Designation: E 2150 – 01

Standard Classification for Life-Cycle Environmental Work Elements—Environmental Cost Element Structure[1]

This standard is issued under the fixed designation E 2150; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard establishes a classification of the comprehensive hierarchical list of elements for life-cycle environmental work. The classification is based on the Interagency Environmental Cost Element Structure (ECES)[2]. Elements, as defined here, are major components common to environmental projects. The elements represent the life-cycle activities for environmental projects regardless of the project design specification, construction method, technology type, or materials used. The classification serves as a consistent reference for cost estimating, analysis, and monitoring during the various phases of the project life cycle. Using ECES ensures consistency, over time and from project to project, in the cost management and performance measurement of environmental projects. It also enhances reporting at all phases of a project, from assessment and studies through design, construction, operations and maintenance (O&M), and surveillance and long-term monitoring (SLTM).

1.2 This classification applies to all environmental work, including environmental restoration, waste management, decontamination and decommissioning (D&D), surveillance and long-term monitoring, and technology development.

1.3 The use of this classification increases the level of standardization, uniformity, and consistency of collected environmental project costs. Such uniformity and standardization allows for ease of understanding project costs, provides a common "cost language" for sharing and comparing cost information, and allows for easier analysis and calibration of cost data. This standard classification can be used as a checklist of activities to be completed in environmental projects.

2. Terminology

2.1 *Definitions*—For definition of terms used in this classification, refer to Terminology E 833.

2.1.1 *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*—Also known as "Superfund," CERCLA prescribes actions, and regulatory requirements for reducing risks to human health and the environment resulting from releases or threatened releases of hazardous substances into the environment.

2.1.2 *Resource Conservation and Recovery Act (RCRA)*—A congressional mandate that requires the management of regulated hazardous waste and requires that permits be obtained for facilities (both private and public) that treat, store, or dispose of hazardous waste.

2.1.2.1 *Discussion*—RCRA also establishes standards for these facilities and requires corrective actions (e.g., remediation) of past releases of hazardous waste from regulated waste management units.

2.2 *Acronyms:*

2.2.1 *AST*—Aboveground Storage Tank

2.2.2 *CERCLA*—Comprehensive Environmental Response, Compensation, and Liability Act

2.2.3 *CLP*—Certified Laboratory Procedure

2.2.4 *CMS*—Corrective Measure Study

2.2.5 *COA*—Code of Accounts

2.2.6 *CWM*—Chemical Warfare Materials

2.2.7 *D&D*—Decontamination and Decommissioning

2.2.8 *DOE*—Department of Energy

2.2.9 *(EC)*^{2}—Environmental Cost Engineering Committee

2.2.10 *ECAS*—Environmental Cost Analysis System

2.2.11 *ECES*—Environmental Cost Element Structure

2.2.12 *EM*—Environmental Management

2.2.13 *EPA*—Environmental Protection Agency

2.2.14 *ER*—Environmental Restoration

2.2.15 *FRTR*—Federal Remediation Technologies Roundtable

2.2.16 *FS*—Feasibility Study

2.2.17 *HRS*—Hazard Ranking System

2.2.18 *HTRW*—Hazardous, Toxic, and Radioactive Waste

2.2.19 *LTSM*—Long-Term Surveillance and Maintenance

2.2.20 *O&M*—Operations and Maintenance

2.2.21 *OECD*—Organization of Economic Cooperation and Development

2.2.22 *PA/SI*—Preliminary Assessment/Site Investigation

2.2.23 *RA*—Remedial Action

2.2.24 *RACER*—Remedial Action Cost Estimating Requirement (System)

2.2.25 *RCRA*—Resource Conservation and Recovery Act

[1] This classification is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.81 on Building Economics.

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[2] ECES was developed by the lnteragency Environmental Cost Engineering Committee to increase effectiveness of cost management for federal environmental projects. The complete ECES is available at http://www.em.doe.gov/aceteam.

2.2.26 *RD*—Remedial Design
2.2.27 *RFA*—RCRA Facility Assessment
2.2.28 *RFI*—RCRA Facility Investigation
2.2.29 *RI*—Remedial Investigation
2.2.30 *SLTM*—Surveillance and Long-Term Monitoring
2.2.31 *S&M*—Surveillance and Maintenance
2.2.32 *SM&A*—Sampling, Monitoring & Analysis
2.2.33 *USACE*—U.S. Army Corps of Engineers
2.2.34 *UST*—Underground Storage Tank
2.2.35 *WBS*—Work Breakdown Structure
2.2.36 *WM*—Waste Management

3. Significance and Use

3.1 This classification identifies and hierarchically arranges the work elements, activities, and tasks required for environmental projects. This classification increases the level of communication and allows for more effective exchange of cost and performance data between environmental projects.

3.2 This classification defines environmental work elements as major components of environmental projects. It is the common thread linking activities and participants in an environmental project from initial planning through operations and maintenance, D&D, and SLTM.

3.3 The users of ECES include program and project managers, cost estimators, and cost analysts in both the public and private sector.

3.4 This classification uses an increased level of standardization, uniformity, and consistency that provides a common basis for comparing, analyzing, and calibrating cost data. This classification can also be used as a checklist of project activities to be completed.

3.5 Use this classification when:

3.5.1 Developing a company-specific Code of Accounts (COAs) for capturing and reporting cost early in the project development for more effective project controls and management. COA is a logical breakdown of a project into controllable elements for the purpose of cost collection, control, and reporting. COA is organized at lower detailed levels that summarize to higher levels and is company and/or site and project-specific.

3.5.2 Developing a work breakdown structure (WBS) early in the project development for proper management of the project. The WBS provides a framework for managing the cost, schedule, and performance objectives of a project. This framework allows the project to be separated into logical components and makes the relationship of the components clear. The WBS defines the project in terms of hierarchically related action and product-oriented elements. Each element provides logical summary points for assessing technical accomplishments and for measuring cost and schedule performance.

