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INNOVATIVE TECHNOLOGY
Summary Report

System for Tracking Remediation, Exposure, Activities and Materials

Deactivation and
Decommissioning Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

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INNOVATIVE TECHNOLOGY
Summary Report

System for Tracking Remediation, Exposure, Activities and Materials

OST Reference #1947

Deactivation and
Decommissioning Focus Area

Demonstrated at

Hanford Site
Richland, Washington

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this Document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov.

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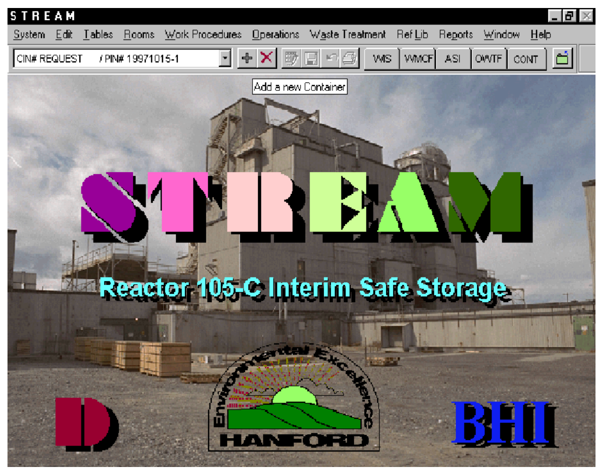
SECTION 1

EXECUTIVE SUMMARY

The System for Tracking Remediation, Exposure, Activities, and Materials (STREAM) technology is a multi-media database that consolidates project information into a single, easily-accessible place for day-to-day work performance and management tracking. Information inputs can range from procedures, reports, and references to waste generation logs and manifests to photographs and contaminant survey maps. Key features of the system are quick and easy information organization and retrieval, versatile information display options, and a variety of visual imaging methods. These elements enhance productivity and compliance and facilitate communications with project staff, clients, and regulators. Use of STREAM also gives visual access to contaminated areas, reducing the number of physical entries and promoting safety and as low as reasonably achievable (ALARA) principles. The STREAM system can be customized to focus on the information needs of a specific project, and provides a capability and work process improvement well beyond the usual collection of paperwork and independent databases. Especially when incorporated early in project planning and implemented to the fullest extent, it is a systematic and cost-effective tool for controlling and using project information. The STREAM system can support up to 50 different work stations.

■ Technology Summary

The STREAM software was integrated with four standard computer work stations; however, it can accommodate up to 50 separate work stations. Because there is little cost associated with connecting additional stations, it is cost-effective to make it accessible to a large number of project staff. The work stations can be integrated with digital cameras, an optical scanner, projectors, and printers to take greatest advantage of the visual imaging capabilities. The STREAM system is easy to use - icons, "point-and-click" technology, and a system of electronic "tabs and folders" helps a user navigate the system and select topics or images of interest. The STREAM support capabilities include visual imaging, a reference library, waste management tracking and reporting, and tracking of personnel exposure and training.



Problem Addressed

STREAM is a multimedia database developed by Delphinus Engineering, Inc., and is generally based on the well established FOXPRO database technology. It is designed to consolidate large volumes of existing information into a single, easily accessible electronic location for day-to-day work performance and tracking, and is not meant to replace any present database systems in use. STREAM accommodates a wide variety of inputs, both written (e.g., historical references, reports, procedures) and visual (e.g., photographs, video, contaminant surveys).

Features and Configuration

The key features of STREAM are highlighted below:

- Consolidates large amounts and various types of project information (photographs, videos, survey maps, waste management tracking and disposition information, procedures, reports, and similar data) into one electronic location.
- Provides easy location, retrieval, and viewing of information. Information can be sorted in various ways and viewed at any STREAM work station, printed in black and white or color, and/or projected.
- Allows engineers, planners, and craft workers to "see" contaminated areas before entry, reducing frequency and duration of entries.

- Displays data in tables, reports, and chart formats, thus allowing easy understanding of progress and trends.

- Simplifies waste tracking and allows direct download of waste data to various organizations.

- Provides a comprehensive legacy document for historical purposes.

- Connects up to 50 separate computer work stations and assorted visual aids.

STREAM is designed to be flexibly configured to meet project-specific needs. The configuration for the C Reactor demonstration consisted of four work stations and a file server. STREAM can be connected to up to 50 work stations at one time, allowing wide-spread use by a project team. In addition, STREAM can be integrated with various visual aids such as digital cameras, optical scanners, printers, and projectors. Hardware, server, and workstation requirements are described in detail in Section 2.

Potential Markets

STREAM is well-suited to any project where large volumes of information in a variety of formats exist and /or will be generated. At DOE, it is applicable to D&D activities as well as remedial action projects and surveillance and maintenance tasks. It can be applied to both public and private project management functions.

Advantages of the Innovative Technology

Specific information was not available to quantify increased productivity, improved communications, or reductions in facility entries, but logs maintained by personnel indicate significant benefits. Craft personnel briefed using the STREAM system demonstrated increased understanding of tasks, worker/supervisor communications improved, facility entries and associated exposures were reduced, meetings were more productive, engineering/planning personnel noted more effective use of project information, and the quality and timeliness of communications with outside groups. In addition, STREAM makes possible cost savings and schedule enhancements on future similar projects at the Hanford Site because much of the information collected in STREAM for the C Reactor can also be used as a starting point in preparing work packages for D&D of other Hanford Site reactors. This will reduce the need to perform costly definitive engineering for similar work.

Disadvantages/Operator Concerns

The primary disadvantage with STREAM is the inability to electronically export information for use with other word processing software.

Skills/Training

Because of the user-friendly configuration of the STREAM technology, and the fact that the system uses standard computer hardware, training requirements are minimal. Basic skills in the use of personal computers are required.

■ Demonstration Summary

This report covers the period February through October 1997, when the STREAM software program, owned by Delphinus Engineering, was demonstrated at the Hanford Site's C Reactor Interim Safe Storage (ISS) Project.

Demonstration Site Description

Presently, the DOE is conducting an evaluation of innovative technologies that might prove valuable for facility D&D at various DOE sites. As part of the Hanford Site Large-Scale Technology Demonstration (LSTD) at the C Reactor ISS Project, at least 20 technologies will be tested and assessed against baseline technologies currently in use. DOE's Office of Science & Technology/Deactivation & Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved and innovative technologies at its sites nationwide, and if successfully demonstrated at the Hanford Site, these innovative technologies could be implemented at other DOE sites and similar government or commercial facilities.

The C Reactor facility is located in the 100-B/C Area of the Hanford Site. The C Reactor building is 105.5 m by 45.7 m by 36.6 m. Except for reinforced sections, the building can be classified as a light, non-airtight industrial structure. The lower levels of the building and the central portions surrounding the reactor are constructed of reinforced concrete. The massive reinforced concrete walls surrounding the reactor are 0.9 to 1.5 m thick. The upper portions of the building are enclosed with corrugated asbestos cement (Transite). Other exterior walls are concrete block. The roof is mainly cast concrete panels.

The building complex has seven elevation levels with a number of rooms and areas within the structure, such as sample rooms, machine shop, tool rooms, metal examination facility, spent fuel storage basin and transfer bay, reactor core and rod rooms.

Applicability

The U.S. Department of Energy, Richland Operations Office (DOE-RL) has successfully completed a demonstration to verify the capabilities of the STREAM database. The system represents an innovative technology that can be effectively used on any project where there are large volumes of information, particularly visual information. The system is particularly useful for decommissioning, maintenance, and remedial action activities where access may be limited due to hazards, waste tracking is complex, quick and easy reference to large amounts of reference information is desirable, it is important to track hours/material use, or it is important to document information for historical reference or follow-on activities.

