influent to Building 3544 contains strontium-90 (^{90}Sr), cesium-137 (^{137}Cs) and low concentrations of heavy metals and organics. Radionuclide concentrations are routinely measured, but only a few analyses are available for the other contaminants (Table B-6).

Table B-6. Typical contaminant concentrations in Building 3544 influent.

Contaminant	Concentration	Units
Strontium-90	750	Bq/L
Cesium-137	110	Bq/L
Cobalt-60	25	Bq/L
Europium-153	30	Bq/L
Zirconium-95	50	Bq/L
Silver	0.006	mg/L
Arsenic	0.095	mg/L
Cadmium	<0.005	mg/L
Chromium	0.008	mg/L
Copper	0.037	mg/L
Mercury	0.0006	mg/L
Lead	<0.2	mg/L
Zinc	0.27	mg/L
Total Organic Carbon	1.9	mgL

The effluent from Building 3544 typically contains 1 Becquerel per liter (Bq/L) ^{90}Sr (99.9% removal) and 59 Bq/L ^{137}Cs (46% removal). Metals concentrations in the effluent are not measured, but the precipitation and ion exchange processes should be very efficient at removing heavy metals. Organics would not normally be removed at Building 3544, but would be removed at Building 3608 before the water is discharged.

3.3 ALTERNATIVE PROCESS WASTE TREATMENT EVALUATIONS

3.3.1 Treatment Options For SNS, HFIR, And REDC Process Waste

Four waste streams are expected to be above the UT-B process wastewater discharge criteria, including the: HFIR, REDC, SNS, and the ORNL radiological laundry. The wastewater from the HFIR had an average flow rate of 2.2 gpm in early FY03, and contains

- 420,000 Bq/L of tritium (^{3}H),
- 2,295 Bq/L chromium-51(^{51}Cr),
- 15.5 Bq/L americium-241 (^{241}Am),
- low concentrations of several other metallic radionuclides, and
- nonradioactive Cr.

All of the radionuclides are below the Derived Concentration Guide (DCG) values in DOE 5400.5 except ^{3}H and ^{241}Am.

The process wastewater from the REDC had an average flow rate of 5.2 gpm in early FY03 and does not normally contain any measurable radionuclides or other contaminants. The process wastewater from the SNS is expected to have an average flow rate of 3 gpm and contain a range of metallic radionuclides (Appendix E – Future New Waste Generators at ORNL, Table E-2). The ORNL radiological laundry generates 1 gpm of wastewater contaminated with ^{90}Sr, ^{137}Cs, detergents, and particulates.

Options were evaluated for treating the SNS, HFIR, and REDC process waste as a combined stream. The ORNL radiological laundry wastewater was not considered appropriate to mix with the other streams for treatment; options for its treatment are discussed separately. Four alternatives were considered for treating the SNS, HFIR, and REDC process wastewater, including:

1. discharging to the LLLW system,
2. installing an evaporator in Melton Valley to evaporate to a salt cake for disposal,
3. direct solidification for disposal, and
4. treatment by ion exchange to remove contaminants and discharge to the creek.

Alternative 4 was selected for future investigation. In Alternative 4 is described below in detail followed by a discussion of the alternatives that were not selected.

Alternative 4 is an ion exchange system designed to treat the SNS, HFIR, and REDC process wastewater streams, and was conceptually evaluated for location in Melton Valley. Skid-mounted package treatment units are available commercially. These units would require only periodic operator intervention. A package ion-exchange treatment system could be used to treat HFIR process wastewater. Both cation and anion exchange columns would be required. The process wastewater from the REDC does not normally contain any measurable radionuclides or other contaminants. This wastewater could be treated by the package ion-exchange system to remove any heavy metals that might be present. The SNS process wastewater could be treated in the same package unit. Construction costs for the system are estimated to be $1.7 Million, and the operating costs will be on the order of $1.4 Million per year.

Using resins in the ion exchange system that were selective for heavy metals over calcium and magnesium should greatly increase the amount of water that could be treated before the resins were spent, but laboratory testing would be required to determine the optimum resins. The spent resin would likely be a mixed waste because of the nonradioactive Cr in the HFIR wastewater. Alternatively, the resins could be regenerated, producing a LLLW for disposal.

Initial evaluations indicate that the effluent from ion-exchange treatment system could be discharged to Melton Branch. However, the treated water would still contain all of the ^{3}H from the HFIR process wastewater, so discharge into Melton Branch, which has a low flow rate, would significantly increase the ^{3}H concentration in the creek. If NPDES permits would not allow direct discharge, the pretreated wastewater could be discharged to the sanitary/sewage system and treated at the STP. The proposed capacity increase to the STP would accommodate the additional flow if necessary. Initial indications are that upgrades to the Melton Valley sanitary/sewage collection system would be not required, but additional evaluations would needed to be done if this alternative were to be seriously considered in the future.

The three other alternative treatment options were not considered viable as discussed below.

- Treatment in the LLLW system was not considered viable because the volumes of process wastewater generated by the SNS, HFIR, and REDC could not be handled by the existing LLLW system.
- Evaporation to a salt cake was considered to be too costly. The existing 7911 stack could not handle the volume of water vapor that the evaporation of process wastewater would generate. Therefore, this option would require the installation of a new stack in Melton Valley at a rough cost of $5 Million compared to $1.7 Million for the construction of the contaminant removal system. The operating costs for such a system are expected to be as high as the contaminant removal treatment system.
- Direct solidification would also be significantly more expensive than treatment by ion exchange. Brookhaven National Laboratory (BNL) uses Water Work America's Waste Lock 770 to stabilize process wastewater for disposal.[1] Using 0.4 pounds of material per gallon of waste, at a purchased cost of $3 per pound, the solidification agent procurement alone would cost $7.7 Million per year. These costs are significantly higher than the $1.4 Million estimated for operating the proposed ion exchange treatment system for process wastewater, and they do not include the additional costs required to solidify, sample, package, certify, transport, and dispose of the solid waste forms.

3.3.2 Treatment Options For the ORNL Radiological Laundry Process Wastewater

Because of the detergent and particulates in the ORNL radiological laundry process wastewater, it will not be easily treated for radionuclide removal by any existing or proposed treatment system, unless it is significantly diluted with other wastewater prior to treatment (as it is now by other PWTC feed streams). If this waste stream does not meet future waste acceptance criteria for the sanitary/sewage system, pretreatment at the site of generation, or treatment at the proposed process waste ion exchange treatment facility for HFIR, REDC, and SNS process wastes, are not likely to be viable options. In addition to problems caused by detergents and particulates, the proposed process waste ion exchange treatment facility will not remove ^{90}Sr and ^{137}Cs, which are the main contaminants in the laundry wastewater.

Two potential alternatives for the ORNL radiological laundry wastewater, which could be evaluated further include:

[1] Personal communication with Steven Coleman, BNL.

1. direct solidification (detergents may cause problems for some waste forms), or
2. contracting laundry operations to an off-site vendor.

Scientific Ecology Corporation (SEC), a subcontractor to Bechtel Jacobs Company LLC (the DOE Office of Environmental Management's contractor at ORNL) currently has a laundry contract with Aramark Uniform Services in South Carolina.

3.3.3 Treatment Options For Contaminated Groundwater

Although treatment of groundwater is a DOE-EM responsibility, future treatment options were evaluated to obtain an overall picture of the ORNL wastewater program. The volume of groundwater requiring treatment in the future will depend upon the DOE-EM remedial actions performed in Bethel and Melton Valleys. If minimum action is taken to contain existing groundwater contamination plumes without complete remediation, it is estimated that up to 100 gpm of contaminated groundwater[2] could require treatment from the ORNL Central Campus. Treatment for ^{90}Sr and ^{137}Cs would likely be needed. This could be accomplished using the existing PWTC, the zeolite system being designed for the Melton Valley Groundwater Treatment System (See Chapter 5), or new local treatment systems. Other radionuclides rarely need to be removed, but limited treatment capacity would be provided, if needed, by zeolites for most metallic radionuclides, if a system such as the Melton Valley Groundwater Treatment System were considered.

Low concentrations of Cu (0.03 mg/L) and Zn (0.05 mg/L) are present in the groundwater, which are below the current NPDES limits. Zeolite would provide partial removal of these metals, which would provide a safety factor for discharge. Hg averages 0.0006 mg/L, which exceeds the NPDES limit. An Hg specific ion-exchange resin would provide the required treatment. Chlorine can damage the Hg resins, so pretreatment to remove free chlorine might be needed. If the Hg-resin treatment system could be dedicated to treating the contaminated groundwater, the amount of spent resin would be greatly reduced, and the chlorine removal step would probably be eliminated. Treatment for organic removal would not currently be needed. However, there is a volatile organic compound (VOC) plume in East Bethel Valley. If this plume enters the process wastewater system in the future, which is unlikely due to the physical location of the system, organic removal might be needed. The ORNL STP could adequately treat the organics and metals if the plant capacity were available. Hg and radionuclides should be removed by pretreatment prior to discharge to the sanitary/sewage system.

If the PWTC is to be operated long-term for the treatment of contaminated groundwater, portions of the system will need to be replaced due to the age of the complex. Analysis of the PWTC indicates that the existing organic ion-exchange resin that removes Sr and the zeolite system that removes Cs could be replaced with one zeolite system designed to remove both Cs and Sr. If this process were implemented, the resulting LLLW stream (which accounts for 40% of the annual LLLW generated for storage in the Melton Valley Storage Tanks {MVSTs}) and the precipitator sludge would be eliminated from the PWTC operations. The resulting solid zeolite waste stream would be approximately 60% of the total solid waste presently generated at the PWTC.

3.3.4 Process Wastewater Trucking Evaluations

Estimates for the number of people required to transport process wastewater at ORNL were made with the assistance of Duratek personnel (the BJC subcontractor that operates the PWTC). Assuming that all storage tanks have the pumping capacity to fill a tanker within about one hour (approximately 100 gpm),

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[2] *Engineering Study Work Plan for Groundwater Actions in Bethel Valley, Oak Ridge, Tennessee*, DOE/OR/01-2035&D2, March 2003

one driver and chemical operator could load, deliver and unload about 3 tankers per day. Part-time support from a health physics technician and some management oversight, scheduling, and paperwork would also be required. Assuming storage tanks, with appropriate loading and unloading facilities, are available at each generator site, and that the tanks are big enough to fully load a 5000-gallon tanker, about 15,000 gallons per workday could be transported by 2.5 to 3 full time equivalents (FTEs). This would total 3.9 mgy, or an average flow rate of 7.4 gpm.

If all the waste streams above the UT-B wastewater discharge criteria (HIFR, REDC, SNS, and the ORNL radiological laundry) were to be transported to the existing PWTC, the generation rate would be approximately 15 gpm. Approximately 6 FTE will be required to load, haul, and unload this wastewater. Two additional tanker trucks ($70,000 to $90,000 each) would be required to assure continuous operation.

If a process waste ion exchange treatment facility was constructed in Melton Valley for the HFIR, REDC, and SNS process waste, as previously described, only SNS and possibly the ORNL radiological laundry waste would require trucking. This would reduce the trucked volume to approximately 4 gpm. It is estimated that this would require 1.7 FTE.

Lawrence Livermore National Laboratory has estimated the probability of trucking accidents in "*Shipping Container Response to Severe Highway and Railway Accident Conditions*", NUREG/CR-4829, February 1987. The estimated rate is 6.4 x 10^{-6} per mile for accidents that might damage a tanker. Assuming that each tanker hauling wastewater at ORNL would travel 3 miles per day, the probability of a transportation accident would be about 2 x 10^{-5} per day or 0.007 per year. Spills are probably more likely while connecting or disconnecting hoses or during filling operations, but no quantitative risk information was found for these operations.

4. PROPOSED SCOPE AND COST ESTIMATES FOR PROCESS WASTE SYSTEM PROJECTS

Conceptual level engineering cost estimates were obtained for the following capital projects, which are listed in Chapter 7 of the *ORNL Liquid and Gaseous Waste Treatment System Strategic Plan*.

4.1 BETHEL VALLEY PROCESS WASTE COOLING WATER ELIMINATION GENERAL PLANT PROJECT (GPP)

The scope of this GPP includes elimination of approximately 106 mgy of once-through cooling water from the process and sanitary/sewage systems (Table B-2) by installing recycle systems, replacing water-cooled chillers with air-cooled chillers, or diverting to the storm sewer. The once-through cooling water elimination projects that will eliminate discharge to the ORNL process and sanitary/sewage waste systems are summarized in Table B-7. The on-going Building 1506 Renovation Project ($3 Million GPP, FY03 - FY04) and the Surplus Facility Clean Out Deactivation & Demolition Project ($62 Million expense, FY05 - FY06) eliminate 4 mgy of once-through cooling water as a result of upgrading or deactivating facilities. A Facilities and Operations upgrade project for Building 3502 will eliminate 6.5 mgy of once-through cooling water from the sanitary/sewage system. The remaining once-through cooling water streams will eliminated by the proposed Bethel Valley Process Waste Cooling Water Elimination GPP. The engineering cost estimates include $0.46 Million to tie Building 4515 to central chillers (diverts 26 mgy), $0.42 Million to divert Buildings 4500 North and 4500 South cooling water to storm drains (diverts 33 mgy), and $0.95 Million to divert 47 mgy from all other UT-B managed buildings. The cost estimates have a 35% contingency factor.

4.2 BETHEL VALLEY PROCESS WASTE DRAIN ELIMINATION (GPP)

The project reroutes process wastewater drains for UT-B buildings (Table B-1) in Bethel Valley from the process wastewater collection system to the sanitary/sewage waste collection system. In general, the process waste drain lines will be excavated just outside the building wall, cut and then rerouted to the closest sanitary manhole. The existing connection to the process waste collection system will be capped. The cost estimate for this project is $4 Million, and the contingency factor is 50%. This estimate is based on digging up 75 pipes just outside of research facilities and reconnecting them to a manhole approximately 30 feet away by using 8-inch ductile iron piping buried 10 feet deep in the ground. It was assumed that 35 new pumping stations would be required for the sanitary/sewage waste collection system. The existing process waste piping would be abandoned in place.

Table B-7. Once-through cooling water elimination projects.

Project	Building	Volume eliminated (mgy)	Task[1]
Process Wastewater System - Total Eliminated = 103.6 mgy			
Building 1506 Renovation	1506	0.5	Eliminates cooling water as part of R&D upgrade
Surplus Facility Clean Out, Deactivation & Demolition	2019	3.6	Eliminates cooling water as part of surplus facilities deactivation
Bethel Valley Process Waste Cooling Water Elimination	1505	3.2	Eliminates once-through cooling water by connecting to existing central chiller system
	3025E	2.1	
	3025M	2.1	
	3137	0.5	
	3150	5.3	
	4500 North	4.1	
	4500 South	28.5	
	4501	1.2	
	4505	0.5	
	4508	20.0	
	4515	26.0	
	5500	1.6	
	5505	4.4	
Sanitary/Sewage System – Total Eliminated = 10.2 mgy			
Surplus Facility Clean Out, Deactivation & Demolition	2018	0.5	Eliminates cooling water as part of surplus facilities deactivation
Building 3502 F&O Division Upgrade	3502	6.5	Replace current equipment with recirculating unit
Bethel Valley Process Waste Cooling Water Elimination	3025M	3.2	Eliminates once-through cooling water by connecting to existing central chiller system

1. Unless otherwise noted, these elimination projects reroute once-through cooling water to the storm drain system.

4.3 MELTON VALLEY PROCESS WASTE DRAIN CONTAMINANT DISCHARGE ELIMINATION (GPP)

It is proposed that process wastewater from the HFIR, the REDC, and eventually from the SNS be treated using a new package ion-exchange unit located adjacent to the existing MVSTs system. Wastewater will be pumped from the MVSTs, through the treatment unit, and then discharged to either the Melton Branch or to the sanitary/sewage system. The existing process wastewater underground pipelines from HFIR and REDC to the MVSTs will be abandoned in place and replaced with new below ground PVC lines.

The proposed ion-exchange unit is capable of treating up to 35 gpm of wastewater, and will use resins that are selective for metal ions in these waste streams (chromium, cobalt, copper, etc.) over common ions (sodium, calcium, magnesium) to minimize the generation of secondary waste. Wastewater from the SNS, and possibly other buildings, will be trucked to the MVSTs. An existing, diked caustic unloading station will be upgraded for unloading process wastewater tankers. The treatment system would be located just north of the caustic unloading station, in a small prefabricated building. The estimated cost is $1.71 Million and includes a 21% contingency factor. Title I and II design are assumed to take 5 months, and construction is estimated to take 6 months.

