AML HANDBOOK

TAB III PROJECT MANAGEMENT

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Mining and Minerals Branch
Land Resources Division-WASO
National Park Service

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INTRODUCTION

This booklet outlines how to manage an AML mine closure and remediation project. Topics include the elements of project management, project planning, levels of engineering detail, management of project construction, a checklist of quality assurance procedures, and finally a brief description of project management tools. Where appropriate, the discussion focuses on the unique aspects of AML projects. With this booklet, park staff have the guidance to manage small engineering and construction projects. For more detailed guidance, refer to the documents listed in the following box.

The planning phase for construction projects is most important in that early decisions affect the ultimate design and cost of a project. It is during this phase that the size, function, and technical performance requirements are determined and the budget is set. Once preliminary decisions are made, the nature and cost of a project are virtually predetermined.

The planning phase commences at initial identification of a project, and continues until receipt of detailed design and construction funds. Then the execution or construction phase begins and continues until completion and client (NPS) acceptance of the construction work.

LESSONS LEARNED

It is important to focus some attention on problems that repeatedly plague construction projects. These problem areas with recommended solutions include the following:

Failure to Design to Requirements. A tendency exists during design of a project to improve design by consideration of only the benefits of different design options. This tendency results in changes to project scope and cost that are substantially in excess of initial baseline estimates. Avoid this problem by insisting on a "design to cost" policy and tight fisted adherence to the project functional requirements.

Failure to Establish Realistic Baselines. There is a tendency to scope projects and establish schedules in such a manner that initial estimates are favorable. Establish baselines for cost, schedule, and technical requirements only when there is sufficient data to define realistic estimates. Further, require a careful review of project data by an independent organization prior to establishing baseline estimates.

Inadequate Change Control Procedures. Inadequate change control procedures lead to large scope and schedule changes that result in large cost increases. Change control procedures should be detailed, include cost considerations, and independent review.

Inadequate and Inaccurate Project Status Reports. To perform properly, project managers must continuously assess and analyze the project status. This analysis is impossible if reports are inaccurate or untimely. Minimize this problem by identifying early in the planning process what information is needed and when, and requiring the information in the contract. In addition, periodically verify submitted data against the data sources, and make corrections to the reporting procedure as necessary.

Lack of Experienced Project Management Staff. Personnel assigned or hired to manage a project must be experienced and knowledgeable in the specific type of construction. Assigned staff must be trained in the techniques for measuring performance against baselines, must have interdisciplinary experience related to the work, and must understand management techniques for successful project management.

Insufficient Use of Incentives. Even though incentives have been effective in the construction industry, the Federal government has not used incentives frequently. An incentive contracting policy could provide significant benefits.

PROJECT ELEMENTS

Effective management of construction projects requires the following elements:

* Clearly defined scope.
* Break down of work into appropriate contracts.
* Reliable cost estimates.
* Realistic schedules.
* Applicable functional requirements, performance criteria, constraints, and construction standards.
* Competent personnel.
* Efficient organization.
* Clearly designated authorities and responsibilities.
* Timely monitoring and reporting the status of work.
* Effective comparisons of progress and costs with schedules and estimates.
* Timely identification of potential or actual problems.
* Prompt action to eliminate or resolve problems.

The importance of planning in developing the preceding project elements cannot be overemphasized.

PROJECT ROLES

Responsibility for development of a project plan rests with the project manager. The role of project manager and other individuals and organizations that may participate in planning, design, and construction include the following:

The **contracting officer** is a representative of NPS who has the authority to enter into and/or administer contracts and make related decisions and findings.

The **project manager** has direct primary responsibility and accountability for management of the engineering and construction effort. He/she is designated the contracting officer's technical representative. Among the usual functions of the project manager are the following:

1) Assures costs, schedule, and scope requirements are met.

2) Acts as the principal contact between contractor and NPS.

3) Assures that instructions to the contractor are within terms of the contract.

4) Assures compliance by the contractor with technical, quality, safety, and administrative requirements of the contract.

5) Participates in formulation of plans and schedules, and recommends their approval/disapproval to the contracting officer.

6) Assures effective communication between project participants.

7) Submits requests for contract modifications to the contracting officer.

The **architect-engineer** furnishes preliminary and detailed plans and cost estimates, and sometimes validates construction engineering and contract bid cost estimates. The architect-engineer may also assist in preparation of design criteria, and perform special studies, trade-off studies, risk assessments, alternatives analysis, and estimates of contingency reserves.

The **construction contractor** usually furnishes all materials of construction, performs all construction work, and procures and installs equipment in accordance with construction drawings and specifications.

A **construction manager** provides professional management services, and functions in support of the project manager. The construction manager is generally not the same firm as the architect-engineer or construction contractor because there is a possibility of organizational conflict of interest. The decision to use a construction manager depends on size and complexity of the project, capabilities of the project management staff, and scope of the architect-engineer and construction contracts. Generally AML projects are small and straight forward, and do not require a construction manager.

TYPES OF PROJECT PLANS AND COST ESTIMATES

Six general types of plans and cost estimates are developed and used in the life of a construction project. Identification of a plan type denotes a certain level of accuracy and confidence

in the plan. These six types are defined below and in Fig. 1. The figure defines plan types by the required content, and provides guidance on the probable level of accuracy and appropriate contingency allowance. Note that the figure provides contingency guidance for both first time (green-field) and routine projects.