Key Demonstration Results

The STREAM system was successfully demonstrated at C Reactor with the following key results:

- ALARA was promoted by reduced numbers of facility entries and thus reduced exposure of personnel.
- The quality and retrievableness of work job planning documents was enhanced.
- Worker comprehension of tasks to be performed and working conditions in the facility was increased.
- Quality of meetings was improved by providing greater focus.
- Productivity, cost effectiveness, and quality were improved by providing a library for the storage and retrieval of data such as procedures, engineering guidance, regulatory requirements, and equipment safety and operating information.
- Communications with D&D management personnel and other groups were improved by providing up-to-date information related to work in progress and facility safety and radiological conditions.
- Project managers and staff gained quick access to detailed information for day-to-day work activities, presentations, and project reviews.
- Use of digital photographic equipment with STREAM allowed photographs to be available on a "next-day" or sooner basis for briefing workers, developing higher quality and more user-friendly work packages, and for presentations.

Regulatory Issues

There are no regulatory permits required to use STREAM, and no changes in regulatory requirements are anticipated that would require permitting.

Technology Availability

The STREAM technology is available from Delphinus Engineering, Inc. It requires standard computer hardware to implement, and because of its user-friendly configuration, training requirements are not extensive. As a result of its success on the C Reactor ISS Project, STREAM is already being deployed on other projects:

- At the DOE's Savannah River Site, it currently is being used during the engineering and planning phase for the D&D of the Heavy Water Components Test Reactor (HCTR).
- At Russia's Chernobyl Nuclear Power Plant, it is being used under subcontract with Pacific Northwest National Laboratory for the initial planning of D&D for the plant.

Limitations/Needs for Future Development

- Assuming that data entry on the Waste Inventory Sheet (WIS) proves to be beneficial in the future, a follow-on activity would be to implement computer data entry in the field through the use of hand-held data recording units. This would enhance both the integrity of the data and increase productivity by eliminating the need to complete a WIS in the field and later transfer each entry into STREAM. The hand-held data entry device would "prompt" the field entry person for information, and this information could later be batch entered into STREAM.
- As presently configured, only "hard-copy" data and reports can be produced by STREAM. A follow-on development would be the ability of STREAM to export data electronically to various customers who presently receive the hard-copy reports. This would significantly increase productivity by expediting information delivery and eliminating the need to re-enter the data.

■ Contacts

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Other
All published Innovative Technology Summary Reports are available at http://em-50.doe.gov. The Technology Management System, also available through the EM-50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for the System for Tracking Remediation, Exposure, Activities, and Materials (STREAM) is 1947.

SECTION 2

TECHNOLOGY DESCRIPTION

■ Process Overview

STREAM is a multimedia database developed by Delphinus Engineering, Inc., and is generally based on the well established FOXPRO database technology. It is designed to consolidate large volumes of existing information into a single, easily accessible electronic location for day-to-day work performance and tracking, and is not meant to replace any present database systems in use. STREAM accommodates a wide variety of inputs, both written (e.g., historical references, reports, procedures) and visual (e.g., photographs, video, contaminant surveys).

STREAM consists of four work stations and a file server. STREAM can be connected to up to 50 work stations at one time, allowing wide-spread use by a project team. In addition, STREAM can be integrated with various visual aids such as digital cameras, scanners, printers, and projectors.

Server requirements:

- 166 MHZ or better Pentium CPU
- Minimum 32 MB RAM
- 4.3GB each capacity (4 hard drives)
- Wide SCSI interface
- 8.5 ms average seek time
- 7200 rpm rotational speed
- 49-82 Mbps Internal Data Rate (disk-to-buffer)
- 20 Mbps Data Transfer Rate (buffer-to-host)

Workstation requirements:

- 32 MB RAM
- 2 GB hard disk
- 100 MB LAN adaptor
- 17" SVGA Monitor, capable of displaying 32-bit color at 640x480 resolution (Note, at some locations the ability to project the video image may be desired)
- Video Accelerator with 2 MB video RAM
- Sound card (8-bit or better)
- Speakers

Icons and “point-and-click” technology are used to navigate through STREAM and to select topics or images of interest. A variety of “tabs or folders” are used to organize information. Because of the user-friendly setup, training requirements are minimal.

Several functions are integrated into STREAM. As configured for use on the C Reactor ISS Project, only three of the most significant functions were used: Visual Imaging, a Reference Library, and Waste Management Tracking and Reporting. These functions are described in detail in the following subsections. The system provides additional capabilities, but these additional functions were considered by the Project to be either secondary functions or functions not presently needed by the Project. These other functions are discussed briefly in the last subsection.

■ Visual Imaging

Site photographs and video footage of virtually any size, along with facility diagrams, drawings, radiological survey maps, and similar types of visual information, are readily incorporated into STREAM. These visual elements can be catalogued according to location so that the system is able to provide a comprehensive view of each sector and room of the facility. This visual information, which may be viewed at any STREAM work station, printed, and/or projected, provides visual “access” to the facility without requiring entry into the facility. By using STREAM, project personnel and other individuals can reduce their exposure to potential hazards within the facility. Such visual access is valuable to engineers and planners during work planning, to operations personnel for review and training for upcoming work, and to management for gaining an immediate "picture" of any facility location and presenting project status. Additional photographs, radiological maps, and similar information can be quickly downloaded, either electronically or by optical scanning, for immediate use. Use of a digital camera with STREAM allows new information to be available on a "next-day" or sooner basis and video information can be easily digitized and electronically downloaded.

The "point-and-click" technology is used to navigate through STREAM by elevation, sector, and room (Figure 1). Once a room has been selected, the screens allow the user to choose various Tabs to select a range of visual information about the room (Figure 2). Each of the Tabs is described below.

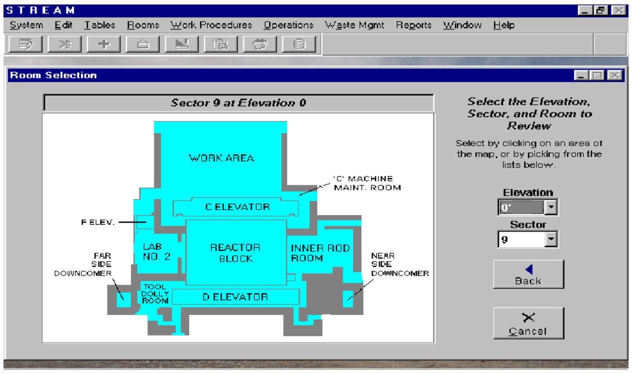

Figure 1. Screen for Sector 9 room selection.

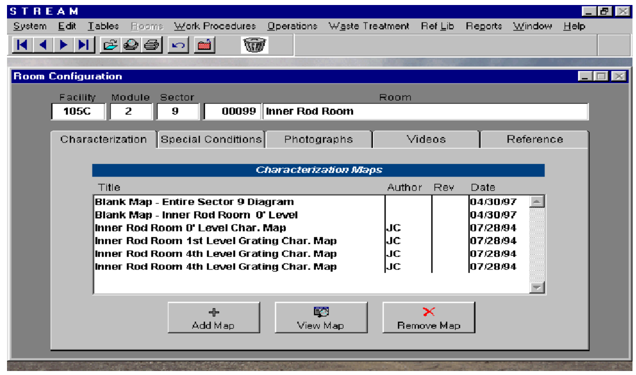

Figure 2. Typical Characterization Data Tab screen.

Characterization Data Tab - The Characterization Data Tab screen (Figure 2) presents a list of maps, documents, and diagrams that STREAM contains for a particular room or area. The function provides the capability to enter and store multiple-page documents (radiation survey reports, characterization maps, blank room diagrams, etc.) about the specific room or area. The information can then be viewed, printed, or projected for day-to-day use or maintained for historical purposes (Figure 3). Characterization maps can be enlarged for easier viewing. The radiological survey maps can also be enhanced by the use of hyper-links, which allow detailed data tables containing radioactive or hazardous waste information to be associated with a particular location on the characterization map.

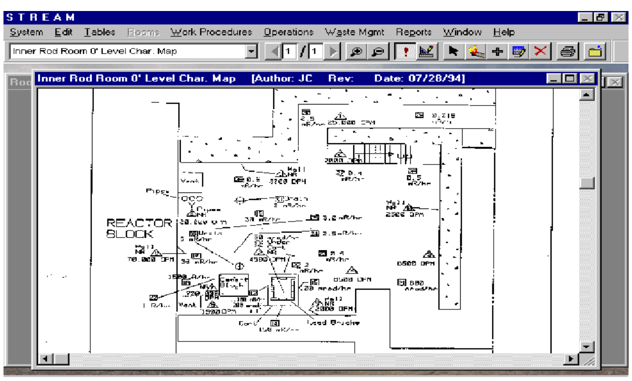

Figure 3. Example characterization map.

