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ENVIRONMENTAL COST ENGINEERING BULLETIN

District Cost Engineering Capabilities for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects

1. **Purpose.** This bulletin describes the U.S. Army Corps of Engineers (USACE) Cost Engineering capabilities at Corps districts to develop HTRW project cost estimates and other cost engineering support activities from the programming/budgeting phase to final closeout.

2. **Introduction.** The HQUSACE Military Programs Cost Engineering and Programs Formulation Branch and the HTRW Center of Expertise (CX) have taken a number of actions in recent years to assist district cost engineering personnel to more effectively estimate HTRW Remedial Action (RA) and Operation and Maintenance (O&M) project costs and to support the entire HTRW project team. This bulletin addresses (1) USACE cost engineering policy; (2) the complexity of estimating the cost of HTRW projects; (3) cost engineering capabilities; (4) cost engineering tools, software programs and databases; and (5) cost engineering training to enhance the capabilities of cost engineers/estimators and other engineering staff elements.

3. **Policy.** ER 1110-3-1301 establishes the Cost Engineering office as a member of the project team. ER 1110-3-1301 clearly establishes the Cost Engineering office as having the responsibility for development and/or review of RA and O&M cost estimates for HTRW projects. This includes RA and O&M costs that must be developed during each applicable phase of the project such as Preliminary Assessment/Site Inspection (PA/SI), Remedial Investigation/Feasibility Study (RI/FS), Record of Decision (ROD), or Remedial Design (RD). This includes life-cycle cost estimates for competing technologies and alternatives during the RI/FS phase, and development of RA and O&M estimates during the RD phase or earlier.

4. **Developing HTRW Cost Estimates.**

a. HTRW projects differ from more traditional projects because they must comply with complex environmental laws that require Federal, state, and public coordination involvement. Therefore, development of an HTRW cost estimate of environmental restoration projects is often more complex and more involved.

b. Developing a cost estimate for environmental restoration projects is often more challenging than conventional projects. Because of the migratory nature of contamination, it is often costly and time consuming to determine the full extent of contamination before initiating work. As a contrast, the development of a cost estimate for construction of a conventional office building is relatively straightforward. Quantities of construction materials are readily calculated from design drawings and materials are available from many suppliers. Labor is normally available locally and worker production rates are well documented. In normal surface construction projects the dimensions can

more readily be defined with a good measure of precision. Whereas in a heterogenous subsurface environment, interpolations need to be continually made between data points.

c. The scope and cost of a cleanup project are largely determined by what is in the ground, whereas with vertical construction, the structure largely determines the scope and cost of the project. For a remediation project, quantities of contaminated groundwater or soil are not easily determined. Until actual remediation begins, the complete project scope is often developed based on professional judgements because the types of contaminants and extent of contamination are not completely known. Therefore, the chance of substantial variations in materials and quantities for remedial action projects is high. Additionally, the time it takes to begin and complete a remediation project once a site is determined to be contaminated is often lenghty. This is due to the time required to characterize a site (identify type and extent of contamination) as well as to optimize to the efficiency of the treatment process.

d. The treatment process may vary from original estimates and require additional processing time and expense. Also, there is usually intense interest and scrutiny by the public of any environmental contamination cleanup. This can lead to intervention by third parties (local public officials, regulators, or protest groups) resulting in suspension of work or delays while in performance of the contract. This intervention can, and often does, lead to delays in projects that will increase the costs. Finally, the need to wear personal protective equipment has significant impact on worker productivity and the time to complete a project. Accordingly, direct costs for environmental work are more difficult to estimate for both competing contractors and the government. Indirect costs for environmental work are also typically higher than those for conventional construction, and contractors must also include larger reserves for the higher risk they take on HTRW projects.

5. **Cost Engineering Capabilities.** USACE Cost Engineering offices responsible for developing HTRW cost estimates can generally provide the following services. Individual districts should be contacted to obtain specific capabilities.

a. Develop RA and O&M cost estimates from programming/budgeting phase to final project closeout;

b. Obtain and develop pre-remedial action (non-construction) costs such as cost estimates to prepare study activities and documents;

c. Develop Life Cycle cost estimates for comparing alternatives;

d. Review all contractor prepared or in-house HTRW cost estimates at all project phases;

e. Develop cost estimates for RA modifications/change orders and assist in negotiations;

f. Make comparative analysis of contractor’s proposals and assist in negotiations;

g. Provide technical cost support as a primary basis for development of project schedules;

h. Provide cost engineering assistance on reimbursable cost contracts to control contractors costs;

i. Provide cost input to designers on HTRW innovative technologies;

j. Track and record 'real time' costs for field activities during construction phases;

k. Develop contingencies for HTRW projects for any project phase;

l. Collect and analyze HTRW historical cost data.