4.4 ALTERNATIVE PROCESS WASTE SYSTEM CAPITAL FUNDING CONSIDERATIONS

AmerescoSolutions has a contract with DOE to implement energy-saving projects with private sector funding and receive payment through the cost savings. They are looking for opportunities to implement such projects for replacing once-through cooling water systems. If such projects are approved by DOE in the future, they will be dropped from the above proposed capital project scopes.

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APPENDIX C – LIQUID LOW-LEVEL WASTE SYSTEM

1. LIQUID LOW-LEVEL WASTE SYSTEM DESCRIPTION

The Oak Ridge National Laboratory (ORNL) liquid low-level waste (LLLW) system collects, neutralizes, concentrates, and stores aqueous radioactive waste solutions from:

- “hot” sinks and drains in research laboratories,
- radiochemical pilot plants,
- nuclear reactor facilities, and
- other wastewater treatment systems.

The LLLW system’s waste acceptance criteria (WAC) administratively limits the wastes that can be added to the LLLW system to a total radionuclide concentration of the ingestion dose equivalent of 2 x 10^{10} Becquerels per liter (Bq/L) strontium-90 (^{90}Sr).

The LLLW system facilities are located throughout ORNL.

- The LLLW collection/storage tanks are located near the LLLW source buildings in Bethel and Melton Valleys,
- the LLLW Evaporator is located on the corner of White Oak Avenue and Third Street in Bethel Valley,
- the Melton Valley Storage Tanks (MVSTs) system is located in the 7800 area of Melton Valley, and
- the LLLW Solidification Facility is also located in the 7800 area in Melton Valley.

The Federal Facilities Agreement (FFA) of 1992 required that the ORNL LLLW system meet requirements for the Resource Conservation and Recovery Act (RCRA) underground storage systems. This resulted in major upgrades to the LLLW system that took single-contained piping and tanks out of service and upgraded or replaced portions of the system to make all pipes and tanks double-contained.

1.1 LLLW COLLECTION SYSTEM

The LLLW collection system generally consists of one or more

- generator-maintained collection tanks located in the generator building,
- collection tanks located outside the generator buildings (managed by Bechtel Jacobs Company LLC {BJC}), and
- underground pipelines to transfer waste from the source buildings to the LLLW Evaporator and ultimately to the MVSTs.

Generator facilities that have pipeline access to the LLLW system include:

- Building 2026, the Radioactive Materials Analytical Laboratory;
- Building 3019A, the Radiochemical Development Facility;
- Building 3025, the Metals and Ceramics Division's Physical Examination Hot Cells; and
- Buildings 7920 and 7930, the Radiochemical Engineering Development Center (REDC).

The collection tanks inside these buildings range in age from 7 to 38 years old. These tanks are all double-contained and meet FFA requirements.

There is one BJC-managed collection tank in Bethel Valley. Tank F-1401 is located at Building 2099 and services Building 2026. It is fabricated of stainless steel and was placed into service in April 1996. This tank is double-contained in a stainless-steel-lined concrete vault that is outfitted with leak detection devices. Waste from tank F-1401 is transferred to one of five 50,000-gallon stainless steel, double-contained collection tanks that service the LLLW Evaporator, known as the Bethel Valley Evaporator Service Tanks (BVESTs). Other buildings in Bethel Valley on the LLLW system transfer directly to the BVESTs from the generating facilities.

There is one BJC-managed collection tank in Melton Valley. Tank F-1800 (located at Building 7966) is a 10,000-gallon horizontal collection tank that serves the REDC. This tank is fabricated of 304L stainless steel and was installed in 1997 in a reinforced underground concrete vault, which is lined with stainless steel to provide secondary containment.

There is an extensive LLLW pipeline system that connects the generator facilities to the LLLW Evaporator and the MVSTs. All pipelines are double-contained and have leak detection devices. The pipes between Melton Valley and Bethel Valley are buried in a specially prepared bed of select clay and are cathodically protected. Approximately 7,800 linear feet of pipeline was installed in 1997 and connects the REDC in Melton Valley to the LLLW Evaporator System in Bethel Valley. Approximately 3,000 to 4,000 linear feet of piping connects the gaseous waste system LLLW feed and Bethel Valley LLLW generators to the LLLW Evaporator System. The transfer lines between Building 2026 and the LLLW Evaporator System were installed in 1994. Approximately 6,300 linear feet of piping, installed in 1982, connects the LLLW Evaporator System to the MVSTs.

LLLW is also transported by surface vehicles to the LLLW collection system for treatment. Bulk LLLW that is not transferred by pipeline is transported from the generating facility by tanker truck to the collection header in the South Tank Farm, located on the southwest corner of Central Avenue and Third Street for further transport by pipeline to the BVESTs and the LLLW Evaporator for processing. Facilities with trucking stations include:

- Building 3074, the Manipulator Shop;
- Building 3525, the High-Rad Level Examination Lab; and
- the Process Wastewater Treatment Complex (PWTC).

Two tanker trucks are presently in use. The first is a 1,000-gallon flatbed-mounted tank operated by Duratek Federal Services (a BJC subcontractor) personnel to transport up to 800 gallons of LLLW to the LLLW collection system, where it is gravity drained to the hard-piped system. The second tanker is the Building 3074 dumpster tank, which is owned by the ORNL Facilities Management Division. Duratek Federal Services personnel empty this tanker as requested by Facilities Management Division personnel.

Small quantities of LLLW are routinely transferred from the generators' facilities to the LLLW Evaporator System in a Department of Transportation (DOT) Specification 7A, Type A, Bottle Package System, which consists of a 2.5-gallon thick-walled, reusable, polyethylene bottle with a 20-gallon drum overpack. Generator facilities that currently bottle waste include:

- Building 3047, the Isotope Technology Laboratory;
- Buildings 4500 North and 4500 South Central Research Laboratories;
- Building 4501, the Radiochemical Laboratory; and
- Building 5505, the Transuranium Research Laboratory.

1.2 LLLW TREATMENT SYSTEM

1.2.1 LLLW Evaporator (Building 2531)

The LLLW evaporator system at ORNL collects, concentrates, and stores aqueous radioactive waste solutions from various sources at the Laboratory. The LLLW evaporator is located in Building 2531 and receives LLLW from a variety of sources, including

- waste solutions from radioactive fuel and target processing facilities,
- decontamination operations,
- hot cells,
- analytical laboratories, and
- waste treatment systems.

The waste may contain RCRA characteristic materials (but no listed wastes), as well as other contaminants.

LLLW is concentrated in one of the two 600 gallon-per-hour evaporator systems housed in Building 2531. This facility was constructed in 1954. The first of the evaporators was put into operation in 1965, and the second was place in service in 1979. The second evaporator vessel was replaced in 1994 due to deterioration of the internal steam coils. The original evaporator is served by a 4,400 gallon feed tank. The newer evaporator is fed directly from one of the BVESTs (tank W-23). Both evaporator installations consist of

- an evaporator vessel,
- a vapor filter,
- a water-cooled condenser, and
- a condensate catch tank.

The overheads from the evaporator vessels are condensed and receive treatment at the PWTC for the removal of radiochemicals from the evaporation process. There are vapor filters and entrainment separators in each system before the condensers. Cooling tower water is used for heat removal from the tube-and-shell condensers. Both incoming waste and evaporator concentrate are stored in the BVESTs located in vault 2537, which was constructed in 1978. The BVESTs are five 50,000-gallon tanks, which were installed in 1964 (tanks C-1 and C-2) and 1979 (tanks W-21, W-22, and W-23). The evaporator concentrate is transferred to the MVSTs system (tank vaults 7830 and 7856) to await further treatment and/or solidification.

1.2.2 The Melton Valley Storage Tank System (Tank Vaults 7830 and 7856)

The original MVSTs include eight 50,000-gallon stainless steel storage tanks, which are installed in two underground vaults at (Facility 7830). The two concrete vaults have stainless steel liners and leak detection instrumentation. The MVSTs were placed in service in 1980. The MVSTs Capacity Increase Project installed six additional 100,000-gallon stainless steel storage tanks in 1998. These are located at Building 7856, southeast of the original MVSTs. The tanks are contained in individual concrete vaults lined with stainless steel and are equipped with leak detection instrumentation.

1.2.3 Low-Level Waste (LLW) Solidification Facility (Building 7877)

In the early 1980s, it became apparent that a LLLW treatment system was needed to create additional storage capacity in the MVSTs. The Low-Level Waste (LLW) Solidification Facility (Building 7877) was constructed to allow grouting of the LLLW for disposal. Building 7877 is a pre-fabricated butler building built in 1987 that is a Class III nuclear facility. The building is not designed to handle alpha or transuranic (TRU) materials and is not air-conditioned. To provide clarified LLLW feed to the LLW Solidification Facility, a LLLW decant system was added to the MVSTs. The decant system included the installation of dip-leg piping into tanks W-29 and W-30 to allow decanting of about one-half of the working volume of each tank. The dip legs were piped to a shielded double-diaphragm pump located within a containment structure on top of vault 7830. The discharge piping of the pump was routed within a shielded pipe chase along the top of the vault into Building 7877. The grouting materials and equipment were provided through a subcontract to a private service company specializing in mobile radiological waste grouting services. All operations were contact-handled (CH), but an adjacent storage facility was used as a remote camera monitoring station. During the grouting campaigns, the cesium-137 (^{137}Cs) concentration in the LLLW increased from 3,000 nanocuries per milliliter (nCi/ml) to approximately 10,000 nCi/ml. As the levels of cesium in the supernate became higher, it became more difficult to treat the waste by CH operations, and the process was discontinued.

During the period from December 1997 though April 2000, the Wastewater Triad Project was deployed in the facility to increase the available capacity in the MVSTs by evaporating the LLLW, and reducing the radioactivity by removing cesium. Skid-mounted evaporator and ion-exchange systems were installed in Building 7877. The equipment was remotely operated but required hands-on maintenance. Modular shield walls were used to reduce the general area radiation dose within the building, and a remote operating system was installed in an adjacent building. A filtration system was installed at the MVSTs to assure that no alpha-containing sludge entered Building 7877. The ability to drain and flush the systems and to shield individual components were key factors in facilitating hands-on maintenance work. Approximately 268,000 gallons of LLLW with a ^{137}Cs concentration of 5,100 - 27,000 nCi/ml was processed by the Wastewater Triad Project, reducing the MVSTs volume by ~117,000 gallons and removing 7,700 Ci of ^{137}Cs. Building 7877 has been shut down since 2000 and has residual contamination. It will most likely be of limited use for meeting long-term LLLW treatment needs.

1.2.4 TRU Waste Processing Facility (Building 7880)

The U.S. Department of Energy (DOE) Office of Environmental Management (EM) has a fixed-price, unit-rate contract with the Foster Wheeler Environmental Corporation (FWENC) the to treat legacy solid TRU waste, as well as the existing inventory of legacy LLLW (and associated remote-handled TRU sludge) for disposal. There is a 15% contingency exception clause in the contract to address uncertainties in the volume of inventoried waste. The contract includes treatment of:

- 2,750 cubic meters (m^3) of LLLW,
- 1,000 m^3 of solid CH-TRU waste, and
- 550 m^3 of solid remote-handled (RH) TRU waste.

FWENC has constructed a Category II nuclear facility with hot cells for processing these waste streams in Melton Valley, which will begin operation in FY03 and have a 15-year design life. The process for treating LLLW consists of

- separating the LLLW and associated sludge into two processing streams,
- washing the sludge,
- adding stabilizing agents to each stream if needed to meet the RCRA toxic characteristics leaching procedure (TCLP) criteria, and
- solidifying each stream by vacuum evaporation.

The solidified LLLW will be a RH-LLW that can be disposed of at the Nevada Test Site (NTS), and the solidified sludge will be RH-TRU waste for disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico. The facility is sized to treat 46,000 gallons per month (gal/month) of LLLW and 13,500 gal/month of TRU sludge.

Delays in WIPP accepting RH-TRU waste is resulting in schedule changes for the TRU WPF operations. LLLW and associated RH-TRU sludge processing is currently planned through approximately FY08. The delays occurred because the DOE National TRU Program has not issued the WAC for RH-TRU waste at the WIPP. If the WIPP RH-TRU WAC is not finalized soon, the TRU WPF treatment schedule could be delayed again.

2. LLLW GENERATION

Research and development (R&D) waste presently accounts for 14,000 gallons per year (gal/yr) of the 169,000 gal/yr of LLLW generated at ORNL (See Chapter 3). After the Spallation Neutron Source (SNS) becomes operational, the R&D generation rate is projected to increase to 110,000 gal/yr. The waste generation rates from R&D activities are expected to be fairly constant after the SNS startup. However, the total volumes of waste generated at ORNL will vary considerably while DOE-EM remediation and DOE Office of Nuclear Energy, Science and Technology (NE) uranium-233 (^{233}U) processing at the Building 3019A complex occur (both are expected to end in FY14). The amount of DOE-EM related LLLW generated after FY14 will depend upon DOE-EM's actions over the next ten years to address contaminated soils, groundwater plumes, and remediation of existing treatment facilities. Estimated LLLW generation rates are shown in Figure C-1.

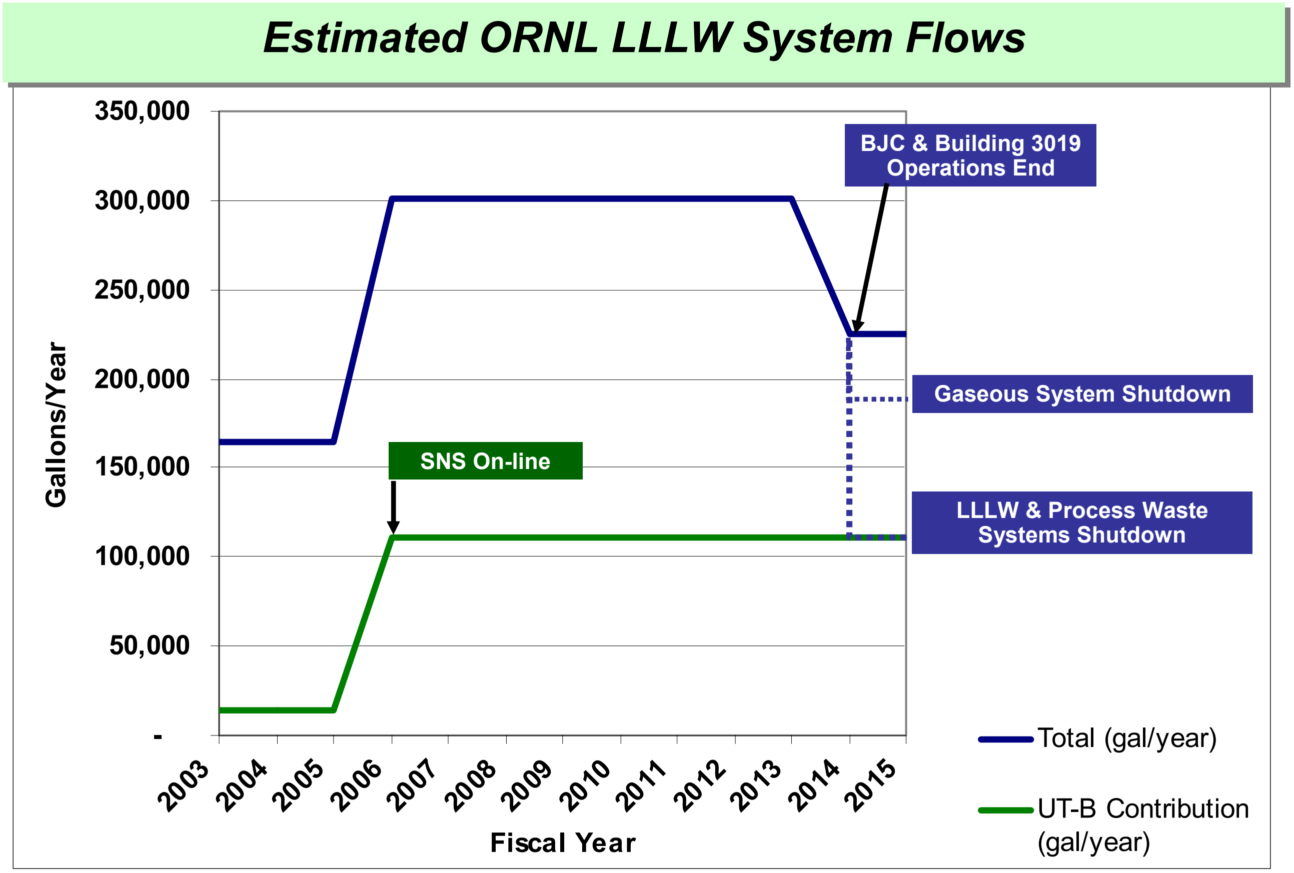

Figure C-1. Estimated LLLW flows at ORNL.