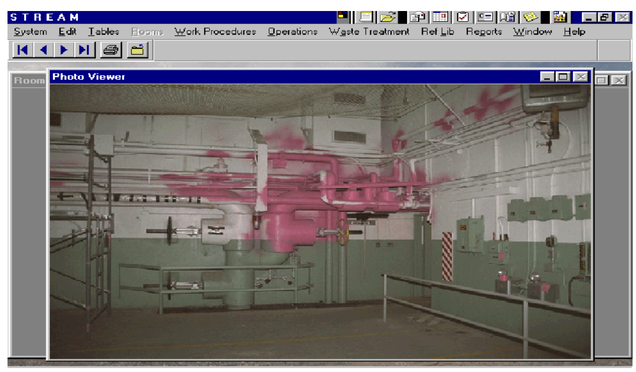

Figure 4. Photograph viewer (enlarges photograph) screen.

Special Conditions Tab - The Special Conditions Tab provides the capability to describe or identify particularly relevant information about the room or area. The information, which can include items such as a listing of hazardous materials, entry requirements, safety hazards or concerns, and physical condition, can be easily accessed by project personnel for quick reference. Special conditions can be changed or new conditions added with relative ease.

Photographs Tab - The Photograph Tab allows the user to view still photographs of the selected room or area. The Room Configuration Photograph screen displays thumbnail views of all relevant photographs available for the selected room/area. Any of the photographs can then be selected and enlarged (Figure 4). These enlarged views are suitable for projecting using an in-focus projector or printing with black and white or color printers. Photographs can be sorted, deleted, or new photographs added.

Video Tab - The Video Tab screen allows the user to view video clips of the selected room or area. The Screen displays a variety of tabs for the operation of video features (play, rewind, etc.). The audio/visual clip is controlled by the *play, stop, rewind, fast forward, scroll forward, scroll backward* button or by clicking on the time/frame indicator and moving it to any location in the clip desired. New video clips can be loaded or old clips deleted by clicking the *Add Video or Delete Video* buttons.

Reference Tab - The Reference Tab screen allows information contained in the Reference Library (discussed below) to be directly "linked" to a particular room or area, thus providing a quick reference to the information. Reference information can be added, deleted, or viewed utilizing the buttons at the bottom of the Reference Tab screen. Individual references can be identified by title, author, document identification number, revision, revision date, and source of the information. The database also lists the file name, file path, file type, and when the file was entered into the Reference Library.

The Reference Library section is discussed below. Whenever the Reference Tab of this section is used to add, view, or delete a reference, STREAM accesses the Reference Library directly and all activities are performed the same as the activities discussed below.

■ Reference Library

The STREAM Reference Library provides a multilevel free-form relational database structure for storing numerous reference documents, engineering reports, equipment operations data, photographs, videos, maps, and a wide range of other information valuable to the project. The information is stored by category and sub-category, rather than by facility location as described for the Visual Imaging function. As a result, such information is easily retrievable by category and sub-category. Informational categories can be any number of topics important to project performance such as completed work packages, task performance and equipment operations information, DOE Orders, and other applicable regulations. As with the Visual Imaging function, the data can be viewed at any STREAM work station, printed, or projected.

Figure 5 shows the Reference Library Topic screen. Folders and subfolders can be easily added, deleted, modified, or moved using the first four icons on the tool bar. Files can be added, deleted, modified, or moved by using the second four tool bar icons.

The STREAM Reference Library provides for file search capabilities and a search may be made by name and location, dates, or fields and types. Also, once a document, photo, or video has been entered into the STREAM Reference Library, it is easily retrieved by selecting the desired folder, highlighting the file (Item), and selecting the View Icon. The item can also be "linked" to the Reference Tab associated with a particular room or area for quick reference as discussed under the Visual Imaging function description.

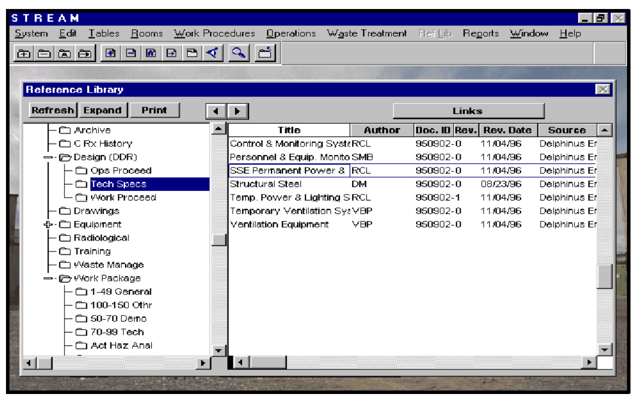

Figure 5. Reference library topic screen.

■ Waste Management Tracking and Reporting

STREAM supports several aspects of waste management including:

- Documenting all waste items removed from the facility
- Tracking each container by type, weight, volume, and other attributes, from generation to disposition

- Preparation of manifests and transportation documents
- Preparation of waste management reports.

A primary goal of STREAM relative to waste management is to reduce redundant data entry and to provide the capability to download data directly to various organizations. In addition, with STREAM the data can be retained within the system to provide an active legacy record of the waste generated. Such historic information can be queried at any time to retrieve the type, amount, location of origin, and nature of waste in any container.

STREAM provides a relational database structure for storing container and waste management data. To enhance information and data entry, computer screens can be formatted to be identical to the existing forms and data sheets used by the field organizations. The waste management database is populated with these data on a periodic basis after it is generated by the field. Additional data are recorded and maintained in the databases as the waste is further processed and ultimately transferred for disposal. By maintaining waste information on the STREAM system, interested users can access data on any container and its waste inventory by simply selecting the specific container by number. To disseminate waste management information, STREAM provides the capability to develop standardized and "ad-hoc" reports. Standardized reports provide a consistent means for waste management and project personnel to view the progress and status of waste management activities. "Ad-hoc" reports are generally geared towards specific information requests and are envisioned for use by the waste management organization in responding to informational requests by the project manager, the DOE, or regulators.

From the Waste Management Form selection screen, selected waste management forms presently used at the Hanford Site can be accessed for data entry, modification, and printing. Important to note is that any information entered on any one of the screens will automatically populate all equivalent entries on the other data entry screens. This capability significantly reduces the multiple entry of information. Also, where possible and appropriate, entry information is available from "drop-down" lists which ensure consistency and accuracy of the information entered. These drop-down lists are easily changed by accessing the appropriate list or table contained under the Tables Section (icon) of STREAM. Table management is discussed under "Additional Functions" below. All screens can be printed, thus providing a hard copy of the information for use by other organizations. Although presently not available, the intent in the future is to collect field data electronically and electronically export all data (forms and reports) to various organizations.

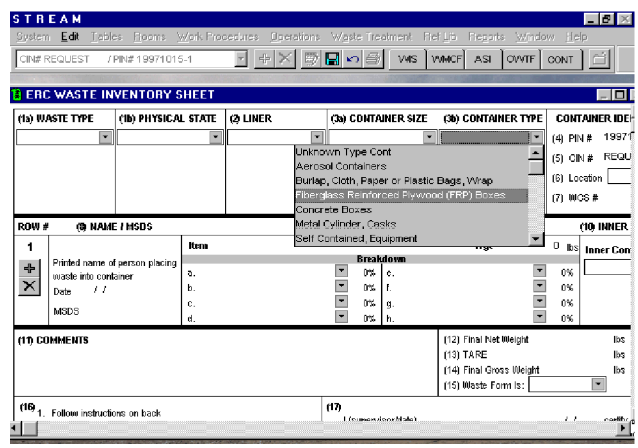

Figure 6. Waste Inventory Sheet (WIS) screen.