3.5.3 Supporting programs and project functions. Use ECES for bid solicitation, collection, and evaluation; communicating project data between installations or agencies and industry; cost and schedule estimating; historical cost and schedule data collection; historical project data collection for technology deployments and project conditions; validating and calibrating cost estimates and software tools; and establishing and disseminating best practices and lessons learned.

3.6 The hierarchical nature of the classification allows for collecting data using more detailed lower level elements or for summarizing data at higher levels.

3.7 ECES, as described in this classification, is being included in the Remedial Action Cost Estimating Requirement (RACER)[3] system and the Environmental Cost Analysis System (ECAS)[4]. RACER is used for estimating cost, and ECAS is used to collect, maintain, and analyze the cost of completed projects. Federal agencies performing environmental work intend to incorporate the ECES.

[3] RACER is a parametric cost estimating tool for environmental projects. More information can be obtained at http://www.talpart.com/products/racer/index.html.

[4] ECAS is being developed by U.S. Department of Energy to capture cost of completed environmental projects. Please contact Bryan Skokan at 301-903-7612 for more information.

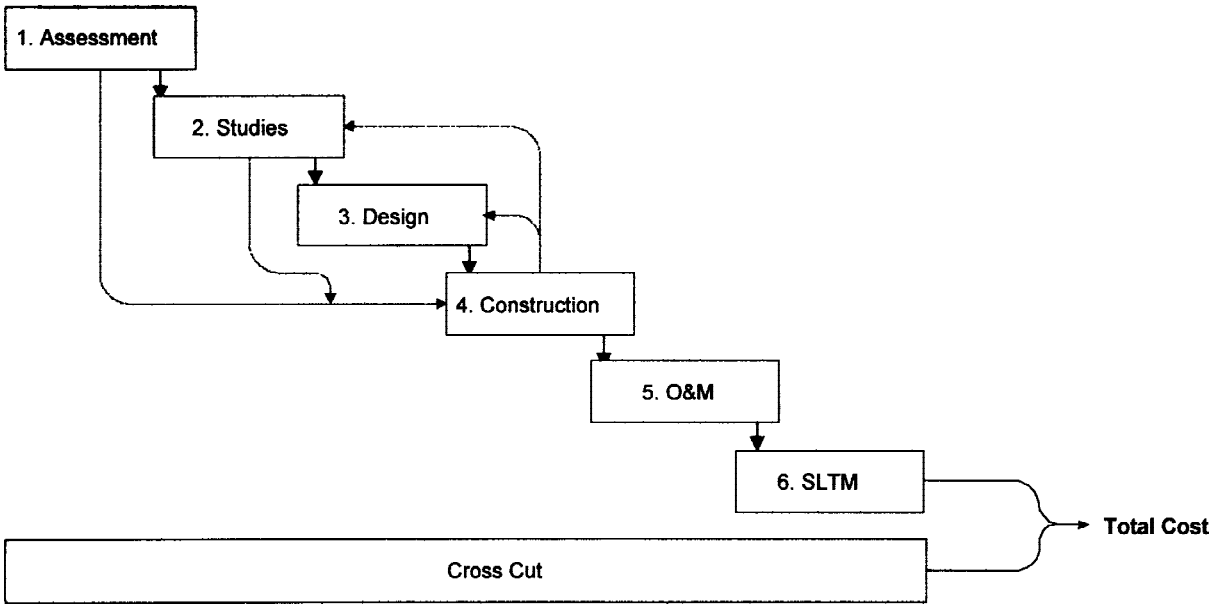

FIG. 1 Level 1 Life-Cycle Phases

4. Basis of Classification

4.1 In environmental management work, the life cycle of the project is represented by six different regulatory phases. With minor variations in the definitions, these life-cycle phases apply to most or all environmental projects including environmental restoration, waste management, decontamination and decommissioning, ordnance and explosive retrievals, underground storage tanks (USTs) and aboveground storage tanks (ASTs). In addition to the six regulatory life-cycle phases, a Cross Cut cost category was added to address costs not attributable to a particular phase or to a specific project. Figure 1 shows the life-cycle nature of environmental phases. As can be seen from Fig. 1 the phases may not be linear and their sequencing may be iterative since results from one phase may require the execution of earlier phases again, to meet the regulatory requirement. Additional information on each of the six Level 1 Phases is provided in Fig. X1.1 of Appendix X1. The six regulatory life-cycle phases are Phase 1 - Assessment, Phase 2 - Studies, Phase 3 - Design, Phase 4 - Construction, Phase 5 - Operations and Maintenance, and Phase 6 - Surveillance and Long-Term Monitoring. Cross Cut covers all phases of the lifecycle.

4.2 Whereas Level 1 depicts the life-cycle phases or timeframe of environmental work, Level 2 of the classification represents the major work elements that need to be performed in an environmental project. There are thirty-four major work elements included in Level 2 of the classification. In addition, there is an "Other," element available for those unique or special tasks that cannot be described closely by available elements. "Other" elements are designated by .9x numbering system. For the purposes of this standard, only two levels are discussed, but more detailed levels are available. Fig. 2 below illustrates a sample Level 2 for the Construction phase. Fig. 3 represents a matrix of the Level 1 elements and how they apply to each of the Level 2 categories. Phases 1 through 6 are listed by their phase number. The cross cut category is listed as "X."

4.3 As seen from Fig. 3, the columns on the left-hand side have been reserved for Level 1 life-cycle phases. The numbers in these columns provide a general guidance on the applicability of that phase to the Level 2 major work elements that are shown in the two columns under the Major Work Elements heading. For example, the Level 2 element, Preparation of Plans, is marked with numbers 1, 2, 3, 4, 5, and 6 in the left-hand columns. This means that this element can be applied or conducted during Phases 1 through 6. If any of the numbered rows under the column entitled Cross Cut is marked with letter "X," then that element is cross-cutting and the costs apply to more than one phase. The numbers are not necessarily all inclusive or definitive. There may be cases where an element may be applicable to a phase that is not marked or may be marked and not applicable for that specific project. This structure is flexible, and the user can use other phases even though they are not marked in the columns.