Order-of-Magnitude Plans and Estimates
Crude plans and estimates are developed for each project at the time of project identification. Since these are developed prior to conceptual design, they are order-of-magnitude, ballpark type plans that have the least amount of accuracy. This type of plan would result from information gathered by the AML Inventory Form, Tab VII.

Conceptual Plans and Estimates
Budget plans and estimates are required to obtain project authorization and funding appropriations. These plans and estimates are generally based on a completed **conceptual** design. Often these plans are used as baselines for justification of cost overruns. Contingency allowances should be substantial from 10 to 18% due to the lack of definitive design information. This type of plan would result from the information gathered by the AML Reconnaissance Form, Tab VII, and the preliminary cost estimate, Tab V.

Preliminary Plans and Estimates
Preliminary plans and estimates are developed from detailed background, topographical, and subsurface data. These plans determine the requirements and criteria which govern subsequent definitive design. Tasks include preparation of preliminary engineering studies, preliminary drawings and outline specifications, life-cycle cost analysis, preliminary construction cost estimates, and scheduling for project completion. Preliminary design provides identification of long lead time procurement items and analysis of risks associated with project development. Contingency allowances generally range between 8 and 13%.

Definitive Plans and Estimates
Definitive design continues development of the project based on approved preliminary design. Definitive design includes any revisions required of the preliminary design; preparation of final working drawings, specifications, bidding documents, and cost estimates; coordination with all parties which might affect the project; development of firm construction and procurement schedules; and analysis of contract proposals and bids. Contingencies generally range from 5 to 10% of the construction cost dependent upon the extent of uncertainties remaining.

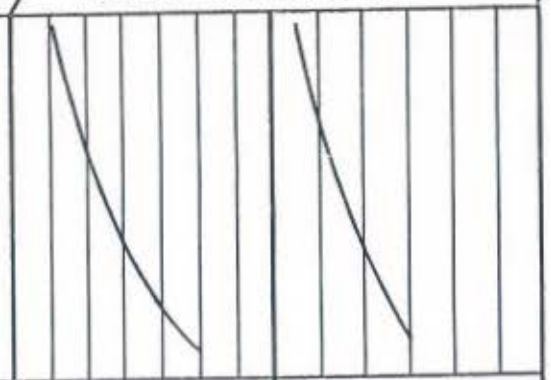
Fig. 1

ESTIMATE TYPES

DESCRIPTION	TYPE	PRODUCT, CAPACITY & LOCATION	FACILITY DESCRIPTION	PLANT LAYOUT	TIME TO PREPARE ESTIMATE	LIST OF EQUIP.-MAJOR EQUIP. PRICED	GENERAL ARRGMTS.-APPROVED BY CLIENT	OUTLINE SCOPE (GENERAL PLANT FEATURES)	ELECTRICAL MOTOR LIST WITH HP	PIPE & INSTRUMENT DIAGRAMS	ONE LINE ELECTRICAL DRAWINGS	DETAIL EQUIPMENT LIST - PRICED	PRELIMINARY DESIGN DRAWINGS	DRAWINGS OF PIPE SYSTEM RUNS	DETAIL SCOPE OF WORK	DETAIL CONSTRUCTION DRAWINGS	DETAIL SPECIFICATIONS	SUBCONTRACT & VENDOR-FIRM L.S. QUOTES
BID	6	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
ENGINEERS	5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
DEFINITIVE	4	•	•	•	•	•	•	•	•	•	•	•	•	•				
PRELIMINARY	3	•	•	•	•	•	•	•	•	•	•	•						
CONCEPTUAL	2	•	•	•	•	•	•											
MAGNITUDE	1	•	•	•	•													

ELEMENTS REQUIRED

PROBABLE CONTINGENCY AS A%



GREEN FIELD PLANT W/O HISTORIC PLANT COST OR WORK IN EXISTING PLANTS

GREEN FIELD PLANTS WITH HISTORIC DATA

Lowell, E. D., 1975, p. 25-3

Engineer's Estimate
The engineer's estimate may be made when bid design (see below) is 30, 60, and 100% complete. These estimates are usually prepared by an architect-engineer (frequently the architect-engineer who prepared the definitive design) 1) to determine the reasonableness of competitive construction bids, 2) as a control in evaluating cost and pricing data in negotiated contracts, and 3) as a check on the construction contractor. They are based on quantity take-offs and pricing of partly or fully designed portions of the project. They are probably unnecessary for small, straight forward AML projects.

Construction Bid Design and Estimate
Bid design and estimates are based on completed construction drawings, technical specifications, and competitive quotations from specialty subcontractors. The quality and completeness of the plans and specifications have a significant impact on the final price of the project.

Each plan and cost estimate should always be fully documented, and contain the plan type, reference year for the dollar figures, and date of the plan. Most importantly, the project manager must follow the NPS procurement guidance as given by Acquisition Guidelines, NPS-62.

The following table indicates the highest level of engineering generally required based on expected construction cost.

Construction Cost	Appropriate Engineering
>$10,000	Conceptual
>$100,000	Preliminary
>$250,000	Definitive
<$250,000	Bid

Exceptions to this guidance include unusual safety and health hazards, unproven or experimental technology, and any closures where the results would be uncertain without careful study and quality assurance.