3. LLLW TREATMENT SYSTEM RE-ENGINEERING EVALUATIONS

3.1 EXISTING LLLW SYSTEM EVALUATIONS

The existing LLLW system was modeled by estimating the volume and composition of each LLLW stream generated at ORNL and predicting the impact of each treatment step on the stream as it progresses through the system. The first volume reduction typically occurs at the LLLW evaporator. The LLLW evaporator concentrates waste to a specific gravity of 1.2. The volume reduction for each waste stream is estimated to vary from 0 (waste is sent directly to the MVSTs without treatment by the LLLW evaporator) to 150 (very dilute waste). The historic average volume reduction factor for the LLLW evaporator has been 25, but this value is expected to vary considerably in the future as the mix of waste streams change.

The second volume reduction would typically occur during a solidification process to prepare the waste for final disposal. Additional volume reductions were also estimated for solidifying the concentrated LLLW stored in the MVSTs for final disposal, assuming the waste was dried to a salt cake. It was assumed that concentrated LLLW would have a volume reduction of 10:1 and sludge would have a volume reduction factor of 2:1.

3.1.1 System Operation with Current LLLW Waste Generation

ORNL currently generates approximately 170,000 gal/yr of LLLW. This is typically processed in the LLLW evaporator and results in 12,000 gal/yr of concentrated LLLW that is piped to and stored in the

MVSTs system. Solidification of this concentrated LLLW at the TRU WPF is estimated to generate approximately 1,200 gal/yr of solidified RH-LLW or TRU waste for disposal. UT-Battelle LLC (UT-B) contributed approximately 10% or less of the LLLW waste stream in 2002.

3.1.2 System Operation with Future LLLW Waste Generation

The total volumes of waste generated at ORNL will vary considerably while DOE-EM operations and Building 3019A radiochemical processing occur. The annual waste generation is expected to increase to as high as 300,000 gal/yr between FY06 and FY14, when the Building 3019A chemical processing and DOE-EM remediation activities are expected to end. After the TRU WPF stops accepting waste in the FY06 timeframe, as much as 300,000 gallons of concentrated waste could be accumulated in the MVSTs by FY14. Only 10% of this waste will have resulted from direct processing of UT-B R&D waste. Currently, no plans are in place for implementing LLLW treatment capabilities to process this waste for disposal.

Preliminary analyses of the LLLW projected to be generated by researchers were performed to determine future waste treatment needs. Annual projections for individual UT-B R&D generators are shown in Table C-1. It is estimated that the LLLW Evaporator System would process 110,000 gal/yr of LLLW, which would be reduced to 2,900 gal/yr and sent to the MVSTs. Assuming that 5% (145 gal/yr) of the concentrated LLLW becomes sludge upon settling in the MVSTs, it is estimated that the TRU WPF would reduce the volume of the waste and produce 72 gal/yr of solid RH-TRU from the treated sludge and 275 gal/yr of solid RH-LLW from the treated LLLW.

The TRU WPF is significantly oversized for processing research generated waste, since the TRU WPF is sized to treat 46,000 gal/month of concentrated LLLW and 13,500 gal/month of RH-TRU sludge, while the future R&D waste production rate is expected to be 230 gal/month of concentrated LLLW and 12 gal/month of sludge.

The volumes of solid waste generated by grouting the waste rather than processing through the TRU WPF are also shown in Table C-1. LLLW supernate was processed in Building 7877 for disposal at the Nevada Test Site in the 1980s. However, there are no treatment facilities presently available for grouting LLLW sludge.

The major radioactive constituents in the waste streams as they progressed through the treatment processes are estimated in Table C-2. These estimates assume that on average the REDC performs one Mark 42 campaign and half of a High Flux Isotope Reactor (HFIR) campaign per year. It is assumed that the waste generated from the future Plutonium-238 Project will be similar to that of the existing Mark-42 campaigns conducted at the REDC. Table C-2 shows that the feed entering the TRU WPF would be high-activity TRU waste, unless the REDC waste is pretreated to remove cesium, strontium, actinides, and rare earths. REDC personnel roughly estimated the amounts of radionuclides that could potentially be separated from three REDC waste streams. The resulting LLLW is also shown in Table C-2. Table C-2 shows that the sludge will be TRU waste if dried to a salt cake regardless of whether pretreatment occurs. It also shows that the cesium levels in the pretreated LLLW would be in the range of the highest levels processed in Building 7877 during grouting operations performed in the 1980s. The secondary solid waste, which would be generated as a result of REDC pretreatment, is estimated in Table C-3.

One option for pretreating select REDC waste streams for TRU element removal was investigated in the 1990s, but several problems arose. The one test of this pretreatment option that was performed did not remove enough TRU elements, and the waste in the centralized waste system was still TRU after pretreatment. The secondary solid waste generated during the pretreatment test was so concentrated that

BJC did not have capabilities to transport and dispose of the waste form. Additional technical studies will be required to define a feasible REDC pretreatment system.

Table C-1. Estimates of future UT-B LLLW generation rates, volume reduction if processed through the existing ORNL LLLW Evaporator System, and potential solidification volumes by various treatment alternatives.

Building	LLLW Generation (gal/yr)	Estimated LLLW Evaporator Volume Reduction Factor	Solidification Plant Feed Rate[1] (gal/yr)	Solidification Options			
				Grouted LLLW[2] (gal/yr)	Grouted Sludge[3] (gal/yr)	Salt Cake From LLLW[4] (gal/yr)	Salt Cake From Sludge[4] (gal/yr)
2026	3,650	20	183	295	27	17	5
3025E	10	5	2	3	0	0	0
3047	18	5	4	6	1	0	0
3074	4,420	60	74	119	11	7	2
4500N	2	5	0	1	0	0	0
4500S	2	5	0	1	0	0	0
4501	125	20	6	10	1	1	0
7920-30	11,000	10	1,100	1,777	165	105	28
Others	20	5	4	6	1	0	0
SNS	91,250	60	1,521	2,456	228	144	38
Totals	**110,497**		**2,894**	**4,673**	**434**	**275**	**72**

1. Estimated volume of waste generated from processing LLLW through the existing LLLW Evaporator System and stored in MVSTs system.
2. Estimated volume if concentrated LLLW stored in the MVSTs were grouted by a process similar to those previously performed in Building 7877.
3. Estimated volume if sludge in the MVSTs were grouted. Facilities are not presently available for this operation.
4. Estimated volume if concentrated LLLW and sludge stored in the MVSTs were processed through the TRU WPF.

Table C-2. Estimates of main radioactive constituents in waste included in Table C-1[1]

Radioactive Constituent	As-Generated LLLW (nCi/mL)	Solidification Plant Feed (nCi/mL)	Grouted LLLW (nCi/mL)	Grouted Sludge (nCi/mL)	Salt Cake From LLLW (nCi/mL)	Salt Cake From Sludge (nCi/mL)
Without REDC Pretreatment						
TRU	3	103	0	688	0	4127
Cobalt-60	0.8	29	2	177	31	1062
Strontium-90	1,506	57,521	3,562	345,128	60,549	2,070,767
Cesium-137	5,263	200,959	62,217	669,864	1,057,681	4,019,186
With REDC Pretreatment[2]						
TRU	0.2	7.9	0	53	0	318
Cobalt-60	1	29	2	177	31	1062
Strontium-90	75	2,861	177	17,166	3,012	102,996
Cesium-137	270	10,294	3,187	34,315	54,182	205,890

1. Based on one Mark-42 and half a HFIR target campaign per year at the REDC.
2. Assumes that 95% of the Cesium-137 and Strontium-90, 97% of the actinides, and 98% of the rare earths are removed from the REDC aqueous LLLW stream and 90% of the plutonium is removed from the REDC organic LLLW stream.

3.2 ALTERNATIVE TREATMENT SYSTEM EVALUATIONS

The concept of real-time processing through a small, centralized treatment facility designed for solidification of R&D LLLW was reviewed. Table C-1 indicates that all of UT-B's waste streams are fairly concentrated, except for the Spallation Neutron Source (SNS) waste. Therefore, a new solidification system was evaluated assuming that SNS waste would be evaporated to 1/60th of the original volume prior to being mixed with LLLW from all other generators. It is estimated that the new solidification system would have an annual feed rate of approximately 21,000 gallons. If the waste streams were processed without evaporation and long-term storage, it is assumed that they would not separate into a sludge and supernate layer as they presently do in the LLLW system. Pretreatment of the REDC was considered.

Two solidification options were considered:

- evaporation to salt cake, and
- grouting.

The results are summarized in Tables C-4 and C-5 and discussed below.

3.2.1 Evaporation to a Salt Cake

3.2.1.1 Argonne National Laboratory Benchmarking

Argonne National Laboratory West (ANL-West) was benchmarked for LLLW treatment. ANL West pretreats waste in hot cells by ion exchange and filtration prior to discharge to the centralized treatment facility (Radiological Liquid Waste Treatment Facility) via underground pipelines. The pretreatment process is quite labor intensive, with some waste streams requiring treatment six to seven times prior to discharge. Pretreatment is required to

- Assure that the non-RCRA waste is not entering the centralized treatment facility,
- keep the inventory in the centralized treatment facility within the limit of a non-nuclear radiological facility, and
- produce waste forms which meet on-site disposal criteria.

Table C-3. Estimation of main radioactive constituents in secondary waste from REDC pretreatment for Mark 42 and HFIR campaign wastes.

Isotopes	Curies in Mark 42 Campaign waste form			Curies in HFIR Campaign waste form		
	Aqueous Streams[1]	Aqueous Streams[2]	Organic Streams[3]	Aqueous Streams[1]	Aqueous Streams[2]	Organic Streams[3]
Strontium-90		6.0E+02				
Zirconium-95				5.00E+00		
Cesium-134		4.5E+01			2.7E+01	
Cesium -137		2.1E+03			3.3E+01	
Barium-140		4.0E+01				
Cerium-141				1.65E+01		
Cerium -144	2.61E-02			3.37E+02		
Promethium-147	6.90E+00			2.17E+01		
Europium-154	4.75E+01			2.31E+00		
Europium -155	1.24E+01					
Europium -156				3.72E-01		
Plutonium-238	2.18E-01		3.00E-02	8.74E-07		1.20E-06
Plutonium -239	4.56E-04		6.27E-05	9.02E-08		1.24E-07
Plutonium -240	4.06E-02		5.59E-03	2.38E-02		3.28E-02
Plutonium -241	4.48E+00		6.17E-01	4.47E-01		6.16E-01
Plutonium -242	2.17E-03		2.99E-04	1.81E-04		2.49E-04
Americium-241	3.45E-01					
Americium -243	8.51E-02			2.88E-04		
Curium-244	1.67E+01			1.70E+01		
Curium -245	1.75E-03					
Curium -246	3.46E-03					
Curium -247	2.59E-08					
Curium -248	3.70E-07					
Californium-252				1.13E+00		
Total Curies	8.87E+01	2.1E+03	6.53E-01	4.02E+02	6.0E+01	6.49E-01
Total Actinides	2.19E+01			1.87E+01		
TRU content (Ci)	6.96E-01		3.59E-02	2.43E-02		3.30E-02
Waste Form Volume (L)	1.7	459	To Be Determined	1.7	13	To Be Determined

1. Waste form volumes and curie content based on information from Operation and Testing of the Right Rack 7 Waste Treatment Module at the Radiochemical Engineering Development Center, R. R. Brunson, et. al., 1998 and actual equipment operating data from October 1997 through July 1998[1].
2. Waste form volumes and curie content based on 95% removal of cesium and strontium by ion exchange resin loaded to just below Class C disposal limits for Nevada Test Site.
3. Waste form loadings based on 90% removal of the plutonium in the waste stream. Volumes estimated to range between 1.7 liters for a process similar to the Right Rack 7 process and 208 liters for direct solidification of the as-generated organic stream with Nochar, a commercially available material tested at the DOE Rocky Flats and Savannah River sites for solidifying high-activity organic waste, with an expected 70% volume increase upon solidification[2].

[1] Personal communications with Robin Taylor, ORNL Nuclear Science and Technology Division
[2] Personal communications with Thomas Klasson, ORNL Life Sciences Division

The ANL-West pretreatment requirements are dictated by physical and regulatory limitations of the centralized treatment facility. Because of funding and schedule constraints at the time of construction, the centralized facility was designed to be a nonnuclear facility that could not handle TRU or high-activity waste. The facility was built before RCRA was a consideration, and management decided to pretreat the feed streams at the source of generation rather than upgrade the facility to RCRA requirements.

ANL-West's centralized nonnuclear Radiological Liquid Waste Treatment Facility receives generator-characterized non-RCRA, non-TRU, low-activity waste via underground pipelines in 800-gallon batches. The treatment facility feed tanks hold up to 1,000 gallons. Each batch of waste is evaporated in 6 parallel shielded hot air drum evaporator (SHADE) systems. The SHADE system consists of a 30-gallon drum inside a 55-gallon drum encased with 6 inches of concrete shielding (Figure C-2). The 30-gallon drum contains baffled evaporator trays, into which 200 cubic feet per minute (cfm) of process air at 200 degrees Fahrenheit (°F) and liquid waste are pumped. Fifteen pounds per square inch guage (psig) steam is used for heating the process air. The evaporated water passes through two stages of high efficiency particulate air (HEPA) filtration before being released through the stack. The SHADE system outlet temperature limit is set at 145°F to protect the HEPA filters. Each SHADE system processes 1 - 2 gallons per hour of liquid waste. The waste is evaporated to dryness, and the entire unit is disposed of a solid low-level waste (LLW).

The ANL-West facility became operational in 1983 and has treated 325,000 gallons of waste. The SHADE system is automated so that operators are only present during startup and shutdown. Back shift operators tour the facility about once every 6 hours. On average the plant treats 16,000 gal/yr, similar to the amount of LLLW that ORNL researchers generate.

How long a SHADE system lasts is primarily a function of solids and radionuclide content in the processed wastewater. The evaporators are usually operated until the evaporation rate drops off. However, with highly radioactive feed, the SHADE systems are changed out earlier to keep the radionuclide inventory in the facility below Category III Nuclear Facility limits. ANL-West has disposed of 14 SHADE sets (6 evaporators per set) since 1983. The evaporator throughput has averaged around 23,000 to 24,000 gallons per set (6 evaporators). The high throughput set was 37,000 gallons with much of the feed being clear liquid used for system startup. The low throughput was 11,000 gallons on an evaporator set used for highly radioactive material, which quickly met disposal limiting factors. Waste forms are presently disposed of on site. After the disposal facility is full, the waste will go to the NTS or Hanford. SHADE systems have not been U.S. Department of Transportation (DOT) Type 7A certified for off-site shipment. SHADE systems are constructed on site and cost approximately $15,000 to $20,000 each.

3.2.1.2 Application to ORNL LLLW

It is estimated that 300 gallons, or ten 55-gallon drums, of solid LLW would be generated each year from processing ORNL LLLW through a SHADE-type system, as shown in Table C-4. The throughput would only be 25% higher than the ANL-West waste facility. Without REDC pretreatment, the final waste form will be a RH-TRU waste requiring disposal at the WIPP. If the TRU elements and ^{137}Cs are removed at the REDC, the LLLW treatment facilities would require less shielding and would, therefore, be less expensive to construct. The bulk of the waste exiting the small, centralized waste treatment system would be solid LLW that could be disposed of at the Nevada Test Site (see Table C-5).