Each of the screens associated with the various forms are addressed below.

Waste Information Sheet (WIS) Screen shown in Figure 6 provides the capability to enter data from the WIS form completed in the field. The figure also includes a typical drop-down list example.

Waste Management Certification Form Screen provides the capability to enter the information required for container request/return/certification. Similar to the other waste management forms, drop-down lists are utilized where possible and appropriate for ease of entering information and to ensure consistency.

On-Site Waste Tracking Form (OWTF) Screen provides through the use of five separate Tabs, access to the data entry forms that make up the OWTF. In addition to providing basic data entry capability, these forms will perform necessary arithmetic functions. The forms that make up the OWTF include a calculation spreadsheet, the two-page OWTF form, and the two-page Department of Transportation (DOT) information form. In addition to the waste management screens above, there is a Shipper Information Form Screen used by the site waste management representative to enter miscellaneous data and a Container Contents Form Screen that provides a quick reference for all waste in a selected container.

STREAM also provides the ability to print out both standardized and user-defined waste management reports. Through the use of software such as MS Access or Seagate Crystal Report, the database containing all the waste management information entered through the data entry sheets can be sorted as desired.

■ Additional Functions

In addition to the functions described above, STREAM provides several other capabilities that generally were not used during the C Reactor ISS Project demonstration because they were redundant to existing systems, utilization by the project was not yet developed to the point of implementation, or the capability was not required. These functions are described below.

The ***Review Tables Screen*** allows for the addition, deletion, or modification of data in the various tables and drop-down lists used throughout STREAM. Icons located on the Task Bar provide for navigating through the various screens identified and provide for information manipulation.

The ***Review Work Procedures Screen*** provides information on the various work procedures contained in the definitive design report (DDR). Available information includes: rooms and tasks included in the procedure, applicable safety documentation, other reference information available by linking to the Reference Library, and additional pre-requisites and predecessor work procedure requirements.

The ***Review of Operations Data Screen*** provides the capability to track a wide range of operational information. Data that can be tracked includes: individual hours expended and dose received by task or by operations procedure, materials expended, equipment used, reports of tests performed during a particular task or procedure, and the current status of the procedure. The status of personnel training qualification can also be tracked.

The Reports Screen allows for the selection of various management and waste management reports and their graphic presentation.

SECTION 3

PERFORMANCE

■ Demonstration Plan

The intent of the STREAM technology demonstration was to evaluate the benefits of STREAM relative to productivity, safety and ALARA, communications, and costs. Due to the broad applicability of STREAM and a recognized need to evaluate performance over a longer period of time, this demonstration consisted of a 30-day initial evaluation and a 7-month follow-on program. For the demonstration, STREAM was installed using four work stations, a single file server, and various visual aids (digital cameras, an optical scanner, projectors, and printers). Approximately 150 project personnel used STREAM, either directly or as participants in meetings, at some time during the demonstration. During the demonstration, STREAM was utilized for the following activities:

- The Visual/Audio attributes of STREAM (video, photographs, radiological mapping data, facility diagrams) were used for pre-job briefings to familiarize craft and project staff with work tasks, location (areas/rooms), and specific hazards or concerns prior to actual facility entry.

- The Visual/Audio attributes of STREAM were used to support the Engineering, Health and Safety, and Radiological Control organizations in: developing work packages and other engineering documents; performing document reviews; answering questions or addressing concerns; providing presentations; and other activities where visual aids facilitated understanding or improved the quality of the activity.

- The Waste Management (WM) attributes of STREAM were used by the WM Organization for: tracking waste from generation to disposal; minimizing the time and effort required by staff entering data and preparing reports; standardizing data; and improving the quality and retrievableness of waste management information.

- The Reference Library attributes of STREAM were used to store: generic reference documents; health , safety, and radiological data; completed work packages and other engineering documentation; and information on equipment, equipment operation, and specific task performance.

■ Monitoring Performance

When evaluating a new technology, the preferred approach is to perform an objective, quantifiable comparison against an existing baseline technology. This was not possible for many of the STREAM applications because there was little measurable baseline information on activities such as: number of entries made into the facility or time spent in hazardous areas; time spent in traveling to and from facilities; the quality of meetings and briefings; or the level of equipment operating knowledge. This lack of baseline information and the fact that many of the applications of STREAM provided enhancements or capabilities that did not previously exist prevented a purely quantitative comparison.

Sufficient baseline information existed to quantify cost savings for: (1) preparation and review of work procedures; (2) waste disposal tracking; and (3) development of presentations. The cost analysis for these activities is presented in Section 5.

A large part of the performance evaluation was based on the subjective judgement of management and staff personnel who utilized STREAM during the demonstration. During the demonstration, a daily log was kept on STREAM uses. This log included observations and discussions with personnel who utilized the system. The observations and discussions focused on the following questions:

- In what capacity and to what extent was STREAM used?

- How easy was the system to use and was the desired information obtained?

- Does the technology improve the cost, reduce the labor required, save time, or increase efficiency?

- Does the technology lower the risk to workers and/or is there an increase in inherent safety?
- Does the technology provide for reduced personnel exposure to hazardous materials?
- Does the technology improve the timeliness or quality of communications?
- Does the technology improve the quality of documents prepared or work performed?
- Does the technology provide for increasing worker knowledge through follow-up and/or on-the-job training, or familiarization with equipment operations or task performance?

■ Technology Demonstration Results

The applications listed in the Demonstration Overview subsection were evaluated as follows:

1. The Visual/Audio attributes of STREAM (video, photographs, radiological mapping data, facility diagrams) were used for pre-job briefings to familiarize craft and project staff with the work task, location (areas/rooms), and specific hazards or concerns prior to actual facility entry.

   Use of the visual imaging information in STREAM was considered very successful. Specific beneficial utilization activities are described below.

   - Progress and work activity photos were shown regularly during craft weekly safety meetings. This allowed personnel to see and understand work being performed by others in the group. It also served as an aid to supervisors and managers in maintaining a positive working climate and helped to enhance meeting interest. Use of the digital camera on a routine basis allowed for the most current information to be available.
   - Photos and videos installed during the initial STREAM setup were used during a limited number of pre-job briefings. Personnel appeared to be very interested in the visual information, which sometimes triggered “side” discussions on a particular aspect of the work to be done. Benefits identified included: (1) workers appeared to have a clearer understanding of the area conditions and task to be done which promoted efficiency; (2) interest by workers appeared to be higher than in similar briefings that did not contain visual information; (3) the exchange of information between the crafts and supervisors was excellent and stayed focused on the task to be done; and (4) the briefings ran smoothly with few extraneous comments or other activities which would detract from the meeting purposes.
   - D&D lead individuals periodically utilized the visual information to gain a better understanding of an area in preparation for entry and work. Generally these individuals would come to the STREAM coordinator for information, although it was not unusual for the individuals to access the system themselves and study the information on their own.
   - The visual information in STREAM was utilized during a three-day briefing and training sessions for a group of personnel newly transferred to the project from another Hanford Site contractor. In this instance, the STREAM coordinator was able to provide some short instruction to one of the individuals in the group who then operated STREAM to show the information.

   As a result of the above uses of STREAM, ALARA practices and safety were improved by reducing the number and duration of facility entries. In addition, worker knowledge and worker/supervisor communications were improved by the use of pictures to describe the work and work areas, and improved worker training and facility familiarization were demonstrated.

2. The Visual/Audio attributes of STREAM were used to support the Engineering, Health and Safety, and Radiological Control organizations in: developing work packages and other engineering documents; performing document reviews; answering questions or addressing concerns; providing presentations; and other activities where visual aids facilitated understanding or improved the quality of the activity.

   Use of the visual imaging information in STREAM was considered successful. Specific beneficial utilization activities are described below.

- Use of STREAM by the Field Support/Field Engineering staff was considered very good. The system was used on numerous occasions to answer questions during work package development and to perform design review meetings. The review meetings contained anywhere from 8-12 staff personnel, and utilizing the visual imaging attributes of STREAM allowed personnel to clearly see and understand the area and task under discussion.

