# CONTROLLING CAPITAL EXPENDITURES IN A MULTI-PROJECT ENVIRONMENT

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## ABSTRACT


### CONTROLLING CAPITAL EXPENDITURES IN A MULTI-PROJECT ENVIRONMENT

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This report deals with the control of capital expenditures, for small and medium-sized projects, in a multi-project environment. The emphasis has been placed on the planning and implementation of a cost control system in a project management organization. A more detailed description of the report is included in Chapter 1. The report format is as follows:

- Chapter 1 includes an introduction to the multi-project environment and defines the prime objectives of the report;
- Chapter 2 deals with the project management organization and environment;
- Chapter 3 and 4 relate to the planning phase for the implementation of the cost control system;
- Chapter 5 defines the cost control system to be used;
- Chapter 6 is the conclusion.

To Ghislain, Martin and Pierre.

## ACKNOWLEDGEMENTS

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## INTRODUCTION

# CHAPTER 1

## INTRODUCTION

The control of capital expenditures, as described in this report, is primarily for small or medium-sized projects in a multi-project environment, involving few engineering disciplines, average-duration schedules (less than 3 years) and budgets in the 10 million dollars or less bracket.

Some of the problems in the planning and implementation of a cost control system in a multi-project environment are examined in this report. The project management firm is called «La Société québécoise d'assainissement des eaux» or «SQAE». It was created in 1980 to offer project management services and financing to municipalities that wished to become involved in the wastewater treatment program. The program includes projects across the province to build main sewers and wastewater treatment plants. It SQAE is hired by a municipality, it is responsible for Engineering, Procurement, Construction, Commissioning (EPCC) and Financing of the project.

The program was officially launched in August 1978, and expanded noticeably in 1980. The Treasury Board approved the program in 1980, and forecasted capital investment at a rate of 450 million dollars per year. At the end of 1981, the program forecasts are for projects in more than 200 municipalities and 3 urban communities, and capital investment estimated at 1.854 billion dollars in constant dollars (1981) over a 10 year period.[1]

The scope of this report is confined to the critical initial steps of planning, organizing and implementing of a cost control system.

The prime objectives of the report are:

1) To define the needs of the project management organization for the cost control system;

2) To establish a project implementation plan in order to get started on the right foot;

3) To define the cost control system; and

4) To examine some problems related to the planning and implementation of a cost control system.

# CHAPTER TWO

## MULTI-PROJECT ENVIRONMENT OVERVIEW

# CHAPTER 2

## MULTI-PROJECT ENVIRONMENT OVERVIEW

### 2.1 THE OBJECTIVES OF THE PROJECT MANAGEMENT ORGANIZATION

The objective of «La Société québécoise d'assainissement des eaux» is to undertake, on behalf of municipalities requesting it:

1) the design and construction of wastewater treatment facilities; and

2) the design and the restoration of existing sewer systems.

A third objective, added later on in 1981, is to undertake, on behalf of the government, studies called «EPIC» related to the infiltration of ground water and collecting of surface running water in existing sanitary sewer systems.

The objectives of the government when it created the firm were:

1) to offer to the municipalities a project management team with technical, professional and administrative skills to undertake the wastewater treatment program;

2) to facilitate financing for municipalities. SQAE is financing these projects through loans, and is reimbursed later on by the government and the municipalities;

3) to lower costs by grouping equipment purchasing for several projects, thus making savings on a large scale;

4) to maximize the economic benefits for Quebecers;

5) to speed up the undertaking of the program and insure better control over the program; and

6) to guarantee the treatment plant performance.

SQAE cannot undertake any project before it is requested by a municipality, which in turn, must first sign an agreement with the government for the program.

## 2.2 MULTI-PROJECT PROCESS

### 2.2.1 The Governmental Agreement

The agreement signed between the government and the municipalities is meant to cover the following types of work:

- construction of main sewers (SEWERAGE) for collecting and carrying all sanitary waters to the wastewater treatment plant;

- construction of pumping stations (SEWERAGE), if required, along the main sewer system and at the treatment plant;

- construction of wastewater treatment plant (TREATMENT) or restoration and enlarging of existing wastewater treatment plant;

- restoration of existing sewer system (RESTORATION) in order to reduce the amount of ground water getting into the system by infiltration and of running surface water being collected by the system;

- studies regarding the infiltration of ground water and collection of surface running water in the existing sewer systems: «EPIC STUDIES».

The agreement contains the following information on the projects:

- Scope;
- Key dates for completion of sewer construction, the treatment plant construction and the restoration work;
- An order of magnitude estimate for the sewerage, treatment and restoration work;
- Provisions describing government grants for the sewerage, treatment and restoration work to cover 90 % of the treatment plant construction and 66-2/3 to 90 % of the sewer construction and restoration work depending on the scope of the project and the municipal valuation.

EPIC studies are also included in the agreement and the government subsidizes 100 % of the studies. The work is performed by SQAE and involvement of the municipalities is minimal.

### 2.2.2 The Process

#### 2.2.2.1 Projects

When an agreement is signed by the municipality, SQAE meets the municipality and proposes project management services. If accepted, SQAE assigns a multidisciplinary team to the project. This team is under the responsibility of a project manager and includes specialists in engineering, cost control, scheduling, construction and finance. A flow diagram of the process is illustrated in figure 2.2.1.

SQAE then proceeds with the selection of a firm, from a list of pre-qualified engineering firms, for the design and technical supervision of sewer construction. The same procedure applies for the treatment plant construction.

Upon approval of the drawings and specifications by the Quebec Environmental Department (MENVIQ), SQAE requests public tenders and awards the contrat to the lowest qualified bidder.

It should be mentioned that SQAE provides construction management services on the site; the consultants are responsible for technical supervision only.

A project committee is formed in order to involve the municipality in the decision-making process. Two municipal officers and two SQAE representatives form the committee and are involved in the following process:

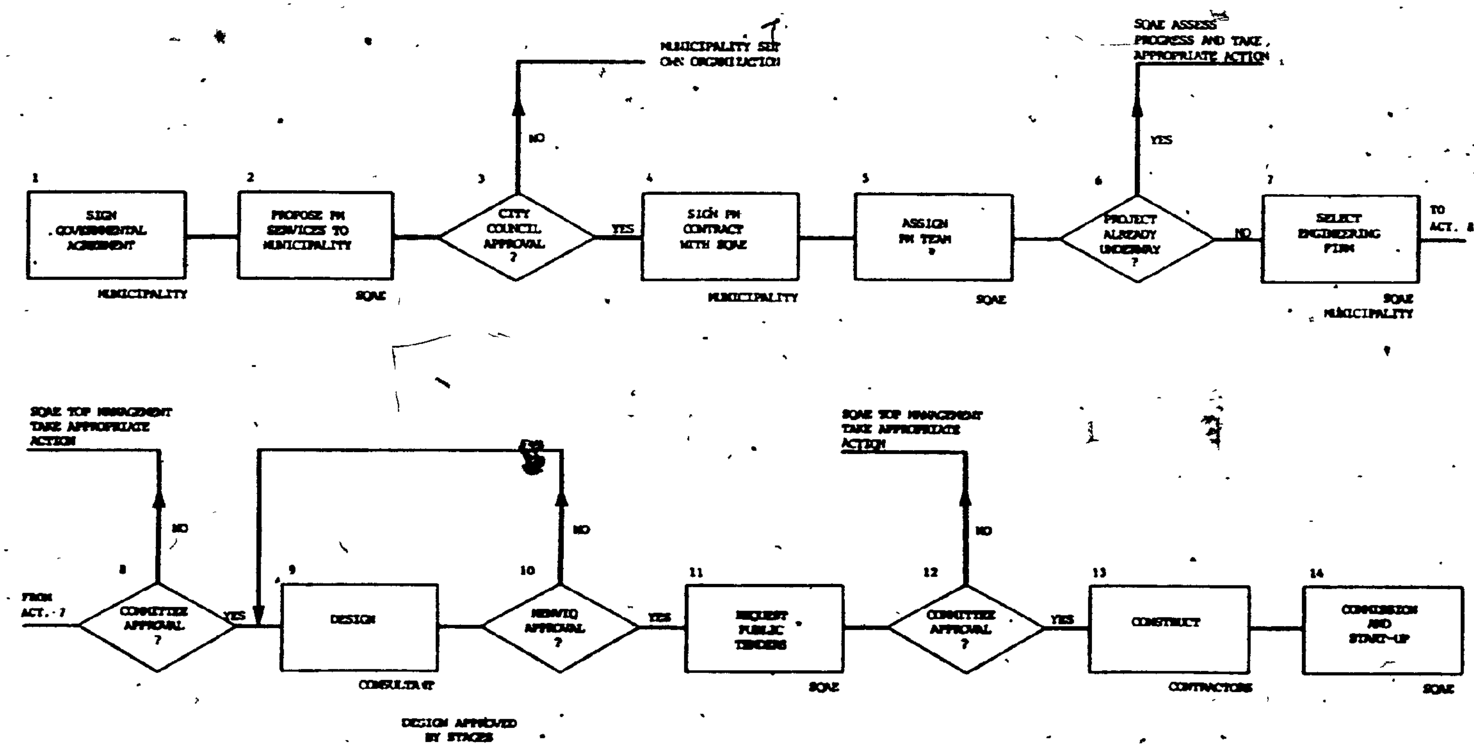



FIGURE 2.2.1:
FLOW DIAGRAM (simplified)
WASTEWATER TREATMENT PROJECTS

. selection of consultants;

. contract award to contractors;

. changes to the scope of work;

. budget revisions; and

. schedule revisions.

After provisional acceptance, SQAE proceeds with the commissioning and start-up of the systems. The systems are then delivered to the municipality after final acceptance.

The fee charged by SQAE is a flat rate of 3.5 % of the total cost of the project, including excalation, without any consideration for the scale of the project. We will comment on this item later in the section on major constraints and problems.

2.2.2.2 EPIC studies

When SQAE is awarded an EPIC study, a project engineer is assigned to the project. This project engineer, acting as a project manager, is in charge of an engineering technician, a scheduler and a cost controller.

A flow chart of this process is illustrated in figure 2.2.2.

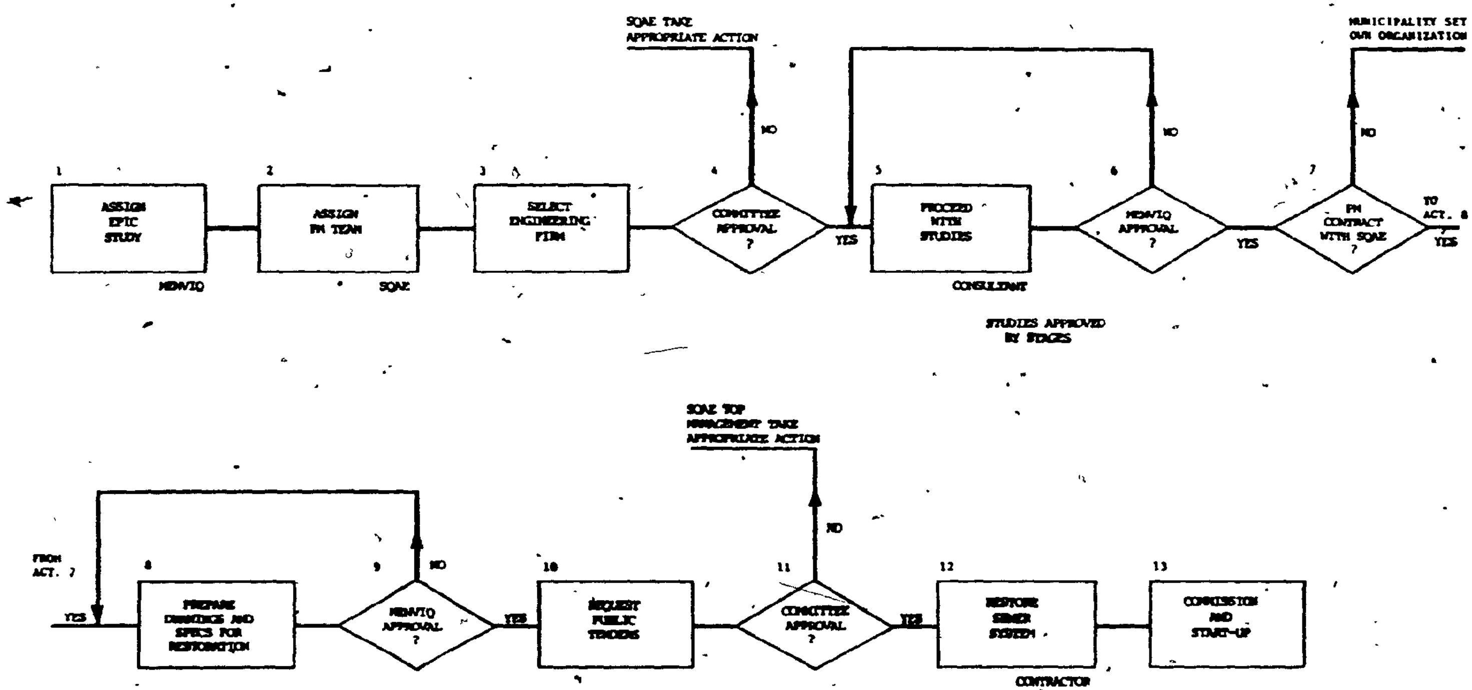



FIGURE 2.2.2

FLOW DIAGRAM (simplified)
EPIC STUDIES

SQAE proceeds with the selection of an engineering firm to make several surveys on the existing sewer systems and recommend solutions to restore the systems.

SQAE then asks the engineering firm to prepare the drawings and specifications for the restoration of the systems, if the consultant's report has been approved by MENVIQ and if an agreement has been signed between SQAE and the municipality. These documents are then submitted to MENVIQ, and if approved, SQAE proceeds with the actual restoration of the systems. If there is no agreement between the municipality and SQAE, the report is transferred to the municipality who takes charge of the restoration work.

The fee charged by SQAE for the EPIC studies is 13.5 % of the total cost of the studies.

### 2.2.3 Multi-project Definition

#### 2.2.3.1 Number of Projects

SQAE operations started in January 1981, after the appointment of a Board of directors and a president, the adoption of rules and standards, the hiring of management personnel and the selection of the head office location.

From that date up to March 31, 1982, 42 municipalities have signed with SQAE for a total investment of 184 million dollars. In the first 8 months of operation, more than 30 projects, for an investment of 150 million dollars, were assigned to SQAE personnel and several of these projects were already in progress by the municipalities.

From May 1981 to March 31, 1982, 40 EPIC studies worth 14 million dollars were also assigned to SQAE.

This quick start-up caused major problems for management in recruting specialists, in developing systems and procedures and in executing operations. This issue will be addressed further in the major constraints and problems section.