The preceding six levels of planning are not all required for each project. For example, it is unnecessary to go through each of the six levels for a group of little prospect pits that have a high total closure cost but individually require nothing more than a few cubic yards of backfill and topsoil. Similarly, some parks have a large number of AML sites, and there is an opportunity to standardize designs and remediation methods. When a park provides standard designs and specifications, it is only necessary to perform conceptual design, and then final bid design and cost estimate.

SPECIAL FEATURES OF AML PROJECTS

Remediation of AML sites differ from typical construction projects in several ways.

First, there is the elimination or mitigation of public safety and health hazards associated with AML sites. Among others, the hazards include hidden shafts, abandoned explosives, bad air, and toxic substances. These hazards necessitate special training for investigators and construction workers, special construction methods, and coordination with mine rescue units. See Tabs VI and VII.

Second, there is the remediation of impacts to NPS resources. This necessitates closing the mines, constructing erosion and sedimentation control, and revegetation. Further, the remediation may constitute a major Federal action which triggers the NEPA process. See Tab II.

Third, there may be preservation of historically or culturally significant AML sites as mandated by the National Historic Preservation Act, and NPS standards and guidelines.

Fourth, management of the AML site for specific wildlife habitats may be necessary, specially for threatened and endangered species as required under the Endangered Species Act.

If you need help with the special aspects of AML sites or have any questions, phone Mining and Minerals Branch, (303) 969-2092.

PLANNING AND ENGINEERING

PURPOSE

The planning phase for AML projects is most important with respect to design and cost. It is during this phase that the closure method (temporary-->permanent), environmental remediation, and historic preservation are determined, and the budget set. Once the preliminary decisions are made, the nature and cost of the project are virtually predetermined.

The planning phase starts with the initial decision to remediate an AML site, and continues until receipt of the detailed design for construction. In most cases, the work beyond conceptual design will be done by others, for example contractors or the federally funded State AML programs. Nevertheless, park AML project managers must decide the conceptual outlines of a particular project, oversee performance of the work, and approve final project acceptance on behalf of NPS.

This section very briefly summarizes the planning process to provide park AML project managers the background for their oversight role. In addition, this section will be useful in developing a plan to coordinate with other agencies and procuring the engineering and construction services. Of the various types of engineering studies shown in Fig. 1, only preliminary and definitive design are described in detail. Conceptual design is described in Tabs V and VII. The other levels simply represent variations of content and purpose from the levels described below.

DESIGN CRITERIA

Development of design criteria begins at the time a project is first identified. The foundation of the criteria is a statement of functional requirements that the project must meet. These functional requirements are further developed, validated, and expanded during conceptual and preliminary design.

The design criteria document should provide the architect-engineer with the following information:

1. Define purpose and functional requirements of project.
   a. Proposed mine closures, erosion and sedimentation control, revegetation, and historic preservation.

   b. Include a general arrangement drawing.

2. Provide a general description.

   a. Site location with map.

b. Construction conditions, temporary access, fencing, work areas, disposal areas, and borrow areas.

c. Site preparations.

d. Existing utilities.

e. Special security, environmental, safety (including mine safety), and health needs.

3. Provide all design requirements to be applied to meet the needs of the project such as performance criteria, limits, constraints, capacities, quantities, and area allocations.

4. Incorporate or reference construction specifications and guidelines.

a. NPS.

b. Applicable national and local building codes.

5. Incorporate or reference environmental regulations and permit requirements.

6. Define quality assurance measures.

7. Provide the designer with the following additional documents:

a. Studies, reports, and conceptual designs.

b. Copies of sketches and drawings including site and location plans, topographic maps, and plan of existing utilities.

c. List of government furnished equipment, supplies, and computer programs available for use by designer.

d. List of required drawings, and their size and scale.

e. Copy of project management plan.

f. Information on the procurement of construction such as required contract clauses, type of specifications, and contents of bid packages.

Completeness of the design criteria is important; however, avoid citing superfluous codes and standards. Superfluous criteria violate a primary goal which is to narrow the criteria to only those applicable to a specific design effort.

Give designer leeway to exercise expertise in the engineering disciplines and to use up-to-date design and construction methods.

REQUEST-FOR-PROPOSALS

When the need arises to procure engineering or construction services, follow NPS guidelines and the Federal Acquisition Regulations. The contracting officer has the prime responsibility for soliciting contract services: however, the project manager must provide technical material. The following outline summarizes the technical information typically provided in a request-for-proposals (RFP).

TABLE I
OUTLINE OF TECHNICAL PART OF REQUEST-FOR-PROPOSALS

I. Introduction
   A. Background and short history of project.
   B. Define project (what, where, when, why, who, how).
   C. Summarize need (level of engineering or construction).

II. Scope of Work
   A. Define the objective functional requirements.
   B. Define the limits and content of the work.
   C. Summarize the primary design criteria.
   D. List available data and reports.
   E. Provide a broad work breakdown structure.
   F. Provide project milestones and expected deadlines.
   G. Describe services, equipment, and facilities provided by client.

III. Client's Project Management
   A. Organization
   B. Responsibility and authority.

IV. Recommend Outline of Contractor's Technical Proposal
   A. Statement of work by work breakdown structure and task.
   B. Project schedule.
   C. Cost estimate (define outline in order to compare proposals and evaluate technical adequacy).
   D. Statement of contractor's qualifications.
   E. Project management and resumes of professional staff.