- Photos from STREAM were printed out and included in some work packages to aid in explaining the work to be done. Narrative in the work package referred to the photo when describing the task to be accomplished.

- STREAM was used for the planning and preparation for several of the technology demonstration activities including utilizing the visual imaging capabilities to review locations to perform the demonstrations, preparing the work packages, and performing Readiness Assessments.

- STREAM was used numerous times for presentations and tours. Attendees at these presentations included a range of organizations (e.g., DOE, oversight and regulating agencies, other government and state agencies, national and international guests, D&D senior management).

- In addition to participating in the reviews and readiness meetings discussed above where STREAM was utilized, the Health and Safety and Radiological Control staff supporting the C Reactor ISS Project have used STREAM on a limited basis to view various areas of the facility to quickly answer questions to avoid making an entry into the facility.

As a result of the above uses of STREAM, ALARA practices and safety were improved by avoiding unnecessary facility entries. Productivity, cost-effectiveness, and communications were improved by providing for easier and more efficient document reviews. Communications with outside groups were timely and productive.

3. The WM attributes of STREAM were used by the WM Organization for: tracking waste from generation to disposal; minimizing the time and effort required by staff entering data and preparing reports; standardizing data; and improving the quality and retrievableness of waste management information.

   The Waste Management function of STREAM was initially set up to reflect the design and assumptions identified in the DDR. Subsequent to completion of the DDR, the decision was made to perform waste handling operations differently than originally designed. As a result, the initial STREAM waste management configuration did not support actual waste management practices. Midway through the demonstration, STREAM was modified so that the configuration supported actual waste management practices. As a result of the time required to define the changes needed and the software programming required to make the changes, the actual waste management section reconfiguration of STREAM was not completed until almost six months into the seven-month demonstration. Therefore, waste management data entry and testing of the reconfigured system has only just started. Utilization and evaluation of the waste management and tracking attributes of STREAM are not completed to a point of beneficial use.

4. The Reference Library attributes of STREAM were used to store: generic reference documents; health , safety, and radiological data; completed work packages and other engineering documentation; and information on equipment, equipment operation, and specific task performance.

   A Reference Library was not included as part of the initial STREAM configuration and setup. However, based on a request by the Project Manager that STREAM have the capability to store for easy retrieval information that could be used as a starting point for D&D of subsequent reactors, a STREAM Reference Library was developed. The initial intent was to store information such as work packages, guidance documents, and similar information that could be used to develop required documentation for D&D of the next reactor and thus eliminate or significantly reduce the engineering required. It was anticipated that this would result in significant cost savings.

The Reference Library software reconfiguration was completed and installed in early August 1997, four months into the seven-month demonstration. Although the Reference Library was not available until late in the demonstration, the two-month period for which it has been in use has provided very good results. Specific beneficial utilization activities are described below.

- All C Reactor ISS Project work packages developed to date were electronically downloaded into the Reference Library. The information is available for easy reference for current project activities and will be available for use as a starting point for future similar work. This met the primary goal for establishing a Reference Library on this project.

- The Reference Library allowed for large documents that contain significant historic information about the C Reactor to be easily entered and retrieved. For example, a 25-page document on the operational history of the C Reactor was entered into STREAM in a matter of seconds. Since entry, the document has been accessed numerous times, and, using the "find/search" function, information needed by the project was made available easily and quickly.

- The Reference Library has allowed the entry, storage, and retrieval of photos by "topic" similar to the manner in which the Visual Imaging Section of STREAM stores visual information by area/room location. Topical storage and retrieval of information has allowed for information on specific areas of interest, such as D&D equipment used by the project, to be available. Although only limited use of this information has been made to date, it is anticipated that such information could easily be used for worker introduction and training related to both equipment and specific tasks. In addition, it is anticipated that significant amounts of information (photos, reference documents) related to waste management and other topical areas will be entered into STREAM over the next several months.

As a result of the above uses of STREAM, productivity was improved by providing for easier and more efficient access to project information. Information that can be use as a starting point for future similar work is available and if used, will result in cost-savings for performing future work.

Throughout the demonstration period, hundreds of photos, documents, maps, and similar pieces of information have been added to STREAM. In all instances, the entry of this data was found to be easily and quickly performed. Most information was entered electronically, although optical scanning of information was also performed on occasion. Use of a digital camera in conjunction with STREAM was found to be particularly beneficial. It allowed large numbers of photos to be taken on short notice by numerous members of the project staff. Because there was no film or processing, significant benefits were realized from a material cost savings and timely availability of the information.

The retrieval of information from STREAM was also found to be easily and quickly performed. With a "click" of a print icon, photos, maps, and a wide variety of other information could be printed out as a hard copy in either black & white or color for use as needed. One disadvantage noted was the inability to electronically export information from STREAM.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

■ Technology Applicability

STREAM is well-suited to any project where large volumes of information in a variety of formats exist and/or will be generated. It was initially designed to support project management and staff in performing D&D activities; however, it is also applicable to remedial action activities and maintenance activities associated with any large facility where:

- Access may be limited due to hazard concerns, and visual information would be beneficial.
- Tracking of waste from generation to disposition is required, and/or report generation is difficult, complicated, and/or burdensome.
- Quick and easy access to large amounts of reference information is desirable.
- It is important to track hours expended and materials used.
- It is important to document information about the facility or work activities for historical purposes or to utilize the information for reference and follow-on activities.

■ Competing Technologies

This technology is unique and except for its use by the developer (Delphinus Engineering, Inc.) was demonstrated for the first time as part of the Hanford Site C Reactor ISS Project technology demonstration and D&D activities .

■ Patent/Commercialization/Sponsor

Since the initial development of STREAM by Delphinus Engineering, the system has been used for the following:

- Used by Delphinus Engineering as a tool in performing definitive engineering and preparing the DDR for the C Reactor ISS Project.
- Selected as one of the Technology Demonstrations to be demonstrated for use on the Hanford Site C Reactor Interim Safe Storage Project.
- Presently at the DOE Savannah River Site for use in the D&D of HCTR.
- Currently being configured for use at Chernobyl.

Although several modifications have occurred to reconfigure STREAM to accommodate specific aspects of the above-listed activities, the technology is considered well developed. A primary reason for this is that STREAM utilizes existing and well-established technologies and integrates them using a FOXPRO database.

SECTION 5

COST

■ Introduction

This cost analysis compares the STREAM innovative technology to conventional practices employed in D&D activities at the Hanford Site. In this analysis, the cost impacts observed during the limited demonstration period have been extrapolated to approximate the cost impacts that would be anticipated if STREAM had been utilized for the full duration of the C Reactor ISS Project. In addition, as the demonstration progressed, the STREAM software was modified and its use was optimized. This cost analysis assumes optimum use of STREAM for the entire duration of the ISS Project and does not factor in costs associated with initial startup.

The cost analysis considered the purchase and implementation of STREAM for three specific activities:

- Development and approval of work packages
- Waste tracking
- Development of presentations.

For these activities, cost is primarily a function of labor hours involved. The necessary information was based on the number of hours required to complete a task as estimated by the individuals involved. The amount of experience that an individual user had with STREAM varied from several hours of use to several months, depending on the area of application.

In this analysis, the baseline technology was the use of existing information resources such as paper copies of documents and multiple databases.

■ Cost Analysis

The STREAM technology is available from the vendor as a stand-alone product with or without startup support or as an element of overall engineering services. The rates for these options are indicated in Table 1:

Table 1 - Innovative Technology Acquisition Costs

Acquisition Option		Item		Cost
1	Purchase software	Alternative A:	Five Users	$40,000 - $60,000
		Alternative B:	Twenty Users	$70,000
2	System and setup service (includes software, initial photograph of facility, and input of characterization data)	Limited software customizing		$130,000
		Major software customizing		$160,000
3	As part of engineering services			Not estimated separately

The costs for customizing the software after it is purchased or after the system is set up depend on the specific changes required. The use of STREAM on the C Reactor ISS Project required approximately $62,000 for modifications to the software. The modification costs for applications at other DOE sites would be lower because subsequent users gain the benefit of previous refinements to the software.