4.4 Positioned between the Cross Cut column and Level 2 is the Sub-Project Identifier that uses the alphabetical designations from a to z. The purpose of the Sub-Project Identifier is to allow users to differentiate between similar tasks that have the same designation number. For example, there may be two different Disposal Facility/Process, 4.13 (Level 1 - Phase 4, and Level 2-.13) to be constructed. To distinguish the first facility from the second, the letters "a" and "b" (i.e., "4.a .13" and "4.b .13") could be used to designate the first and second facility respectively. The use of the Sub-Project Identifier is not typical in many environmental projects, but it is included to provide flexibility to the structure.

5. Description of Environmental Cost Elements

5.1 The following describes the Level 1 phases. These descriptions outline what elements are generally included and, as appropriate, provide guidelines on what is not included. Generic definitions of the phases are included as are more specific application of the life-cycle phases to various types of environmental projects. Additional information on each of the six Level 1 Phases is provided in Fig. X1.1 of Appendix X1.

5.1.1 Below is a generic definition of Level 1 phases.

5.1.1.1 *Phase 1: Assessment*—Assess and inspect site and prepare site inspection reports.

5.1.1.2 *Phase 2: Studies*—Risk assessment, characterization and investigations, development and analysis of treatment or remediation options, and treatability studies.

5.1.1.3 *Phase 3: Design*—Engineering design and preconstruction activities of treatment or remediation alternatives.

5.1.1.4 *Phase 4: Construction*—Construction of selected treatment or remediation alternatives. Includes start-up, but excludes operations.

5.1.1.5 *Phase 5: Operations and Maintenance*—Includes all operations and maintenance, after startup and testing, for the selected treatment or remediation alternatives. Examples of O&M activities include inspection of facilities or areas, cost of utilities, preventive and corrective maintenance, operations of the equipment and facilities, cost of consumable materials, performance testing, replacement parts, and other miscellaneous activities.

5.1.1.6 *Phase 6: Surveillance and Long-Term Monitoring*—Activities, conducted after remediation, such as monitoring, repairing and replacing parts, record keeping, maintenance, and other activities that are required to maintain an adequate level of human health and environmental protection from hazardous and radioactive waste residues.

5.1.2 The Cross Cut category includes overhead or

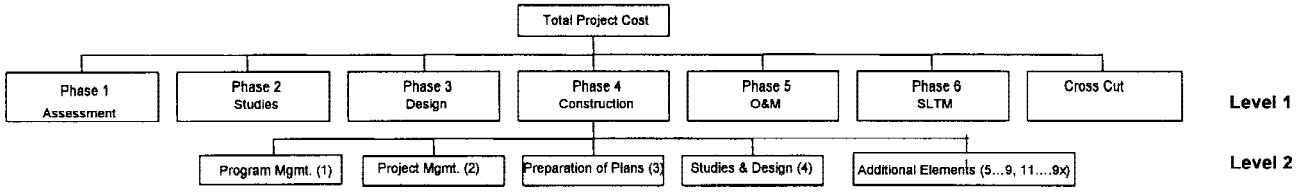

FIG. 2 Hierarchical Organization of ECES Classification Standard

Level 1								Level 2	
Ph 1 (1)	Ph 2 (2)	Ph 3 (3)	Ph 4 (4)	Ph 5 (5)	Ph 6 (6)	Cross Cut (X)	Sub. Proj.	Major Work Elements	
1	2	3	4	5	6	X		.01	PROGRAM MANAGEMENT, SUPPORT & INFRASTRUCTURE (Optional -Installation/Complex Wide Activities)
1	2	3	4	5	6	X		.02	PROJECT MANAGEMENT & SUPPORT (Operable Unit/Solid Waste Management Unit)
1	2	3	4	5	6	X		.03	PREPARATION OF PLANS
1	2	3	4	5	6			.04	STUDIES/DESIGN & DOCUMENTATION
1	2	3	4	5	6	X		.05	SITE WORK
1	2	3	4	5	6	X		.06	SURVEILLANCE & MAINTENANCE
1	2	3	4	5	6	X		.07	INVESTIGATIONS & MONITORING/SAMPLE COLLECTION
1	2	3	4	5	6	X		.08	SAMPLE ANALYSIS
1	2	3	4	5	6	X		.09	SAMPLE MANAGEMENT/DATA VALIDATION/DATA EVALUATION
	2	3						.10	TREATABILITY/RESEARCH & DEVELOPMENT
			4	5				.11	TREATMENT PLANT FACILITY/PROCESS
			4	5	6			.12	STORAGE FACILITY/PROCESS
			4	5	6			.13	DISPOSAL FACILITY/PROCESS
			4					.14	ORDNANCE & EXPLOSIVES REMOVAL & DESTRUCTION (CWM is included in Treatment Plant/Facilities WBS X.11 & Technologies WBS X.20-X.30)
			4		6			.15	DRUMS/TANKS/STRUCTURES/MISC. & REMOVAL
			4	5	6			.16	AIR POLLUTION/GAS COLLECTION & CONTROL
			4	5	6			.17	SURFACE WATER/SEDIMENTS CONTAINMENT, COLLECTION, OR CONTROL
			4	5	6			.18	GROUNDWATER CONTAINMENT, COLLECTION, OR CONTROL
			4	5	6			.19	SOLIDS/SOILS CONTAINMENT (e.g., CAPPING/BARRIER) COLLECTION, OR CONTROL
			4	5				.20	LIQUIDS WASTE/SLUDGES (e.g., UST/AST) COLLECTION AND CONTAINMENT
			4	5				.21	IN SITU BIOLOGICAL TREATMENT
			4	5				.22	EX SITU BIOLOGICAL TREATMENT
			4	5				.23	IN SITU CHEMICAL TREATMENT
			4	5				.24	EX SITU CHEMICAL TREATMENT
			4	5	6			.25	IN SITU PHYSICAL TREATMENT
			4	5				.26	EX SITU PHYSICAL TREATMENT
			4	5				.27	IN SITU THERMAL TREATMENT
			4	5				.28	EX SITU THERMAL TREATMENT
			4	5				.29	IN SITU STABILIZATION/FIXATION/ENCAPSULATION
			4	5				.30	EX SITU STABILIZATION/FIXATION/ENCAPSULATION
			4	5				.31	FACILITY DECOMMISSIONING & DISMANTLEMENT
1	2	3	4	5				.32	MATERIAL HANDLING/TRANSPORTATION
1	2	3	4	5	6			.33	DISPOSAL
			4	5				.34	AIR-EMISSION AND OFF-GAS TREATMENT
1	2	3	4	5	6	X		.9X	OTHER (Use Numbers 90-99)

FIG. 3 Level 1 and Level 2 Classification Matrix

program-wide activities that are required to implement environmental projects but which are not specific to a distinct project or phase. The designation X in Level 1 is used to represent those activities that are not readily segregated into phases 1-6. These activities are not generally associated with individual projects, but are essential in order to plan and implement the collected projects that comprise the majority of the program. These activities apply to both government/owner and prime contractor.