2.2.3.2 Project Estimates

The estimated cost of projects vary from 100 000 dollars to 35 million dollars. Table 2.2.1 below shows the distribution of the projects based on the order of magnitude estimate mentioned in the agreement signed with the government.

TABLE 2.2.1

PROJECT DISTRIBUTION BY ORDER OF MAGNITUDE ESTIMATES

| PROJECT ESTIMATE | NUMBER OF PROJECTS | PERCENTAGE |
|---|---|---|
| 0 to 1 250 000 | 13 | 31 |
| 1 250 000 to 2 500 000 | 10 | 24 |
| 2 500 000 to 5 000 000 | 9 | 21 |
| 5 000 000 to 10 000 000 | 5 | 12 |
| 10 000 000 to 20 000 000 | 3 | 7 |
| 20 000 000 + | 2 | 5 |
| TOTAL: | 42 | 100 % |

Note: *These estimates are in constant dollars, i.e. using prices at the time the agreement was signed.*

As seen from the Table, more than 75 % of the projects fall into the categories 0 to 5 000 000 dollars. This is an important factor in the implementation of systems and procedures, and will affect greatly the services rendered to clients. We shall discuss this item in more detail in the major constraints and problems section.

2.2.3.3 Consultant's Contracts

For each of these projects, there are at least five contracts to be signed with consultants for the following work:

1) Design of sewers and field technical supervision;

2) Design of wastewater treatment plant and field technical supervision;

3) Measurement of the rate of discharge of existing sewers;

4) Soil exploration; and

5) Quality control.

Contract values vary from 3 000 dollars to 1.5 million dollars. As of March 31, 1982, more than 75 % of the contracts were in the 0 to 100 000 dollars range. It should be mentioned here that the contracts are awarded by phase for the design of wastewater treatment plants, the first phase being the preliminary studies and the second phase the preparation of drawings and specifications and field technical supervision; the consultant's fees for the first phase are normally under 100 000 dollars.

Land purchasing is often required and involves the following consultants:

. Surveyors
. Land appraisers
. Notaries

2.2.3.4 Construction Contracts

Each project requires an average of four construction contracts: two for sewer construction and one each for wastewater treatment plant construction and restoration of existing sewer systems. In some cases, up to 15 contracts for sewer construction are required, and up to 5 contracts for treatment plant construction.

Contract values vary from 50 000 dollars to 10 million dollars. As of March 31, 1982, most of the contracts awarded were below 2 million dollars. It should be mentioned that most of the contracts awarded were related to sewer construction; only one contract for treatment plant construction was awarded in 1981.

2.2.3.5 EPIC Contracts

These contracts are awarded to consultants by phases. The first phase is the diagnosis of the system; most of the contracts awarded in 1981 were for the first phase.

The average value for phase 1 contracts is 65 000 dollars and the total average value for all phases is 200 000 dollars.

## 2.3 PROJECT MANAGEMENT ORGANIZATION AND FUNCTIONAL RESPONSIBILITIES

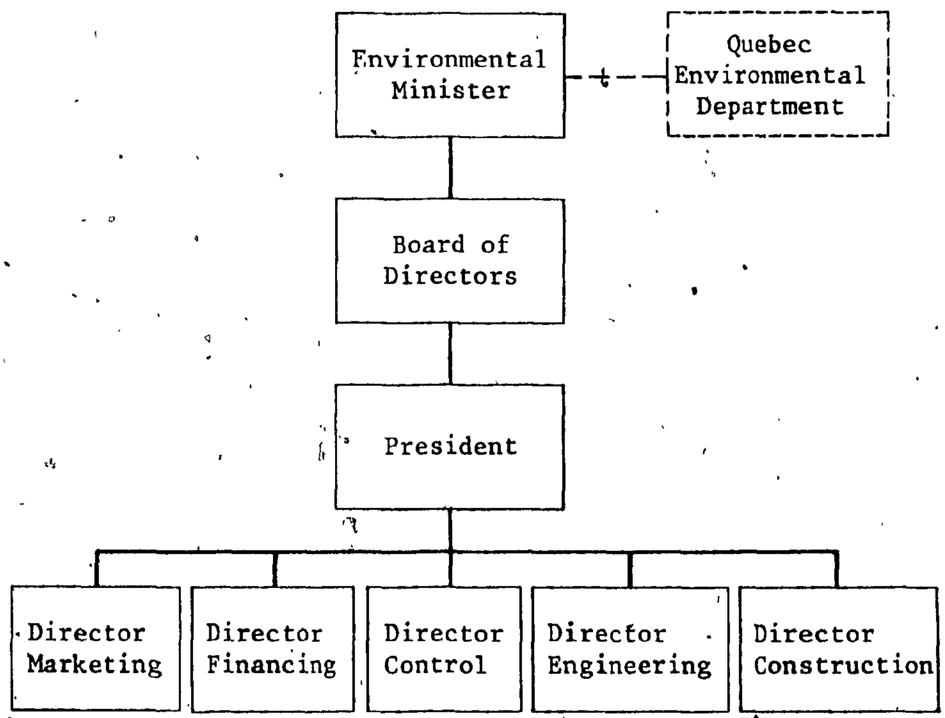
### 2.3.1 Project Management Organization

The initial organizational approach defined by SQAE was functional. Figure 2.3.1 shows the original organization structure.

FIGURE 2.3.1

ORIGINAL FUNCTIONAL ORGANIZATION STRUCTURE

SQAE




Under this structure, 5 functional directors reported to the president:

1) The Marketing director, responsible for public relations and contract signatures with municipalities;

2) The Financing director, responsible for corporate accounting and financing;

3) The Control director, responsible for planning and scheduling, cost control, contract negotiation and signature with consultants and contractors, and equipment purchasing;

4) The Engineering director, responsible for all technical aspects and overall coordination during the design phase excluding the design itself given to outside consultants; and

5) The Construction director, responsible for all construction aspects and overall coordination during the construction phase.

As mentioned previously, the Engineering department acted as the lead discipline during the design phase, and the Construction department as the lead discipline during the construction phase.

The decision to implement a project management organization was taken within six months of SQAE's existence. The major reasons for the change were:

1) The necessity of having a single point of information and responsibility for the project life cycle. The single point of information was important not only for top management but also because of the need for external coordination with consultants, contractors, municipalities and the Quebec Environmental Department; and

2) The number of departments involved on the project could and did slow down and complicate the process of making decisions.

A revised version of the organizational structure was issued in November 1981. Figure 2.3.2 shows the revised organization.

The Construction department became the Project management department. Although the Project management director reports to the president like the other directors, his actual status is more at the VP level. The Financing department assumed additional responsibility for administration, and the Control department became the Control and Procurement department. The Engineering department remains unchanged. The Marketing department, now responsible for land purchasing, shifted at a managerial level being too small for a department, and a Personnel manager was added because of pressing needs for the development of job descriptions and the development and implementation of a salary structure.

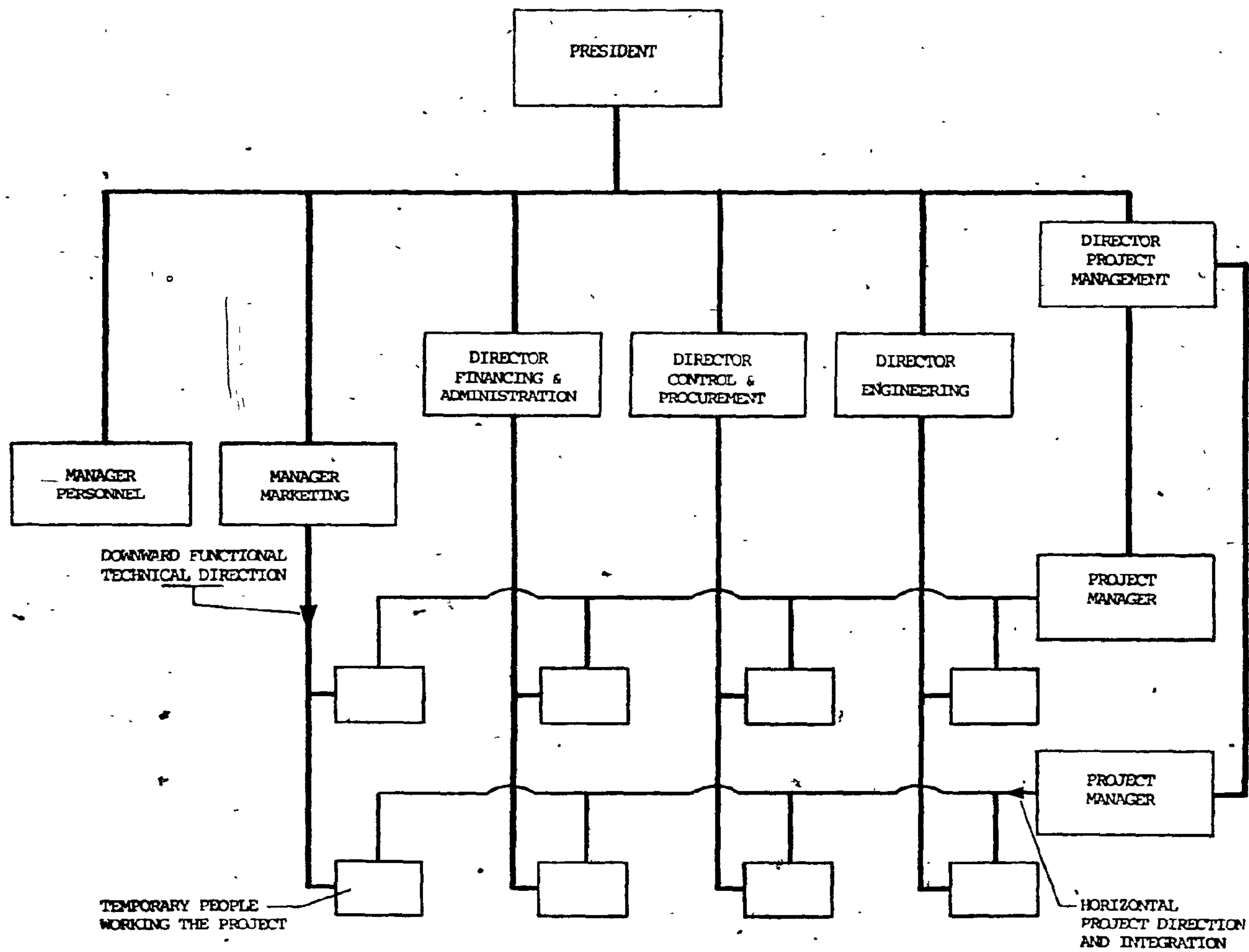



FIGURE 2.3.2

REVISED MATRIX ORGANIZATION

SQAE

The revised organization is a matrix organization or a multi-disciplinary team whose members are drawn from both functional and project management groups. Functional directors provide downward functional technical direction and project managers provide horizontal project direction and integration.

2.3.2 Project Management Department

This department is responsible for the management of all the projects.

The director:

1) Establishes project management policies and standards, and insures their rigid application on projects;

2) Insures overall planning of projects according to the agreements with municipalities and in accordance with established technical and financial criteria and resources available to the firm;

3) Assigns and supervises project managers and insures efficient coordination of the project teams;

4) Makes sure that the project schedule and budget are met;

5) Manages the construction function, so that the construction standards are met and that uniform construction methods are used; and

6) Takes appropriate actions to solve problems occurring on projects.

The project management director is responsible for the following personnel, as shown on figure 2.3.3:

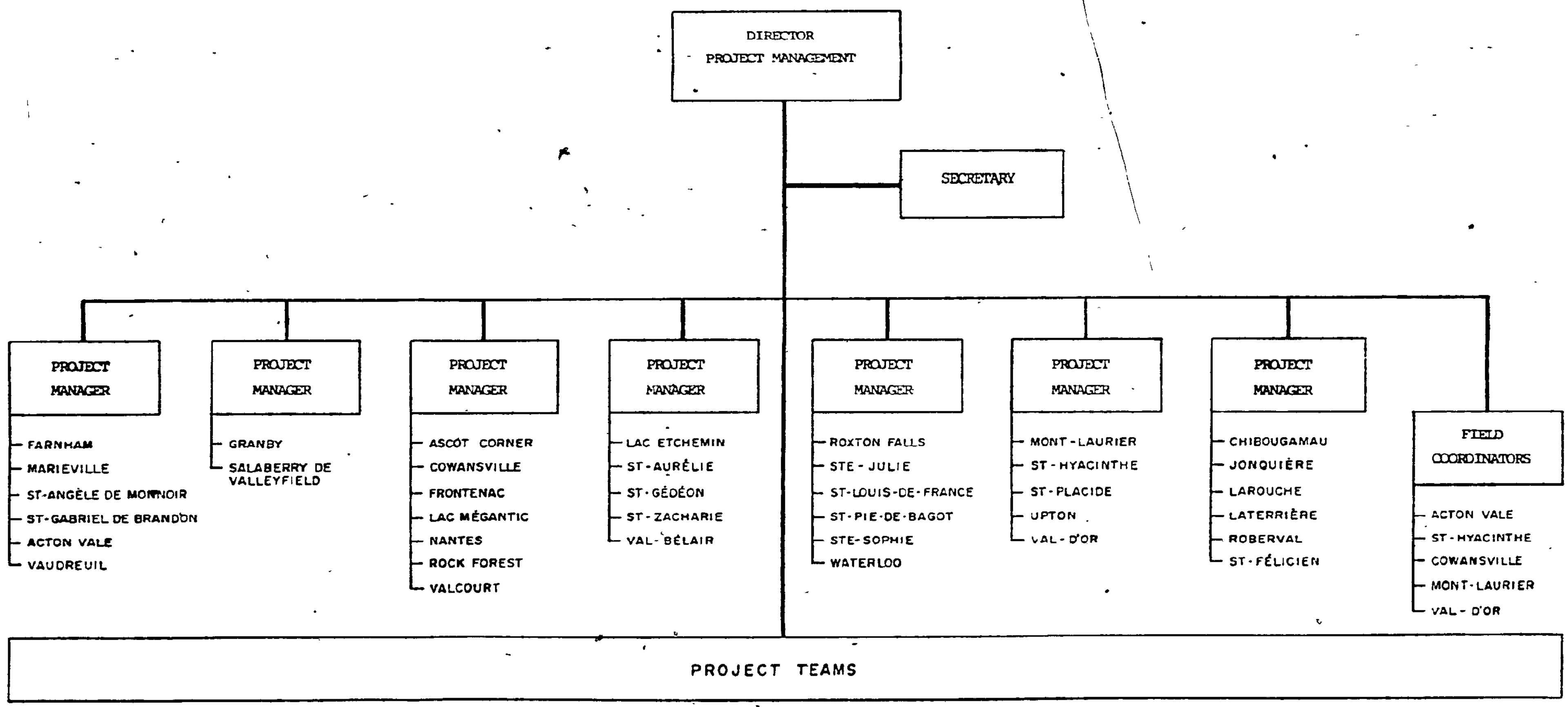
1) Project managers
2) Field coordinators

The project management director is an engineer with eighteen years of experience with different organizations, crown corporation and contractors.