6. **Cost Engineering Tools for Developing HTRW Cost Estimates.** The Cost Engineering offices at each district have cost estimating software, databases, and documents available to use in developing HTRW RA and O&M cost estimates at various project phases. Each of them are described below:

a. **Micro Computer-Aided Cost Engineering System (MCACES).** MCACES is the standard cost estimating system used by all district Cost Engineering offices. It is a detailed cost estimating program which is utilized primarily for development of cost estimates where detailed design information is available. MCACES is a proven system and has been used by the Corps to estimate the cost of military, civil works, and HTRW projects. A number of enhancements have been made to improve the use of MCACES for estimating HTRW projects. For example, MCACES includes a Unit Price Book (UPB) database that contains cost information on more than 21,000 unit price line items for construction labor, equipment, and material. Approximately 4,000 of these items are HTRW items which reflect costs for personal protective equipment, drum overpackings, treatment technologies, etc. In addition, a host of HTRW models and assemblies have been developed for MCACES that can be used to prepare remedial action cost estimates. The use of models and assemblies has several advantages including predefined tasks, standardization using the Remedial Action Work Breakdown Structure (RA WBS), and applicability when detailed design is not completed. Some of the technologies for which cost models and assemblies have been developed include bioremediation, air stripping, landfarming, carbon adsorption, slurry walls, extraction/injection wells, drum and tank removal, gas collection, soil vapor extraction, stabilization, etc. MCACES also includes an example HTRW remedial action estimate and templates.

MCACES is available both in DOS and Windows. The latest DOS version is MCACES Gold version 5.30. The latest windows version is MCACES for Windows (MFW) version 1.1a. It was was developed in FY 96 and is also currently being used by Corps Districts. MFW includes all the above UPB items and assemblies, but does not include models.

b. **HTRW Remedial Action (RA) and Operation and Maintenance (O&M) Work Breakdown Structures (WBS):** Both the RA WBS and O&M WBS are hierarchical breakdowns of work tasks in a numbered structure, organized in a logical construction sequence. Both structures provide a uniform standard to organize and report RA and O&M

work to be performed in accomplishing an HTRW project. The primary purposes of the structures are to (1) collect HTRW RA and O&M cost data in a standard format for cost reporting and tracking using the Project Management Information System (PROMIS); and, (2) to report, aggregate, and disseminate historical cost data in a standard format using the Historical Cost Analysis System (HCAS). The WBSs thus facilitate communication between management and technical disciplines concerning project elements during all project phases. Tracking and reconciliation of estimates between project phases is also accomplished more easily because of consistency of structure. WBS templates for RA and O&M are in MCACES for use in structuring cost estimates. Interpretation of the tasks listed in both WBSs is clarified by a data dictionary which indicates what is included in each task. The second (system) level of the WBSs is attached as an encl. The WBSs and data dictionaries are also available on the CX Internet. .

c. **RA Cost Contingency Analysis.** Contingencies include RA costs of unknowns, unforeseen uncertainties, and/or unanticipated conditions that are not possible to adequately evaluate from the data on hand at the time a cost estimate is prepared, but must be represented by a sufficient cost to cover the identified risks. Contingencies are normally separated into two elements for incremental analysis - design contingencies and construction contingencies.

(1) Design contingencies include estimated RA cost increases due to design incompleteness, detail changes, alternative design changes, and associated pricing inaccuracy. The extent of site characterization and assessment that has been accomplished to compute project quantities must be considered when determining design contingencies for HTRW construction costs. For example, estimates of groundwater volume and concentration are often possible only after field pump tests are completed. Many feasibility studies are prepared prior to these tests and so must rely on assumed volumes and concentrations. Design contingencies will normally decrease as design information becomes known.

(2) Construction contingencies are a reserve for RA cost growth due to adverse or unexpected conditions such as unforeseeable relocations, foundation conditions, utility lines in unknown locations, quantity overruns, or other unforseen problems beyond interpretation at the time of or after contract award.

One of the most important tasks in estimating the cost of RA projects is predicting contingencies that will cover all the uncertainties associated with the nature and extent of the contamination and the design and effectiveness of the remedy being used. The project/technical managers must be aware of the cost risk in RA projects and manage it by allowing for contingencies commensurate with the level of cost risk.

The Corps has acquired a site license to use a computer-based analysis software and database called HAZRISK, which is a windows-based program that analyzes a project and predicts cost contingencies. The HAZRISK database consists of historical costs and schedules of completed remedial actions from both Government and industry sites. It links cost growth and schedule with project characteristics such as the nature of the site, the contaminant(s) involved, the technologies selected, and the characteristics of the federal, state, and local regulatory requirements. HAZRISK is based on statistical analysis of 400+ HTRW projects. The program's Cleanup Contingency Allocation Model produces a bell-shaped curve that represents the range and probable distribution of both design and construction contingencies required for various confidence levels on similar-type projects.