5.1.3 The six phases described in 5.1.1.1-5.1.1.6 apply to all environmental projects including environment restoration, waste management, and facility decontamination and decommissioning projects, but there are slightly different definitions for each. Fig. 4 provides examples of how the phases apply to various project types. The examples are not in any particular order.

5.2 The following sections describe the major elements of work established at Level 2 of the cost classification. These descriptions indicate what items are included or not included for the element and refer to those elements that are more applicable. Also note that some of the definitions refer to Level 3 or 4 elements that are available, but not currently included in this standard. Each element presented below includes the phase number and applicable definition, a list of subordinate elements, and supplemental notes where required.

5.2.1 *(.01) Program Management, Support, and Infrastructure*:

5.2.1.1 *All Phases*—This element includes expenses for main office personnel, overhead, and contract activities associated with the development of plans and programs for environmental restoration, compliance, waste management, pollution prevention, and other environmental management activities. Program support includes services rendered by offices and agencies in support of program planning such as legal, community relations, procurement, and contracting. Contract procurement activities, when the individual projects are unknown, would be included in this element. Program infrastructure includes overhead elements such as insurance, interest, fees, rent, warehousing, building maintenance, and equipment maintenance, required to implement environmental programs. A Government agency, contractor, or other organization may choose to account for its program management activity costs, including overhead, in this Level 2 element (.01) or may choose to spread such activity under individual elements (.02-.34, and .9x) of the structure. If program management costs, including overhead are spread across individual elements, then this (.01) element should not show any costs. Note that some costs are reported in this element even though some overhead charges are included in the project. Caution should be used to prevent double counting.

5.2.1.2 Also, for cross cutting activities that cannot be allocated among the phases, the designation X is used to identify that the cost is distributed for all activities.

5.2.2 *(.02) Project Management and Support*:

5.2.2.1 *All Phases*—The Project Management and Support element includes the development of project engineering, engineering support, and other management activities specific to individual projects. Unlike program management, the costs in this element cannot be spread over individual elements of the structure. While the definition for this element does not change from phase to phase, the magnitude of the effort may. For example, project support for community relations may be more predominant during Phase 2 (Studies). This element includes the project engineering tasks to develop project plans and reports such as cost estimates, schedules, implementation plans, project control plans and reports, procurement plans, and

Project Type	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
CERCLA	Preliminary Assessment/Site Investigation (PA/SI)	Remedial Investigation/ Feasibility Study (RI/FS)	Remedial Design (RD)	Remedial Action (RA)	O&M	Post Closure Surveillance and Long-Term Monitoring
RCRA	RCRA Facility Assessment	RCRA Facility Investigation/ Corrective Measure Study	Design portion of Corrective Measure	Corrective Measure	O&M	Post Closure Surveillance and Long-Term Monitoring
Waste Mgmt.	Preliminary Planning – Waste/Special Materials Operations	Pre-conceptual Design/Research and Development	Waste Management Facility Design	Waste Management Facility Construction	Waste Management Facility O&M	On-site Storage/Disposal Facility Surveillance and Long-Term Monitoring
D&D	Pre-Decommissioning Actions	Facility Shutdown/ Decommissioning and Research and Development	D&D Design	D&D Construction/ Actions	D&D O&M	Post Closure Facility Surveillance and Long-Term Monitoring

FIG. 4 Generic Description of Phases by Project Type

other project related tasks.

5.2.2.2 Some project management and support elements are performed across numerous phases of the same project or site, and these project management function costs are captured by using "X" at Level 1. An example of this type of activity is "institution controls" that takes place at the site-wide level and where costs cannot be clearly allocated to a distinct project. If such costs are included under Cross Cut, do not include the same cost in the Project Management and Support element.

5.2.3 *(.03) Preparation of Plans*:

5.2.3.1 *All Phases*—This element consists of developing all plans necessary to conduct environmental remediation, waste management, facility D&D, and SLTM projects. When using Phases 1-6, the plans are being prepared for specific projects. Activities include plan development from the beginning or planning stages to the end or closure of a site or project. The element work plan is intended to include all work plans (e.g., RD or RA work plans) needed for all projects. This task includes only the effort required to develop the plans. Work such as data acquisition (e.g., sample collection and analysis) is not part of this element. These activities are covered under Level 2 elements .07, .08, and .09.

5.2.3.2 For those situations where the preparation of plans applies to the site and program level, use number "X" at Level 1. For example, site wide health and safety plan, management plans, technical goals and objectives, and other plans that are prepared for more than one project. If these types of cost are included under Program Management, Support, and Infrastructure, do not include them in the Project Management and Support element.

5.2.4 *(.04) Studies/Design and Documentation*:

5.2.4.1 *Phase 1*—During Phase 1, the studies work for this element is far more limited. The only study element of significance during Phase 1 is the Hazard Ranking System (HRS).

5.2.4.2 *Phase 2*—The Studies/Design and Documentation element includes the development of all studies necessary to conduct environmental restoration, waste management, or facility D&D projects.

5.2.4.3 *Phase 3*—All of the design elements (included in the lower levels) address the preliminary, intermediate, pre-final, and final design. Project design includes design for environmental restoration projects, for decontamination and decommissioning projects, as well as for the design of treatment, storage, and disposal facilities. This element addresses only design work and should not be confused with the entire design phase. Phase 3, Design, includes all elements of work during this life-cycle phase (e.g., Program Management, Project Management, Preparation of Plans).