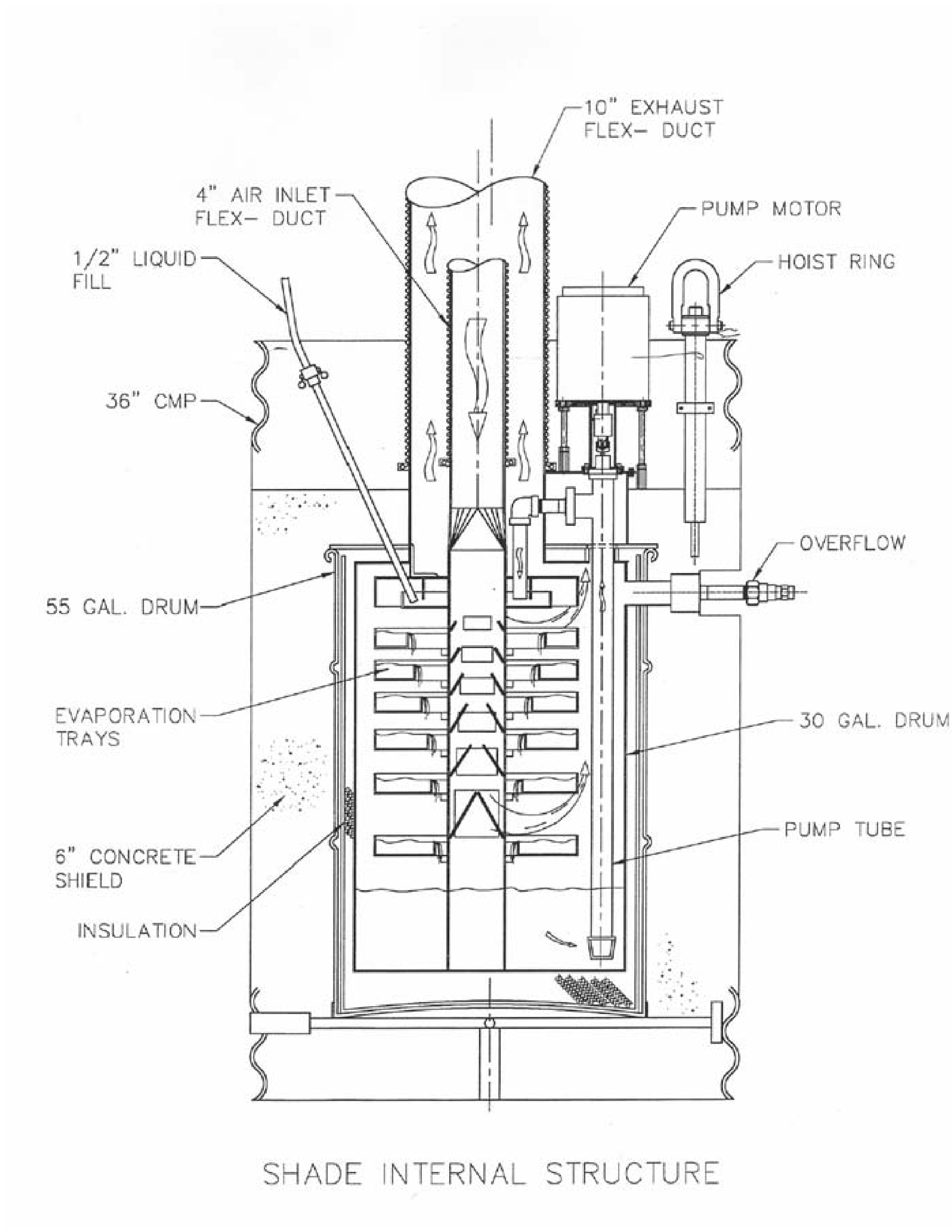

Figure C-2. Diagram of the ANL West's SHADE system internal structure.

3.2.2 Grouting

Grouting the LLLW at a new facility was also considered. Assuming 20,000 gal/yr is grouted, it is estimated that 35,000 gal/yr of solid LLW would be generated from treating R&D generated LLLW, compared to 300 gal/yr if dried to a salt cake through the SHADES-type evaporator, as show in Table C-4. The grouted waste would not be TRU, but it would be high-activity due to the cesium content. If cesium were removed from the waste stream, the shielding required for the processing plant would be significantly reduced (see Table C-5).

3.2.3 Comparison of Alternatives

Tables C-4 and C-5 provide a comparison of the resulting solid low-level waste streams resulting from the evaluated solidification options. They show that very small quantities of highly-radioactive RH-TRU and RH-LLW could be generated by pretreating REDC waste. This could result in making the remainder of the LLLW generated at ORNL a non-RH, non-TRU waste form, which could be dispositioned at the NTS. Additional evaluations are required to determine the technical and economic tradeoffs of the LLLW treatment alternatives before the new treatment system can be designed.

Table C-4. Estimates of future UT-B LLLW generation rates if processed through a new LLLW treatment system compared to grouting.

				SHADE System Evaporation		Grouting	
Building	LLLW Generation (gal/yr)	Estimated Volume Reduction Factor	Solidification Plant Feed Rate (gal/yr)	Salt Cake Solidification Volume Reduction Factor	Salt Cake Waste (gal/yr)	Grout Solidification Volume Reduction Factor	Grouted Waste (gal/yr)
2026	3,650	1	3,650	200	18	0.6	6,205
3025E	10	1	10	50	0	0.6	17
3047	18	1	18	50	0	0.6	31
3074	4,420	1	4,420	600	7	0.6	7,514
4500N	2	1	2	50	0	0.6	3
4500S	2	1	2	50	0	0.6	3
4501	125	1	125	200	1	0.6	213
7920-30	11,000	1	11,000	100	110	0.6	18,700
Others	20	1	20	50	0	0.6	34
SNS[1]	91,250	60	1,521	10	152	0.6	2,585
Totals	110,497		20,768		289		35,305

1. Assumes SNS waste is evaporated to a specific gravity of approximately 1.2 prior to being mixed with all other LLLW sources for solidification.

Table C-5. Estimation of the main radioactive constituents in the waste included in Table C-4[1].

Radioactive Constituent	As-Generated LLLW (nCi/ml)	Solidification Plant Feed (nCi/ml)	Evaporated Salt Cake Waste (nCi/ml)	Grouted Waste (nCi/ml)
Without REDC Pretreatment				
TRU	3	14	1,032	8
Co-60	0.8	4	295	2
Sr-90	1,506	8,015	575,213	4,714
Cs-137	5,263	28,000	2,009,593	16,471
With REDC Pretreatment[2]				
TRU	0.2	1.1	79	0.7
Co-60	1	4	295	2
Sr-90	75	399	28,610	234
Cs-137	270	1,434	102,945	844

1. Based on one Mark-42 and half a HFIR target campaign per year at REDC.
2. Assumes that 95% of the cesium-137 and strontium-90, 97% of the actinides, and 98% of the rare earths are removed from the REDC aqueous LLLW stream and 90% of the plutonium is removed from the REDC organic LLLW stream.

3.3 LLLW TRUCKING

ORNL has a 800-gallon tanker that is used to transport LLLW. If the current LLLW lines in Bethel Valley are removed from service, about 8,000 gal/yr of LLLW will need to be trucked to a treatment facility. Assuming the Manipulator Shop is moved to Melton Valley, this volume would be reduced to 4,000 gal/yr. In addition, the SNS will generate about 91,000 gal/yr of LLLW. Loading, transporting, and unloading 800 gal of LLLW using the existing LLLW tanker truck would require 2 chemical operators and one health physics technician for 6 hours and a driver for 3 hours, or about 24 man-hours per trip. Transporting 95,000 gal/yr of LLLW would require 3 trips per week on average, assuming the existing 800 gal tanker was filled to 80% of capacity each trip. If SNS waste could be evaporated prior to trucking, the transfer volume would be reduced to 6,000 gal/yr. This would require approximately 7 trips per year. To minimize storage of waste at the generator facilities, waste transfers could occur more frequently.

4. PROPOSED SCOPES AND COST ESTIMATES FOR LLLW SYSTEM PROJECTS

Preliminary cost estimates for a capital project were performed in FY03 for upgrading the LLLW system. The ORNL Liquid Low-Level Waste Treatment line item consists of three subtasks:

- removing high gamma and TRU elements from REDC waste,
- constructing a centralized treatment facility for solidifying waste for disposal, and
- installing a trucking station for Building 2026.

This line item capital project was estimated to cost $9.5 Million.

4.1 ALTERNATIVE LLLW SYSTEM CAPITAL FUNDING CONSIDERATIONS

The option of using private-sector funding to construct and operate a facility to treat newly generated liquid low-level waste (LLLW) was also considered. The U.S. Department of Energy (DOE) Office of Environmental Management (EM) recently used this approach to award a fixed price unit rate treatment contract to treat the inventory of legacy LLLW and solid transuranic (TRU) waste. Foster Wheeler Environmental Corporation (FWENC) used private sector funds to construct the $75 Million hot cell facility and will receive payment of approximately $96 Million from DOE to treat 4,300 m^3 of waste over a six-year period. The average unit price for treatment of LLLW is \$12,000 per m^3 or \$11 Million per year. UT-B is expected to only generate 10 m^3 per year of this stream in the future. It does not appear that this would be a viable contracting option for newly generated waste since the hot cell facility's construction costs would be relatively insensitive to throughput rates. If source treatment of high gamma and TRU waste could be used to produce a waste stream that would require a significantly less expensive treatment facility, private sector funding may become a viable alternative. The viability of private sector funding should be assessed as the results from engineering evaluations for source treatment become available.

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APPENDIX D – GASEOUS WASTE SYSTEM

1. GASEOUS WASTE SYSTEM DESCRIPTION

This appendix covers major stack systems for gaseous waste at Oak Ridge National Laboratory (ORNL); it does not include minor gaseous sources. A major source is a source or activity that has the potential to emit radionuclides in sufficient quantity to cause a dose to the nearest resident of 0.1 millirem (mrem) per year or more. There are several local stacks at ORNL that typically serve a single facility. Building 2026 is served by stack 2026, and Buildings 7900, 7920, and 7930 in Melton Valley are served by stack 7911. Building 3019A, the Radiochemical Development Facility, which will be operated by a private sector contractor beginning in 2004, is served by local stack 3020. The 7503 Molten Salt Reactor Experiment (MSRE) stack supports remediation of the MSRE and is managed by Bechtel Jacobs Company LLC (BJC), the U.S. Department of Energy (DOE) Office of Environmental Management (EM) contractor at ORNL.

ORNL has one central stack system in Bethel Valley (stack 3039, also known as the Central Radioactive Gas Disposal Facility) that serves several facilities. The DOE Office of Science (SC)/UT-Battelle, LLC (UT-B)-managed facilities connected to the central gaseous system include the:

- Building 3025 cell ventilation,
- Building 3027 cell ventilation,
- Building 3047 cell ventilation and off-gas,
- Building 3525 cell ventilation,
- Building 4501 cell ventilation and off-gas,
- Building 4505 off-gas, and
- Building 4500 North off-gas.

1.1 THE CENTRAL GASEOUS WASTE COLLECTION SYSTEM SERVING STACK 3039

The central gaseous waste collection system is the oldest waste collection system at ORNL. This system has had the least amount of upgrades and repairs. The system was built in the 1950s, and much of the system has had little to no upgrades. There are 1,900 feet of concrete ducts, which are part of the central gaseous waste collection system. These ducts have not been upgraded since construction, and virtually all of the ductwork was contaminated during early days of operation when buildings operated with no local filtration.

Visual inspections performed in the 1980s indicated deterioration of most duct joints, tree roots growing into the piping, and groundwater/rainwater inleakage into contaminated ductwork. Readings of 50 milliroentgen per hour (mR/hr) were noted in the 3500-area ducts, and the 4500-area ductwork is contaminated with transuranic (TRU) materials. The assessment indicated that contaminated wastewater is likely leaking out of the ducts. The inspectors recommended structural integrity assessments and repairs to eliminate inleakage of the collection ducts, but neither have been performed[1, 2, 3 ,4]. This ductwork must be significantly upgraded if it is to be used in the future.

Inleakage into gaseous waste collection ducts produces both liquid low-level waste (LLLW) and process wastewater. These have not been totally quantified. The 3500 area gaseous duct system and 4500 area ducts collect inleakage that goes to the process waste system. When the 3500 area sump pump failed in January 1986, the duct filled with water and almost completely blocked the ventilation air flow. Average flow rate was estimated to be 2,000 gallons per day in the late 1980s during the above structural integrity projects. The inleakage into the 4500 ducts has increased substantially over the last several years, and is estimated to be 50,000 gallons to 100,000 gallons per rainfall event by the facility manager. It has become hard to maintain air flow requirements in Building 4501 during periods of heavy rain, and water has occasionally backed up into the Building 4501 basement. BJC estimates these total flows to be 5 to 10 gallons per minute (gpm). Inleakage into the 3019 filter pit results in 300 gallons per year (gal/yr) of LLLW contaminated with TRU materials.

1.2 CENTRAL GASEOUS WASTE TREATMENT SYSTEM (STACK 3039)

Stack 3039 consolidates emissions from numerous radionuclide sources at ORNL. These sources include:

- laboratory hoods,
- research and development activities,
- maintenance activities,
- ventilation from out-of-service reactors,
- other facilities planned for or currently being remediated, and
- potentially contaminated work areas.

Appropriate control devices, including high efficiency particulate air (HEPA) filters for particulate matter removal, are located at the source facility in most cases. After these local control devices, the exhaust gas is routed to Stack 3039. Exhaust gas consists of cell ventilation exhaust and process off-gas. In general, cell ventilation exhaust consists of large volumes of low pressure gas containing low levels of radiation, and process off-gas exhaust consists of small volumes of much higher pressure gas with higher radiation levels. The exhaust from the process off-gas is routed through HEPA filters prior to exhausting through stack 3039. As an additional control measure, the process off-gas is routed through a venturi scrubber. This scrubber was originally installed to reduce corrosion of downstream HEPA filters and off-gas fans. However, since the shutdown of all reactors associated with the process off-gas system and a decline in ORNL's isotopes program, the Tennessee Department of Environment and Conservation (TDEC) approved placing the scrubber in standby, but the scrubber is still active.

[1] *Evaluation Report Structural Integrity of Concrete Ducts 3500 Area of ORNL*, Report 87052, April 1988, Lee Wan & Associates.
[2] *Evaluation Report Methods of Upgrading Joints in Concrete Ducts 3500 Area of ORNL*, Report 87051, April 1988, Lee Wan & Associates.
[3] *Assessment Report Structural Integrity of Concrete Ducts ORNL*, Report 87033, July 1988, Lee Wan & Associates.
[4] *Evaluation Report Methods of Upgrading Joints in Concrete Ducts ORNL*, Report 87027, July 1988, Lee Wan & Associates.

The 3039 stack was originally built in 1950. The 3039 stack is a 76.2-meter-high (250 feet), unreinforced radial brick masonry chimney. It has an acid-proof lining utilizing a special acid-proof brick. The stack is supported on an octagonal reinforced concrete footing that is 50 feet in diameter. The footing was cast on bedrock with a varying thickness ranging from 11 to 17 feet. The fans and connecting ducts to the stack are located near the stack to minimize the length of ducts between the stack and the fans. Verbal communication with BJC employees indicate that recent structural integrity assessments indicated that "minor" repairs are needed, but the stack is structurally sound. However, the system will require major structural upgrades/replacements for continued operation over the next 50 years.

The 3039 stack off-gas and cell-ventilation facilities include various cell-ventilation, off-gas scrubber, air, water, electrical, and waste systems. The system components (e.g., ducts and fans) in the immediate vicinity of the stack that are exposed to the weather and/or corrosive gases are fabricated from stainless steel, typically 304-L.

The 3039 stack ventilation system consists of seven collection systems, each with its own underground and/or aboveground ducting, fans, and controls. Five of these collection systems are designed to handle the cell-ventilation waste streams from limited-access areas and hot cells. The other two systems are designed to handle the off-gas from process equipment and laboratory experiments.

Each collection system is provided with two fans for the air or off-gas transport through the system. The cell/off-gas fan is a direct-drive motor unit and is used as the normal operating unit for the system. The other fan, a steam turbine unit, is employed as a standby. However, each week for a 15-minute period, each electrically driven cell ventilation unit is shut down and the turbine unit put into service. In addition, the electrically driven off-gas unit is shut down and the turbine unit put into service each day for a 1 hour period. Each collection system (with the exception of the Building 3042 {Oak Ridge Research Reactor} collection system) is instrumented such that a loss of on-site electrical power will activate both the standby fan and a 750 kilowatt (kw) diesel engine backup generator. When the diesel generator reaches normal operating speed, the sequencing relays will automatically restart the electrically driven fans. The steam turbine-driven fans will then automatically reset to their standby condition when the negative pressure at the suction side of the fan returns to normal.