Membership in a user group is offered by the vendor for $20,000 per year and includes help desk service and automatic software updates.

The costs for performing work under baseline conditions versus using the innovative STREAM technology are shown in Figure 7. The costs shown in Figure 7 do not include overhead costs or general and administrative markup costs.

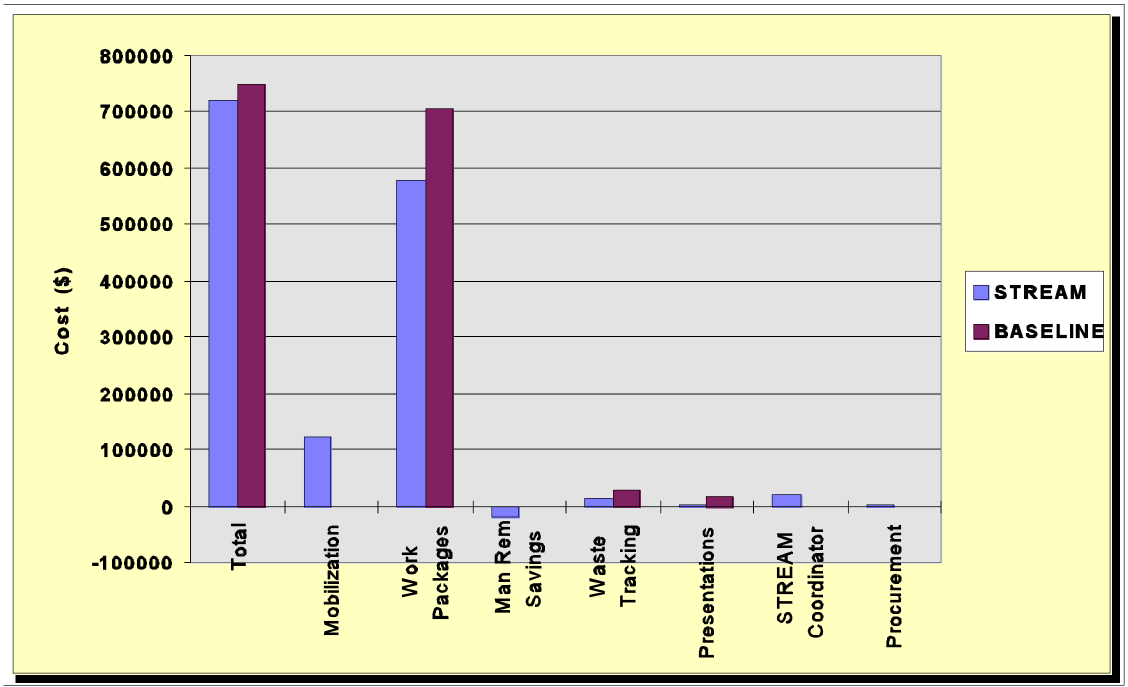

Figure 7. Estimated costs for innovative and baseline technologies.

(Note: Figure created in Excel 97)

The demonstration occurred under specific conditions that directly controlled costs. A detailed table of costs in Appendix C allows computation of costs for site-specific quantities. The most significant conditions that affected costs for the demonstration were:

- Nature of the D&D project (production reactor requires approximately 150 work packages)
- Radiologic conditions (the highest exposure in the C Reactor was in the Ball 3X area, Inner Rod Room, Metal Exam Room, and tunnels with an average exposure of 20 millirem per hour in these areas)
- Work control processes (Bechtel Hanford, Inc. document requirements, format, review and approval process).

Specific ways in which STREAM provided a cost benefit are as follows:

- Work package development effort was reduced by using STREAM as a source of data for the report and using photographs to avoid drawing/drafting costs.
- Work package reviews and approvals were conducted more effectively by reviewing the document in a STREAM-based review meeting.
- Facility entry and associated exposure (as measured in man-rem) for the purpose of gathering data for work packages and operational readiness review was avoided using STREAM.

- Waste tracking operations were simplified using STREAM as a source of data for completing the waste tracking forms.

Cost Conclusions

For the three activities analyzed, STREAM saved approximately 4% compared to baseline costs. Details of the cost comparison are covered in Appendix C of this report and summarized in Figure 5-1. Compared to the baseline, STREAM reduced the numbers of personnel entries into radioactively contaminated areas for work package development, has the potential for reducing labor for waste tracking, and reduced preparation time for presentations.

Other ISS Project activities also utilized STREAM but were not considered in this cost analysis because the use of STREAM changes the nature of the work in a way that makes comparison difficult. For example, when STREAM was used in Plan of the Day meetings for briefing personnel, the questions and interaction of the workers result in increased meeting duration (which increases costs), but the increased understanding of the workers potentially reduced the risk of injury and exposure (potential for reduced costs). The cost benefits of increased worker comprehension and reduced risk and exposure are difficult to quantify, therefore, this type of activity was not considered in the cost analysis. However, personnel interviews indicate that both workers and field supervisors perceived an overall benefit in the use of STREAM that justified the longer meetings and continued use of STREAM. There were activities where use of STREAM might have provided a cost savings, but STREAM was not implemented sufficiently during the demonstration to allow measurement of the changes to work duration (e.g., radiological survey reporting). These activities also are not considered in this analysis.

The costs and cost savings of setting up and using STREAM can vary widely based on site-specific situations. Key setup assumptions that affected costs in this analysis were:

- The number of computers connected to STREAM. This cost analysis assumed 15 computers.
- The level of vendor support. This cost analysis assumed a full-time STREAM coordinator for the first 5 months and a quarter-time coordinator thereafter.

Other approaches to implementing STREAM could have lower initial costs, but the demonstration experience suggests that STREAM is most beneficial when it is available on the computers of all key users and when data in the system are continually updated.

The analysis also includes a savings of approximately $22,000 in man-rem costs for avoiding entry to several radiation areas. This assumed a unit cost of $30,000 per man-rem based on Bechtel Hanford, Inc.'s experience at the Hanford Site. This man-rem unit cost will vary from site to site. Additionally, much of STREAM's savings hinges on innovative approaches to review meetings and the work package approval process, and this type of variation may not be allowed under certain types of work control managements. Most importantly, workers at some facilities are reluctant to incorporate computer-based processes into their daily routines, and this can result in under-utilization of a technology such as STREAM.

Given the many variables, it is recommended that this cost analysis be used as an indicator rather than a predictor of potential cost savings. Based on the demonstration, the STREAM technology does provide some level of cost reduction by providing a convenient, organized source of data and by providing photographs and video that facilitate communication. The savings will be in proportion to efforts to implement the system and to adjust conventional work procedures to take advantage of a computer-based format.

SECTION 6

REGULATORY/POLICY ISSUES

■ Regulatory Considerations

- There are no regulatory permits required to use STREAM, and no changes in regulatory requirements are anticipated that would require permitting.
- Although the demonstration took place at a comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply to the system demonstrated at C Reactor.

■ Safety, Risk, Benefits, and Community Reaction

Worker Safety

There are no adverse safety impacts that result from using STREAM. Rather, STREAM enhances and facilitates safety in the following ways:

- Occupational Safety and Health Administration (OSHA) regulations require appropriate worker training when working with hazardous wastes or at remedial action sites. STREAM provides a list of training requirements for each task and displays a matrix showing operators who have the required training.
- Title 10 Code of Federal Regulations (CFR) Part 20 establishes radiation exposure limits for personnel working on DOE-related activities. STREAM provides a means for tracking dose received by personnel.
- STREAM allows access to visual information about the facility without physical entry. This helps implementation of ALARA principles (10 CFR 20) and enhances worker health and safety (29 CFR 1910.120) by reducing personnel exposure to radiation and hazardous materials.
- Identification and assessment of work place hazards may be required by OSHA. In such an event, STREAM provides an excellent tool to develop Hazard Assessment certification.
- STREAM can be effectively used for meetings and pre-job briefings. Access to still photographs and video clips of work areas facilitates an increased understanding and awareness of the work area, hazards, and activities to be performed.