5.2.4.4 *Phases 4-6*—Includes all design necessary during construction, operations, and during the actual SLTM phases.

5.2.5 *(.05) Site Work*:

5.2.5.1 *All Phases*—This element includes activities to establish the physical infrastructure necessary to accomplish the project. The site work activities are for non-contaminated areas or for "clean-work." The element includes activities such as access road, clear and grub, excavation and earthwork, lighting, and other elements needed for site preparation, site improvement, and site utilities. It should also be noted that technology setup costs sometimes known as freight on board or technology specific mobilization and demobilization costs are fourth level costs included in the technologies (Level 2 elements.21 to .31, and .34) and not under site work.

5.2.5.2 For those situations where the site work applies to the site and program level, the users are to use number "X" at Level 1. For example, road construction and utilities may be common to more than one project. If the costs for this work are included under Program Management, Support and Infrastructure, do not include them in the Sitework element.

5.2.5.3 For more conventional projects and facilities (e.g., office buildings, guard houses, laboratory buildings), refer to building classifications such as UNIFORMAT II or MasterFormat.

5.2.6 *(.06) Surveillance and Maintenance (S&M)*:

5.2.6.1 *All Phases*—This element includes activities to ensure acceptable risk to the environment and human health and safety posed by radiological hazards, chemical munitions, or other hazardous materials inventory of active/inactive waste sites and facilities. Examples of S&M activities consist of facility transition, indoor and outdoor surveillance and maintenance, inspections, and other elements.

5.2.6.2 Letter "X" at Level 1 has been reserved for those surveillance and maintenance activities conducted across the program. For example, this will include S&M activities associated with cumulative impacts for the whole site such as an entire military base or entire set of facilities.

5.2.7 *(.07) Investigations and Monitoring/Sample Collection*:

5.2.7.1 *Phases 1-3*—This element includes the initial site reconnaissance and other generally available site characterization approaches such as meteorological monitoring. It also includes other site investigation methods including contaminant surveys, groundwater/surface water geological and soil investigations, and other geophysical investigations. Sample collections for all media are also included.

5.2.7.2 *Phase 4*—This element includes other site investigations including contaminant surveys, groundwater/surface water geological and soil investigations, and other geophysical investigation conducted during Phase 4. The sample collections for all media are also included.

5.2.7.3 *Phases 5 and 6*—This element includes all of the field work necessary to conduct on-site investigations of the site's physical (e.g., geological) characteristics and sample collection during O&M or SLTM.

5.2.8 *(.08) Sample Analysis*:

5.2.8.1 *All Phases*—This element addresses the analysis of samples in a laboratory, analysis in mobile facilities, and real-time analysis of the samples. The analyses for these items are in accordance with the Certified Laboratory Procedures (CLP) when they are conducted in fully equipped on-site laboratory facilities or off-site laboratory facilities. The mobile analyses (often performed in a trailer) are less extensive. The real-time analyses are conducted on location, often with instruments that provide an immediate reading.

5.2.8.2 The user of this structure must exercise caution to determine if costs included for the on-site CLP analyses are

burdened or unburdened. If they are unburdened the user should note whether the overhead costs are included in the element .01, Program Management, Support, and Infrastructure.

5.2.9 *(.09) Sample Management/Data Validation/Data Evaluation*:

5.2.9.1 *All Phases*—This element provides the chain-of-custody for the sample, the quality assurance, usability, and data analysis. The entire procedure for sample collection through final analysis is addressed. Sample disposal and modeling costs are included in this element.

5.2.10 *(.10) Treatability/Research and Development*:

5.2.10.1 *Phases 2 and 3*—This element includes the technology development testing and evaluation necessary to ensure successful cleanup implementation. All types of technologies (e.g., in situ biological, ex situ thermal, decontamination) regardless of whether they are deployed for environmental restoration, waste management, or decontamination and decommissioning are all included in this element.

5.2.11 *(.11) Treatment Plant/Facility/Process*:

5.2.11.1 *Phase 4*—This element includes construction of environmental management plant and facilities. These facilities are used for housing technologies for environmental cleanup, waste treatment, treatment or destruction of ordnance and explosives, destruction of decontaminated materials, or other purposes. These subordinate elements follow typical construction procedures. UNIFORMAT II and MasterFormat classifications use are recommended for each facility type at the lower level of the cost structure.

5.2.11.2 *Phase 5*—The operation of treatment plants/facilities includes the operations labor, material, utilities and consumables. The maintenance for these facilities includes the maintenance labor, equipment, replacements, material, and consumables. When multiple technologies are located in one treatment facility, a user may use either this element for all operations and maintenance costs or may include the operations and maintenance costs under the individual technology elements (cost elements .21-.30 and .34) when it is desirable to separate them. The actual facility design (Phase 3) is conducted under cost element .04, Studies/Design and Documentation, and the treatability and research and development is included in element .10.

5.2.12 *(.12) Storage Facility/Process*:

5.2.12.1 *Phase 4*—This element includes the construction of waste management storage facilities. The subordinate elements follow typical construction procedures. UNIFORMAT II and MasterFormat classifications can be used for each facility type at the lower level of the cost structure.

5.2.12.2 *Phase 5*—The Phase 5 definition is waste management storage facility O&M. The operation for these facilities includes the operations labor, material, utilities, and consumables. The maintenance for these facilities includes the maintenance labor, equipment replacements, material, and consumables.

5.2.12.3 *Phase 6*—Phase 6 for this element is on-site storage facility surveillance and long-term monitoring. The surveillance for these facilities applies to storage facilities that are no longer in operation (e.g., accepting/processing waste).

5.2.13 *(.13) Disposal Facility/Process*:

5.2.13.1 *Phase 4*—This element includes the construction of waste disposal facilities for sanitary, radioactive, hazardous, or toxic waste. These facilities are used for disposal of ordnance and explosives, radioactive waste, hazardous waste, or other waste as required for compliance. The subordinate element follows typical construction procedures. UNIFORMAT II and MasterFormat classifications can be used for each facility type at the lower level of the cost structure.