For example, if a project or technical manager needs to be 50% confident that a particular project cost won't be overrun, HAZRISK will predict contingency for that level of confidence. Contingency amounts/percentages are calculated for each of the system (second) level RA WBS elements that are identified for the project. As would be expected, HAZRISK predicts higher contingencies for those projects that are less-defined such as those in study phases. As the project progresses from study to preliminary design and on to final design, the project team may have additional project-specific information that may override the statistical approach used in HAZRISK. Therefore, the Cost Engineering office can utilize all available project data and the project or technical manager's desired confidence level to arrive at a proposed contingency for each of the project second level RA WBS elements.

d. **Historical Cost Analysis System (HCAS).** Historical project cost data is valuable information that can be used as an aid in developing budget estimates and comparing estimated project costs to actual experience. An interagency group was formed in 1990 to coordinate HTRW cost engineering activities and developments among various Federal agencies. One of the initiatives of the group was to develop an interagency cost collection database for HTRW remedial action project costs, that would provide for standardization of RA cost collection among agencies. An interagency historical cost committee was formed in 1992 to coordinate development of the HCAS database which was initially completed in November 1993. HCAS does not produce cost estimates, but is used by the Cost Engineering office to obtain historical remedial action cost information for comparison or programming purposes. The current database contains award costs for over 60 remedial action projects mostly from the Corps but also from other agencies. Remedial action costs are collected and grouped in HCAS primarily by the HTRW RA WBS. HCAS is being reprogrammed in FY 97 into a windows-based environment. Also, HTRW Area Cost Factors are being proposed to normalize the HCAS cost data by location in the United States (refer also to paragraph 7.d.)

e. **Remedial Action Cost Engineering and Requirements (RACER) System.** RACER was designed by the Air Force to assist in the development and evaluation of alternatives for remediation, and to estimate costs of HTRW projects. The RACER system uses parametric models of cleanup systems to develop costs for HTRW remediation at all phases from characterization through final closeout. RACER uses generic cost models based on historical HTRW projects and technologies. The generic models available in RACER are modified to reflect actual conditions of new projects. The tailored models are then quantified and priced in accordance with the current costing data contained within the current UPB. RACER will estimate costs for studies, design, remedial action, and operation and maintenance. Over 100 generic cost models have been developed to date.

f. **HTRW Productivity Study.** Worker productivity is one of the most variable cost elements in a RA project. The HTRW CX developed a productivity study for HTRW projects by observing remedial action work in progress, reviewing construction progress records, performing a literature search, and conducting face-to-face interviews with remedial action contractors and Corps field personnel. The study documents the dramatic impact that worker protection level requirements have on construction production rates. Variables that affect production include work intensity, personal protective equipment requirements, temperature, meetings, suiting up/off, air tank/filter changes, personal decontamination, monitoring delays, breaks, cleanup, and dexterity. Two tables were developed identifying HTRW productivity factors for both light work and heavy work. The tables provide factors for each OSHA protection level, i.e., A, B, C, D+, and D. For example, if a person is performing heavy work, i.e., hand excavation, in 80 degree weather, and is in Level B protection, their

productivity factor from the table is .36. In other words, if they could excavate 1 cubic yard per hour under normal conditions in street clothes, they could only excavate .36 cubic yards per hour under this scenario. The results of the study were distributed to all districts as the "Productivity Study for Hazardous, Toxic, and Radioactive Waste (HTRW) Remedial Action Projects", dated October 1994.

g. **Treatment, Storage, and Disposal Facilities (TSDF) Report.** The TSDF report was completed and distributed in December 1994 to each district Cost Engineering office and construction division at each USACE division and district. This report identifies all known commercial hazardous waste treatment, storage, and disposal facilities in the United States. The report includes charges identified by each facility for items such as disposal of various types of waste, state taxes and fees imposed on the disposal of hazardous waste, points of contact with telephone numbers for each facility, and transportation costs for hazardous waste. The report also identifies what the treatment capabilities and restrictions are for each facility. The report will be updated in early FY 98.

h. **Engineer Instructions (EI) 01D010- "Construction Cost Estimates".** This is a Corps of Engineers "how to" manual to prepare construction cost estimates for all programs, Military, Civil Works, and HTRW. The manual provides the cost engineer with the necessary HTRW unique requirements and features to prepare an HTRW RA cost estimate. The final manual will be distributed to all cost engineering offices in FY 97.

i. **Cost-to-Complete (CTC)/RACER II:** This software was developed by the Navy primarily as a mechanism to provide a consistent, defensible and trackable program cost estimates for their HTRW budget submittals. The software is currently being reprogrammed to support the DOD Formerly Used Defense Site (FUDS) Program. USACE intends to use CTC in development of its FUDS budget cost estimates. The CTC module is a parametric budget cost estimating software that will predict a program cost for a project, based on a set of parameters entered into the system. CTC uses the Navy's cost estimating system, SUCCESS as its platform to obtain cost data. The RACER II module is included in the SUCCESS software, and contains many of the same models that are in RACER, but is developed in a conventional windows environment.