The responsibilities of the project managers at SQAE are to:

1) Make sure that each functional director assigns coordinator on their projects and that they accomplish their tasks according to the schedules and manhours available;

2) Make sure that projects are on time and within budget; authorize progress payments and assure proper filing of project documents;

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PROJECT MANAGEMENT DEPARTMENT    FIGURE 2.3.3

3) Call coordination meetings, assure that information transfer takes place and that the necessary actions are taken by their team members and other project participants;

4) Act as chairman on the project committee to select consultants and contractors, and to recommend major changes to scope, budgets and schedules;

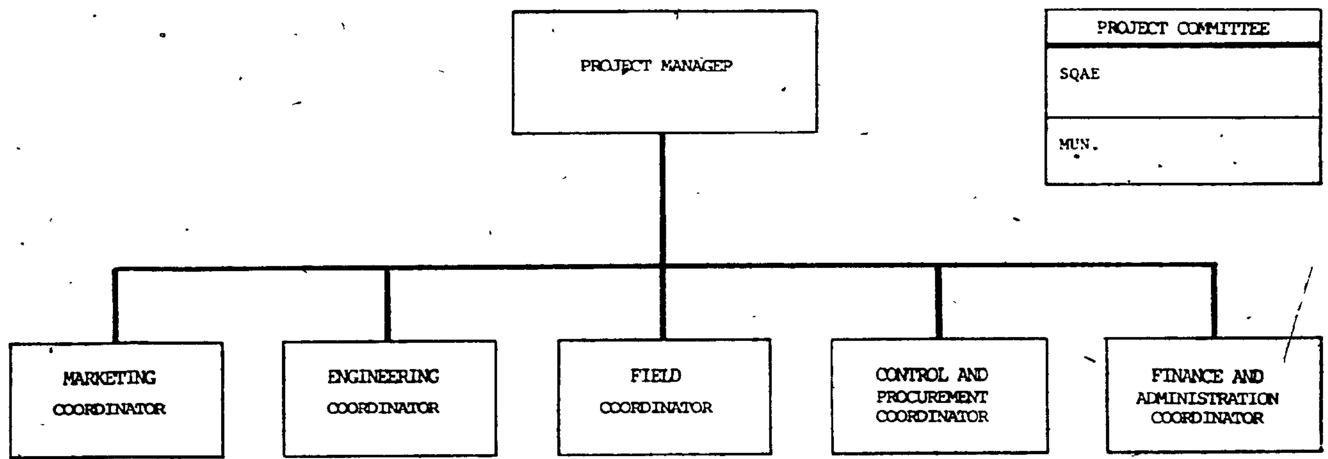
5) Visit construction sites, or request a field coordinator to supervise consultants and contractors. Assure proper field coordination; report on a daily basis all aspects requiring immediate action by the engineering specialists, or by other management personnel;

6) Assure proper reporting by the team members including progress reports;

7) Take appropriate actions on urgent matters, involving the proper specialists on the project team;

8) Evaluate every team member and report on their performance to their functional director.

Figure 2.3.4 shows the typical project team at SQAE. There are five coordinators assigned by each functional director or manager under the direction of a project manager. The coordinator acts as liaison agent between the project manager and




CONSULTANTS:

CONTRACTORS:

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PROJECT TEAM
PROJECT MANAGEMENT

FIGURE 2.3.4

the department as well as a functional department member. For example, a member of the Control and Procurement department can be assigned to a project to perform cost control and, at the same time, coordination for the project manager in the Control and Procurement department.

Engineering, control and procurement coordinators and the project manager are involved with a project on a daily basis. Marketing, finance and administration coordinators have less involvement on a project. A field coordinator is assigned by the Project management director if required.

Most project managers at SQAE are engineers with ten or more years of experience with various organizations: consulting engineers, contractors, project management firms, and municipalities.

### 2.3.3 Functional Departments

The responsibilities of the functional directors at SQAE are:

#### 2.3.3.1 Engineering Department

This department is responsible for all the technical aspects of projects, from preliminary studies to final acceptance of the work.

The director:

1) Establishes technical policies and standards and insures their rigid application on projects;

2) Establishes the consultant's mandate and budget (manhours); checks and approves all technical aspects of the studies and the construction work;

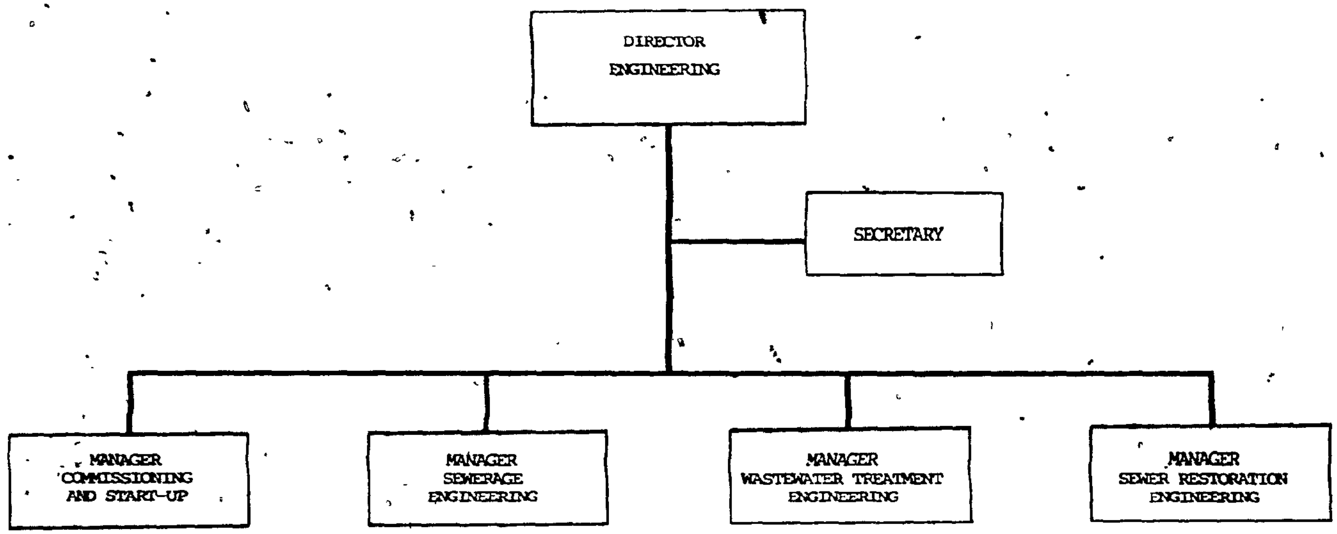
3) Takes part in the development and implementation of consultants pre-qualification procedures for engineering, soil investigation and quality control; takes part in the evaluation of consultant's proposals and contractor's bids;

4) Assigns engineering coordinators on projects, gives the necessary back-up and takes appropriate action to solve problems occurring on projects;

5) Insures quality control from the conceptual phase to the start-up of the plant; and

6) Takes part in the provisional and final acceptance of the work.

The engineering director is responsible for the following managers, as seen on figure 2.3.5:

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ENGINEERING DEPARTMENT

FIGURE 2.3.5

1) Manager of sewerage engineering

2) Manager of treatment engineering

3) Manager of sewer restoration engineering

4) Manager of commissioning and start-up

The engineering director is an engineer with a masters degree in engineering and ten years of experience with a consulting firm, the Quebec Environment Department and a municipality.

2.3.3.2 Control and Procurement Department

This department is responsible for the planning, scheduling, estimating, cost control and procurement of all projects.

The director:

1) Establishes standards, systems and procedures for planning and scheduling, for estimating and cost control, and sees to their application;

2) Insures that schedules are prepared and up-dated by the planners for every project and that project reports are written on a monthly basis highlighting major variances to the schedules;

3) Insures that the budgets are established and up-dated by the cost controllers for every project, that project

reports are written on a monthly basis to report trends as far as project cost is concerned;

4) Forecasts expenditures for all projects and makes sure that funds are available from the Finance department;

5) Establishes procurement standards and procedures for tenders (construction and equipment), engineering proposals and contract awards;

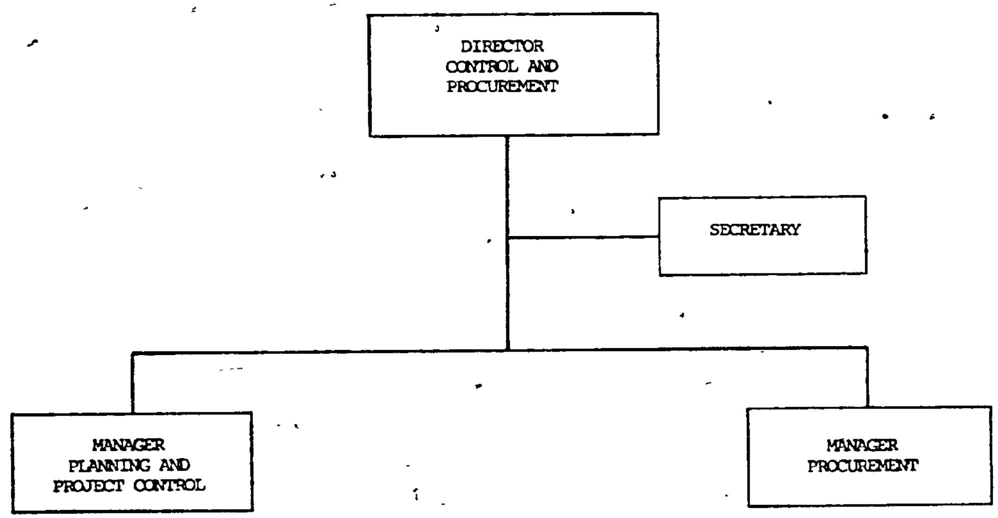
6) Develops and implements pre-qualification procedures for engineering, soil investigation and quality control consultants; and

7) Develops standard contract formats, prepares back-up and takes the appropriate action in order to meet the approved schedules and budgets.

The control and procurement director is responsible for the following managers, as shown on figure 2.3.6:

1) Procurement manager
2) Planning and project control manager

The control and procurement director is an engineer with forteen years of experience in project management, mostly with consulting firms.






CONTROL AND PROCUREMENT DEPARTMENT

FIGURE 2.3.6

2.3.3.3 Finance and Administration Department

This department is responsible for all financial aspects of the firm, bridge financing and long-term financing for capital investments. It is also responsible for accounting, management of the operating budget, and for auxiliary services.

The director:

1) Establishes a financial plan, manages financial resources and a cash budget;

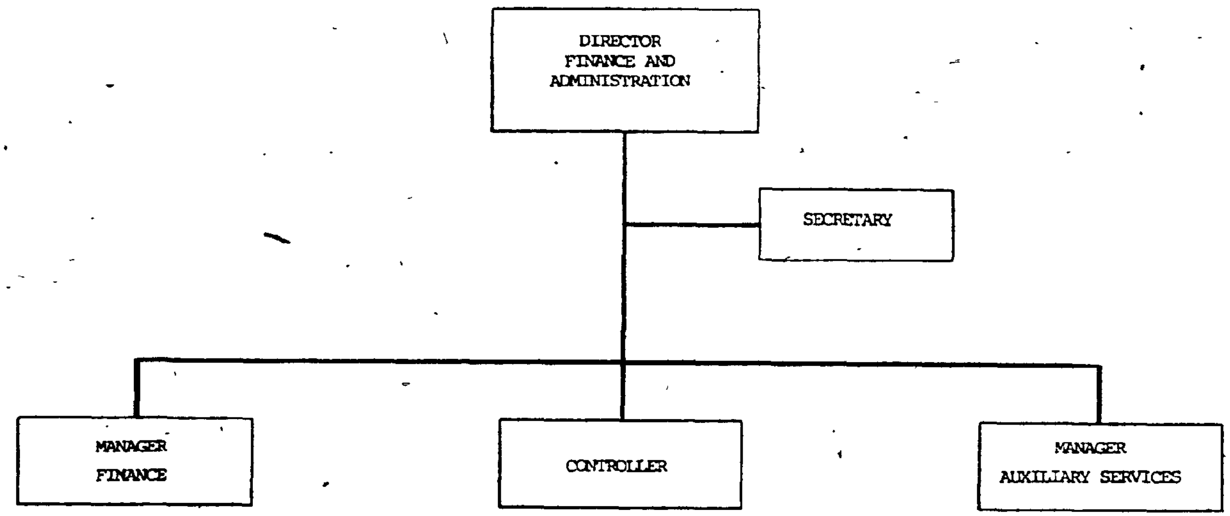
2) Manages debt in order to meet financial commitments;

3) Establishes a budgetary information system and insures stiff control over operating budget;

4) Manages computer services and auxiliary services such as office layout, messenger services, communications, photocopy; and

5) Establishes systems and procedures for document conservation and control.

The finance and administration director is responsible for the following managers, as shown on figure 2.3.7:

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FINANCE AND ADMINISTRATION DEPARTMENT

<u>FIGURE 2.3.7</u>

1) Finance manager

2) Financial controller

3) Auxiliary services manager

The responsibility of the following services are summarized since their involvement in project management is minimal.

2.3.3.4 Marketing Services

This unit is responsible for public relations and contrat signature with municipalities as well as the purchasing of land or rights-of-way.

2.3.3.5 Personnel Services

This unit is responsible for recruiting, job descriptions, organizational structure, salary structure and working conditions.

## 2.4 MAJOR CONSTRAINTS AND PROBLEMS

### 2.4.1 Quick Start-up

SQAE had a very rapid growth, as mentioned earlier; more than 30 projects were assigned to project management personnel within 8 months of the start of operations. Thirteen of these projects were already underway by the municipality and six of them were at the construction phase, mainly for sewer construction.

Several municipalities decided to sign an agreement with SQAE, even though their projects were already underway because of financial reasons. The municipalities did not have to raise loans for several months for the project, so they could use the money for other purposes. Also they could not get interest rates as low as those provided by SQAE.

It should be mentioned that the marketing plan was to take as many projects as possible, without any consideration for the scope of work, the location, or the actual stage of the job. Also, SQAE, being a government agency, could not refuse to sign an agreement with a municipality requesting it, even if their project was too small, too far, or too far advanced in the construction process; politically, it could not be done.

Thus, management personnel had a lot of catching up to do on these projects. The cost controller had to collect all the cost data: commitments, expenditures, budget estimates, change orders, etc. Most of these municipalities did not have a detailed budget including escalation, financing and contingency allowances. The scheduler had to collect all the data because most of the time, no master schedule existed for the project, even though construction was underway.

From January 1981 up to March 31, 1982, more than 42 municipalities signed with SQAE for a total investment of 184 million dollars.