When deciding on who will perform design and construction work, consider the following factors:

1. Mine engineering and remediation expertise.

2. Availability, existing and projected work loads.

3. Size, complexity, and urgency of the project in regard to the candidate organizations qualifications and previous work experience.

4. Suitable professional and labor skills.

5. Adequate and appropriate construction equipment.

Some of the larger parks have substantial construction capabilities within their maintenance departments. The preceding factors also can be used to evaluate whether a particular maintenance department has the qualifications and availability to provide AML engineering and construction services.

CONCEPTUAL DESIGN

For an AML project, conceptual design is accomplished by completing the Site Reconnaissance Form in Tab VII and the cost estimate in Tab V.

PRELIMINARY DESIGN

The fundamental objectives of preliminary design are to satisfy the AML program objectives and the various statutory requirements while achieving minimum construction costs. The objectives that distinguish preliminary design from conceptual design include validation of technical adequacy and project feasibility; identification and quantification of any project risks; and estimation of reliable project costs and completion schedule. An outline of a typical preliminary design and cost report is given below.

These objectives are accomplished by developing the following (see also Fig. 1):

1. Requirements

   a. Project scope, performance requirements, general project criteria, and design parameters including applicable codes and standards.

   b. Statutory or other special requirements.

   c. Health, safety, and security requirements.

   d. Quality assurance requirements.

2. Design and Engineering

a. Potential environmental damage and methods of remediation.

b. Site development -- mine closures, erosion and sedimentation control, surface remediation, revegetation, historic preservation. Describe work breakdown structure and engineering methods. Include traceable backup details.

c. Trade-off studies and alternative design approaches to optimize design and minimize costs.

d. Types and materials of construction.

e. Specifications of major equipment and long lead-time items.

f. Drawings include layout and general arrangement. Generally, one line electrical, and piping and instrument drawings are also provided; however, these are not applicable to AML sites unless the project involves significant historic preservation.

3. Project Planning

a. Estimate resource needs -- labor, equipment, and capital.

b. Project schedule including engineering, procurement and construction. Special care must be placed on identifying long lead-time items and critical tasks.

c. Identification and elimination of uncertainties.

4. Feasibility

a. Estimate costs for the subsequent phases of design, engineering, and construction.

b. Estimate construction labor, equipment, and material quantities. Major items of construction and equipment should be estimated from quantity take-offs while remainder may be estimated by factors.

c. Provide contingency requirements and analysis.

d. Describe cost estimating methodology and provide backup details.

TABLE II

OUTLINE OF PRELIMINARY DESIGN REPORT

I. Introduction

II. Project Overview
- A. Project Background and Justification
- B. General Site Description
- C. Mine Closure and Remediation Options

III. Selected Mine Closure and Site Remediation
- A. Mine Closure
- B. Surface Remediation
- C. Revegetation
- D. Material Requirements
- E. Equipment Requirements
- F. Labor Requirements

IV. Engineering and Construction Schedules

V. Cost Estimate
- A. Mobilization
- B. Excavation and Backfill
- C. Mine Closure
- D. Site Grading
- E. Erosion and Sedimentation Control
- F. Site Cleanup
- G. Revegetation
- H. Wildlife Restoration
- I. Risk Assessment and Contingency Allowance
- J. Detailed Engineering
- K. Construction Cost and Maintenance

Appendix: Technical Specifications
1. General
2. Mobilization
3. Mine Closure
4. Excavation and Backfill
5. Site Grading
6. Site Cleanup
7. Revegetation
8. Wildlife

Engineering Drawings
- D1 Site Location Map
- D2 Pre-Remediation Site Plan
- D3 Mine Closure Plan and Cross Sections
- D4 Post-Remediation Site Plan

Preliminary designs may be performed by State AML programs, NPS park or central engineering services, and architect-engineering firms. A typical preliminary design report has the content and organization shown in the above box.

DEFINITIVE DESIGN

The architect-engineer firm utilizes the client (NPS) approved preliminary design and any revised project design criteria as the base for definitive design. Completion of definitive design ends the design phase of a project, and normally allows the beginning of the construction phase. Definitive design includes:

1. Restudy and redesign work resulting from necessary changes identified by preliminary design.

2. Development of final working drawings and specifications for procurement and construction.

3. Plan for construction and methods of performance.

4. Schedules for build-up and phase-out of construction labor, equipment, and materials. Schedules must provide for items that require a long lead-time for procurement, and adequate time for administrative actions and permitting.

5. Identification of work packages and subcontracts.

6. Identification of all required permits and plan for permit applications.

7. Preparation of procurement plan.

8. Detailed estimates of the cost of construction. Estimates based on detailed quantity take-offs.

9. Design reviews by client. Client reviews typically occur after completing 30%, 60%, and 100% of design work.

10. Procedures for change control and client acceptance of work completed.

11. Quality assurance/quality control

As discussed above, many AML projects will not require detailed engineering design. If they do, generally it will be procured from engineering firms.

PROJECT RECORDS

A project record is maintained by the project manager, and typically contains the following documents:

1. All engineering plans.
2. Design criteria.
3. Management plan and changes thereto.
4. Selection plans for contractors.
5. Contracts.
6. Project authorization and all modifications.
7. All cost estimates.
8. Project reports.
9. Construction photographs (before, in-progress, and after).
10. Minutes of project meetings.
11. Construction completion, inspection, and acceptance reports.
12. As-built drawings.
13. Documentation required by NPS guidelines and Federal Acquisition Regulations.