Community Safety

There are no adverse community safety impacts as a result of using STREAM. The system can be used to enhance community safety by providing a single, complete, and readily-retrieved source of information on the location and quantity of hazardous materials at a facility. The Emergency Planning and Community Right-To-Know Act requires that information related to hazardous materials be provided to local Emergency Planning Committees and responsible agencies to facilitate preparation of an Area Contingency Plan (40 CFR 300) and to plan for emergencies.

■ Environmental Impact

There are no adverse environmental impacts as a result of using STREAM. The system enhances environmental management through the following:

- STREAM is utilized as a comprehensive data storage and retrieval source for various data forms and provides on-line access to this data. This reduces or eliminates the requirements for maintaining the same data on paper copies, thereby aiding in the formation of a paperless system.

- Photographs of the facility are taken using a digital camera and directly transferred into STREAM. This eliminates the use of conventional photographic chemicals that are proven to be toxic on prolonged exposure, enhancing worker safety as well as reducing waste generation.

■ Socioeconomic Impacts and Community Perception

There are no adverse socioeconomic impacts as a result of using STREAM. By providing an easy-to-access, up-to-date repository of information, STREAM can bridge the gap between federal agencies and the public which, in turn, will improve community perception.

SECTION 7

LESSONS LEARNED

■ Lessons Learned

As discussed in earlier sections, the use of STREAM resulted in improvements in productivity, safety, and communications as well as producing a cost savings. However, during the seven months of the demonstration, several lessons were learned that, if implemented, should significantly improve these areas. Lessons learned include:

Implementation Considerations

- STREAM can accommodate up to 50 separate workstations. Because there is little cost associated with connecting additional workstations to STREAM, it is recommended that the STREAM software be provided to each project staff member who would be expected to utilize the system. The system should also have controls in place for revisions made to the information, whether additions, deletions or updates so everyone is informed of the changes.

- Capabilities should be added to allow photo entries by sector to accommodate progress photos as portions of the sectors are demolished and individual rooms/areas no longer exist. A single "general" photo location should also be added to allow entry of a single set of overall progress photos in one location for ease of presentation.

- A "general" section should be added for each sector and for the entire facility. This would accommodate progress photos and other information by sector as portions of the sector are demolished and it would provide a single location where a grouping of the best photos could be added for easy presentation of the progress on the whole project.

- For maximum benefit, STREAM should be implemented as early in the planning phase of a project as possible. Incorporating a wide variety of information into the system early in the planning and staffing stage will greatly enhance work package development and should result in substantial improvements in ALARA practices, safety, and productivity.

- As much information as possible related to the project (photos, videos, characterizations surveys, blank rad maps and diagrams, facility drawings, and important reference material) should be entered into STREAM as early in the planning, work package development, and staffing phases as possible to provide maximum utilization of the system.

- Strong management support and leadership is needed to ensure that technologies that have been demonstrated or have a high potential to enhance performance, promote ALARA and safety, or increase productivity are used for pre-job briefings, training, and other meetings, particularly involving craft forces. This will maximize the benefits of new technologies such as STREAM.

■ Technology Limitations/Needs for Future Development

- Assuming that data entry on the Waste Inventory Sheet (WIS) proves to be beneficial in the future, a follow-on activity would be to implement computer data entry in the field through the use of hand-held data recording units. This would enhance both the integrity of the data and increase productivity by eliminating the need to complete a WIS in the field and later transfer each entry into STREAM. The hand-held data entry device would "prompt" the field entry person for information, and this information could later be batch entered into STREAM.

- As presently configured, only "hard-copy" data and reports can be produced by STREAM. A follow-on development would be the ability of STREAM to export data electronically to various organizations that presently receive the hard-copy reports. This would significantly increase productivity by expediting information delivery and eliminating the need to re-enter the data.

Technology Selection Considerations

- The STREAM technology is suitable for DOE and non-DOE nuclear facility sites involved in D&D or remedial action activities.

- The technology would also be very suitable and beneficial for facility and equipment maintenance programs where the ability to store and quickly retrieve a wide range of information about a facility, organized by area and system, would be helpful in performing day-to-day work activities and tracking activities such as preventative maintenance, machinery history, and equipment condition.

APPENDIX A

REFERENCES

Related Publication

Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary." 1996, Headquarters United States Army Corps of Engineers, 20 Massachusetts Avenue, N.W., Washington, D.C., 20314-1000.

APPENDIX B

ACRONYMS AND ABBREVIATION

Acronym/Abbreviation	Description
ALARA	as low as reasonable achievable
BHI	Bechtel Hanford, Inc.
CFR	Code of Federal Regulations
CPU	central processing unit
D&D	decontamination and decommissioning
DDR	definitive design report
DOE	Department of Energy
FETC	DOE Federal Energy Technology Center
FTE	full-time equivalent (employee)
G&A	general and administrative
H&S	health and safety
HCTR	Heavy Water Components Test Reactor
HTRW	hazardous, toxic, and radioactive waste
ISS	interim safe storage
LAN	local area network
LSTD	Large-Scale Technology Demonstration
OSHA	Occupational Safety and Health Administration
OWTF	On-site Waste Tracking Form
RA	Remedial Action
RAM	random access memory
SCSI	small computer system interface
STREAM	System for Tracking Remediation, Exposure, Activities, and Materials
SVGA	super video graphic adaptor
USACE	United States Army Corps of Engineers
WBS	work breakdown structure
WIS	waste inventory sheet
WM	waste management

APPENDIX C

TECHNOLOGY COST COMPARISON

■ Technology Cost Analysis

The demonstration of the STREAM innovative technology was conducted at the C Reactor at DOE's Hanford Site with on-site personnel who used STREAM in the course of their normal work. A wide range of workers used STREAM and applied it to many different activities. This analysis focuses on three particular applications of STREAM:

- Support for preparation and approval of work packages
- Waste tracking
- Preparation of presentations.

Cost analyses for other STREAM applications were not prepared due to the difficulty in assessing benefits or because of the lack of baseline data or observation-based data to support an analysis. The selected activities that are analyzed come from the *Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS) (USACE 1996). The HTRW RA WBS was developed by an interagency group and was used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis to make it easier to understand and to facilitate comparison with costs for the individual site. The overhead and general and administrative (G&A) markup for the site contractor managing the demonstration are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without first having to back-out the rates used at the Hanford Site. This omission does not sacrifice the cost savings accuracy, because overhead is applied to both the innovative and baseline technology costs. Engineering, quality assurance, administrative costs, and taxes on services and materials are also omitted from this analysis for the same reasons indicated for the overhead rates.

The following assumptions were used in preparing the cost analysis:

- A procurement cost of 4.5% was applied to all software purchases, digital photo equipment purchases, and upgrades to Pentium computers. This factor accounts for costs of administering the purchase.

- 150 work packages are required for the C Reactor ISS project. For preparation of work packages, 50 two-person entries are required under the baseline, and 25 entries are required when STREAM is used. But, for operation review walk downs, 50 two-person entries are required for the baseline and 46 entries for STREAM. Use of the STREAM minimizes followup on work package comments 50% of the time.

- STREAM software is purchased for use on 15 computers.

- A full-time STREAM coordinator is identified for three months during startup, with transition to 62.5 percent time for five months and 25 percent time for seven months.

Because of the large number of personnel involved, it was not possible to systematically measure the durations of work activities with and without STREAM. Consequently, the analysis is based on the judgement of the users (interview logs are contained in the detailed back-up in the project file) as to the average duration of the activities. Tables C-1 and C-2 provide unit durations for work activities and labor and equipment unit costs in a format that will accommodate insertion of site specific quantities (in the total quantity column). This will allow a site-specific cost to be developed by the potential technology user.

The rates shown are standard rates for the Hanford Site and include base wages, fringe benefits, and some departmental overhead. The rates exclude BHI overhead and G&A.