5.2.13.2 *Phase 5*—Waste Disposal Facility O&M is included in this element. The operation of these facilities includes the operations labor, material, utilities, and consumables. The maintenance for these facilities includes the maintenance labor, equipment, replacements, material, and consumables.

5.2.13.3 *Phase 6*—Phase 6 for this element is disposal facility SLTM. The surveillance for these facilities applies to disposal facilities that are no longer in operation (e.g., accepting/processing waste) and is performed to ensure that facility integrity is maintained. Examples of disposal facilities include landfills, aboveground vaults, underground vaults, deep well injection, silo disposals, and other disposal facilities.

5.2.14 *(.14) Ordnance and Explosives Removal and Destruction*:

5.2.14.1 *Phase 4*—This element includes the location, removal, and destruction of all ordnance conventional or chemical, fused or defused related scrap, propellants, and delivery vehicles during remedial action. It provides for subsurface data to delineate the extent of the contamination. It also includes the construction of temporary explosive storage bunkers.

5.2.14.2 The handling and treatment of the chemical warfare materials (CWM) after removal is not included in this element. Waste treatment is included in element .11, Treatment Plant/Facility/Process.

5.2.15 *(.15) Drums/Tanks/Structures/Miscellaneous Demolition and Removal*:

5.2.15.1 *Phases 4 and 6*—These include the demolition and removal of drums, tanks, and other structures contaminated with hazardous, toxic, and radioactive waste (HTRW). This element does not include filling portable hazardous waste containers or transporting of wastes to treatment or disposal facilities. Refer to elements .19, Solids Collection and Containment, and .32; Material Handling/Transportation for those activities.

5.2.16 *(.16) Air Pollution/Gas Collection and Control*:

5.2.16.1 *Phase 4*—This element includes the construction of trench systems, well systems, and other systems needed to capture fugitive dust, vapor, and gas.

5.2.16.2 *Phase 5*—This element includes the operation of trench systems, well systems, and other systems needed to capture fugitive dust, vapor, and gas. O&M also covers repairing and replacing components, cleaning areas and equipment, operation of the equipment, utilities, inspection of sites, and other miscellaneous activities.

5.2.16.3 *Phase 6*—This element includes all costs associated with long-term surveillance, maintenance, and monitoring

activities needed to ensure compliance with various requirements. Examples of tasks include inspection of site and making repairs.

5.2.17 *(.17) Surface Water/Sediments Containment, Collection, or Control*:

5.2.17.1 *Phase 4*—This element provides for the containment, collection, or control of contaminated surface water through excavation/dredging, through the construction of storm drainage piping and structures, erosion control measures, and through construction of civil engineering structures such as berms, dikes, and levees.

5.2.17.2 *Phases 5 and 6*—This element provides for the O&M and monitoring of storm drainage piping and structures, erosion control measures, and civil engineering structures such as berms, dikes, and levees. The effluent piping to treatment facility is included this element. Examples of activities include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs.

5.2.18 *(.18) Groundwater Containment, Collection, or Control*:

5.2.18.1 *Phase 4*—This element provides for the containment, collection or control of contaminated groundwater through the construction of piping, wells, trenches, slurry walls, sheet piling, and other physical barriers.

5.2.18.2 *Phase 5*—This element provides for the O&M, monitoring, and inspection of piping, wells, trenches, slurry walls, sheet piling, and other physical barriers to ensure proper functioning of structures and equipment. The effluent piping to the treatment facility is also included in this element. Examples of cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs.

5.2.18.3 *Phase 6*—This element includes costs of long-term surveillance, maintenance, and monitoring activities associated with abandoned wells, drains, slurry walls, and other elements to ensure there are no contaminant pathways or leakage of contaminants.

5.2.19 *(.19) Solids/Soils Containment, Collection, or Control (e.g., Capping/Barrier)*:

5.2.19.1 *Phase 4*—This element provides for the containment, collection or control of contaminated solids and soil through the construction of caps, construction of engineered barriers, excavation of contaminated materials, and other methods. Note that landfill construction is listed under Level 2, element .13.

5.2.19.2 *Phase 5*—This element provides for the O&M of caps, barriers, containment structures and equipment, and other items. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs.

5.2.19.3 *Phase 6*—This element includes the surveillance and long-term monitoring of caps to ensure that the caps are functioning as designed.

5.2.20 *(.20) Liquid Waste/Sludge (e.g., UST/AST Collection, and Containment*:

5.2.20.1 *Phase 4*—This element includes containment, collection, or control of liquid and sludges contaminated by hazardous, toxic or radioactive substances through dredging and vacuuming, and the furnishing and filling of portable containers. It includes the containment of liquids and sludges through the construction of lagoons, basins, tanks, dikes, and drain systems.

5.2.20.2 *Phase 5*—This element includes the O&M of vacuuming equipment, lagoons, basins, tanks, dikes, and drain system. The effluent piping to the treatment facility is included this element. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs.

5.2.21 *(.21) In Situ Biological Treatment*:

5.2.21.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of biological treatment systems. Biological treatment is the microbial transformation of organic compounds. Biological treatment processes can alter inorganic compounds such as ammonia and nitrate, and can change the state of oxidation of certain metal compounds. This element includes treatment technologies such as land farming, composting, and phyto-remediation.

5.2.21.2 *Phase 5*—This element includes the O&M of in situ bioremediation systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs. This element addresses the in situ application of these technologies; therefore, it is not part of a treatment train and does not require hazardous material handling or transportation.

5.2.22 *(.22) Ex Situ Biological Treatment*:

5.2.22.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of biological treatment systems. Biological treatment is the microbial transformation of organic compounds. Biological treatment processes can alter inorganic compounds such as ammonia and nitrate, and can change the oxidation state of certain metal compounds. Examples of ex situ biological treatments include activated sludge, composting, trickling filters, anaerobic digestion, and aerobic digestion.