Additional work came by May 81 when SQAE took over the management and financing of EPIC studies. More than 40 studies were managed and financed by SQAE up to March 1982. The Quebec Environmental Department was still managing 20 additional studies as of March 1982 since they had started prior to their transfer to SQAE; SQAE assumed financing of these projects. It is expected that all these studies will be transferred to SQAE in 1982.

### 2.4.2 Project Locations

Project locations are causing a major problem to the project management organization. The projects are scattered all over the Quebec province. Table 2.4.1 shows the distribution of the projects by region.

TABLE 2.4.1

PROJECT LOCATIONS BY REGION

| REGIONS | NUMBER OF PROJECTS | TOTAL PROJECT ESTIMATES ($000) |
|---|---|---|
| Abitibi | 1 | 12 500 |
| Saguenay | 7 | 48 250 |
| Quebec and Beauce | 4 | 6 250 |
| Eastern Townships | 20 | 79 500 |
| Montreal and suburbs | 6 | 24 000 |
| Laurentians - Mauricie | 4 | 13 500 |
| | 42 | 184 000 |

After a few months of operations, SQAE faced the problem of decentralizing its operations. The project management director decided to hire some project managers in regions and to open regional offices in Quebec City, Jonquière (Saguenay) and in Sherbrooke. The decision was based on the following factors:

Marketing: By hiring a project manager that already knew the region and the clients, it was easier to be accepted and to communicate with the client's representatives.

<u>Efficiency</u>: The project manager was closer to the job, and most of the consultants and contractors are regional, so he did not have to travel extensively for meetings and to see job progress.

It was decided to keep the rest of the team at head office for training purposes while the policies, procedures and standards were being developed. This situation caused a major communication barrier between the project manager, the team members and the functional managers. Normally, at least 50 percent of a project manager's time is spent talking to people, getting information, clarifying directives and resolving conflicts and misunderstandings. While communicating by phone is a good medium, it is not suitable for resolving conflicts and misunderstandings. The project manager would come to the head office once a week or once every second week for a day or two, to meet the team members, but this was not sufficient for resolving problems.

Quite often, the project manager would communicate a piece of information to a team member by phone and ask him to act as a communications expediter by transferring the information to the other team members. This procedure is acceptable but if a communication barrier occurs in the process, the team member does not have the authority that the project manager has and the problem might end up in the functional director's lap.

Thus, a decentralized operation structure is bound to come in the near future at SQAE for some regions and the project managers in regions would then assume all functions on small projects.

2.4.3 Matrix Organization Problems

The implementation of a matrix organization structure at SQAE resulted in problems inherent in the matrix organization as described below.

Two bosses

The project personnel in a matrix organization have two bosses. Continuous conflict existed for several months between the project management and the functional management, mostly because the division of authority and responsibility was not clearly defined and understood.

The division of authority and responsibility between the project managers and the functional directors can be broken down as shown on Table 2.4.2.(2)

TABLE 2.4.2

PROJECT MANAGER'S AND

FUNCTIONAL DIRECTOR'S RESPONSIBILITIES

| | |
|---|---|
| Project Manager's Responsibilities: | 1)What is to be done?<br>2)When will the task be done?<br>3)Why will the task be done?<br>4)How much money is available to do the task?<br>5)How well has the total project been done? |
| Functional Director's Responsibilities: | 1)How will the task (function) be done?<br>2)Where will the task be done?<br>3)Who will do the task?<br>4)How well has the functional input been integrated into the project? |

In a shorter form, the project manager is responsible for: What? When? At what cost? and the functional director is responsible for: Who? Where? How?

Major sources of conflicts were on «How will the task be done» and «What is to be done» because the procedures and standards were not defined.

Further problems of conflicts are caused by project personnel being assigned to 2 or 3 project managers at the same time; project personnel had two bosses on a project but 3 or 4 bosses to report to.

Complexity

The complexity shows itself in the difficulties in monitoring and controlling for the number of people that must be kept informed.

The information flow is complex because there are so many people and organizational units involved. This problem occurred quite often at SQAE at the beginning but the situation has improved since the hiring of document control personnel and more discipline.

Priorities

The organization faces real problems with project priorities and resources allocation. With more than 42 projects to manage, some project personnel were responsible for more than 12 projects at a time. In the Control and Procurement Department, the preparation of monthly reports was causing priority problems, since some cost controllers or schedulers had 4 reports to issue in a week's time.

Project personnel assigned on several projects were not available to all projects at all times. Also, for every question being asked, the functional person had to get back in the context of the particular project in question.

2.4.4 Financial Constraints

2.4.4.1 Project Management Fees

The fee charged by SQAE to the municipalities for project management is 3.5 % of the total cost of the project, without any consideration for the scale of the project. This fee was set by top management at SQAE based on experience in the private sector without any consideration for governmental bureaucracy.

Most of the projects are relatively small: 30 % of the projects estimates are under 1.25 million dollars, 50 % under 2.5 million dollars, and 75 % under 5 million dollars. For a project estimated at 1.25 million dollars, the project management fee is approximately 45 000 dollars, and the project duration is 2 years. If a project manager and five coordinators are assigned to the project on a part-time basis, there won't be enough money to cover expenses.

One solution to the problem would be to allocate manhours per department for the duration of the project and ask the project manager to control the manhours spent on his project in order to stay within budget. This solution would require some historical data that SQAE does not have.

For various reasons, manhour budgets were not prepared and the manhour reporting system was not implemented in the first year of operation.

On a project estimated at 1.25 million dollars or less, the project manager should be the only person assigned to the project. If the project manager requires a specialist for a short period of time, a director could assign a person on a temporary basis, after a manhour budget has been negotiated.

For example, a scheduler could be required at the beginning to develop a master schedule and the project manager would be responsible for updating it. It requires a knowledgeable and versatile project manager to assume all these functions. The project manager would have to keep functional managers informed on all aspects that required immediate action.

2.4.4.2 Order of Magnitude Estimates

The order of magnitude estimates included in the agreement between the municipalities and the Quebec government were far from being realistic. Several projects from phase I of the wastewater treatment program showed budget variances of more than 50 %.

All the agreements between SQAE and the municipalities were signed for these amounts. No estimates were prepared by SQAE prior to the contract signature with the municipalities.

When SQAE preliminary estimates were prepared, major discrepancies appeared. MENVIQ, placed in an embarrassing position, started cutting in the quality of wastewater treatment by lowering the treatment level or eliminating phases in the treatment process, or reducing estimates of population and/or industrial growth. Some projects were stopped completely in order to reevaluate their scope. It caused major delays on projects and major conflicts between SQAE and the environmental department.

It is the author's opinion that SQAE should concentrate on producing more realistic estimates prior to the preliminary design phase. It would save time and money if it was known prior to the start of the preliminary studies that the budget was inadequate for the scope of work defined by MENVIQ.

It should also be mentioned that the first several governmental agreements did not include a provision for escalation. Some municipalities thought that the amounts mentioned in the agreement were the total cost of the project. MENVIQ decided to include a provision for escalation after SQAE had been in operation for one year.

2.4.4.3 Project Financing

The original financial plan included bridge financing for the duration of the project or a phase of the project, with long-term financing to be taken 6 months after the provisional acceptance for each phase. This was mentioned by marketing as one of the benefits that the municipalities could get by signing with SQAE, since they did not have to raise loans for several months for the project.

The cost of this bridge financing could be capitalized up to a maximum of 5 % of the construction cost. Because of high interest, the amounts considerably exceeded those that MENVIQ had allocated in the budget.

SQAE revised their financial plan one year after it started its operation in order to stay within the 5 % limit. They did this by seeking long-term financing in stages (every 3 months) for different phases of the project. The municipality and the government would start reimbursing the loan to SQAE 6 months later proportionally to their financial contribution to the project.

## 2.4.5 Quebec Environmental Department (MENVIQ)

Continuous conflicts existed between SQAE and MENVIQ on several aspects of management. Major conflicts occurred on projects that were already underway and were transferred to SQAE.

MENVIQ project engineers were deeply involved in the management of these projects prior to SQAE involvements, conducting design coordination meetings, assistance to field meetings, cost estimating, change order approvals, etc. When SQAE took over these projects, their involvement in project management had to be reduced; that is when most of the conflicts started.

Major conflicts occurred during the preliminary studies. MENVIQ wanted to have the final word for the technical aspects of the project. SQAE wanted to be involved in order to defend client's preoccupation with construction and operating costs.

During the construction phase, MENVIQ got involved in the construction methods used by the contractors on the site for environmental protection and quality assurance. SQAE's response was that they were responsible for these aspects of the project.

All these conflicts affected the projects; quite often, the consultants or the municipalities were caught between the Quebec Environmental Department and SQAE. After one year of conflicts and discussions between the two organizations, a document was prepared and signed by both parties; this document, called the "marriage contract", defined the responsibilities and authority of both organizations and the management procedures to be used in the engineering and construction phases.

### 2.4.6 Personnel Constraints

Finding suitable project managers and specialists in project planning and cost control proved to be a major problem in the implementation of the project management organization.

When SQAE was being established, there was a shortage of project management personnel on the market; several attempts were made by advertising in the newspapers but the results were disappointing.

The worst sectors were planning and scheduling, and cost control. Out of five cost controllers that were hired, only one had some experience with automated cost control, work breakdown structure and code of account structure. Most of the schedulers and cost controllers had no experience in wastewater treatment plant and sewer construction.

Selection of project managers was also difficult; there were very few candidates who had some experience with a project management organization, with multi-project and multidisciplinary environments for municipal and wastewater treatment projects.

2.4.7 Project Manager's Limited Authority

Top management at SQAE wanted to limit the authority of the project managers. They were not willing to give up some of their decision-making prerogatives for the following reasons:

1) The authority for commitment of money is limited in a governmental agency;

2) The difficulty of finding good project managers with strong communication motivation and team-building skills and who were oriented to multidisciplinary projects, who were innovative, possessed integrative skills and a high tolerance for rapid change and frustration; and

3) The need for functional management to be involved in the decision-making process in the early stage of implementation of project management.

In general, the project manager's authority is a direct function of the level at which he reports in the organization. To be effective, the project manager must be at least on an equal level with the highest level of functional management with which he must deal.(3)

Going back to figure 2.3.2, it can be seen that the project managers report to the director of project management who is at the same level as the other functional directors. It was previously mentioned that the director of project management is at a higher level than the other directors but, as shown on the organizational structure, they are not reporting to him. It is now obvious that the project manager is not on equal basis with the functional directors. It might be necessary, in the near future, to revise the structure by creating a Vice-President level for the project management group to give more power to the project managers.

## 2.5 PROJECT CONTROL PHILOSOPHY

Project control philosophy relates to the project control principles to be applied by the firm.

All these principles were not actually defined and laid down on paper by project management personnel. A few meetings took place between the president and the directors to discuss the philosophy to be followed.

### 2.5.1 Principle no.1: MENVIQ responsibility

MENVIQ must be provided with the necessary information to report to the environmental minister on the status of the projects as far as quality, cost and time.

The major governmental contribution to the projects requires control inherent with the management of public funds. MENVIQ reports to the minister regarding the use of public funds as per MENVIQ's mandates and the minister in turn reports to the government.

The municipalities must provide MENVIQ with the necessary information, as stated in the governmental agreement; if SQAE is involved in the project, they have to provide the information for the municipality.

It must be fully understood that MENVIQ has the ultimate responsibility for the wastewater treatment program.

MENVIQ requested the municipalities (or SQAE) to prepare project progress reports on a quarterly basis; the content of these reports, defined by MENVIQ, is explained in the next chapter. These reports represent an additional burden for SQAE; the cost control system must be designed to facilitate their preparation.

2.5.2 Principle no.2: Centralized Responsibility at SQAE

Planning and control functions for each project are to be provided through a consistent and constant point of leadership, namely the project manager.[4]

Responsibility for the following key items will be centralized in one individual:

1) Budgeting and cost control
2) Time schedules
3) Resource allocation
4) Technical quality
5) Public relations with the municipalities, MENVIQ, etc.

In the project management organization, the project manager is responsible for project control. The Control and Procurement department must provide the control data to the project manager in order to manage within the budgeted cost and the time schedules.

This mean that the project managers must be deeply involved in the definition of needs for the cost control system.

### 2.5.3 Principle no.3: Adequate Delegation of Authority

The project manager is to be provided with the authority necessary to get the job done on time, within budget, and to the satisfaction of the client.

The project manager has the overriding responsibility for evaluating every key project decision to determine how it interfaces with the other project tasks and with the time schedule and budget. The project manager therefore must get involved and influence every project action, and as a last resort, always have appeal rights or veto power for the good of the project.(5)

As previously mentioned in the major constraints and problems section, top management at SQAE wanted to limit the authority of the project managers. The veto power that the project manager should have is somewhat limited for key decisions; also MENVIQ has the ultimate responsibility and authority on the projects as seen in principle no.1.

The impact of this principle on the system is the involvement of the project manager in all cost control activities.

### 2.5.4 Principle no.4: Dual Control Mechanism

Two separate entities must be involved in any decision-making process related to the following financial transactions on a project:

1) Budgetary transactions
2) Commitment transactions
3) Contract awards
4) Approval of invoices
5) Progress payments

The dual control mechanism, the basis for controlling public funds, means that the person requesting a job involving a commitment of money, is not the same who authorizes the payment. This process is designed to reduce the possibility of collusion or fraud.

The dual control mechanism must be integrated in the cost control system; a second entity must be involved in cost control activities related to financial transactions. Most of the time, a representative of the Control and Procurement department is the second individual who participates in any transaction involving the project manager. The project manager's interpretation could be that this department is there for controlling them rather than for supporting them or for guiding them on the projects to stay within budget and meet the schedule.

### 2.5.5 Principle no.5: Work Breakdown Structure (WBS)

The total project must be broken down into sufficiently small subdivisions to permit accurate cost estimates and adequate visibility and control over cost and time limits.

This principle requires the application of the WBS technique. The WBS is a family tree subdivision of a project, beginning with the end objective and then subdividing these objectives into successively smaller work packages. The WBS establishes the framework for:

. defining the work to be accomplished;
. construction of a network plan;

. summarizing the cost and schedule status of a project for progressively higher levels of management.» (6)

The WBS is a very important cost/schedule control tool; the level of detail should be in accordance with the level of control required, as explained in section 3.4.

After the WBS is established, the coding is done from top to bottom of the structure. The first level starts by a code, this code is contained in each succeeding level and so on.

### 2.5.6 Principle no.6: Engineering, Procurement and Construction Packaging

The total project is to be broken down into engineering, procurement and construction packages, and to be controlled accordingly.

Depending on the size of the project, SQAE must break down the engineering work for main sewers in different packages to favor local engineering firms. SQAE should use the same approach for construction contracts.