CONSTRUCTION FOR SMALL PROJECTS

TYPES OF CONTRACTS

The two basic types of contracts are fixed-price (also called lump-sum) and cost-plus. Basis of payment for fixed-price is a stipulated amount. Fixed-price contracts should be used to the maximum extent feasible. Basis of payment for cost-plus is the actual cost of the construction plus a fee. Cost-plus contracts should be used only for specialty work and where it is unreasonable to expect the contractor to take the client's (NPS) risk on unknown elements. For example, when the volume of a shaft is unknown, the quantity of backfill should be contracted on a unit cost plus fixed or incentive fee.

If it is determined that a cost-plus contract is appropriate for a certain part of the project, separate this part from the main contract and handle the main contract on a fixed-price basis. As many elements of the project as practicable should be contracted on a fixed-price basis.

Other contract variations include fixed-price-incentive-fee, cost-plus-award-fee, and cost-plus-incentive-fee.

NPS PLANNING FOR CONSTRUCTION

NPS functions should be done on time with no unnecessary disruption to contractor plans. When equipment or materials are supplied by NPS or other participants, assure that deliveries comply with schedules to minimize requests for time extensions and cost increases. Allow time for bidding, bid evaluation, award, and subsequent mobilization by the contractor.

For cost-plus contracts, select contractor early so that contractor can contribute practical and economical suggestions, and help in project design and construction schedule.

In addition:

1. Set aside adequate work space for the contractor and free access to the work area. In situations where several independent contractors will be working in the same area at the same time, develop procedures to coordinate their work and handle the unavoidable conflicts.

2. Orient the contractor as to:

    a. Authority and responsibilities of the contract officer, project manager, architect-engineer, inspectors, and other project participants.

b. Administrative procedures for review and approval of shop drawings.

c. Procedures for changes to the contract.

d. Provisions for special safety (such as abandoned mines), environmental protection, security, quality assurance, and other requirements for performance.

e. Conditions under which the work shall be performed and accepted.

f. Reporting procedures, and coordination of contractor's cost and schedule control with NPS project management staff.

g. Furnish contractor with applicable NPS regulations and procedures.

3. Cost and schedule breakdowns must be reviewed by the project manager, architect-engineer, and approved by the contract officer. Upon approval, the breakdown and reimbursement factors become the basis for progress payments.

4. Approve contractor's management plan including organization, key personnel, reporting and records procedures, subcontract procurement, construction plan, manpower scheduling, and cost control.

As appropriate, the contract should incorporate the preceding items.

INSPECTION

The project manager may elect to have inspection services performed by the architect-engineer, a construction manager, or with in-house experts. NPS personnel should not conduct the inspections unless the construction is routine or qualified experts are performing the inspections. Inspection services are never performed by the construction contractor.

Generally, inspection services include the following:

1. Establish and maintain survey control and benchmarks for horizontal and vertical references.

2. Verify all shop drawings to assure conformity with approved design, working drawings, and specifications.

3. Inspect and approve workmanship, materials, and equipment.

   a. Functional inspections determine the overall compliance with contract drawings and specifications, determine the adequacy of the design work, and include testing of operating equipment.

   b. Detailed inspection includes verification of details, such as checking location and size of reinforcing bars, maintaining records of concrete testing, verifying the use of proper welding rods, checking riveting and welding, and other inspection for quality assurance purposes. It starts with initial construction operations and extends through all construction stages.

   c. Continuous inspection and testing must be done for all work where the quality cannot be determined after construction without detriment to the work. This would be the case for all permanent mine closures.

4. Inspection instructions should provide the following:

   a. Statement of quality characteristics to be inspected.

   b. Organization or individuals responsible for inspection.

   c. Acceptance and rejection criteria.

   d. Methods of inspection.

   e. Evidence and records of inspection.

5. Conduct or procure field or laboratory tests of construction workmanship, materials, and equipment.

6. Evaluate scope changes and other proposals submitted by the construction contractor. Prepare estimates of changes in the contract price and schedules.

7. Prepare monthly progress reports including the status of material and equipment deliveries, and reports of work performed for payment.

8. Furnish reproducible "as built" drawings and marked up specifications showing construction as actually accomplished.

<u>Inspection schedules</u> should be based on the construction schedules and the project quality assurance plan.

1. Inspection should be conducted prior to acceptance of the work.

2. Inspection should be done when and where necessary to provide the degree of assurance required to determine that the materials and construction comply with the contract, drawings, and specifications.

3. Inspection requirements and testing should be clearly defined in the contract documents along with the authority, duties, and responsibilities of the inspectors.

Final acceptance is a written statement by the project manager that the work performed by the construction contractor has been accepted as being in accordance with approved plans and specifications.

QUALITY ASSURANCE

The goals of quality assurance are to assure that the AML remediation projects are designed in a controlled manner; and designed and constructed according to sound engineering standards, quality practices, and technical specifications. Quality assurance begins with conceptual design and continues through preliminary design, definitive design, and construction. It comprises both quality engineering and quality control (inspection).

DESIGN

Quality assurance during design includes review of materials of construction and installed equipment for economics, compatibility with other components, and maintainability.

Continuous review of the design is required to ensure the project can be constructed as designed using the most efficient techniques. The cost of construction is greatly dependent on the design work. Constructability includes consideration of interference between project components and engineering disciplines, compatibility of specifications with changing seasons, and integration of different contractors on the job site.