5.2.22.2 *Phase 5*—This element includes the O&M of ex situ bioremediation systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, and utility costs. If this element is part of a treatment train or facility, then the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility. O&M cost of the individual technology can be included in this element if the specific cost can be clearly attributed to a technology.

5.2.23 *(.23) In Situ Chemical Treatment*:

5.2.23.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of

chemical treatment systems. Chemical treatment is the process in which hazardous wastes are chemically changed to remove toxic contaminants from the environment. In situ treatments include chemical barriers, oxygen release compounds, neutralization, and soil flushing.

5.2.23.2 *Phase 5*—This element includes the O&M of in situ chemical treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs. This element addresses the in situ application of these technologies; therefore, it is not part of a treatment train and does not require hazardous material handling or transportation.

5.2.24 *(.24) Ex Situ Chemical Treatment*:

5.2.24.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of chemical treatment systems. Chemical treatment is the process in which hazardous wastes are chemically changed to remove toxic contaminants from the environment. The types of ex situ treatments include oxidation/reduction, solvent extraction, chlorination, ozonation, ion exchange, neutralization, hydrolysis, photolysis, dechlorination, electrolysis reactions, and other technologies.

5.2.24.2 *Phase 5*—This element includes the O&M of these ex situ chemical treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs. If this element is part of a treatment train or facility, then the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility. The O&M cost of an individual technology can be included in this element if the cost can be clearly attributed to that technology.

5.2.25 *(.25) In Situ Physical Treatment*:

5.2.25.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of physical treatment systems. Physical treatment is the physical separation of contaminants from solid, liquid, or gaseous waste streams. Physical treatments generally do not result in total destruction or separation of the contaminants in the waste stream, consequently post-treatment is often required. In situ physical treatments include circulating wells/in-well air stripping, air sparging, soil flushing, vacuum blasting, and bioslurping.

5.2.25.2 *Phase 5*—This element includes the O&M of in situ physical treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, and utility costs. This element addresses the in situ application of these technologies; therefore, it is not part of a treatment train and does not require hazardous material handling or transportation.

5.2.25.3 *Phase 6*—With some in situ physical treatment methods such as coating, this element includes the regular application of paints, adhesive substances, or bonding substances on structures or equipment to contain the contaminants or to reduce exposure to contaminants as part of the operation and maintenance or long-term monitoring activity.

5.2.26 *(.26) Ex Situ Physical Treatment*:

5.2.26.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of physical treatment systems. Physical treatment is the physical separation of contaminants from solid, liquid, or gaseous waste streams. Physical treatments generally do not result in total destruction or separation of the contaminants in the waste stream, consequently post-treatment is often required. Ex situ physical treatments include filtration, sedimentation, flocculation, precipitation, equalization, evaporation, stripping, soil washing, and carbon adsorption. Cost includes process equipment, labor, and material associated with the construction or installation of the treatment unit.

5.2.26.2 *Phase 5*—This element includes the O&M of ex situ physical treatment systems. Such costs include chemicals required for treatment, replacement of parts, operation of the technology, preventive and corrective maintenance, and utility costs. If this element is part of a treatment train or facility, then the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility. Operation cost of the individual technology can be included in this element if the cost can be traced to a specific technology.

5.2.27 *(.27) In Situ Thermal Treatment*:

5.2.27.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of thermal treatment systems. Thermal treatment is the destruction or immobilization of wastes through exposure to high temperatures. In situ treatments include thermal blanket, six-phase extraction, and high temperature thermal desorption. In situ vitrification is included under cost element .29, In situ Stabilization/Fixation/Encapsulation.

5.2.27.2 *Phase 5*—This element includes the operations and maintenance of these in situ thermal treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, utilities, and preventive and corrective maintenance. This element addresses the in situ application of these technologies; therefore, it is not part of a treatment train and does not require hazardous material handling or transportation.

5.2.28 *(.28) Ex Situ Thermal Treatment*:

5.2.28.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one specific project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of thermal treatment systems. Thermal treatment is the destruction of wastes through exposure to high temperature in combustion chambers and energy recovery devices. Ex situ thermal treatments include several processes capable of incinerating a wide range of liquid and solid wastes such as fluidized bed, rotary kiln, multiple hearth, infrared, circulating bed, liquid injection, pyrolysis, plasma torch, wet air oxidation,

supercritical water oxidation, molten salt destruction, and solar detoxification.

5.2.28.2 *Phase 5*—This element includes the O&M of ex situ thermal treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, and utility costs. If this element is part of a treatment train or facility, the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility. Operation cost of the individual technology can be included in this element if the cost can be traced to an individual technology.

5.2.29 *(.29) In Situ Stabilization/Fixation/Encapsulation*:

5.2.29.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of stabilization/fixation/encapsulation treatment systems. Stabilization/fixation/encapsulation processes attempt to improve the handling and physical characteristics of the wastes, decrease the surface area, limit the solubility of any pollutants and detoxify contained pollutants. In situ treatments include inorganic/asphalt-base encapsulation, in situ vitrification, and pozzolan process. In situ vitrification is included in this element to encapsulate radionuclides and mobile contaminants.

5.2.29.2 *Phase 5*—This element includes the O&M of these in situ stabilization/fixation/encapsulation treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs. This element addresses the in situ application of these technologies; therefore, it is not part of a treatment train and does not require hazardous material handling or transportation.

5.2.30 *(.30) Ex Situ Stabilization/Fixation/Encapsulation*:

5.2.30.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of stabilization/fixation/encapsulation treatment systems. Stabilization/fixation/encapsulation processes attempt to improve the handling and physical characteristics of the wastes, decrease the surface area, limit the solubility of any pollutants and detoxify contained pollutants. Ex situ treatments include inorganic/asphalt-based encapsulation, sludge stabilization, vitrification, and other technologies.

5.2.30.2 *Phase 5*—This element includes the O&M of these ex situ stabilization/fixation/encapsulation treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, and utility costs. If this element is part of a treatment train or facility, the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility.

5.2.31 *(.31) Facility Decommissioning and Dismantlement*:

5.2.31.1 *Phase 4*—This element includes specific equipment procurement and installation of dismantlement systems. Decommissioning and dismantlement includes all activities associated with shutdown, dismantlement, and final cleanup of a nuclear, CWM, or other facility.