For the wastewater treatment plant, the approach is different. One firm is selected to perform the engineering work for the total plant. For the construction contracts, the plant must be broken down by physical areas (systems) and/or by trades to favor local contractors.

The cost control system should allow regrouping of all the elements of the WBS that form a package, as explained in section 3.4.

### 2.5.7 Principle no.7: Consultant Manhours Control

A manhour budget is to be set for each design package and included in the contract as an upset limit. The process of control of additions, deductions, and changes is to be established at the outset.

A manhour control mechanism had to be implemented since the governmental agreement stated that the engineering firms should be paid on an hourly basis for all phases of the project.

Manhour estimates are prepared by the consultants from a list of activities established by the Engineering department for each phase of the project. These estimates form part of the proposal documents.

The consultant must sign a contract with an upset limit and record the manhours spent by his personnel for each activity.

Engineering performance is measured in terms of physical percentage complete of drawings, specifications, reports, or tasks related to each activity, and the manhours expended to obtain that percentage. Actual percentage complete, associated manhours, and schedule dates are compared with the plan and budget for each phase . The composite effect of these is used as a basis for forecasting future performance.

The system must provide cost data retrieval, in manhours and in dollars, for the engineering work. It must also provide control of change orders for design work.

### 2.5.8 Principle no.8: Construction Contract to Lowest Bidder

The construction contract is to be awarded to the lowest qualified bidder.

The governmental decree forces SQAQ to go out for public tenders and to award the contract to the lowest qualified bidder. Negotiation with the lowest bidder to try to reduce prices in order to stay within the budget was practically impossible under this process.

The SQAE approach is to review the bid documents with MENVIQ and the consultants to make scope changes, if possible, and then return for public tenders.

Another approach is to assume some of the risks normally assumed by the contractor. For example, SQAE could assume some of the contractor's risk of flooding when building main sewers along a river. This in fact was done in one case by setting the level of the coffer-dam and a number of «flooding events» that should be assumed by the contractor; any additional events were to be assumed by SQAE on a unit price basis.

2.5.9 Principle no.9: Project Priorities

2.5.9.1 Project priorities are to be given to quality and cost control over scheduling.

From the first day, it was obvious that scheduling was not the critical issue for MENVIQ and the municipalities. As of March 31, 1982, more than 50% of the projects were not expected to be completed within the key dates set by MENVIQ in the governmental agreement.

Most of the delays were in the design phase. As previously mentioned, MENVIQ requested changes to the preliminary studies in order to stay within the budget, even though it was unrealistic. The quality objectives and poor estimates caused many setbacks and recyclings, thus delaying the project by several months, increasing cost engineering fees and escalation charges. The ability to pay did not match the quality objectives set by MENVIQ.

Another aspect that was not considered in delaying the projects was the return on investment. On some projects, there were main sewers burried in the ground and ready to be used. Because of major delays in constructing the wastewater treatment plant, they went unused.

Cost control is a sensitive issue for the municipalities because of the impact on the taxation rate. On some projects, the schedules are prepared or revised taking into account the impact on the taxation rate each year; major increases in the taxation rate is not viewed favorably prior to an election in the municipality.

The author is not supportive of this philosophy. If one can control the schedule, then equally they can control the cost, as long as the time schedule and budget are realistic and the scope of work is fixed.

2.5.9.2 Cost control priorities are to be given to estimating and value engineering over forecasting.

The basic requirement for an effective cost control system is to have accurate cost baselines from estimating. If the baselines are not valid, there is no cost control.

Total project cost forecasting was difficult with variable scope of work. SQAE was faced with a «moving target» situation. SQAE did not know what MENVIQ wanted to build. The estimate to complete, for the portion of the project not yet approved by MENVIQ, would vary significantly depending on MENVIQ's decisions. Because of this situation, it was decided not to do any forecasting prior to the approval of the preliminary studies by MENVIQ.

Again, the author does not support this philosophy. Forecasting is a prime function of cost control and should be done at all phases of the project. The objective in preparing the estimate to complete on a regular basis is to be able to forecast any variance from the budget and initiate corrective action. By challenging MENVIQ's estimates early in the design phase, SQAE would force MENVIQ to reexamine the scope of the project and reduce it, if possible, in order to stay within budget and schedule.

### 2.5.10 Principle no.10: Project Budgeting

Preliminary studies for all engineering packages related to sewerage and treatment are to be completed prior to any final design.

The intention is to get the project scope and budget approved by MENVIQ and make the necessary changes prior to the final design.

This principle would improve the accuracy of the estimate to complete, since a definitive scope and budget would be approved. The impact on the time schedule should be examined.

2.5.11 Principle no.11: Project Reporting

2.5.11.1 External

Project reports are to be prepared on a monthly basis for each municipality by each department coordinator under the direction of the project manager.

These reports include the following sections:

1) Summary

This section must be prepared by the project manager and treat project status (summary) and potential problems.

2) Control and Procurement

This section must be prepared by the control and procurement coordinator and include progress reports on scheduling, cost control and procurement.

3) Engineering

This section must be prepared by the engineering coordinator and treat project status for engineering work, and technical problems.

4) Marketing

This section must be prepared by the marketing coordinator and contain reports on land acquisition.

5) Financing

This section must be prepared by the finance and administration coordinator and include details on all the short-term and long-term loans raised and/or required by the project.

2.5.11.2 Internal

Monthly reports are to be prepared by the project management director and the functional directors highlighting the problems related to the projects and the administration.

These reports contain the following sections:

1) Project management

2) Control and procurement

3) Engineering

4) Finance and administration

# CHAPTER THREE

## COST CONTROL NEEDS

# CHAPTER 3

# COST CONTROL NEEDS

## 3.1 BASIC NEEDS

The need for cost control has been established in the previous chapter. The cost control system must be able to cope with the environment already described:

i) A multi-project environment, mostly small and repetitive type project, located across the province;

ii) A multidisciplinary project management organization;

iii) The existence of major and complex external interfaces with governmental departments, municipalities, consultants, contractors;

iv) The procedures associated with the management of public funds; and

v) Ecological and political influences that could have major impacts on the viability of projects.

The basic needs of most project management organizations for a cost control system are:

### 3.1.1 Early warning system

The system should be able to forecast any deviation from established budgets when they appear and pinpoint sources of variance in order to be able to take corrective measures before commitments are made.

Effective and timely communication system is a key factor to fulfill this basic need. Regardless of other means of cummunication for forecasting input data, the most effective and reliable means available to the cost controller is by personal contact with all other project functions. This means almost daily contact with project management, design engineering, procurement and construction personnel.

Other sources of input data are the project correspondence; the cost controller must review the project correspondence file daily and make sure that he is placed on distribution of all correspondence that pertains to cost information.

Another significant requirement for an effective system is project meetings to review all trends initiating during the previous weeks for content and validity prior to incorporation into the cost report. It is essential that responsible personnel from all project functions be present at these meetings and also discuss in turn any potential trends that they may be aware and what effect they could have on the project.

### 3.1.2 Short-response system

The information should be provided rapidly and periodically by the cost controller. If this basic need is not fulfilled, management will loose confidence in the system.

The key factor here is discipline in the project management organization. It is most important to determine cut-off dates for progress reports and to make sure that they are met. The cost controller should issue early-warning reports for major variances prior to the monthly report.

The computer system should be a short-response system. Lack of discipline and poor quality of the input data are responsible most of the time for delays in the processing of data. Checking input data is vital prior to any processing. An interactive system should be examined to reduce the number of intermediaries in batch processing and to provide immediate response in case of input errors.

### 3.1.3 Accuracy

Major decisions are taken based on information provided by the system. All cost data input/output should be investigated and corrections made prior to the transmittal of any report. If this is not done, management will loose confidence in the system.

The accuracy of the cost data varies with the level of scope definition; the accuracy of cost estimating and forecasting will improve once the preliminary studies have been completed.

Manual checking of computer reports will be required to make sure that all the data are included and coded accordingly.

### 3.1.4 Simplicity

The cost control system should be simple and adequate to assure compliance with the level of control required.

Simplicity shows itself in the level of detail of the control budget, in the reporting format, in the number of procedures and their complexity and in the degree of sophistication of the computer system. They should all be developed according to the level of control required and the complexity of the projects. The level of control is defined from the typical WBS and related coding structure.

### 3.1.5 Flexibility

A certain degree of flexibility is required because of the range of projects from small to middle size.

Flexibility takes the following forms in the cost control system:

i) Use a detailed WBS for middle size projects and a less comprehensive WBS for small projects;

ii) Engineering manhour control should be at a more detailed level for middle size contracts than for small contracts (less than 100 000 $); the basic unit for controlling manhour for small contracts should be at the engineering activity level instead of being at the drawings and specifications level.
This will be discussed in section 3.4;

iii) Invoice checking procedures should be more rigorous for large contracts than for small contracts;

iv) Cost reports should be available in different formats for large projects and summary reports with cumulative data should be prepared for small projects.

### 3.1.6 Economical

The cost control system should be designed to suit most project requirements at a reasonable cost. Reporting superfluous information or using overly sophisticated computer hardware should be avoided.

## 3.2 ENVIRONMENTAL DEPARTMENT NEEDS

### 3.2.1 Capital Investment Plan

The environmental department has the ultimate responsibility for the wastewater treatment program.

Every year, in January, they submit to Treasury Board the capital investment plan for the year for approval.

This plan includes for each municipality:

a) The scope of the work;
b) The total cost of the project;
c) The impact of the project on the municipality's long term liabilities and taxation rate;
d) The overall schedule of the project;
e) The capital investment for the year.

### 3.2.2 Capital Investment Plan Progress Reports

The department prepares on a quarterly basis a progress report on the capital investment plan for every project. This report is submitted to Treasury Board and includes:

a) The list of municipalities included in the plan;
b) The list of agreements signed;

c) The capital investments for the year;

d) A cash flow projection on an annual basis by sub-projects (Epic studies, restoration, sewerage, treatment);

e) The amount of money spent for each sub-project;

f) The status of governmental debt and annual commitments.

This information allows for a comparison, on an annual basis, of the actual total governmental financial commitments with the authorised total budget, the individual project budget and forecast and provides a basis for explaining major variances.

These reports are prepared for the following dates of each year June 30, September 30, December 31 and March 31. The first report was prepared for December 31, 1981.

3.2.3 Project Progress Quarterly Reports

In order to prepare the Capital Investment Plan Progress Report, the MENVIQ project coordinators are requested to prepare project progress reports on a quarterly basis. These reports include for each sub-project (restoration, sewerage, treatment) the following information:

a) A schedule showing the original completion dates and the forecasted dates for each phase: preliminary studies, drawings and specifications, construction.

b) The original and the forecasted costs for each phase.

c) The original and the forecasted cash flow on a quarterly basis for the present fiscal year and on a yearly basis for the following years for each phase.

d) The incurred cost for each phase.

e) The progress of each phase in percentage.

This information is to be provided by construction packages. The cost data are in constant dollars (the present fiscal year) and escalation is calculated on a yearly basis for the remaining portion of the project. Figure 3.2.1 shows the format used.

For the Epic studies, the format is different (see figure 3.2.2) but the information required is the same; the phases are numbered for the Epic studies. These reports are prepared on a monthly basis.

The frequency of these reports was set by MENVIQ. SQAE was requested by MENVIQ to prepare these documents for the municipalities who hired them. The following problems were encountered in their implementation.

1) The original data either were not available or were not broken down the way the report was set up.

2) Budget cost items, such as engineering fees were not broken down by construction packages but rather by phases (preliminary studies, drawings and specifications and field supervision)

ASSAINISSEMENT URBAIN
**PROGRAMMATION ET SUIVI**
**CONVENTIONS SIGNEES**

MUNICIPALITE ______
BASSIN ______
PROJET OU PHASE ______
TRAVAUX ______
DATE DE SIGNATURE DE LA CONVENTION ______
FINANCEMENT GOUVERNEMENTAL ______ %

CHARGE DE PROJET ______
S Q A E ☐
MENVIQ ☐
CONSULTANT (PLANS & DEVIS) ______
CONSULTANT (SURVEILLANCE) ______
ENTREPRENEUR ______
SOUMISSION $ ______

| ETAPES | REALISATION | ✓ | PREVISIONS DUREE DE L'ETAPE ET INVESTISSEMENT ($000) | | | | | | | | | | | | | | DEPENSES ($000) | | % |
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| | | | TOT ORIG. | ANT 1982-83 | 1982-83 1er TRIM. | 1982-83 2e TRIM. | 1982-83 3e TRIM. | 1982-83 4e TRIM. | 1983-84 1er TRIM. | 1983-84 2e TRIM. | 1983-84 3e TRIM. | 1983-84 4e TRIM. | 1984-85 | 1985-86 | ULT | TOT REV | TRIM | CUM | TRAV COMP |
| A- TRAVAUX DEJA REALISES (RACHAT) | | $ | | | | | | | | | | | | | | | | | |
| B- ETUDES PRELIMINAIRES | DATE | | | | | | | | | | | | | | | | | | |
| 1- REGLEMENT D'EMPRUNT | PRESENTATION | | | | | | | | | | | | | | | | | | |
| | APPROBATION | | | | | | | | | | | | | | | | | | |
| 2- EMBAUCHE DU CONSULTANT | RESOLUTION | | | | | | | | | | | | | | | | | | |
| 3- ETUDES PRELIMINAIRES | DEBUT | | | | | | | | | | | | | | | | | | |
| | FIN | $ | | | | | | | | | | | | | | | | | |
| 4- APPROBATION DU MENVIQ | PRESENTATION | | | | | | | | | | | | | | | | | | |
| | APPROBATION | | | | | | | | | | | | | | | | | | |
| C- PLANS ET CAHIERS DE CHARGES | | | | | | | | | | | | | | | | | | | |
| 1- REGLEMENT D'EMPRUNT | PRESENTATION | | | | | | | | | | | | | | | | | | |
| | APPROBATION | | | | | | | | | | | | | | | | | | |
| 2- PLANS ET CAHIERS DE CHARGES | DEBUT | | | | | | | | | | | | | | | | | | |
| | FIN | $ | | | | | | | | | | | | | | | | | |
| 3- APPROBATION DU MENVIQ | PRESENTATION | | | | | | | | | | | | | | | | | | |
| | APPROBATION | | | | | | | | | | | | | | | | | | |
| 4- APPELS D'OFFRES ET CONTRATS | ENVOI | | | | | | | | | | | | | | | | | | |
| | SIGNATURE | | | | | | | | | | | | | | | | | | |
| D- EXECUTION DES TRAVAUX | | | | | | | | | | | | | | | | | | | |
| 1- REGLEMENT D'EMPRUNT | PRESENTATION | | | | | | | | | | | | | | | | | | |
| | APPROBATION | | | | | | | | | | | | | | | | | | |
| 2- TRAVAUX | DEBUT | | | | | | | | | | | | | | | | | | |
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| 3- ACCEPTATION | PROVISOIRE | | | | | | | | | | | | | | | | | | |
| | FINALE | | | | | | | | | | | | | | | | | | |
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| COMMENTAIRES | | | | | | | | | | | | | | | | | | | |