Extensive modifications and upgrades in 1984 increased its efficiency and reliability. This includes upgrades to the above ground piping in the general vicinity of the central stack. In 1997, several of the cell ventilation blowers and the off-gas primary blower and backup fan were replaced to increase the system's reliability. Also in early 1997, a new scrubber solution tank and associated transfer equipment was installed that met requirements of the Federal Facilities Agreement (FFA) for the LLLW system.

The systems environmental compliance is demonstrated through the use of a continuous emissions monitoring (CEM) system, installed in 1992. The CEM extracts a sample stream from the stack effluent. Gases are collected on charcoal and tritium is trapped on silica gel. These sample media are analyzed periodically for radionuclides.

1.3 STACK 2026 - LOCAL TREATMENT SYSTEM FOR BUILDING 2026

Stack 2026 serves Building 2026, also known as the Radioactive Materials Analytical Laboratory. Stack 2026 was built in 1984 and operates continuously with an exhaust flow rate of approximately 19,600 cubic feet per minute (cfm). The stack stands 75 feet above grade and has an inside diameter of 3.46 feet at the outlet. Normal operations use multiple HEPA filters to control particulate radionuclide emissions. Each HEPA filter system is tested and certified at least annually to be 99.95% efficient for controlling particulate matter. A continuous emissions monitoring (CEM) system[5] that monitors for radionuclides was installed in 1992 to verify compliance. In addition, a charcoal filter system (installed in 1985) is used when work activities involve more than 10 millicuries (mCi) of radioactive iodine. A real-time beta monitor assesses bed breakthrough which is defined as <99% iodine removal efficiency.

1.4 STACK 3020 - LOCAL TREATMENT SYSTEM FOR BUILDING 3019 COMPLEX

Stack 3020 serves the Building 3019 complex, the national repository for uranium-233. The stack was built in 1943 and is 200 feet high with an inside diameter at the outlet of 6.43 feet. Operation is continuous at an exhaust flow rate of approximately 43,000 cfm. Normal operations use multiple HEPA filters to control particulate radionuclide emissions. Each HEPA filter system is tested and certified at least annually to be 99.95% efficient for controlling particulate matter. A CEM system[5] that monitors for radionuclides was installed in 1992 to verify compliance. The CEM system extracts a sample stream from the stack effluent. Particulates are collected on filter paper and absorbable gases are collected on charcoal. These sample media are analyzed periodically for radionuclides.

1.5 STACK 7911 - LOCAL TREATMENT SYSTEM FOR THE 7900 AREA

Stack 7911 serves the High Flux Isotope Reactor (HFIR) located in Building 7900, and the Radiochemical Engineering Development Center (REDC), located in Buildings 7920 and 7930. Stack 7911 was constructed in 1965 and stands 250 feet above grade with an inside diameter of 11.25 feet at the outlet. Operation is continuous at a flow rate of approximately 58,600 cfm. The stack is equipped with a CEM system[5], installed in 1993, that provides continuous sampling for absorbable gaseous and particulate radionuclides. In addition, as part of the CEM system an in-line analyzer is used to detect the presence of non-absorbable, or noble, gases. Each facility has separate treatment systems designed for their particular needs as described below.

1.5.1 HFIR Gaseous Waste Treatment Systems

The HFIR has two air-handling systems in service that discharge to Stack 7911. The Hot Off-Gas (HOG) system collects gaseous effluents from various operations in process areas. The HOG system off-gas passes through multiple HEPA filters and charcoal absorbers prior to release through the stack. The Special Building Hot Exhaust (SBHE) system is the main building exhaust, but it is installed primarily as the engineered safety feature for accident mitigation. The SBHE system utilizes multiple filters and absorbers prior to exhausting through the stack.

1.5.2 REDC Gaseous Waste Treatment Systems

The REDC, Building 7920 collects vessel off-gas that is treated by an alkaline scrubber and several stages of HEPA filters. The spent scrubber solution is discharged to the LLLW system. When irradiated materials containing radioactive iodine are being processed, an iodine retention system is used as well. The iodine absorption solution is discharged to the LLLW system. The cell off-gas system in Building 7920 exhausts air through several stages of HEPA filters prior to discharge through the 7911 stack. The REDC, Building 7930 off-gas passes through multiple HEPA filters for removal of particulate radionuclides prior to discharge through the stack

[5] Sierra Instruments Sidetrack Flow Controller and Totalizer

2. GASEOUS WASTE SYSTEM INTERFACE DEFINITION

UT-B and BJC undertook an effort to define the central gaseous waste collection system boundary for the 3039 stack following the strontium release event at ORNL in June 2002. Following several meetings between UT-B and BJC to discuss the attributes of the gaseous waste system and mutual sharing of information, UT-B identified an isolation valve at each facility, which was proposed to BJC as the system boundary. At some facilities no isolation valve was identified, so a bolted flange or other system feature was identified as the proposed boundary.

The UT-B proposed boundary definition was transmitted to BJC for review and approval in June 2003. Subsequent to the transmission of the proposed boundary, knowledgeable individuals representing both companies walked down the proposed boundary and identified numerous minor changes. Two serious disagreements over specific boundary points emerged from this walk down.

The minor changes were subsequently discussed and the representatives of both UT-B and BJC agreed generally to establish the boundary point at the outside wall penetration of the gaseous duct work. Both UT-B and BJC agreed that the pipe, and all contamination in the pipe from the boundary point to the 3039 stack, belonged to BJC, and everything from the boundary point back into the facility was the responsibility of UT-B. The two serious disagreements involve the underground steel pipe that connects Building 3019 to the 3092 Scrubber, and the underground concrete duct work that connects the 4500 area to the 3106 filter housing.

The Building 3019 issue involves the gaseous waste stream from the vessels in Building 3019 that is neither filtered nor scrubbed at the facility. The first treatment point is the 3092 scrubber. BJC rejected the UT-B proposed boundary point of an above-ground flange near the outside wall penetration at the southeast corner of the building. BJC counter proposed that the first treatment point, i.e. the under-ground duct from the facility all the way down to the 3092 scrubber, should be the boundary. Further complicating the Building 3019 issue is the fact that the U.S. Department of Energy (DOE) is about to award a contract to remove the uranium from Building 3019. If UT-B were to accept responsibility for the under-ground duct and the incoming contractor refused to accept responsibility for it, then UT-B would be left with a contaminated duct that is not connected to a UT-B facility at either end. Nevertheless, UT-B is weighing the possibility of accepting responsibility for the duct as a means of being able to settle the matter when and if there is a new contractor for Building 3019 management and operations. The other alternative is to re-plumb the existing duct work to route the untreated waste stream through existing HEPA filters or build a new filter bank. In either case, BJC has tentatively agreed to accept responsibility for the underground duct when treatment is online at facility 3019.

The 4500 Area issue involves whether BJC or UT-B takes responsibility for the underground concrete duct that runs from the 4500 area to the 3106 filter house. Both companies have facilities in the 4500 area that are ventilated by this ductwork. This ductwork crosses beneath Fifth Street, turns north along the creek crossing beneath Central Avenue and passes by Building 3047 to the 3106 filter house.

At the writing of this document the gaseous system boundary has not been finalized between UT-B and BJC. However, the two companies have agreed that the system boundary will be included in the gaseous system waste acceptance criteria (WAC).

3. GASEOUS WASTE SYSTEM TREATMENT RE-ENGINEERING EVALUATIONS

ORNL stack sampling systems were designed to meet regulatory standards for a major source at the time of their installation. The new American National Standards Institute (ANSI) standard ANSI N13.1-1999 for major sources requires continuous stack monitors and verification that uniform sampling occurs. Existing stacks are presently exempt from the new uniform sampling certification requirements. If "major modifications" are made to a system, such as significantly changing the amount of radioactive material in the building, the existing stack would need to be upgraded to meet the new regulations. The central gaseous waste treatment system has been upgraded, but it is 50 years old. The two local stacks are 20 and 40 years old, respectively. These stacks will likely need significant upgrade or replacement to meet the new ANSI standards over the next several years.

3.1 CENTRAL GASEOUS WASTE TREATMENT SYSTEM

The central gaseous waste treatment system is oversized for ORNL's future research and development (R&D) missions. Currently, balancing the airflow in the system is tricky, and will become more difficult as BJC remediates buildings and UT-B hot cell consolidation occurs. Approximately half of the capacity of the system is being used at the present time. In the future, this is expected to drop to less than 30%. The gaseous waste treatment system should be replaced with a system that is tailored to meet ORNL's future flow requirements and treatment needs.

Order-of-magnitude feasibility studies for replacing the existing central gaseous waste system were performed. Two alternatives were evaluated for the buildings on the central gaseous waste treatment system:

- replacement of the existing central system with individual local stacks and
- replacement of the existing central system with a new central system.

Both options are depicted in Figure D-1. The costs for the two alternatives are given in Section 4 of this appendix. They indicate that 4 to 5 local treatment facilities could be built for the costs of replacing the central system. Preliminary hot cell planning activities indicate that it may be less expensive and technically favorable to replace the centralized gaseous waste system with local building stacks.

Additional detailed technical assessments will needed after decisions on hot cell consolidation activities are completed to determine how many facilities actually need gaseous waste treatment in the future. Needed technical assessments for the buildings currently on the existing central gaseous waste system include:

- evaluating whether buildings are generating waste that fall into the regulatory categories of major or minor sources,
- determining the waste treatment requirements beyond HEPA and charcoal filtration (such as off-gas scrubbers),
- determining if new programmatic (such as the Plutonium-238 project at the REDC and new radiochemical processing at Building 3019) or hot cell consolation activities will trigger modification requirements in the ANSI standards, and
- evaluating the total life cycle costs, including D&D costs, for modifying the existing system compared to replacing the system with a new central system or local building systems.

Evaluations of the upgrades required for long-term operation of stacks 7911 and 2026 are also required.

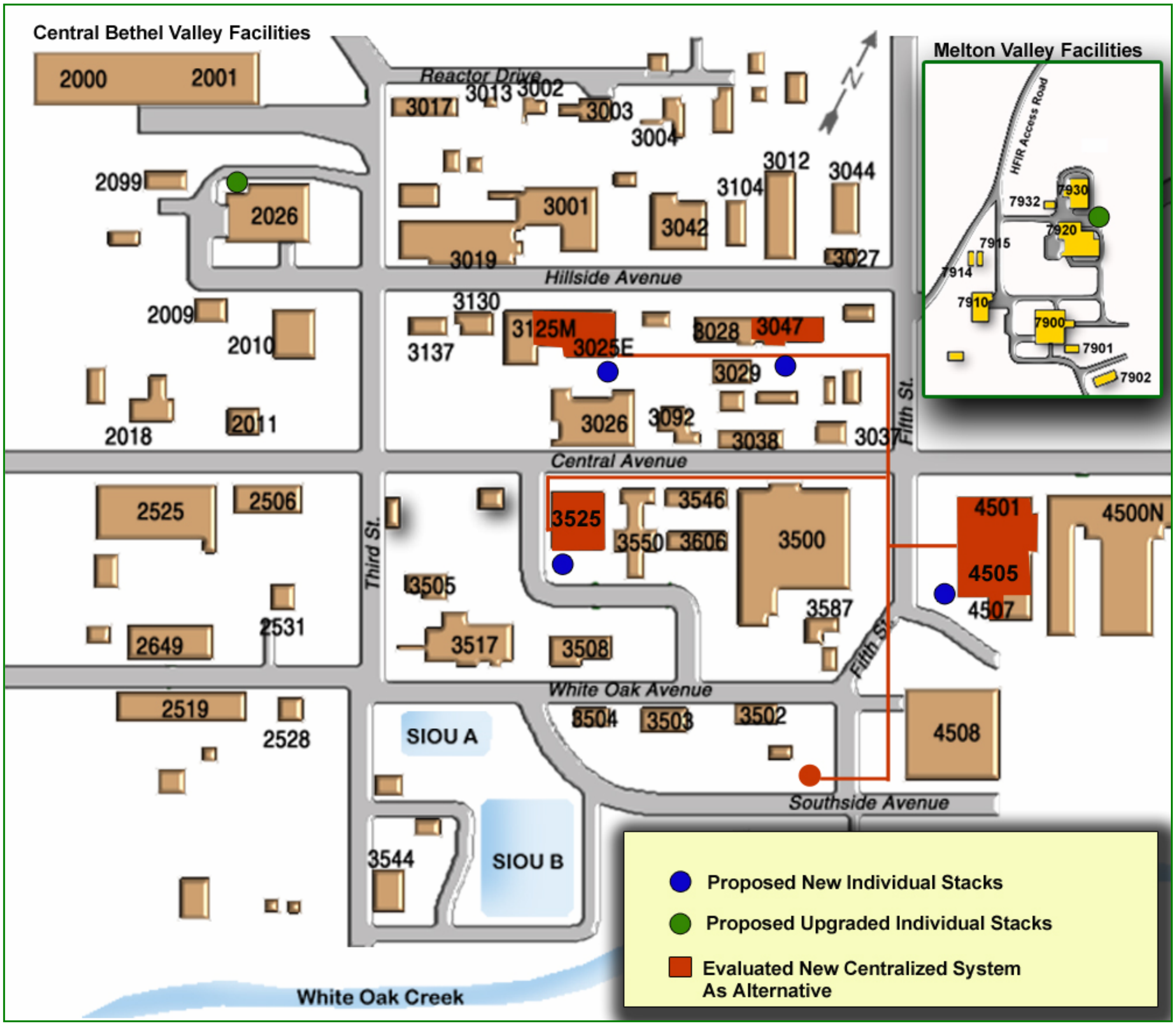

Figure D-1. Location of proposed future gaseous waste systems.

4. PROPOSED SCOPES AND COST ESTIMATES FOR GASEOUS WASTE SYSTEM PROJECTS

Conceptual level engineering cost estimates were obtained for the following two alternatives for upgrading the gaseous waste system. They were used in defining the gaseous waste system capital project listed in Chapter 7 of the *ORNL Liquid and Gaseous Waste Treatment System Strategic Plan*.

4.1 SCOPE AND COST ESTIMATES FOR REPLACING THE EXISTING CENTRAL GASEOUS WASTE SYSTEM WITH LOCAL BUILDING STACKS

The scope of this study was to examine the feasibility of providing individual site treatment, monitoring, and stack systems for the Building 3047 cell and process off-gas ventilation; Building 3025E cell ventilation; Building 3525 cell ventilation; Building 4501 cell and process off-gas ventilation; Building 4505 cell and process off-gas ventilation; and Building 4500 North process off-gas ventilation, and disconnecting these facilities from the central 3039 Stack Ventilation System. A summary of the cost estimates are given in Table D-1. Costs were included for optional scrubbers, fire protection, and back up power since the needs for these operations will be determined by the future long-term mission of the facilities. The cost estimates include a 40% contingency factor.

The following sections describe the minimum or base cost presented in the Table D-1 cost estimate summary, plus the costs for optional add-ons for each system. Detailed information on exhaust stream constituents and clean up requirements was not available during the study. Due to these uncertainties, costs are provided for options, including the installation of a new process off-gas system with scrubber, high efficiency particulate air (HEPA) filter fire protection, and backup power for the exhaust system. Discussions with operations personnel concluded that current operations do not require a scrubber in the cell or hood exhaust system. Consideration of future research programs may need to be factored into the final definition of exhaust system requirements.

Table D-1. Order-of-magnitude cost estimates for building local stacks.

Facility	Building 3525	Building 3025E	Building 3047	Buildings 4501, 4505, and 4500 North
Base Cost	$ 3,815,250	$ 3,952,576	$ 4,792,211	$ 6,327,700
Options				
Cell Ventilation Scrubbers	$ 592,961	NA	$ 435,699	NA
Process Off-Gas Scrubbers	NA	$ 636,728	$ 908,869	$ 898,800
Fire Protection	$ 58,144	$ 75,962	$ 51,419	$ 167,600
Back Up Power	$ 161,458	$ 159,292	$ 117,596	$ 254,700
Grand Total	**$ 4,627,813**	**$ 4,824,558**	**$ 6,305,794**	**$ 7,648,800**

4.1.1 Proposed Local Stack Serving Building 3047

New process off-gas and cell exhaust systems were designed for Building 3047. The proposed new systems would be located south of the Building in the area near existing temporary waste storage shelters. A schematic layout is shown on Figure D-2. Existing concrete pads will be removed and underground utilities will be relocated to allow for the construction of the new equipment pads. The filtration systems will be located within concrete shield walls to minimize personnel exposure.