5.2.31.2 *Phase 5*—This element includes the O&M of these dismantlement systems. Some of the removal actions (e.g., asbestos abatement, piping & pipeline removal) are included in cost element .15, Drums/Tanks/Structures/Miscellaneous Demolition and Removal.

5.2.32 *(.32) Material Handling/Transportation*:

5.2.32.1 *Phases 1-5*—This element includes all costs associated with packaging, handling and transportation of waste to various facilities and sites.

5.2.33 *(.33) Disposal*:

5.2.33.1 *All Phases*—This element provides for the final placement of HTRW at on-site and off-site government and third-party commercial facilities that accept waste depending on a variety of waste acceptance criteria. Fees are assessed based on different waste categories, methods of handling, and characterization. Disposal may be accomplished through the use of secure landfills, surface impoundment, deep well injection, or incineration.

5.2.34 *(.34) Air-Emission and Off-Gas Treatment*:

5.2.34.1 *Phase 4*—This element includes the procurement of treatment equipment (the equipment can be acquired for one specific project or can be used on multiple projects or subprojects and can be either portable or stationary), and installation of air-emission and off-gas treatment systems. Air-emission and off-gas treatment systems treat air and off-gas to decrease the particulate material or to remove volatile organic compounds.

5.2.34.2 *Phase 5*—This element includes the operations and maintenance of these air-emission and off-gas treatment systems. Examples of O&M cost include inspections, replacement of parts, operation of the equipment, preventive and corrective maintenance, utilities, and other miscellaneous costs. If this element is part of a treatment train or facility, then the overall operation of the facility will be included in cost element .11, Treatment Plant/Facility.

5.2.35 *(.9X) Other (Use Numbers .90-.99)*:

5.2.35.1 *All Phases*—This element is provided to allow the user to include an element for items or activities that are not addressed in .01-.34. The phase-based approach has attempted to include all applicable elements to the extent practical. To allow the structure to remain consistent and useful, users are discouraged from using the "other" elements except for those activities that are unique or for special tasks that cannot be described closely by available elements. The .9X categories will be reviewed periodically to determine if new elements should be added to the structure.

6. Keywords

6.1 CERCLA; characterization; code of accounts; cost elements; cost estimation; decommissioning; decontamination; ECES; environmental cost structure; environmental management; environmental restoration; HTRW WBS; life-cycle costs; life-cycle phases; operations and maintenance; phases; program management; project management; RCRA; remediation; site investigation; standard classification; surveillance and long-term monitoring; waste management; work breakdown structure

APPENDIX

(Nonmandatory Information)

X1. DESCRIPTION OF LEVEL 1 PHASES

X1.1 The matrix below (Fig. X1.1) provides a description of each of the Level 1 phase cost elements. It shows who participates, gives an idea of when each phase begins and ends, lists general activities, and breaks down typical expenditures.

Phase	Start/Stop	Typical Activities & Products	Typical Cost Elements
Phase 1: Assessment Typical Participants: • Client/owner personnel • Technical professionals • Past or current plant employees	Start: Identify site or facility with potential contamination Stop: Site inspection report is complete	• Prepare plans • Assess & inspect site • Gather and review historical data • Sampling, Monitoring & Analysis (SM&A) • Meet with regulators • Write inspection report	• Fees for technical personnel • Sampling & analysis cost • Cost for document development • Mostly professional labor fees and expenses
Phase 2: Studies Typical Participants: • Client/owner personnel • Specialty expertise • Regulators & stakeholders • Technical labor & professionals	Start: Site assessment identified the contamination Stop: Potential technology or corrective action identified	• Attempt to discontinue contamination activities • Risk assessment • Characterization & investigation • Research & development • Remediation studies • Develop & analyse treatment/remediation options	• Planning & consultation fees • Collect & analyze samples • Model dev. & application • Tests & demonstrations • Prep. for meeting with regulators & public • Evaluate alternatives • Sitework & field work • Document development
Phase 3: Design Typical Participants: • Engineers • Project Management • Procurement and contracting	Start: Corrective or Remediation technology identified Stop: Completion & approval of all drawings, specifications & plans	• Design workplans • Engineering design prep. • Technical reviews • Cost estimate & schedule preparation • Pre-construction activities	• Fees for designers & planners • Document development & review costs • Meeting with regulators & permitting • Bid/procurement packages

FIG. X1.1 Description of Level 1 Phases

Phase	Start/Stop	Typical Activities & Products	Typical Cost Elements
Phase 4: Construction Typical Participants: • Construction contractors & subs • Inspection, quality assurance/control • Health & safety • Field techs (SM &A)	Start: Mobilization for construction Stop: Start-up & testing complete	• Mobilization & site prep. • Procurement of material & equipment • Construction or remedial action • Start-up & testing • Demob. & cleanup • Complete post-construction report	• Construction labor, material & equipment • Subcontractor costs & fees • Project mgmt & control • Regulatory permits • Document development • Sampling, monitoring & analysis • Secondary waste handling
Phase 5: Operations & Maintenance Typical Participants: • Facility maintenance & operations personnel • Field techs • Program manager	Start: Complete start-up & testing Stop: Cleanup or waste management goals are met	• Operation of facilities & equipment • Preventive & corrective maintenance • Regulatory sampling, monitoring, & analysis • Regulatory documentation • Training	• Utilities • Labor - O&M, inspections • Consumables (chemicals, resins, lubricants, etc) • Replacement parts & equipment • Sampling & analysis cost • Training cost & time • Permitting & report development costs
Phase 6: Surveillance & Long-Term Monitoring Typical Participants: • Facility maintenance crew • Field techs	Start: Operations have ceased Stop: When regulatory agreements are met or health risks are acceptable	• Sampling, monitoring & analysis • Records maintenance & management • Inspections & repairs • Regulatory doc. & reports	• Cost of admin. or records management personnel • Cost of inspection & repairs to facilities • Site maintenance • SM&A

FIG. X1.1 Description of Level 1 Phases *(continued)*