FORMULAIRE No. AU 2-82-03

FIGURE 3.2.1

MENVIQ PROJECT REPORT

RESTORATION, SEWERAGE, TREATMENT

ASSAINISSEMENT URBAIN
PROGRAMMATION ET SUIVI
ETUDES EPIC

MUNICIPALITE ____________
BASSIN ____________
PROJET OU PHASE ____________
SIGNATURE DE LA CONVENTION (DATE) ____________
TRANSFERT A S.Q.A.E. (DATE) ____________

CHARGE DE PROJET (MENVIQ) ____________
RESPONSABLE S.Q.A.E. ____________

| ETAPES | DATE DE REALISATION | ✓ | PREV ORIG ($000) | PREVISIONS DUREE DE L'ETAPE (___) ET INVESTISSEMENTS ($000) | | | | | | | | | | | | | | % TRAV COMP |
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| | | | | ANT | 19__ 1er TRIM | 2e TRIM | 3e TRIM | 4e TRIM | 19__ 1er TRIM | 2e TRIM | 3e TRIM | 4e TRIM | | ULT | TOTAL REVISE | DEPENSES TRIM | DEPENSES CUM | |
| TRANCHE I | DEBUT ______ | | | | | | | | | | | | | | | | | |
| | FIN ______ | $ | | | | | | | | | | | | | | | | |
| TRANCHE II | DEBUT ______ | | | | | | | | | | | | | | | | | |
| | FIN ______ | $ | | | | | | | | | | | | | | | | |
| TRANCHE III | DEBUT ______ | | | | | | | | | | | | | | | | | |
| | FIN ______ | $ | | | | | | | | | | | | | | | | |
| TRANCHE IV | DEBUT ______ | | | | | | | | | | | | | | | | | |
| | FIN ______ | $ | | | | | | | | | | | | | | | | |
| TRANCHE V | DEBUT ______ | | | | | | | | | | | | | | | | | |
| | FIN ______ | $ | | | | | | | | | | | | | | | | |
| ORIGINAL DATE ______ TERMINE | TOTAL | | | | | | | | | | | | | | | | | |
| MISE A JOUR DATE) ______ | ☐ | | | | | | | | | | | | | | | | | |

***COMMENTAIRES:***

FIGURE 3.2.2

MENVIQ PROJECT REPORT

EPIC STUDIES

or were given simply as global amounts. This item will be discussed later on in the work breakdown structure.

3) SQAE budgets already developed in current dollars had to be de-escalated to the present fiscal year to obtain constant dollars figures; the constant dollar base kept shifting from one fiscal year to another. The author's view is that the format of these reports should be changed so as to be useful for both organizations including use as a control tool.

4) Forecasting on the portion of the project for which preliminary studies were not approved by MENVIQ, created major conflicts with MENVIQ; SQAE forecasts were rejected by MENVIQ.

5) In order for SQAE's financial plan to be reliable would require forecasting final project cost in current or future dollars.

### 3.2.4 Preliminary Estimates

During the preliminary studies for sewerage and treatment, the consultants have to prepare preliminary estimates of all the proposed alternatives and include in the final report a detailed estimate of the selected alternative.

If this report is approved by MENVIQ but the estimate exceeds the escalated order of magnitude estimate set in the governmental agreement by more than 20%, negotiations must be carried out with the municipality involved.

MENVIQ is responsible to negotiate with the municipality a revision to the governmental agreement. If it is accepted by both parties and by the Treasury Board, SQAE can then revise their agreement with the municipality.

The author suggests that upon the start of preliminary studies, the consultant evaluates the level of treatment possible with the available budget rather than follow the process just described.

3.2.5 Tender Estimates

From the preliminary estimate approved by MENVIQ with the preliminary studies, a definitive or control estimate is prepared during the final design phase for the portion of the project being approved.

When the drawings and specifications are submitted to MENVIQ for approval, a tender check estimate is also submitted by the consultant. If approved, SQAE then goes out for tenders and when the tenders are in, MENVIQ requests a copy of the bid comparison table.

When the contractor is selected, MENVIQ is informed of the amount of the contract.

3.2.6 Change orders

MENVIQ must be informed of any overrun to the contract amount of more than 5%. SQAE cannot proceed before MENVIQ's approval.

3.3 CLIENTS NEEDS (MUNICIPALITIES)

Most of the cost control needs were set by MENVIQ because of their major contribution to the project. The municipalities are quite preoccuped with cost control, but most of the basic needs expressed by MENVIQ satisfy them. The municipalities requested the following specific needs:

3.3.1 Forecasting Annual Reimbursement
Long Term Liabilities

The municipalities, when preparing their annual budget in September-October of each year, need a forecast in current dollars of the disbursements for the project for the following year.

3.3.2 Joint Municipal Construction Work

On most projects, the municipality requested the installation or restoration of municipal services jointly with main sewer construction.

The municipality made some savings, for the services that were in the same trench as the main sewer since the work was done by the same contractor. MENVIQ agreed for joint construction work, but the governmental grants did not cover these services; separate prices were obtained from the bidders.

Again to make some savings, the municipality hired the same consultant for the design and field supervision. The municipal services were shown, most of the time, on the same drawings as the main sewers and the consultant gave the theoretical baselines to prorate the excavation and back fill, the granular material and the asphalt for resurfacing. His fees could not be charged to the SQAE project.

Controlling engineering fees and change orders that affected both services is made difficult when joint construction work occurs.

### 3.3.3 Operating Costs

The municipalities are mostly preoccupied with the operating costs of wastewater treatment plants.

The total annual operating costs for a mechanical plant run from 8 000 $ (or 80 $/person) for 10 000 Gal/day capacity, to 32 000 $ (or 34 $/person; for a 100 000 Gal/day capacity and 105 000 $ (or 11 $/person) for a 1 000 000 Gal/day capacity. For aerated lagoon type plants, the operating costs are lower and even minimal for lagoon type plants with no aeration.(7)

Life cycle costs have to be provided by the consultant with his preliminary studies as requested by SQAE.

## 3.4 ORGANIZATION NEEDS (SQAE)

Most of the organization needs were expressed in the section related to the project control philosophy in the previous chapter but some will be reviewed here with emphasis on cost control.

### 3.4.1 Dual Control Mechanism (principle no 4)

Two separate entities must be involved in any decision-making process related to the following financial transactions, on a project:

1) Budgetary transactions;
2) Commitment transactions;
3) Contract awards;
4) Approval of invoices;
5) Progress payments.

For the budgetary transactions, the cost controller cannot "load" the preliminary budget into the system prior to approval by the control and procurement director. As for the definative budget, it has to be approved by the president. The project manager's role, in these transactions is to check the estimate making sure that the most recent information is included and that all the cost items are included in the estimate. He then approves the estimate and submits it to the appropriate level of authority.

For the commitment transactions and changes to previous autorized commitments, the project manager cannot commit any money for consultant's or contractor's contracts, purchasing or rental of equipment, land purchasing without the authorization of the control and procurement department.

For the approval of invoices and progress payments, the project manager will approve the expenditure, the control department will authorize the payment and the finance personnel will proceed with the payment.

3.4.2 Work Breakdown Structure (WBS) (principle no 5)

The total project must be broken down into sufficiently small subdivisions to permit accurate cost estimates and adequate visibility and control over cost and time limits.

The first level of the WBS is the project level. The major subdivisions of a typical project are:

1- Epic studies;
2- Restoration of sewers;
3- Sewerage;
4- Treatment.

These major subdivisions are called sub-projects and represent the second level of the WBS as shown on figure 3.4.1. In the governmental agreement, key dates and budget estimates are usually given for each sub-project. These estimates are obtained from the project brief prepared by MENVIQ. The project is defined in sufficient detail to allow preparation of the order of magnitude estimate. In order to generate this estimate, the project is broken down up to level 4 of the WBS; the sections of sewer are known as well as the number of pumping stations and their capacity.

The third level is the area or group of systems level. Separate estimates are required for the sewer and pumping systems.

For the fourth level, the building or system level, separate estimates for each section of main sewers or each pumping station are required. This is the order of magnitude estimate level.

On the fifth level, the sub-system level, separate estimates are required: estimates for each pumping station for civil (bldg), mechanical, electrical and instrumentation work. For a large pumping station, the process services would be separate from the building services.

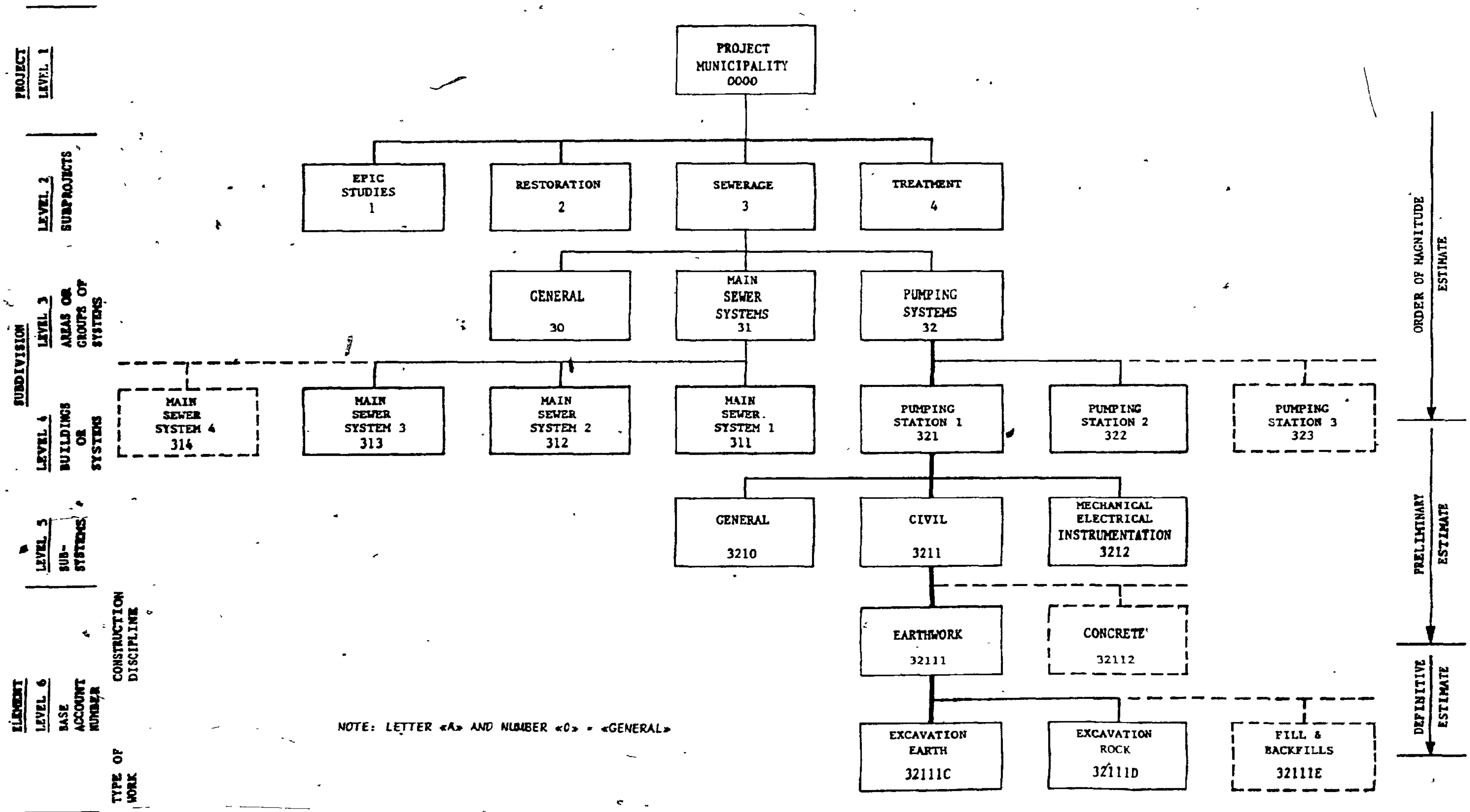
On the sixth level, the element level or account number level, separate estimates are required for each construction discipline, earthwork and concrete. The project must be broken down up to this level in order to generate the preliminary estimate. Detailed estimates are required by type of work (excavation earth, excavation rock, fill and back fill).

In order to permit adequate visibility and control over cost, the SQAE control level must be set at the sixth level (type of work level). The project must be broken down to this level in order to generate the definitive estimate.

The sixth level includes the capital elements related to construction as shown on Figure 3.4.1 and service elements such as management, engineering, laboratories. It would be more logical to have the "Epic studies" at the service element level and create a major subdivision called "general" since it involves engineering services only. The author believes it should not be changed because the "Epic studies" constituate a project (or sub-project) by itself since SQAE can be responsible for the "Epic studies" only for a municipality. Another reason not to change is the fact that the accounting system is already implemented with these codes and it would represent a major task to revise them on all ongoing projects.

The coding must be done on the WBS using an numeric coding system. Figure 3.4.2 shows the coding system to be used at SQAE. The last two characters of the capital element will only be used for large projects.