The baseline cost estimate for the process off-gas system, with a capacity of 600 cubic feet per minute (cfm) includes the following components: demister (1), electric heating coil (1), carbon/HEPA filter trains (2) and turbo-compressor exhausters (2). A spare exhauster and filter train is provided. Backup power was provided as an option to maintain operation during power outages. Costs for a primary and backup scrubber and fire protection were also estimated as options. Exhaust ducts, piping, scrubbers, and the stack are constructed of 304L stainless steel. Since the process off-gas system operates at significantly higher negative pressure than the cell exhaust system, it is not feasible to combine the process off-gas system with the cell exhaust system.

The cell exhaust system, with a capacity of 6,000 cfm consists of the following components: demister (1), electric heating coil (1), carbon/HEPA filter trains (2), and exhaust fans (2). Spare carbon/HEPA filter trains and fans are provided. Exhaust ducts, piping, filter housings and optional scrubber are constructed of 304L stainless steel. Backup power is provided as an option to maintain operation during power outages. The cell exhaust system and process off-gas exhaust to a common stack. Particulate and tritium single point shrouded gas stack sampling probes are located in the stack as recommended by American National Standards Institute standard, ANSI N13.1 – 1999. Continuous sampling is utilized with periodic lab analysis of extracted effluent used to determine emissions.

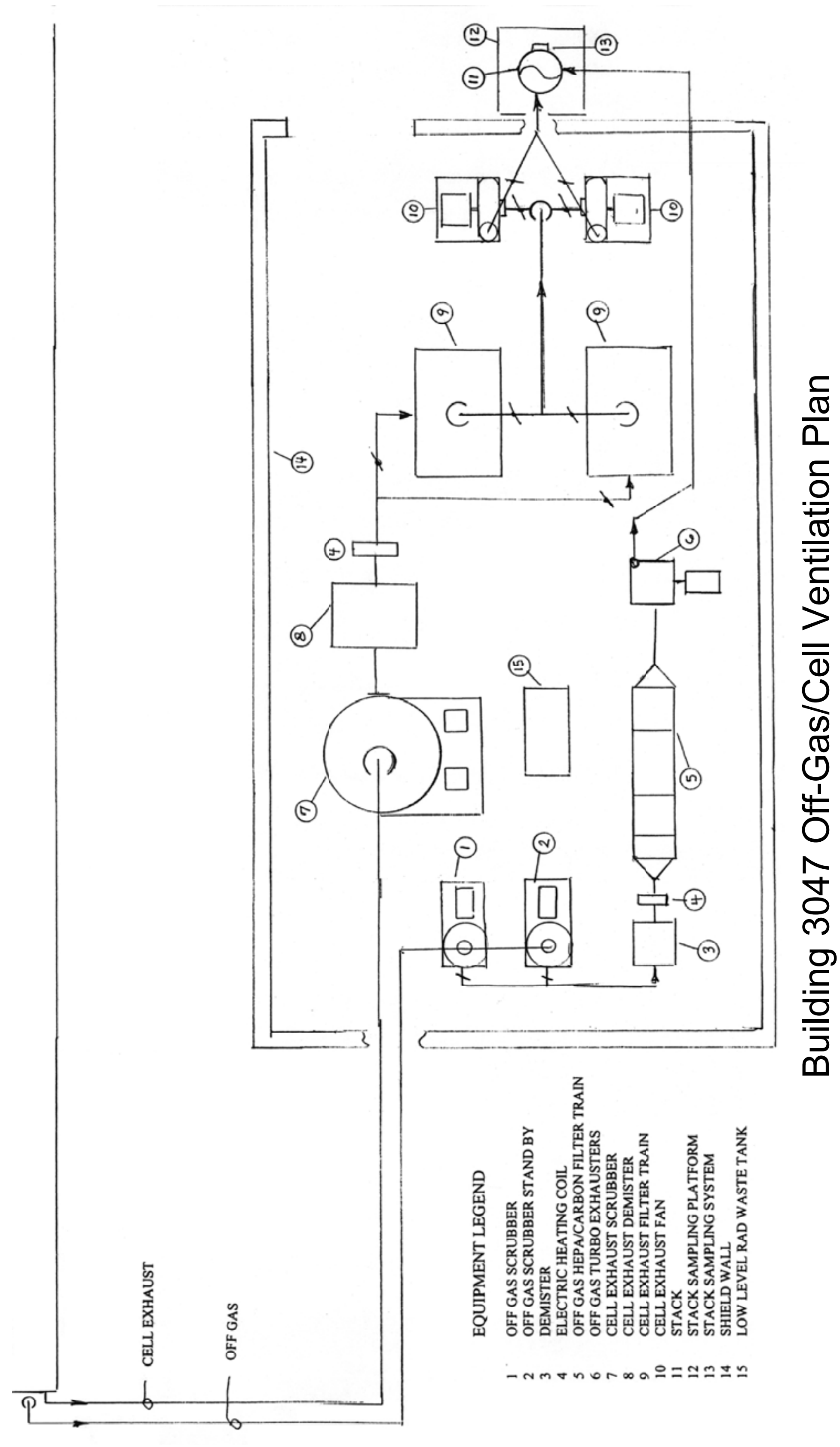

Figure D-2. Schematic of the proposed Building 3047 Off-Gas/Cell Ventilation Plan.

4.1.2 Proposed Local Stack Serving Building 3025E

Two new exhaust systems were designed for Building 3025E. A scrubber/filtered system and a filtered-only cell exhaust system are located between the southeast corner of the Building and the parking lot as shown on Figure D-3. Above ground and underground utilities will be relocated to allow for construction of the new equipment pads. The filtration systems are located within concrete shield walls to minimize personnel exposure.

The scrubber/filtered system, with a 1,000 cfm capacity, will consist of the following components: optional scrubber (1), demister (1), LLW storage tank (1) for optional scrubber, electric heating coil (1), carbon/HEPA filter trains (2), and high pressure exhaust fans (2). A spare filter train and fan is provided. Exhaust ducts, piping, scrubber, and filter housing are constructed of 304L stainless steel. Backup power was provided as an option to maintain operation during power outages. The optional scrubber/filtered system is provided to treat small quantities of process exhaust requiring radioactive gas removal. The addition of a low-flow scrubber system eliminates the need for a scrubber in the larger cell exhaust system.

The filtered-only cell exhaust system, with a capacity of 10,000 cfm consists of the following components: carbon/HEPA filter trains (2), exhaust fans (2), and stack (1). A spare fan and filter train is provided. The filter trains will be located within concrete shield walls to minimize personnel exposure. Exhaust ducts, filter housings and the stack will be constructed of 304L stainless steel. Backup power was provided as an option for maintaining operation during power outages. The scrubber/filtered system and filtered-only system will exhaust to a common stack. Particulate stack sampling probes will be located in the stack. A single point shrouded particulate sampling probe will be located in the stack as recommended by ANSI N13.1-1999. Continuous sampling is utilized with periodic lab analysis of extracted effluent used to determine emissions.

4.1.3 Proposed Local Stack Serving Building 3525

A new cell exhaust system with a capacity of 6,000 cfm, as shown in Figure D-4, was designed for Building 3525. It will be located between the southwest corner of the Building and Fourth Street. Underground utilities and a utility pole will be relocated to allow for construction of the new equipment pads. The filtration system will be located within concrete shield walls to minimize personnel exposure.

The cell exhaust system consists of the following components: optional scrubber (1), optional LLW storage tank (1), demister (1), electric heating coils (1), carbon/HEPA filter trains (2), high pressure exhaust fans (2), and stack (1). A spare fan and filter train are provided. The exhaust ducts, piping, optional scrubber, filter housings and the stack will be constructed of 304L stainless steel. Backup power is provided as an option to maintain operation during power outages. A single point shrouded particulate sampling probe is located in the stack as recommended by ANSI N13.1-1999. Continuous sampling is utilized with periodic lab analysis of extracted effluent used to determine emissions.

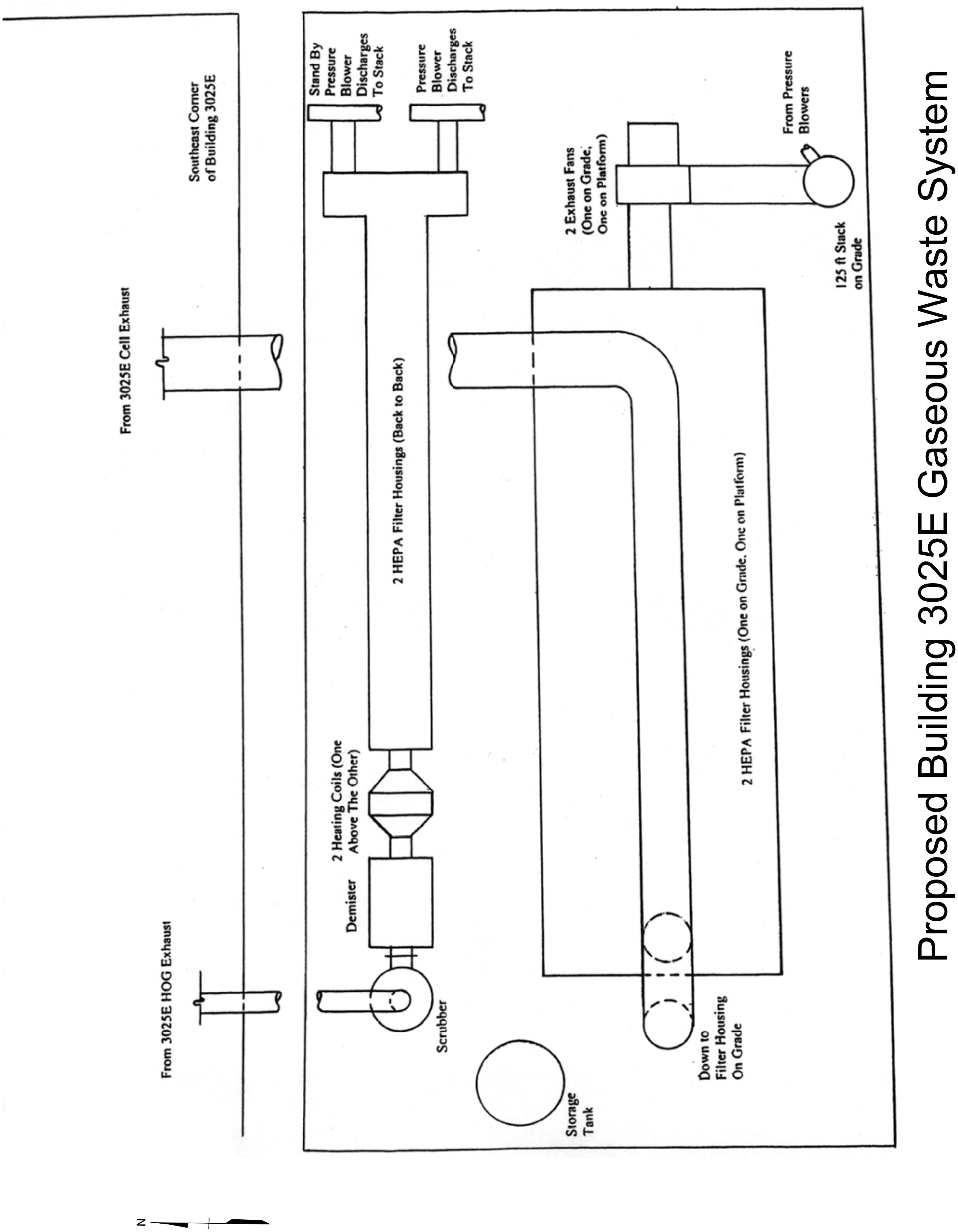

Figure D-3. Schematic of the proposed Building 3025E gaseous waste system.

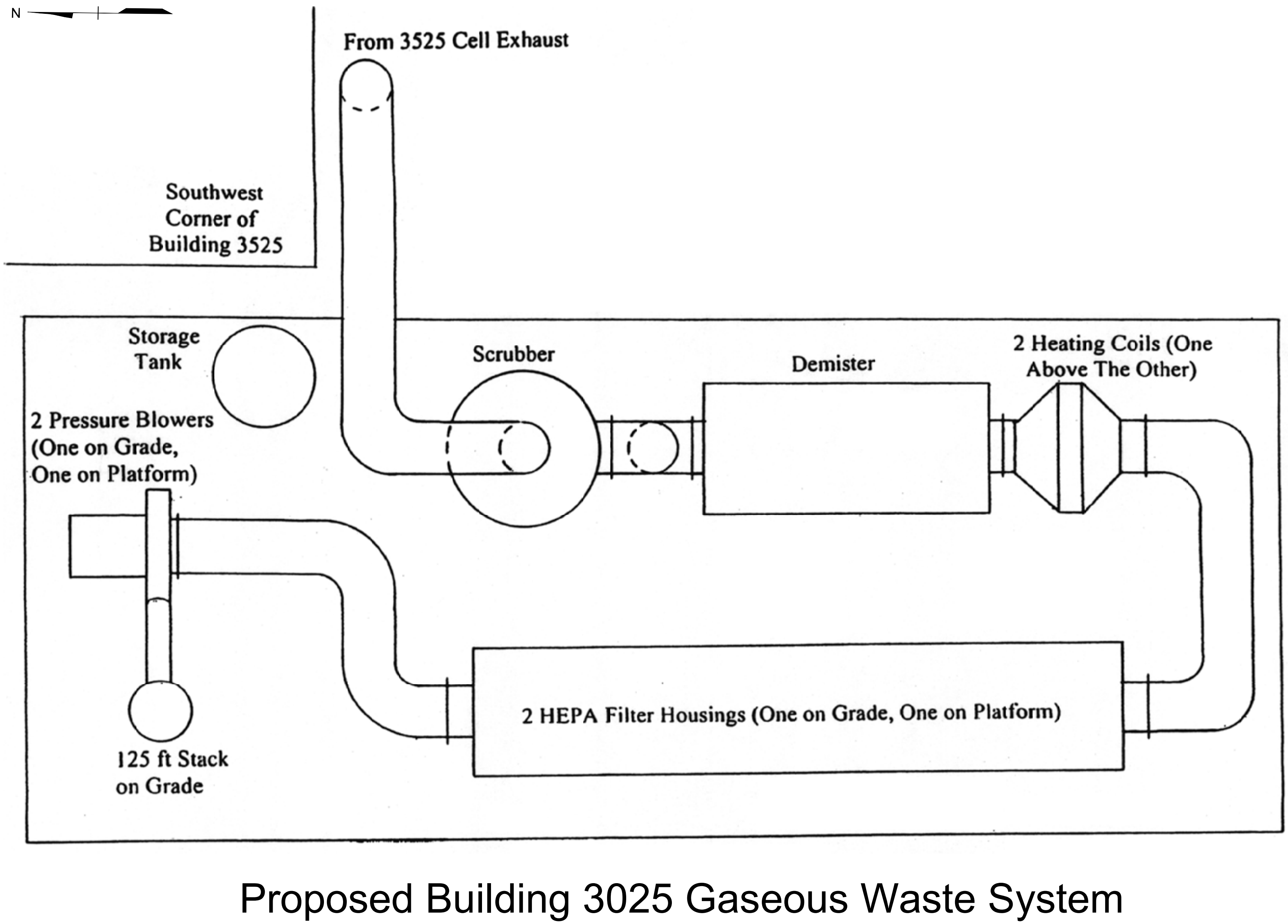

Figure D-4. Schematic of the proposed Building 3025 gaseous waste system.

4.1.4 Proposed Local System Serving Building 4500 North

The 3039 process off-gas system is connected to various wings in Building 4500 North. The process off-gas piping is routed through the underground cell exhaust to the 3039 process off-gas system. During the duration of the study, no users of the process off-gas system were identified. The ORNL Facilities and Operations Directorate indicated that at this time there is no current or anticipated need for off-gas ventilation in Building 4500 North. Therefore, a new HEPA filtered exhaust system was designed for Building 4500 North, Wings 1 and 2 and possibly Wings 3 and 4. The process off-gas drawings that exist were inconclusive as to whether Wings 3 and 4 are presently on the central system. The proposed new exhaust system will connect to the existing process off-gas piping. The existing process off-gas piping will be disconnected from the 3039 process off-gas system. The proposed HEPA exhaust system will be located on the roof of 4500 North. New exhaust duct will be routed from the process off-gas tie-in to the roof mounted HEPA filter system. The HEPA filtered exhaust system has a maximum capacity of 1,000 cfm, and consists of the following components: HEPA filter train with one prefilter and one HEPA filter (2), and exhaust fans (2). A spare exhauster, and filter train is provided. Exhaust ducts and piping are constructed of 304L stainless steel. Backup power is provided as an option to maintain operation during power outages.