6. **Training.** The HTRW Center of Expertise, in conjunction with HQUSACE and Huntsville Engineering and Support Center offer a variety of HTRW courses and workshops which will enhance the capabilities for HTRW Cost Engineering and other engineering staff elements. The following courses specifically address cost engineering:

a. **HTRW Cost Engineering (PROSPECT)** - This course presents a brief HTRW program overview and instructions for the latest cost estimating systems/software in use for development of a HTRW cost estimate, such as the HTRW RA WBS; the HTRW O&M WBS ; HAZRISK; HCAS; and TRACES parametric estimating software. HTRW cost information included in MCACES databases are presented including HTRW items in the UPB; and HTRW assemblies and models. Direct and indirect cost considerations unique to HTRW cost estimating are covered including productivity effects due to level of protection requirements; decontamination; health and safety requirements; permits; taxes and fees; bonding; transportation; disposal; contingencies; Government costs; and HTRW historical cost collection. Approximately half the class time involves hands-on microcomputer usage.

b. **HTRW Overview Course (PROSPECT)** - This course summarizes USACE HTRW programs such as Superfund, Defense Environmental Restoration program (i.e.

Installation Restoration, Formerly Used Defense Sites) Base Realignment and Closure (BRAC), and support for others programs. The course addresses the Corps' HTRW organizational structure, HTRW project execution and management, contracting strategies, applicable environmental laws and regulations, community relations, ordnance and explosive wastes, risk assessment, health and safety, site characterization, environmental monitoring, cost engineering, UST projects, geotechnical and treatment design technologies, and lessons learned.

c. **Other HTRW PROSPECT Courses.** Other prospect courses available for Cost Engineering and other engineering staff elements include but are not limited to the following:

Cost Estimating Basics
Advanced Civil Works Construction Cost Engineering
Geotechnical Aspects of HTRW Sites
HTRW Construction Inspection
HTRW Risk Management and Decision-Making
Hazardous Waste Management and Manifesting
HTRW Environmental Regulations Practical Applications
Remedial Action Cost-Reimbursement Training
HTRW Laws & Regulations

d. **Software Specific Courses** - Software specific courses that can be used in the development of HTRW cost estimates are also available through both the Government and private software developers. They include the following:

MCACES Life Cycle Cost (LCC) Module
MCACES for Windows
MCACES for Windows Advanced
HAZRISK
RACER
SUCCESS

The HTRW Center of Expertise also conducts several workshops listed below:

Process Engineers Workshop
Innovative Technology Workshop
Soil Vapor Extraction and Bioventing Workshop
Technical Project Planning Workshop

The training opportunities presented above are not intended to be all inclusive, but represent a number of courses that will assist in understanding and developing HTRW project cost estimates. The HTRW CX continues to support development of new courses and workshops to meet the changing demands of HTRW restoration. Please contact the HTRW CX to discuss the courses that are presently available to meet your needs.

7. **Looking Ahead.** USACE is continuing to work with other agencies to develop and improve HTRW cost estimating standards, cost programs, and to collect and share data. Some specific initiatives now in progress include the following:

a. **MCACES 32-Bit (M32).** MCACES is currently being developed in a 32-bit Windows environment. It is currently scheduled to be complete by April 1998.

b. **HCAS for Windows.** HCAS for Windows (HCAS 3.0) is currently being developed and is scheduled to be complete in FY 97.

c. **Life Cycle Cost (LCC) for HTRW.** Modification of the LCC program to include HTRW specific items in its Maintenance and Repair Database.

d. **HTRW Area Cost Factors.** A study was completed on proposed development of HTRW Area Cost Factors in March 1997. Development of the HTRW Area Cost Factors for use in HCAS for localizing historical cost data.

e. **TSDF Report Update.** The TSDF Report will be updated and distributed to USACE offices in early FY 98.

8. **Summary.** USACE Cost Engineering offices have the resources and capabilities to effectively develop all costs associated with HTRW projects. Developing complete RA and O&M cost estimates from programming to final close out will enable our customers to more effectively manage costs on their HTRW project to completion.

9. **Points of Contact:**

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