It should be mentioned that the initial WBS and coding structure used at SQAE were different; categories were part of the subdivision at level 3. These categories are now at the element level which is more logical since all the levels in the sub-




NOTE: LETTER «A» AND NUMBER «0» = «GENERAL»

FIGURE 3.4.1

WORK BREAKDOWN STRUCTURE

MAIN SEWER CONSTRUCTION

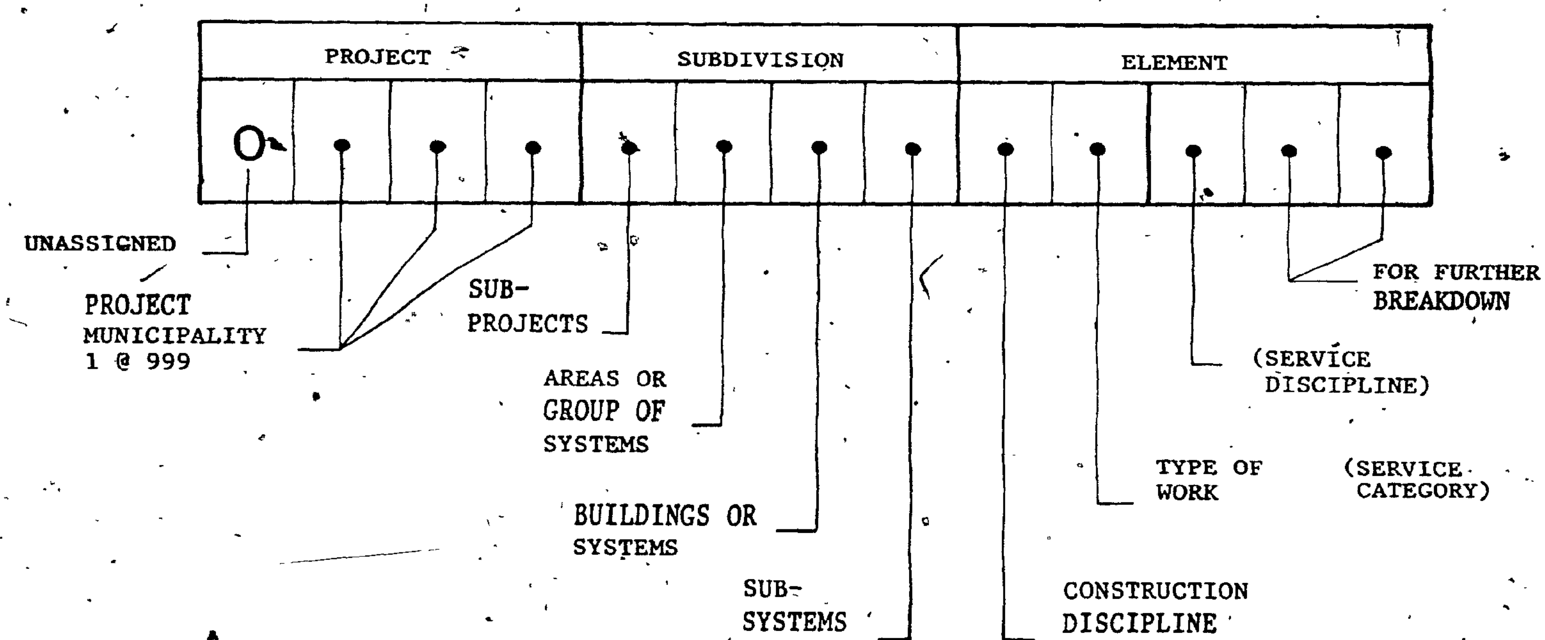



FIGURE 3.4.2

CODING SYSTEM

SQAE

division are related to the project work or the process (or system) to be built. The revised WBS and coding system was proposed but not yet implemented at SQAE.

### 3.4.3 Engineering, Procurement, Construction Packaging (principle no 6)

The total project is to be broken down into engineering, procurement and construction packages, and are to be controlled accordingly.

The intention here is to be able to assign each element of the WBS to a package. The system should then allow regrouping of all the elements that form a package in order to compare this information with the information submitted by the consultants, the suppliers and the contractors for the pertinent package.

Figure 3.4.3 illustrates how construction packages are derived from the WBS given in the previous example (figure 3.4.1). Three packages were formed:

Package C-1: Pumping station 3

- General
- Civil
- Mechanical, electrical, instrumentation

Package C-2: Sewers 3 & 4 and pumping station 2

- General

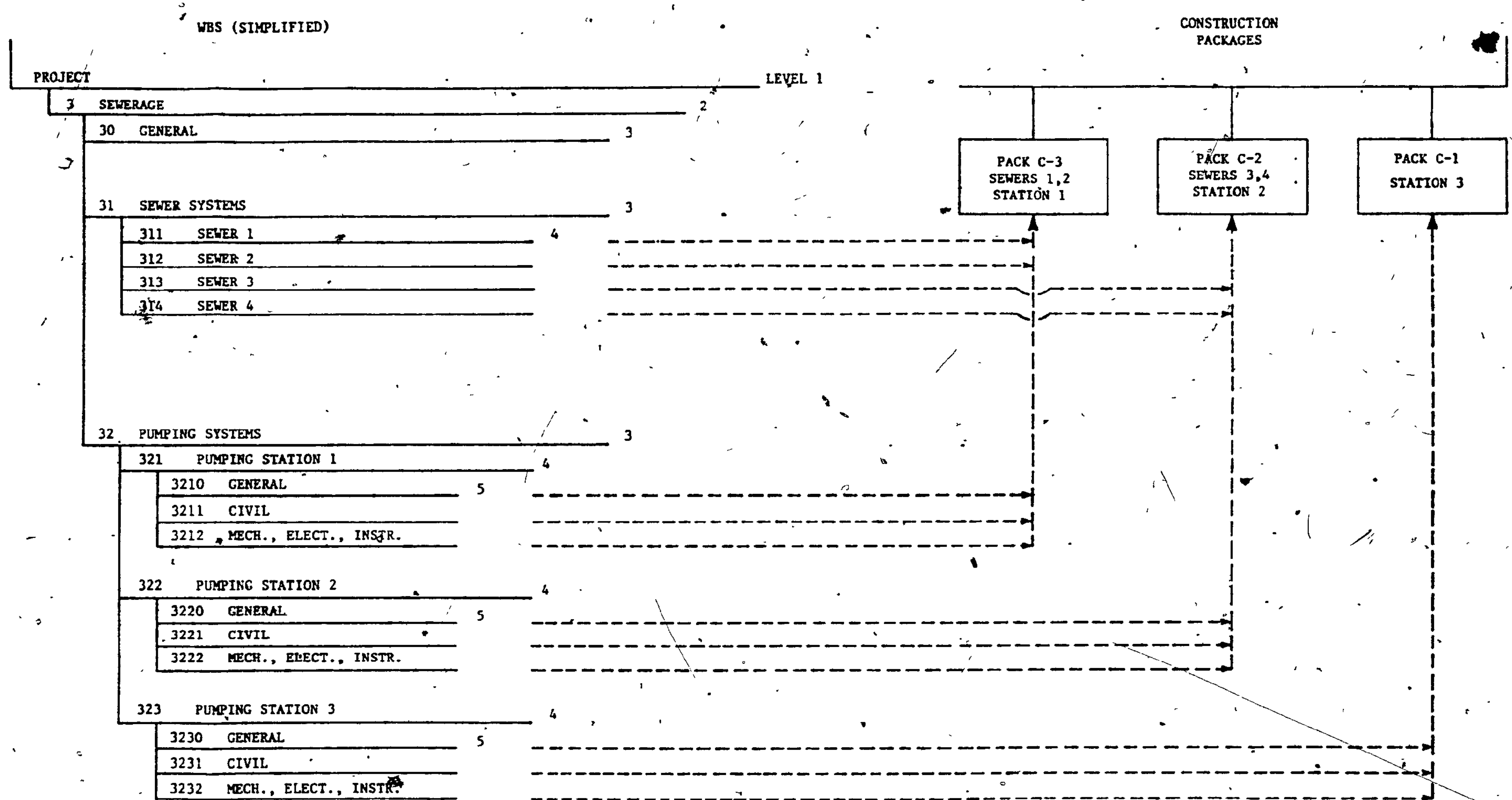



FIGURE 3.4.3

RELATIONSHIP BETWEEN

WBS AND CONSTRUCTION PACKAGES

- Civil
- Mechanical, electrical, instrumentation

Package C-3: Sewers 1 & 2 and pumping station 1

- General
- Civil
- Mechanical, electrical, instrumentation

All the corresponding codes are assigned to each package; for example, all the 313, 314 and 322 codes are assigned to package C-2. This exercise would normally be done at the element level, but for simplicity it was shown at the subdivision level.

The breakdown of the elements included in the package will then be specified in the tender calls for bid analysis purposes. Most of the contracts for civil work at SQAE are unit priced, so the pricing would be done at the element level (type of work). If lump sum prices were requested for some work packages, the selected contractor should break down the lump sum prices up to the element level prior to contract signature. The purpose of this exercise if for comparison with the estimated amounts claimed in the progress payments. In the previous example, in figure 3.4.3, a lump sum price would be submitted for the mechanical, electrical and instrumentation for the pumping station 2 in package 2. The selected contractor would be requested to break it down by trades up to the element level.

- The cost control system must offer the flexibility to change the packages freely, without major changes in the coding of the elements. Attached to each package number there will be a string of element codes which relate to that package and if you want to modify that string, it will be done by reallocating element codes to other packages.

3.4.4 Consultants Manhour Control (principle no 7)

A manhour budget is to be set for each design package and included in the contract as an upset limit. A mechanism for the control of additions, deductions, and changes is to be established.

It is required to set up separate manhour budgets for the following phases: preliminary studies, final design and field technical supervision. In order to achieve better control and because it is very difficult for a consultant to evaluate his manhour requirements for the final design and field supervision before the preliminary studies have been completed and approved, the consultant's contract will be awarded by phases.

A list of activities is prepared by the engineering department for each phase of the project and manhours are estimated for each activity by the consultant. The list of the major engineering activities for the main sewer design is given in Table 3.4.1; this list is included in the consultant's proposal.

The estimate is checked by the engineering department and negotiated, if required, by the project manager with the firm. The baseline for negotiation is estimated by the engineering department and established most of the time on a percentage basis of the construction cost from the order of magnitude estimates; the manhour budget is converted to dollars using the average hourly rate to be charged by the consultant.

The consultant must evaluate his physical progress in terms of

TABLE 3.4.1

MAJOR ENGINEERING ACTIVITIES

MAIN SEWER DESIGN

| | | |
|---|---|---|
| PHASE I - | Preliminary Studies | |
| 1.10 | Coordination and management (including scheduling and estimating) | |
| 1.20 & 1.30 | Definition of waste water inflows and projections | Report - Stage 1 |
| 1.40 & 1.50 | Detailed studies of alternatives and recommendations | Report - Stage 2 |
| 1.60 | Preliminary design of the selected project solution | Report - Final |
| PHASE 2 - | Final Design | |
| 2.10 | Coordination and management (including scheduling and estimating) | |
| 2.20 | Design calculation, drawings and specifications | |
| PHASE 3 - | Field Technical Supervision | |
| 3.10 | Coordination and management | |
| 3.20 | Field technical supervision (including construction guidance, preparation of "as built" drawings, and manual for operation and maintenance) | |

physical percentage complete and the manhour expended for each activity on a monthly basis; the physical progress is checked by the engineering department. During the final design phase, the physical progress must be evaluated using the drawings and specifications as the basic unit. Actual percentage complete multiplied by a weighting factor give the weighted percentage complete for each activity. The budgeted manhours for the activities determine the weighting factor. The weighted percentage complete for the phase is compared with the scheduled percentage complete and the plan in order to forecast future performance. The earned manhours, obtained by multiplying the budgeted manhours by the actual percentage complete, can be compared with the expended manhours to determine the manhour variance.

It should be mentioned that, if a design package contains more than one discipline, the consultant will be requested to set up a separate manhour budget for each discipline. On most of the contracts for preliminary studies, this will not be required since the involvement of the mechanical, electrical and instrumentation disciplines is relatively small compared with the civil discipline.

Change order would be issued for additions, deductions and changes and would increase or decrease the pre-set budget.

### 3.4.5 Non-Construction Costs - Limits

Limits or objectives were set by SQAE and MENVIQ on the following non-construction costs:

i) Engineering fees;

ii) Laboratory fees (soil investigation, quality control, water sampling);

iii) Legal fees, surveyors fees;

iv) Management fees already set at 3.5% of the construction costs and non-construction costs including bridge financing;

v) Commissioning;

vi) Bridge financing.

The non-construction costs plus the contingency allowance should not exceed 30 % of the construction costs based on MENVIQ historical data and standard service fees on the market. This upset limit was to be included in the new governmental agreements to be signed in 1982.

3.4.6 Project Budgeting

3.4.6.1 Order of Magnitude Estimates

The order of magnitude estimates included in the governmental agreement should be checked by the control department immediately after the contract is signed by the municipality.

MENVIQ should provide SQAE with all the information used to prepare the estimate; any discrepancies found by SQAE should be discussed with MENVIQ. Its range of accuracy is ± 20%.

### 3.4.6.2 Preliminary Estimate

The preliminary estimate should be prepared by the consultants and submitted with the final preliminary studies report. They should be checked by the control department prior to being sent to MENVIQ to check their conformity with the preliminary WBS and their validity. Its range of accuracy is ± 15%.

### 3.4.6.3 Definitive Estimate

The definitive estimate should be prepared by the control and procurement department once the preliminary studies have been approved by MENVIQ..

It should be prepared according to the final WBS and code of account structure and before the final design has reached 30%.

This definitive estimate is used as a "yardstick" for cost control during the final design. Its range of accuracy is ± 10%.

### 3.4.6.4 Value Engineering

Estimates and cost comparisons should be made, by the consultants and checked by the control and procurement department, throughout the preliminary and final design to ensure selection of the most economical alternatives.

Life cycle cost comparisons should be made during the preliminary study phase.

3.4.6.5 Spot Check Estimates

Spot check estimates should be prepared by the control and procurement department in the final design phase at 50% to 75% progress to keep the design compatible with the definitive estimate and for use in making monthly cost forecast. Its range of accuracy is ± 5%.

These spot check estimates should be prepared on an exception basis, for critical items only, for each construction package since the packages are relatively small.

3.4.6.6 Tender Check Estimates

A tender check estimate should be prepared for each construction package to identify construction problems or contractor's risks that could affect the pricing and for use as a guide in evaluating contractor's bids. Also, it can be used for "negotiating" adjustments with the selected contractor for the breakdown of the lump sum prices, if any, for progress payment purposes.

It is part of the consultant's contract to prepare an estimate with the final drawings for each package. Tender check estimates could be requested from estimating firms with large construction experience for major tenders or for complex work.

3.4.6.7 Estimates of "Project Change"

Estimates of "project change" should be prepared to revise and update the definitive estimate and to provide checks for contract change orders to contractors.

The consultants should be involved in the preparation of this estimate. The control and procurement department would check its conformity with the WBS and accuracy.

Every estimate, from the preliminary estimate to the project change estimate, should relate to the WBS, but at different levels depending upon the level of detail available. Most consulting firms involved in the wastewater treatment program are small and are not familiar with a WBS and code of account structure. The control and procurement department would have to give the basic WBS coding to the consultant prior to the estimating task.

The control department prepares the definitive estimate and the spot check estimate. It is part of the consultant's contract to prepare the preliminary estimate, the tender check estimate and the project change estimate. The control department's role with these estimates is to check their conformity with the WBS and the quantities and prices used by the consultant. If necessary, SQAE will prepare the estimate (or hire an outside estimating firm at peak period) in order to make sure that the estimate is reliable.

On a project estimated at 1.25 million dollars, only a few thousand dollars can be allocated to the control department for estimating. With an average of four construction contracts and a duration of two years for such a project, the estimating man-hours will have to be spent efficiently.

### 3.4.7 Verification of Invoices and Construction Progress Claims

#### 3.4.7.1 Consultant Invoices

Consultant invoices are to be checked according to the contract agreement. The following items should be checked:

i) Time sheets;
ii) Hourly rates;
iii) Expenses;
iv) Coding;
v) Percentage of completion.