Table C-1. Stream Cost Summary

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour(Hr) Rate	Equipment Hr Rate	Other Rate	Total UC	Total Qnty (TQ)	Unit of Measure	Total Cost (TC)1	Crew Composition 2	Comments
MOBILIZATION (mob)- WBS 331.01						Subtotal:	121838		
Software for 15 Computers			65000	$65,000	1	Each	$ 65,000	Vendor service	
Change to Pentium Computers			$ 1,399	$1,399	7	Each	$ 9,793		Assume that 1/2 of the computers must be changed to Pentium I33
Customizing of Software			35000	$35,000	1	Each	$ 35,000	Vendor service	Customize to match waste tracking formats, etc.
Digital Photo System			$ 4,915	$4,915	1	Each	$ 4,915		Digital camera, video camera, scanner, and color printer
Initial Data Input				$0			$ -	STREAM Coord $33.21	
Photographs	8 $ 33			$266	1	Each	$ 266		
Work Packages	16 $ 33			$533	1	Each	$ 533		
Technical Specifications	16 $ 33			$533	1	Each	$ 533		
Drawings	40 $ 33			$1,332	1	Each	$ 1,332		
Rad Data	16 $ 33			$533	1	Each	$ 533		
Reg.s & Guidance Doc.s	16 $ 33			$533	1	Each	$ 533		
Initial Photographs & Video	16 $ 212			$3,399	1	Each	$ 3,399	1 Field Engr $54.64 1 Safe & Heal $62.25 1 Rad Con $62.25 1 Stream Coord $33.21	Coordinate with vendor and initial input of technical specs, work packages, rad data, & drawings
D&D - WBS 331.17						Subtotal:	593297		
Work Package				$ -			$ -		
Preparation				$ -			$ -		
Gather Work Area Data	3.0 $104.1		$ 44	$ 356	25	each	$ 8,910	1 Field Engr $54.64 1 RCT $ 49.49	Assume that of 150 work packages, 1/6 requires entry of contaminated area to collect data for the work package plus PPE for 2 @ $22 each (50% reduction over normal practice)
Write Narrative of Doc.	42.0 $54.64			$ 2,295	150	each	$ 344,232	1 Field Engr $54.64	Reduction of duration from 50 hrs to 42 hrs as result of using photos rather than narrative and drawings and avoiding hunting for information
Action Items				$ -			$ -		Avoided by accomplish in the Rev. Meeting
Review		0		$ -			$ -		
Document Review	2.0 514.17			$ 1,028	150.0	each	$ 154,251	2 Field Engr $54.64 2 Safe & Heal $62.25 1 Rad Con $62.25 2 RCT $49.49 2 Craft Sup. $59.58	Team of 9 to review for 2 hours each
Disposition Comments	6.0 $ 54.6		$ -	$ 327.84	75.0	Each	$ 24,588	Field Engineer $54.64	Approx. 1/2 of the work packages avoid comments that require follow-up
Oper. Rev. Walkdown				$ -			$ -		
Full Walk Down Review	1.5 $514.2		$ 207	$ 978.26	46.0	Each	$ 45,000	Same team as Review	Entry un-avoidable for 46 work packages
No Entry STREAM Rev.	1.0 $514.2			$ 514.17	4.0	Each	$ 2,057	Same team as Review	Avoids entry (review via STREAM photos)
Man Rem Savings			-30000	$ (30,000)	0.7	Rem	$ (21,600)		4 entries to radiation areas avoided for a team of 9 (0.02 rem exposure X 1 hr entry duration X 4 entries X 9 team members = 0.72 man rem)
Waste Disposal Tracking				$ -			$ -		
Fill Out Tracking Forms				$ -			$ -	1 Technician $46.53	
Municipal Type Waste	0.250 $ 46.5			$ 11.63	50.0	Shipment	$ 582		50% reduction of effort
Low Level Waste (ERDF) ....(same waste stream)	0.083 $ 46.5			$ 3.88	240.0	Shipment	$ 931		No reduction for the same waste stream
Low Level Waste (ERDF) ....(different waste stream)	1.5 $ 46.5			$ 69.80	60.0	Shipment	$ 4,188		50% reduction of effort
Hazardous Waste	2.0 $ 46.5			$ 93.06	20.0	Shipment	$ 1,861		50% reduction of effort
Mixed Waste	10.0 $ 46.5			$ 465.30	5.0	Shipment	$ 2,327		50% reduction of effort
Tracking Info. Requests	3.0 $ 46.5			$ 139.59	30.0	Requests	$ 4,188		50% reduction of effort
Un-Scheduled Presentations	3.0 $ 33.3			$ 99.93	30.0	Present.	$ 2,998	STREAM Coordinator $33.21	
Progress Presentations	0.5 $ 33.3			$ 16.66	12.0	Present.	$ 200	STREAM Coordinator	
STREAM Coordinator	558 $ 33.3			$ 18,587	1.00	Each	$ 18,587	STREAM Coordinator	3 months full FTE, 5 months .625 FTE , and remaining 7 months at 1/4 FTE
Procurement Cost						Subtotal:	$ 3,209		
Procurement Cost			3209	3209	1.0	Each	$ 3,209		Cost for administration of purchase (4.5%) for software, computers, and cameras
						Total		$ 718,344	

Table C-2. Baseline Cost Summary

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour	Labor Rate	Equipment Hour	Equipment Rate	Other Rate	Total UC	Total Qnty (TQ)	Unit of Measure	Total Cost (TC)1	Crew Composition	Comments
D&D - WBS 331.17								Subtotal:	748248		
Work Package						$ -			$ -		
Preparation											
Gather Work Area Data	*3.0*	*$ 104*			*$ 44*	*$ 356*	*50*	*each*	*$ 17,820*	*1 Field Engr $54.64* *1 RCT $ 49.49*	*Assume that of 150 work packages, 1/3 requires entry of contaminated area to collect data for the work package plus PPE for 2 @ $22 each*
Write Narative of Doc.	*50.0*	*$ 55*				*$ 2,732*	*150*	*each*	*$ 409,800*	*1 Field Engr $54.64*	
Action Items	*2.0*	*$109.28*				*$ 219*	*150*	*each*	*$ 32,784*	*2 Field Engr $54.64*	
Review											
Document Review	*2.0*	*$514.17*				*$ 1,028*	*150.0*	*each*	*$ 154,251*	*2 Field Engr $54.64* *2 Safe & Heal$62.25* *1 Rad Con $62.25* *2 RCT $49.49* *2 Craft Sup.$59.58*	*Team of 9 reviews for 2 hours each*
Comment Disposition	*6.0*	*$ 55*				*$ 328*	*150.0*	*each*	*$ 49,176*	*1 Field Engr $54.64*	*One hour per comment to disposition and 6 comments per work package*
Op Review Walk Down	*1.5*	*$514.17*			*$ 68.90*	*$ 840*	*50*	*each*	*$ 42,008*	*Same as Review*	*Team of 9*
Waste Disposal Tracking						*$ -*			*$ -*		
Fill Out Tracking Forms						*$ -*			*$ -*		
Municipal Type Waste	*0.5*	*$ 46.5*				*$ 23.27*	*50.0*	*Shippment*	*$ 1,163*	*1 Technician $46.53*	
Low Level Waste (ERDF) ....(same waste stream)	*0.083*	*$ 46.5*				*$ 3.88*	*240.0*	*Shippment*	*$ 931*		
Low Level Waste (ERDF) ....(different waste stream)	*3.0*	*$ 46.5*				*$ 139.59*	*60.0*	*Shipment*	*$ 8,375*		
Hazardous Waste	*4.0*	*$ 46.5*				*$ 186.12*	*20.0*	*Shippment*	*$ 3,722*		
Mixed Waste	*20.0*	*$ 46.5*				*$ 930.60*	*5.0*	*Shippment*	*$ 4,653*		
Tracking Info. Requests	*6.0*	*$ 46.5*				*$ 279.18*	*30.0*	*Requests*	*$ 8,375*		
Un-Scheduled Presentations	*12.0*	*$ 33.3*				*$ 399.72*	*30.0*	*Presents.*	*$ 11,992*		
Progress Presentations	*8.0*	*$ 33.3*				*$ 266.48*	*12.0*	*Presents.*	*$ 3,198*		
						$ -			*$ -*		
								Total		*$ 748,247.66*	

1. TC=UC x TQ (where TC=total cost; UC=unit cost & TQ=total quantity)