The most important aspect of quality assurance during design is continuous surveillance of the design. Periodic design reviews are seldom, except in very small projects, adequate to assure a quality product. Continuous surveillance assists in reducing critical comments during design reviews, and reduces the total design effort by reducing time spent on change proposals and corrections.

To be acceptable, a quality assurance program for design should have a "yes' answer to the following questions:

	YES	NO
1. Is design surveillance continuous and are there reviews after each design phase (i.e., conceptual to definitive)?		
2. Are performance requirements specified?		
3. Are responsibilities and lines of communication defined?		
4. Are errors documented and corrective actions defined?		

5. Does verification provide for qualified and independent review (immediate supervisors generally are not considered independent)?

6. Are design changes subject to the same review and verification as the original design?

7. Have procedures been established to determine that applicable regulations, codes, standards, design bases, acceptance/rejection criteria are included in procurement documents?

8. Do procurement documents require contractors to provide an acceptable quality assurance program?

9. Are procedures established that describe how obsolete or superseded documents are replaced by revisions?

CONSTRUCTION

The project manager must assure that the contractor establishes and follows a plan for certifying shop drawings, material testing, and work completion. The project manager must also assure that the architect-engineer, construction manager, and government staff act in a timely manner on approval of submittals. An effective program includes quality assurance reports from contractors and quality control inspectors together with procedures for reviewing the reports and taking prompt effective action.

The quality assurance program must be adequately staffed with qualified inspectors. In addition, continual checks must be made to assure that all of the quality assurance functions are being performed and prompt corrective actions are taken.

All quality assurance reports, test results, and inspections should be under the control of the NPS.

To be acceptable, a quality assurance program for construction should have a "yes" answer to the following questions:

	YES	NO
1. Does the program describe what, when, where, and how inspections are performed?		
2. Are the organizational responsibilities for inspection described?		

	YES	NO
3. Do inspection procedures provide acceptance and rejection criteria including receiving inspections for purchased materials, equipment, and services?		
4. Do procedures identify hold points beyond which work may not proceed until inspected?		
5. Are inspectors qualified?		
6. Are inspection results documented and evaluated, and their acceptability determined by a responsible person?		
7. Do test procedures provide instructions, methods of analysis, methods of documentation, acceptability of results, corrective action, and review by responsible individual?		
8. Have procedures been established to calibrate test equipment according to recognized standards?		
9. Have controls been established to identify and track samples?		
10. Are procedures in place establishing an effective corrective action program?		

MANAGEMENT TOOLS

GANTT CHARTS (BAR CHARTS)

Bar charts are the most common project control tool used in the construction industry. An example is shown in Fig. 2. In many cases, it is the only aid used. Perhaps the reason for this popularity is its simplicity, almost universal understanding, and ability to be used at all levels of supervision. Some of the shortcomings of bar charts include the following:

* Do not force detailed analysis and breakdown of activities.
* Do not model interdependencies of tasks.
* Greater likelihood that activities will be omitted.
* Fail to communicate as much detailed information (sequential activities, activities critical to project completion, slack time, earliest and latest start time).
* Fail to adequately show consequences of scheduling deviations.
* Unsuitable for updating purposes.

NETWORKING TECHNIQUES

Networks such as critical path scheduling (CPS, see Fig. 3) and project evaluation and review technique (PERT) were developed to overcome disadvantages of bar charts. Networking is extremely useful in scheduling of construction projects from most complex to a simple job. In complex projects, a hierarchy of networks are developed to meet the needs of different levels of management.

It is important to remember that networks are dynamic and require continuous update from the lowest detail in order to be useful for project management. When considering the use of networks, their dynamic nature must be considered along with the labor and computer resources required to maintain the system. Complicated and expensive procedures for updating the network may result in a useless system and a burden on the project.

PERCENTAGE COMPLETION CURVES (S CURVES)

Percentage completion curves plot forecasted and actual cumulative percent completion on a time scale. For example, during construction plot cumulative labor hours forecasted and actual hours expended to date. See Fib. 4. A number of

different plots can be made including material, equipment, and costs by various breakdowns. Plot variables that dominate progress of the project.