4.1.5 Proposed Local Stack Serving Buildings 4501 & 4505

Typical radioactive materials presently in the exhaust stream for Building 4501 are cesium-137 (^{137}Cs), strontium-90 (^{90}Sr), uranium-233 (^{233}U), uranium-235 (^{235}U), and uranium-238 (^{238}U); all in particulate form. Due to high levels of particulates in the hot cells of Building 4501, a negative pressure is required at all times. The existing hot cell HEPA filters are located in the basement. These hot cell filters are hydrogen floride resistant. Radiation levels in the hood exhaust ductwork are in the 1-rad range. Direct contact is limited to a few minutes. A total of 20 hoods are connected to the central hot cell exhaust system (i.e., the 3039 stack). There are no HEPA filters in the hood exhaust prior to entering the 3039-stack system.

Building 4505 hot cells are served by two exhaust systems. The 3039 stack system serves basement hot cells 1A, 1B, 2, 3, 4A and 4B; first floor hot cells 4A; and second floor hot cells 4A and 4B. Approximately 5,500 cfm is exhausted via the 3039 Stack Cell Ventilation System. A local cell exhaust system located on the third floor, that has a 18,000 cfm filter flow capacity, exhausts approximately 14,000 cfm from basement hot cells 1A and 1B; first floor hot cells 1A, 1B, 2, 3, 4A and 4B; and second floor hot cells 1A, 1B, 2, 3, 4A and 4B. Upgrade of this local cell exhaust system was not included in the study since it is not connected to the 3039 stack.

A new exhaust system was designed to serve both Buildings 4501 and 4505. The proposed system serves the:

- Building 4501 hot cells with a capacity of 5,000 cfm,
- Building 4501 hoods at a capacity of 13,500 cfm,
- Building 4505 hot cells with a capacity of 5,500 cfm, and
- the process off-gas system from both Buildings 4501 and 4505, which is served by a single system.

The new HEPA filter trains would be located in the basement of Building 4501 in an area that is currently used as storage (see Figure D-5). The area is adjacent to the existing underground cell exhaust duct. The fans will be located on the first floor directly above the filter housings in area that is currently unoccupied. The base of stack is located on the first floor and is supported by the building steel.

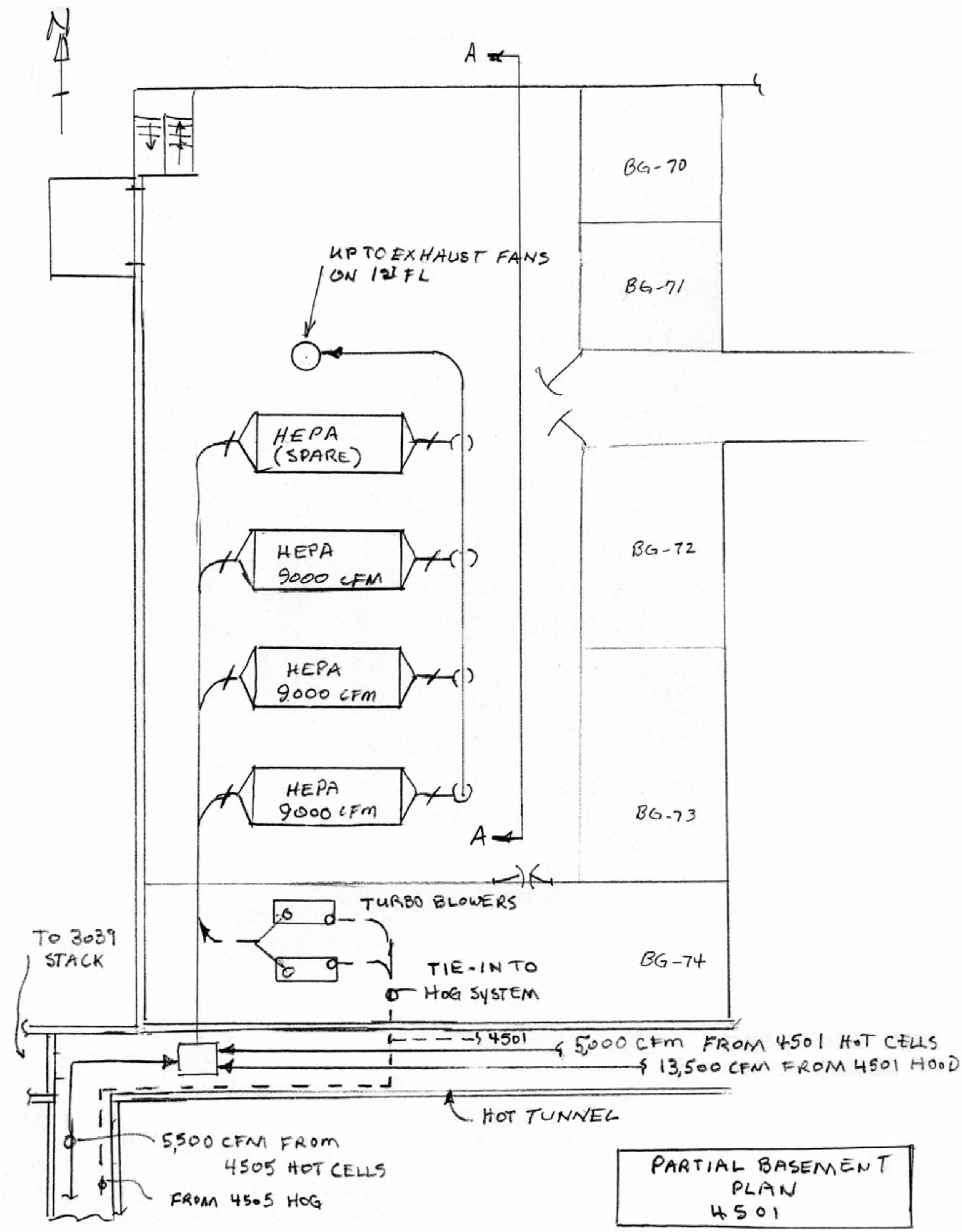

Figure D-5. Schematic of the proposed filter trains in Building 4501. Not to scale.

The proposed exhaust system contains 27 active HEPA filters having a maximum capacity of 27,000 cfm, and consists of the following components: HEPA filter trains (4)(3 active and 1 spare), and exhaust fans (2). The exhaust system consists of three 9,000 cfm capacity filter trains with one spare train to allow filter changes without affecting operations. A spare fan is provided. Exhaust ducts, piping, and filter housings and the stack are constructed of 304L stainless steel. A schematic layout is shown on Figure G-6. Back up power is provided as an option to maintain operation during power outages. The existing process off-gas system will exhaust through the new cell/hood exhaust system to a new stack. Particulate and single point shrouded gas stack sampling probes are located in the stack as recommended by ANSI N13.1 – 1999. Continuous sampling is utilized with periodic lab analysis of extracted effluent used to determine emissions.

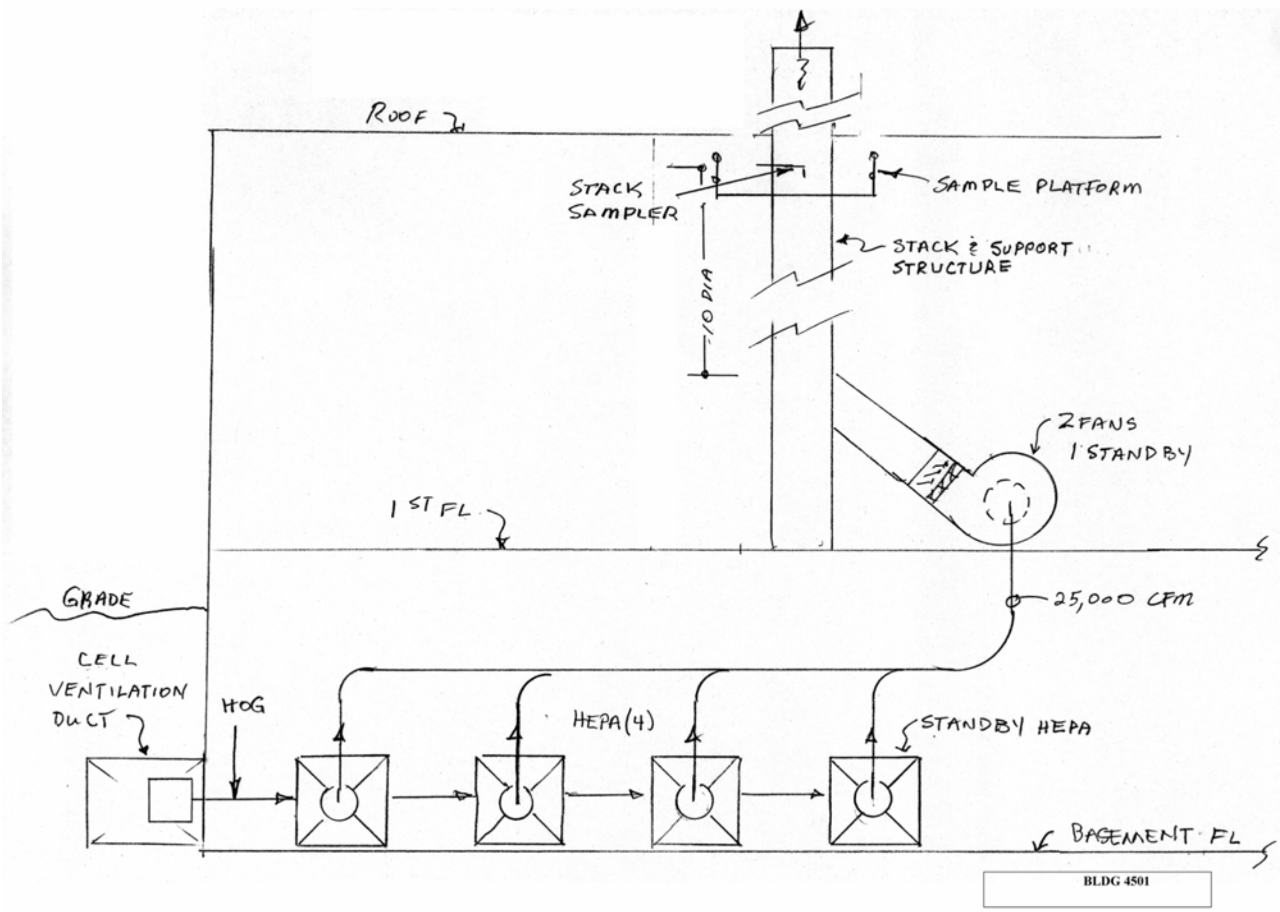

Figure D-6. Schematic of the proposed exhaust system for Buildings 4501 and 4505. Not to scale.

4.1.6 General Comments on Cost Estimates For Replacing The Existing Central Gaseous Waste System With Local Building Stacks

- Determination of exhaust gas treatment techniques was not within the scope of this study. Information regarding the current exhaust system flows and constituents was limited during this phase of the study. Due to the time constraints for the completion of the study, treatment methods and flows were conservatively estimated using engineering judgment.
- It is necessary to assume treatment schemes in order to evaluate the feasibility and to develop project costs. Due to a reduction in stack discharge height from 250 feet to 125 feet, and the uncertainty of the sources of tritium, it was assumed that scrubbers may be required to remove radioactive gasses to achieve as-low-as-reasonably-achievable (ALARA) objectives. The Tennessee Department of Environment and Conservation (TDEC) has recently limited permitted discharges of tritium to 10 curies per year for some private radiological licensed sites. Scrubbers may not be the optimum treatment of choice, but are included in this estimate as an allocation of cost in the event tritium removal is necessary.
- Determinations of shielding requirements were also not within the scope of this study. However, shielding was assumed to be required for all new filtration trains. Complete as-built drawings were not available for the systems contained in this study.
- For cost estimates, it was assumed that all excavated material will be radiologically contaminated, will require sampling and storage in approved containers, and the containers to be stored in newly constructed waste storage areas. It was further assumed that all construction equipment used for excavation will be contaminated and disposed of with costs incurred by the project.
- Stack plume modeling and dose determination were also not included in the scope of this study. A stack height of 125 feet was chosen for estimating costs for new stacks. The sources of the various constituents exhausted from the 3039 stack have not been identified at this time. The 3039 stack emissions are assumed to originate uniformly from connected buildings for the purpose of identifying potential treatment requirements. Since the radioactive gasses currently exhausted at 250 feet may be a problem at shorter stack heights, carbon absorbers and scrubbers were included in the cost estimates for each system.
- Continuous stack sampling and monitoring are required by *Title 40 Code of Federal Regulations, Part 61 (40 CFR 61), subpart G* for all exhaust points with a potential of releasing 1% of the effective dose (10 millirem per year to the public) without taking credit for emission control devices. Since individual building exhaust emissions are not identified, particulate and tritium gas sampling systems are included in the estimates for each stack.
- The waste treatment systems required are conservatively estimated in this report. Cost reductions may be achieved as a result of additional investigations including:
  - Determining additional detailed information regarding the nature of exhaust effluent from individual buildings and or sources.
  - Modeling of effluent discharges using AIRDOS-PC or CAP-88 may justify stack heights of less than 125 feet as used in this report.
  - Obtaining better understanding of ORNL's permit with the State of Tennessee, which may affect the need for monitoring each stack.
  - Walking down the involved ventilation systems, developing as-built ventilation flow diagrams and determining existing exhaust flows will result in more accurately establishing equipment sizes and improve the accuracy of cost estimates.

- If contaminant sources can be isolated to specific processes, "point of source" treatment may be less costly than treatment of larger exhaust streams where a number of sources are combined.

Facility personnel's review of the cost estimate information included comments that should be addressed during more detailed planning of the projects, such as:

- The tie-in point for the hot off-gas system for Building 3047, shown in Figure D-2, is actually downstream of the existing filter pit. Both the Building 3028 and Building 3047 process off-gas systems combine into a single exhaust path in this filter pit. A better tie-in point may be in Room 110 before the cell off-gas system penetrates the floor slab since this would provide complete isolation of the 3047 system from the 3028 system.
- The tie-in point for the cell ventilation system for Building 3047, shown in Figure D-2, is actually downstream of the existing filter housing. If the existing filter house is to be removed, a better tie-in point may be where the underground ductwork extends above the floor slab inside the facility.
- The LLLW storage tank for Building 3047, shown in Figure D-2, is located in the midst of the new exhaust system. May need to consider relocating the tank to an outer wall position to facilitate pumping activity.
- The size of the gaseous waste system designed for Building 4501 and 4505 should be reduced.

4.2 COST ESTIMATES AND SCOPE FOR REPLACEMENT OF THE CENTRAL GASEOUS WASTE SYSTEM WITH A NEW CENTRAL GASEOUS WASTE SYSTEM

A new central gaseous waste system to replace the existing central gaseous waste system was evaluated. The new system would serve Buildings 3047, 3025E, 3525, 4501 and 4505. Local process off-gas systems would serve Buildings 3047, 4501, and 4505. New HEPA filters will be added at each building to minimize accumulation of rad material in the stack system ductwork. The new ductwork would be located above ground on supports 15 feet high to avoid interference with personnel and vehicular traffic. The ductwork and supports are stainless steel. A natural gas-fired generator is provided for emergency power. The stack, generator and fans are assumed to be within 350 feet of the intersection of Fifth Street and Central Ave. The stack is of lined steel construction. The breakdown of the costs between building a new stack, installing new piping from the stack to the buildings, and upgrades at the individual building sites is given in Table D-2.

Table D-2. Cost estimate for replacement of the central gaseous system.