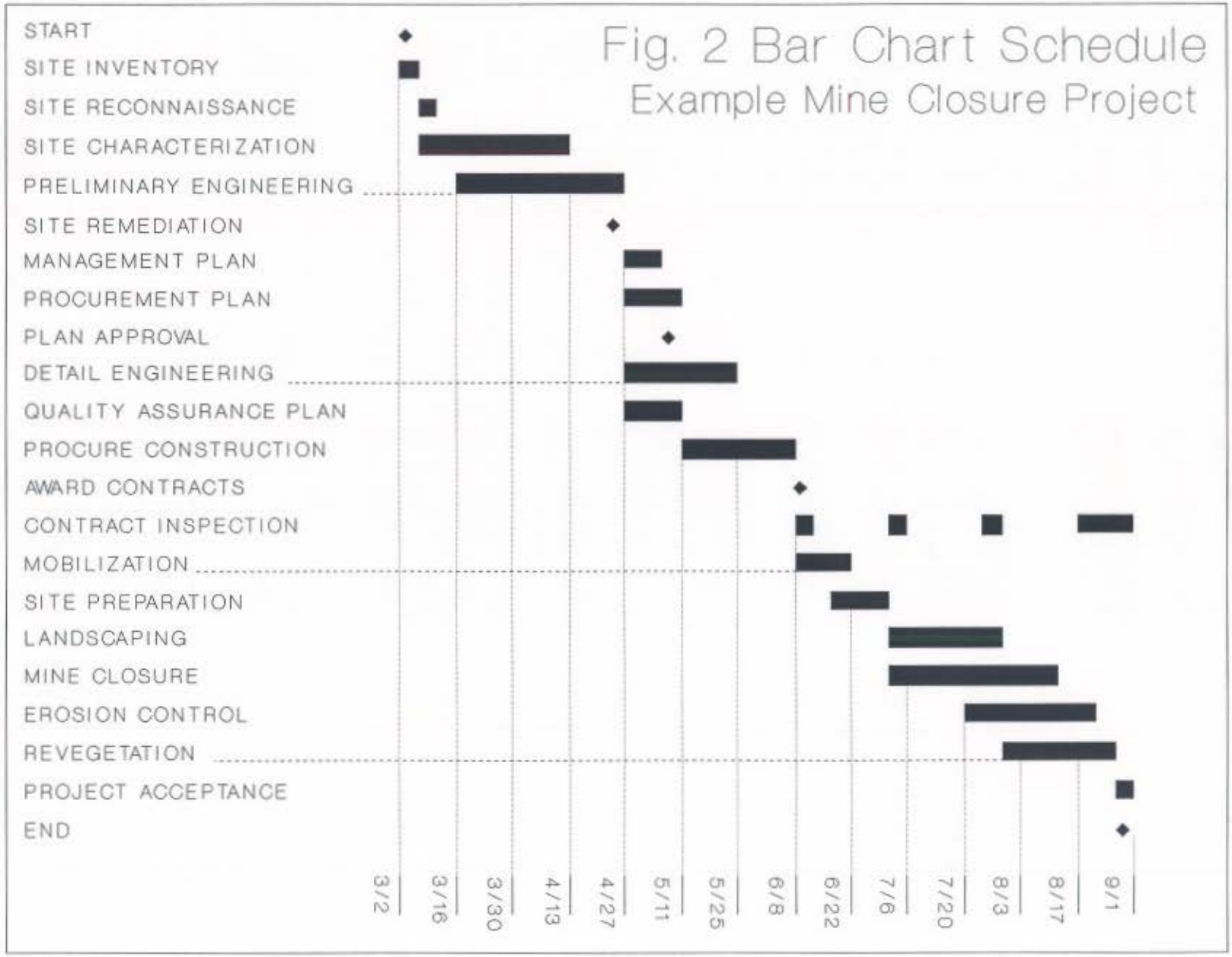


Fig. 2 Bar Chart Schedule
Example Mine Closure Project

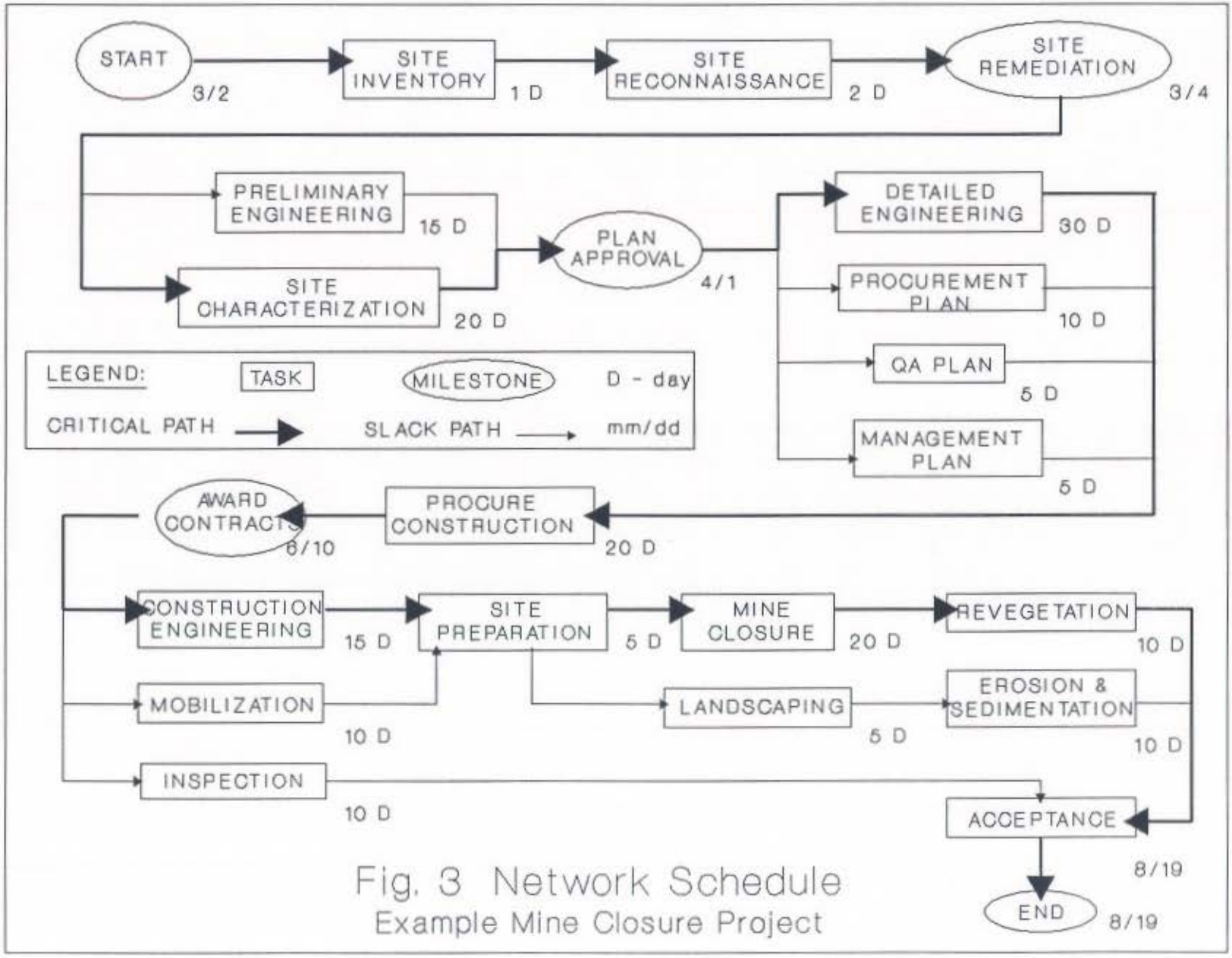
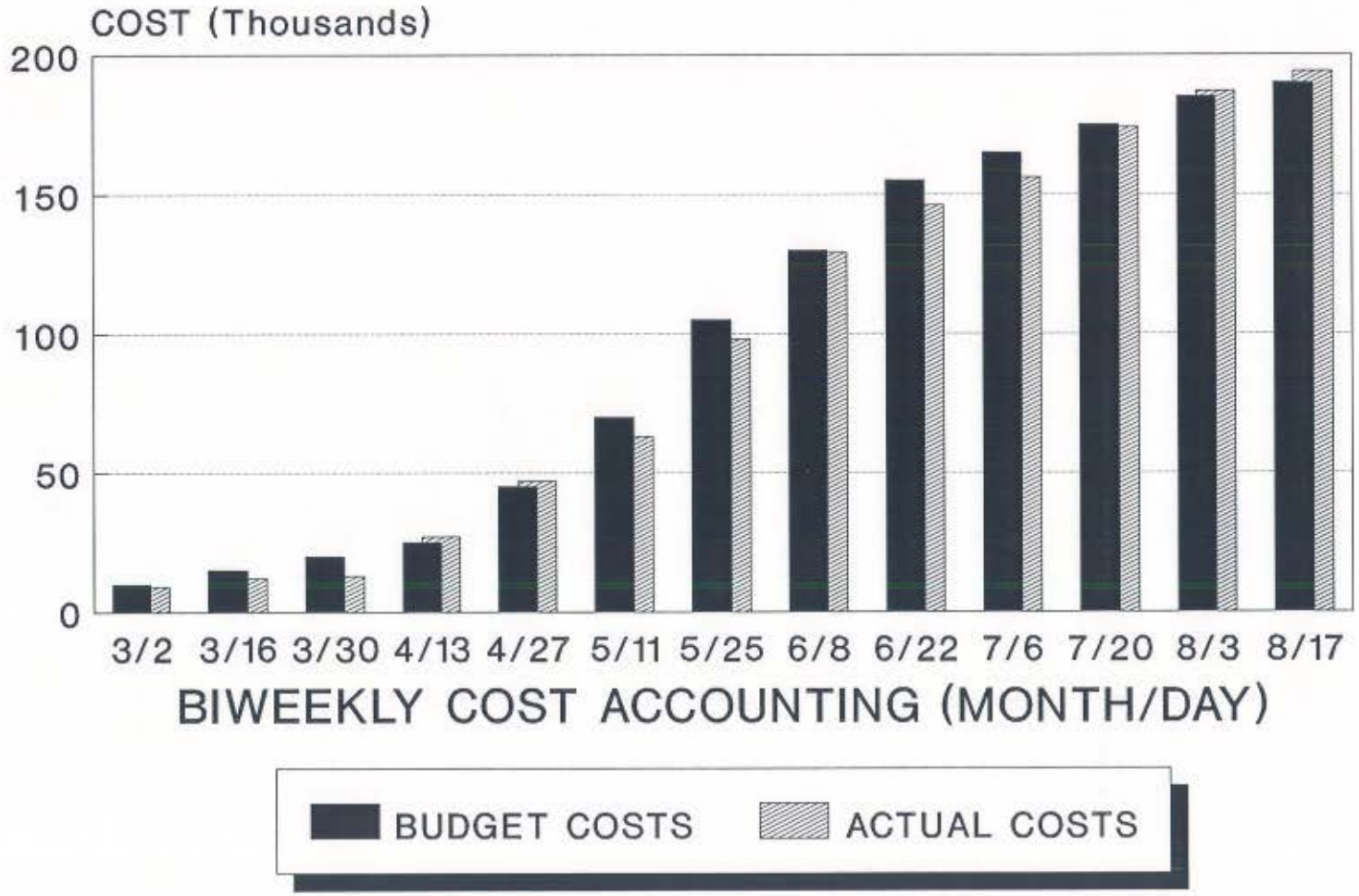


Fig. 3 Network Schedule
Example Mine Closure Project

Fig. 4 Cumulative Cost Graph

Example Mine Closure Project



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