New System Components	Base Cost	Optional Fire Protection	Total
Stack	$3,735,011	NA	$3,735,011
Ductwork and Supports	$1,766,289	NA	$1,766,289
Buildings 4501, 4505, and 4500 Modifications	$6,289,300	$167,600	$6,456,900
Buildings 3525 Modifications	$2,238,190	$58,144	$2,296,334
Buildings 3025E Modifications	$2,333,540	$75,962	$2,409,502
Buildings 3047 Modifications	$5,970,693	$51,419	$6,022,112
TOTAL	**$22,333,023**	**$353,125**	**$22,686,148**

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APPENDIX E – FUTURE NEW WASTE GENERATORS AT OAK RIDGE NATIONAL LABORATORY

1. SPALLATION NEUTRON SOURCE

The Spallation Neutron Source (SNS) is an accelerator-based, next-generation, neutron scattering facility under construction at Oak Ridge National Laboratory (ORNL). It is expected to begin operations in 2007. The SNS will be the largest new source of liquid low-level waste (LLLW) and radioactive process wastewater for at least the next ten years. Preliminary estimates have been made for the volumes and categories of wastes that will be generated. The SNS is expected to generate[1] an average of:

- 1.4 million gallons per year (mgy) of process wastewater,
- 91,000 gal/yr of LLLW, and
- a maximum of 16 mgy of cooling water for discharge to White Oak Creek via the storm drain system.

The main source of radionuclides is from the activation of the metals in the recirculating cooling water loops. Blow down from these primary loops is expected to be LLLW, while blow down from secondary cooling water loops that do not directly contact activated metals, is assumed to be process wastewater. Leaks inside of secondary heat exchangers could allow small amounts of the primary cooling water to enter the secondary cooling loops. The concentrations of radionuclides in four high-activity, low-volume streams has been calculated, based on estimated radionuclide concentrations in the metals and leaching rates. The concentrations in the remaining LLLW streams have not yet been estimated by SNS personnel. For planning purposes, it was assumed that the LLLW discharged from SNS contains 10% of the average radionuclide concentration in the four streams that have been evaluated. Table E-1 shows the estimated concentrations and yearly amounts for the most significant radionuclides (based on concentration and half-life) in the LLLW.

It was assumed that the process wastewater contains the same mix of radionuclides that are present in the LLLW, but at much lower concentrations. The waste acceptance criteria (WAC) for Building 3544 of the ORNL Process Waste Treatment Complex (PWTC), which treats radiological process wastewater, is the derived concentration guide (DCG) values in DOE 5400.5 for all of the radionuclides listed in Table E-1. A variance to discharge higher concentrations would be possible, since most of these radionuclides, except for tritium (^{3}H), would be removed during treatment at the PWTC.

Table E-1. Estimated radionuclides in LLLW from the SNS.

Isotope	Half-Life	Concentration (µCi/L)	Amount (Ci/y)
^{3}H	12 years	917	319
^{7}Be	53 days	1110	386
^{26}Al	710,000 years	5	1.8
^{51}Cr	28 days	1136	396
^{55}Fe	3 years	78	27
^{54}Mn	312 days	3	1.0
^{56}Co	77 days	5	1.9
^{57}Co	272 days	4	1.4
^{58}Co	71 days	9	3.2
^{60}Co	5 years	0.4	0.1
^{63}Ni	100 years	4	1.5
^{64}Cu	13 hours	7194	2504

[1] *Spallation Neutron Source Preliminary Waste Management Plan*, SNS 102030000-TR0002-R01, Steve Trotter and Joe DeVore, June 2002, and source term data from regulatory permitting and safety analysis documents.

Table E-2 shows an estimate of the maximum radionuclide concentrations in process wastewater from the SNS. These values were calculated by assuming that a variance was granted for ten times the DCG value of copper-64 (^{64}Cu), which is the most limiting radionuclide, and that the relative concentrations of the other radionuclides were the same as for the LLLW. All of the other radionuclides are below the DCG value and would not need a variance. Most of the process wastewater discharged from SNS should have much lower concentrations of radionuclides than what is shown in Table E-2. The *SNS Waste Management Plan* will be revised in the summer of 2004. The revised data should be incorporated into future liquid and gaseous waste management activities.

Table E-2. Estimated maximum radionuclide concentrations in process wastewater from the SNS and DCG values.

Isotope	Concentration (Bq/L)	DCG Value (Bq/L)
^{3}H	14,100	74,000
^{7}Be	17,100	37,000
^{26}Al	78	370
^{51}Cr	17,500	37,000
^{55}Fe	1200	7400
^{54}Mn	42	1850
^{56}Co	84	370
^{57}Co	61	3700
^{58}Co	141	1850
^{60}Co	6	185
^{63}Ni	66	11,100
^{64}Cu	110,900	11,100

2. RADIOCHEMICAL DEVELOPMENT FACILITY (BUILDING 3019A)

Current activities at the Radiochemical Development Facility (Building 3019A) involve storage of uranium-233 (^{233}U), which generates a minimal amount of waste. The U.S. Department of Energy (DOE) Office of Nuclear Energy, Science and Technology (NE) is seeking a private sector contractor to process ORNL's inventory of ^{233}U to extract thorium-299 (^{299}Th) to produce actinium-255 (^{225}Ac) and bismuth-213 (^{213}Bi) for medical applications. This will involve chemical processing activities comparable to those currently performed at the Radiochemical Engineering Development Center (REDC) (the largest current generator of LLLW contaminants at ORNL), and has the potential to generate significant amounts of LLLW from FY06 through FY14. Actual waste generation rates will not be available until the contract has been awarded. This data should be incorporated into future liquid and gaseous waste management planning activities.

3. CENTER FOR NANOPHASE MATERIALS SCIENCES

The Center for Nanophase Materials Sciences (CNMS) will be a national facility for advancing the understanding of nanoscale phenomena in materials. This will include interdisciplinary research areas that benefit from access to neutron scattering, including soft materials, interfaces, nanoscale magnetism, and other nanophase systems. The CNMS is expected to begin operations in 2006. The facility is expected to generate approximately 1,000 gallons per day of process wastewater that will contain trace quantities of solvents, neutralized acids and bases, and developer solutions, such as tetramethyl ammonium hydroxide.

4. LABORATORY FOR COMPARATIVE AND FUNCTIONAL GENOMICS

The Laboratory for Comparative and Functional Genomics (LCFG) will house the Mouse Genetics Research Facility, which will be moving from the Y-12 National Security Complex to the West End of the main ORNL complex. Construction is scheduled for completion in August 2003. The facility will generate sanitary waste and will only be connected to the ORNL sanitary/sewage system.

5. OTHER NEW FACILITIES

New ORNL facilities expected to generate additional sanitary waste, include the

- Joint Institute for Neutron Sciences (JINS),
- Joint Institute for Biological Sciences (JIBS),
- Computational Sciences Building,
- Engineering Technology Facility,
- Research Office Building,
- Joint Institute for Computational Sciences and Oak Ridge Center for Advanced Studies (JICS/ORCAS), and
- Energy Reliability and Efficiency Laboratory.

New facilities and facility modifications not expected to add new waste to the liquid and gaseous waste system include the:

- Advanced Materials Characterization Laboratory (AMCL),
- HFIR Maintenance Building,
- Small-Angle Neutron Scattering (SANS) Guide Hall,
- modifications to Buildings 1059 and 1503,
- Center Campus Research Building,
- Laboratory Expansion for Nanoscience Metrology and Instrumentation, and
- Building 4500 North and South renovations.

The Center for Systems Biology and Proteomics and Protein Complex Analysis Laboratory have not been included in waste management planning estimates due to their preliminary stage of development, but they are expected to generate additional sanitary waste.

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APPENDIX F - OPERATING COST ESTIMATES

The annual operating costs for the existing and future waste treatment systems were estimated in Chapter 7, Table 7-2 of the *Oak Ridge National Laboratory (ORNL) Liquid & Gaseous Waste Treatment System (LGWTS) Strategic Plan*. The methodology for estimating facility operating costs is summarized below.

1. CURRENT OPERATING COSTS

1.1 ESTIMATED OPERATING COSTS FOR EXISTING FACILITIES

The costs for operating existing waste treatment systems are summarized in Table F-1. These include the cost for operating the collection systems and treatment facilities and disposing of secondary solid waste. The costs are presently borne by the U.S. Department of Energy (DOE) Office of Science (SC) or Office of Environmental Management (EM) contractors identified below.

- UT-Battelle, LLC (UT-B), the DOE-SC management and operating (M&O) contractor, is responsible for the sanitary/sewage waste system.
- Bechtel Jacobs Company LLC (BJC), the DOE-EM management and integrating (M&I) contractor is responsible for the
    - gaseous waste system,
    - process waste system, and
    - liquid low-level waste (LLLW) collection and storage system.

The annual operating costs for the UT-B and BJC managed facilities were obtained from the facility managers. For evaluation purposes the portion of these costs that could be attributed to DOE-SC/UT-B were calculated based on current waste volume contributions.

Table F-1. Estimated annual operating costs for existing waste treatment facilities.

Existing Waste System	Responsible DOE Contractor	Annual Operating Costs[1] ($ Million)	DOE-SC/UT-B Contribution[2] ($ Million)
Gaseous Waste	BJC	1.6	1.0
Process Waste	BJC	11.0	7.0
Liquid Low-Level Waste Collection/Storage	BJC	4.8	0.5
Sanitary/Sewage Waste	UT-B	0.5	0.5
	Total	**17.9**	**9.0**

1. Does not include environmental monitoring costs.
2. Portion of costs attributable to DOE-SC/UT-B, based on contribution to the total volume.

The cost for environmental monitoring liquid and gaseous effluents is not traditionally included in facility operating costs, but is borne by the UT-B’s environmental monitoring organizations. Therefore, the National Pollution Discharge Elimination System (NPDES) permit monitoring for the Sewer Treatment Plant (STP) and the Process Waste Treatment Complex (PWTC) and the National Emission Standard for

Hazardous Air Pollutants (NESHAPs) gaseous stack monitoring costs were evaluated separately. The present analytical costs associated with the NPDES permit are $0.5 Million per year at the STP and $0.3 Million per year at the PWTC. The annual monitoring costs for the NESHAPs permit is: $0.5 Million for Stack 7911, $0.04 Million for Stack 2026, and $0.06 Million for Stack 3039.

1.2 ESTIMATED LLLW SOLIDIFICATION SYSTEM OPERATING COSTS

The current LLLW waste treatment system does not provide capabilities for solidifying waste for disposal. In order to estimate the costs of a "complete" waste management systems costs for treatment in the Transuranic (TRU) Waste Processing Facility (WPF) was also estimated. The annual operating costs for the TRU WPF were estimated from contract information provided by BJC personnel. The LLLW portion of the DOE-EM fixed-price, unit-rate contract with Foster Wheeler Environmental Corporation (FWENC) is for processing

- 900 cubic meters (m^3) of LLLW sludge at a cost of $14,107/$m^3$, and
- 1,850 m^3 of LLLW supernate at a cost of $10,801/$m^3$.

The processing period for the LLLW is 2.9 years. Therefore, the annual operating cost for the present contract is $11.3 Million per year. This cost includes partial payback of the upfront facility construction costs incurred by FWENC. Since the facility was designed for processing large volumes of waste over a short operating life, it is assumed that the maintenance and upgrade costs for operation over an extended period would be significant. For estimating purposes, these costs are assumed to be similar to the annualized facility construction costs. Therefore, future operating costs for the facility was estimated to be $11.3 Million per year. Since UT-B generated approximately 10% of the LLLW collected in the Melton Valley Storage Tanks (MVSTs) system, UT-B's portion of these costs (based on volume contribution) would be approximately $1.1 Million per year.

2. FUTURE OPERATING COSTS

The future costs for operating new treatment plants proposed in this report were also estimated. The existing PWTC will be replaced by the STP and a small packaged ion-exchange system in Melton Valley. The present operating costs for the STP is $0.5 Million per year. Existing personnel should be able to operate a second package treatment unit with a slight increase in maintenance costs; ten percent of the present plant operating costs was assumed.

The new Melton Valley process waste and LLLW treatment plants will treat small volumes of waste and will be highly automated with continuous monitoring at a central location. Therefore, it is assumed that operators and health physics personnel assigned to other duties can operate these plants on a part-time basis. Each plant was assumed to need one quarter of a full-time equivalent (FTE) operator and one quarter of a FTE health physics technician working the day-shift seven days a week. These values were obtained assuming that regular operations would require 1.5 hours per day at each facility. Once per month, an ion-exchange column change out would be required at the Melton Valley process waste treatment plant, and solid low-level waste (LLW) containers would be changed out in the Melton Valley LLLW facility. Each operation was assumed to require 8 hours for both an operator and health physics technician. The total operating costs for the new Melton Valley treatment plants was obtained using the ratio of overall operating costs to field operators for the existing ORNL STP. The STP's annual operating costs are $0.5 Million, and the facility is operated by one-third of an FTE operator around-the-clock. Therefore, the overall operating costs are $1.5 Million per FTE operator. Since the new treatment facilities will be operated by one half an FTE each, their overall annual operating costs were assumed to be $0.75 Million each. Since the STP operators work around-the-clock, this estimate should provide some leeway in case off-shift monitoring can not be accomplished by existing staff. These estimates are on the same order of magnitude as the projected operating costs of $0.9 Million per year for the new Melton Valley Groundwater Treatment System (see Chapter 5, section 5.7.1)

The *ORNL LGWTS Strategic Plan* assumes that LLLW will be source treated at the Radiochemical Engineering Development Center (REDC) to remove TRU and high-gamma contaminants. It was assumed that REDC operators would perform these operations and half an FTE, working around the clock 365 days per year would be required.

Although solid waste management is included in operating costs for existing facilities, solid waste management costs for the new treatment facilities was estimated separately. The following secondary solid waste streams were assumed to be generated from treatment of process waste and LLLW (see Appendix B {Process Waste System} and Appendix C {LLLW System}):

- 1.7 m^3 of contact-handled (CH) LLW from the PWTC for disposal at Envirocare of Utah, Inc.,
- 0.2 m^3 of cesium-loaded remote-handled (RH) LLW for disposal at the Nevada Test Site,
- 0.5 m^3 of RH-TRU waste for disposal at the Waste Isolation Pilot Plant from REDC source treatment, and
- 1.1 m^3 of RH-LLW for disposal at the Nevada Test Site from the LLLW treatment facility.

Costs for sampling, packaging, certifying, transporting, and disposal of the waste were estimated to be[1]:

- $2,018 per m^3 for CH-LLW,
- $6,805 perm^3 for RH-LLW, and
- $91,045/$m^3$ for RH-TRU waste.

The increase in solid secondary waste from the STP for treating an additional 5 million gallons per year (mgy) of process wastewater was considered to be negligible.

Costs for trucking process wastewater and LLLW were obtained from the analyses discussed in Appendix B (Process Waste System) and Appendix C (LLLW System). It will take 1.7 FTEs working weekdays on day shift to routinely truck the expected 4 gpm of process wastewater, including a: 0.6 FTE driver, 0.6 FTE operator, 0.25 FTE health physics technician, and 0.25 FTE supervisor. It was assumed that maintenance and Department of Transportation (DOT) paperwork would be 15% of the labor costs. At an average FTE cost of $180,000 per year, the total annual process wastewater trucking costs were estimated to be $0.35 Million. Trucking LLLW (91,000 gallons per year from the Spallation Neutron Source (SNS) and 4,000 gallons per year from Building 2026) would require 150 trips at 28 manhours per trip (6 hours for two operators, 6 hours for a health physics technician, 3 hours for a truck driver, and 3 hours for a supervisor). Assuming an average FTE cost of $180,000 per year, 15% additional costs for maintenance and DOT paperwork , the annual LLLW costs would be $0.41 Million per year.

The costs for operating these new facilities is based on the assumption that operators, truck drivers, supervisors, and health physics technicians will be available on an as-needed basis for waste treatment facilities and trucking operations. They will be assigned to other activities when not needed for waste management operations. It was also assumed that personnel from existing operations would be available around-the-clock to remotely monitor the automated systems for the waste treatment facilities. Since the

[1] Personal communications with Martin Tull, UT, Battelle, LLC, ORNL Laboratory Waste Services.

organizational structural for future waste management operations at ORNL has not been established, these assumptions will need to be confirmed at a later date.

Future analytical costs associated with the NPDES permit was estimated based on present costs for the STP and the PWTC. In the future, the STP costs are expected to increase to $0.6 Million per year to cover some of the contaminants presently monitored at the PWTC. The Melton Valley process wastewater treatment plant costs are expected to be similar to the existing plant at $0.3 Million per year. The NESHAPs costs for each new local stack installed in Bethel Valley were assumed to be the same as for the existing 3039 Stack at $0.7 Million per year.