With more than seven consulting contracts per project, including the Epic studies, the volume of paperwork was expected to be relatively high. More than 125 invoices were in process on a regular basis.

Some solutions were examined in order to reduce the work load:

1) Sampling: one out of four invoices would be checked. This method was not implemented as of March 31, 1982.

2) Consultant involment: the engineering consultants would be responsible for checking invoices for the laboratories (quality control and soil investigation), the surveyors, etc. This solution was not fully implemented.

3) Reducing relevant papers: the time sheets and expense slips would not be included with the invoices. Spot checks would be made at the consultant's office. This method was implemented recently.

4) Standard formats: to accelerate the checking of invoices, standard invoice formats would be developed. This method was implemented recently.

3.4.7.2 Construction Progress Claims

Construction progress claims are to be checked by the consultants and the project manager (or field coordinator) on the job and then by the cost controller.

First, the contractor will be requested to break down his bid according to the WBS and coding structure submitted by the cost controller. The breakdown must be approved by the cost controller before the contract is signed with the contractor and will form part of the contractual documents. The consultant is responsible for ensuring that the progress claim corresponds to the actual progress on the site and that the work has been performed in a satisfactory manner.

The cost controller will have to check conformity with the contract conditions for payment, the unit prices used, the actual progress against the scheduled progress, the change orders claimed to make sure that only the change orders which have been agreed upon are incorporated in the progress claim. The engineering coordinator will be responsible for ensuring that the quality of the work performed by the contractor is acceptable. The project manager will then approve the progress claim depending on the comments received from the consultant, the cost controller and the engineering coordinator.

Because of the amount of money involved compared with the consultant invoices, the cost controller must pay more attention to the progress claims. It is required to go to the site, to discuss any discrepancies with the consultant and the contractor.

### 3.4.8 Project Reporting (principle no 11)

#### 3.4.8.1 External

Project reports are to be prepared on a monthly basis for each municipality by each department coordinator under the direction of the project manager.

Because there were more than 40 reports to be issued on a monthly basis, it was decided to abandon the calendar basis and adopt the four weeks basis; the 40 reports would be distributed over 4 weeks, each project report being issued every 4 weeks.

The content of these reports was described in the previous chapter, in the section related to the project control philosophy. Examined in this section is the content of the cost control progress report.

The cost control progress report must include the following information:

i) A status report on the overall financial aspect of the project:

- total forecast (including contingencies and escalation);
- commitments to date;
- expenditures to date;
- disbursements to date.

The status report will also include the variance with the latest authorized budget in current dollars and which sub-project (Epic, restoration, sewerage, treatment) is mostly responsible for the variance.

ii) A variance report for each sub-project with the reasons for the variances; and

iii) Cash flow projections for the next three months and cash flow curves showing planned and actual cash flows.

Because of the difficulties related to forecasting the portion of the project not yet approved by MENVIQ and because of the major conflicts with MENVIQ resulting from the publication of the budget discrepancies, top management of SQAE decided to exclude total forecasting as well as the variance items from the report. The author believes that the content of the report should not change but the major variances should be examined with MENVIQ prior to being reported. The format of this report will be discussed in the next chapter.

3.4.8.2 Internal

Monthly reports are to be prepared by the project management director and the functional directors highlighting the problems related to the projects and the administration of their respective department.

This report is prepared for the board of directors meeting held every month. Each director reports the major problems and the key activities completed during the month, the project management director reports on the major problems on the projects.

### 3.4.9 Cash Flow Requirements

The Financial Department requests cash flow requirements (in current dollars) for projects in order to prepare their financial plan for the next three years. The cash flow requirements should be revised on a quarterly basis.

MENVIQ quarterly report could be used to fulfill this organization need but projects' costs are reported in constant dollars and the financial plan is required in future dollars. Thus the MENVIQ report would have to be escalated.

In March 1982, top management agreed that a reliable financial plan could not be prepared for a period exceeding three months because of the major budget variances on several projects and the decision not to do any forecasting, on the portion on the project not approved by MENVIQ.

### 3.4.10 Cost Accounting

The project cost control system and the accounting and reporting system should be integrated.

After several unsuccessful searches for a system that would be suitable for the financial and the control departments, it was decided to go for separate accounting and project cost control systems.

The account structures would be compatible at the sub-project level only.

### 3.4.11 Cost Data Retrieval

The cost control system should establish a project history for post project analysis and dates retrieval for subsequent projects.

This is important in order to improve the accuracy of estimates for new projects. Historical data on similar wastewater treatment projects in Quebec are scarce. There are some in the United States with the Environmental Protection Agency (EPA) but the building codes and weather conditions are different.

# CHAPTER FOUR

## PLANNING FOR COST CONTROL

# CHAPTER 4

# PLANNING FOR COST CONTROL

## 4.1 THE IMPLEMENTATION PLAN

The first thing that must be done is to carefully plan the implementation process. The implementation plan does not delineate how projects are to be carried out, only how cost control is to be implemented and how will the problems be identified and solved.

The implementation plan must answer such important questions as:

1- How will top management commitment be obtained?
2- How will managers and project personnel be "sold" on cost control?
3- How will the policies and procedures related to cost control be developed?
4- What cost control system will be used?
5- What project will be selected for testing the system?
6- How will cost control interface with internal units of and external units to the project organization?
7- What transition process will be used to go from the initial system to the system being defined?

The objectives of this chapter will be to identify the key actors and the key actions to be taken during the implementation phase. The key actors are:

- Top management;
- Control and procurement department;
- Finance and administration department; and
- Project management department.

The process to be carried during the implementation plan is:

1) Top management defines objectives of the cost control system;

2) Control and procurement department and finance and administration department define systems and procedures to meet them; and

3) Project managers and other functional managers organize their respective effort to implement the system.

## 4.2 TOP MANAGEMENT ACTIONS

If cost control is to be successfully implemented, a number of critical actions must be taken by top management, functional management and project management.

The most important of the many actions that must be taken in implementing cost control are those which must be taken by top management. The most significant of these actions are:

1- Completely selling the cost control concept to the entire organization;

2- Issuance of the broad outlines of policies and procedures;

3- Issuance of a responsibility matrix to completely delineate project vs functional authority and responsibilities;

4- Supplying adequate resources to the organization such as finances, equipment, personnel, computer support, etc; and

5- Giving ongoing support to the concept of cost control and the project manager.

### 4.2.1 Completely Selling the Cost Control Concept to the Entire Organization

Top management commitment is vital to the implementation of an effective cost control system. It might involve a considerable period of education and learning, but a very important step is to force top management to discuss cost control philosophy. For this purpose, it is desirable to require the services of a neutral party to "referee" top management sessions. A consulting firm with considerable experience and expertise in project management services could act as a moderator for these sessions.

The next important action that top management must take is communicating the implementation plan to the entire organization. The project managers must not only be told about cost control, but must be "sold" on the need for it. They must be convinced that cost control is there to help them, and that it is not a threat to their authority; they must understand that the role of the control and procurement department is supporting them on the projects, not watching them. The functional directors and managers involved directly or indirectly in cost control must also be "sold" on the need for cost control.

4.2.2 Issuance of the Broad Outlines of the Policies and Procedures

Top management involment is a vital prerequisite in the development of policies and procedures because policies and procedures will be controversial and will be opposed. It is very important that the chief executive defines the broad outlines of the policies and procedures during top management sessions.

Some of the problems encountered during the implementation of the cost control system were caused by a lack of commitment and involment from top management.

4.2.3 Issuance of the Responsibility Matrix

It is top management's responsibility to issue a responsibility matrix delineating project vs functional authority and responsibilities. This matrix must provide to the project managers and functional managers a full understanding of their individual responsibilities to communicate, coordinate and make interrelated decisions with one another.

### 4.2.4 Supplying Adequate Resources and Support

Success of the system depends on top management committing sufficient resources in terms of money, personnel and their continued advocacy of the system.

## 4.3 CONTROL AND PROCUREMENT DEPARTMENT ACTIONS

Important actions to be taken by the control and procurement department are:

1- Issuance of the implementation plan;
2- Choice of the cost control system;
3- Development of the policies and procedures related to cost control;
4- Choice of the first project to test the system;
5- Definition of the cost control interfaces;
6- Creation of the cost data structure;
7- Gathering of historical cost data on similar projects; and
8- Development of the output reports.

### 4.3.1 Issuance of the Implementation Plan

The control and procurement department is responsible for the issuance of the implementation plan. The development of the plan is not the sole responsibility of this department but it is a joint effort in line with the management organization structure, each contributing to its respective levels; the directors provide orientation and lower levels provide the details.

### 4.3.2 Choice of the Cost Control System

The choice of the cost control system is an important step of the implementation plan. The control and procurement and the finance and administration departments will have to define their requirements. The intent is not to "re-invent the wheel", but to investigate the various systems and programs offered by computer companies and project management consultants and adapt a system to the requirements of both departments. The control and procurement department will have to examine if the coding structure available with the system is suitable, if work packaging is available, if it is possible to make modification to the reporting formats, how the information will be kept confidential if the system is used on a rental basis, how reliable is the system by contacting other organizations using it, and if the system is easily accessible by an "on line" operation or "batch" operation.

### 4.3.3 Development of the Policies and Procedures

Procedures are the most important of the tools which comprise the cost control system. The control and procurement department must define the approach to be used to develop the procedures. One approach is to set up a "task force" with personnel drawn from the functional groups affected by these procedures, and working on a part-time basis on the procedures. Another approach is to set up a parallel group to operations, working on a full-time basis on procedures. In both cases, the control and procurement department must carefully monitor their work to make sure that the outlines from top management are included. A consultant can also be employed to develop the organization procedures. Constant scrutiny, from the control and procurement department, is necessary to avoid having the consultant recommended procedures that are not workable because of organizational idiosyncrasies.(8)

### 4.3.4 Choice of the First Project

The decision as to which project will be the first should not be taken lightly by the control and procurement department. There are two major alternatives that should be considered in the process of deciding how to implement cost control: 1) convert all projects at the same time 2) convert only a single project and use it as a trial of the concept. Converting all the projects at one time is risky. The single project approach or "show case" approach is better. The single project should be the average type project.

### 4.3.5 Define the Cost Control Interfaces

The implementation plan to be issued by the control and procurement department should provide clear guidance to all organizational units to minimize potential conflict. The critical interfaces most likely to cause problems should be identified and plans should then be developed for minimizing their impact on the project. Cost control internal interfaces at SQAE are with the project manager, the finance and administration department and the engineering department; external interfaces are with MENVIQ, the municipalities, the consultants, the contractors and the suppliers.

### 4.3.6 Creation of the Cost Data Structure

The cost control group is responsible to create the WBS and the related cost data structure to be used for projects. Standard code of accounts for engineering, procurement and construction items must also be prepared.

### 4.3.7 Gathering Historical Cost Data

The estimating group must identify sources of cost data on similar projects and gather historical cost data for estimating purposes.

### 4.3.8 Development of the Output Reports

The development of the output reports is the responsibility of the cost control group. The project management department will define the output reports at different levels of the project and organization.

## 4.4 FINANCE AND ADMINISTRATION DEPARTMENT ACTIONS

The actions that must be taken by this department are strongly interrelated with the actions to be taken by the control and procurement department. These actions are:

1- Choice of the cost accounting system;
2- Development of policies and procedures related to cost accounting and financing;
3- Creation of the cost accounting data structure; and
4- Issuance of financial strategies.

### 4.4.1 Choice of the Cost Accounting System

The choice of the cost accounting system must be taken together with the choice of the cost control system. The finance and administration department will have to define their requirements at the project level and at the corporate level. A single accounting and control system should be selected for efficient and cost saving operation.

### 4.4.2 Development of Policies and Procedures

The finance and administration department must identify their interfaces with the cost control procedures. The approach to be used for the development of procedures should be the same as for the cost control procedures because of the major interrelation between both procedures.

### 4.4.3 Creation of the Cost Accounting Data Structure

The financial group must identify at what level of the accounting structure it will integrate with the WBS of a project.

### 4.4.4 Issuance of Financial Strategies

The financial group must define financial strategies for short-term and long-term financing and for cash flow requirements.

## 4.5 PROJECT MANAGEMENT DEPARTMENT ACTIONS

There are a number of specific actions that must be initiated by project management, mostly related to the definition of needs. They are:

1- Input for the implementation plan;
2- Definition of needs for cost control policies and procedures; and

3- Definition of output reports.

### 4.5.1 Input for the Implementation Plan

The project management department plays a major role in the development of the implementation plan. This department will be involved in the definition of the objectives of the cost control system, in the identification of interface problems and solutions and in the implementation.

### 4.5.2 Definition of Needs for Cost Control Policies and Procedures

The project management group must define their needs for cost control to develop the policies and procedures that will be used on the project by the project managers.

### 4.5.3 Definition of the Output Reports

The project management group must also define the format of output reports and the frequency required by the project managers, and the municipalities.

## 4.6 ENGINEERING ACTIONS

This department is also involved in the implementation phase of a cost control system. They must take the following actions:

1- Definition of engineering manhour budget baselines;

2- Issuance of engineering activity lists for manhour control;

3- Definition of the engineering performance measurement baselines; and

4- Obtain complete support from their organizational personnel for the implementation of the cost control system.

4.6.1 Definition of Engineering Manhour Budget Baselines

The engineering group must define the engineering manhour budget baselines that will be used on most projects for the following phases: preliminary studies, final design and field technical supervision and for each discipline.

4.6.2 Issuance of Engineering Activity List

The engineering group must establish lists of engineering activities for each of the phases mentioned above and for each discipline that will be used on most projects to evaluate consultant's proposals and for manhour control.

4.6.3 Definition of the Engineering Performance Measurement Baselines

Physical progress of the engineering activities must be checked by the engineering group.

The engineering group will have to define the baselines to evaluate the physical progress or percent complete for all the engineering activities.

### 4.6.4 Obtain Complete Surpport from Personnel

The engineering director must not only accept the concept of cost control and his role, but he must obtain complete support from his personnel.

# CHAPTER FIVE

## COST CONTROL SYSTEM DEFINITION

# CHAPTER 5

## COST CONTROL SYSTEM DEFINITION

### 5.1 BASIC SYSTEM

The cost control system consists of six components sub-systems which are the basis for: (9)

1- The development and maintenance of a cost control base for the project;

2- The development and maintenance of a code of accounts for the project;

3- An early warning system to detect major deviations from the control base;

4- An efficient data collection system to establish the actual value of commitments, expenditures, performance and other costs occuring during the development of the project;

5- Studies and recommandations for possible action to correct deviations;

6- An effective system for forecasting the costs to complete the project;

7- Cost status reports at regular intervals including graphs, figures, tables; and

8- Development of cash flow profiles.

The six component sub-systems are shown in figure 5.1.1
They are: (10)

1- Cost account coding;

2- Budget control;

3- Data collection;

4- Cost trending/forecasting;

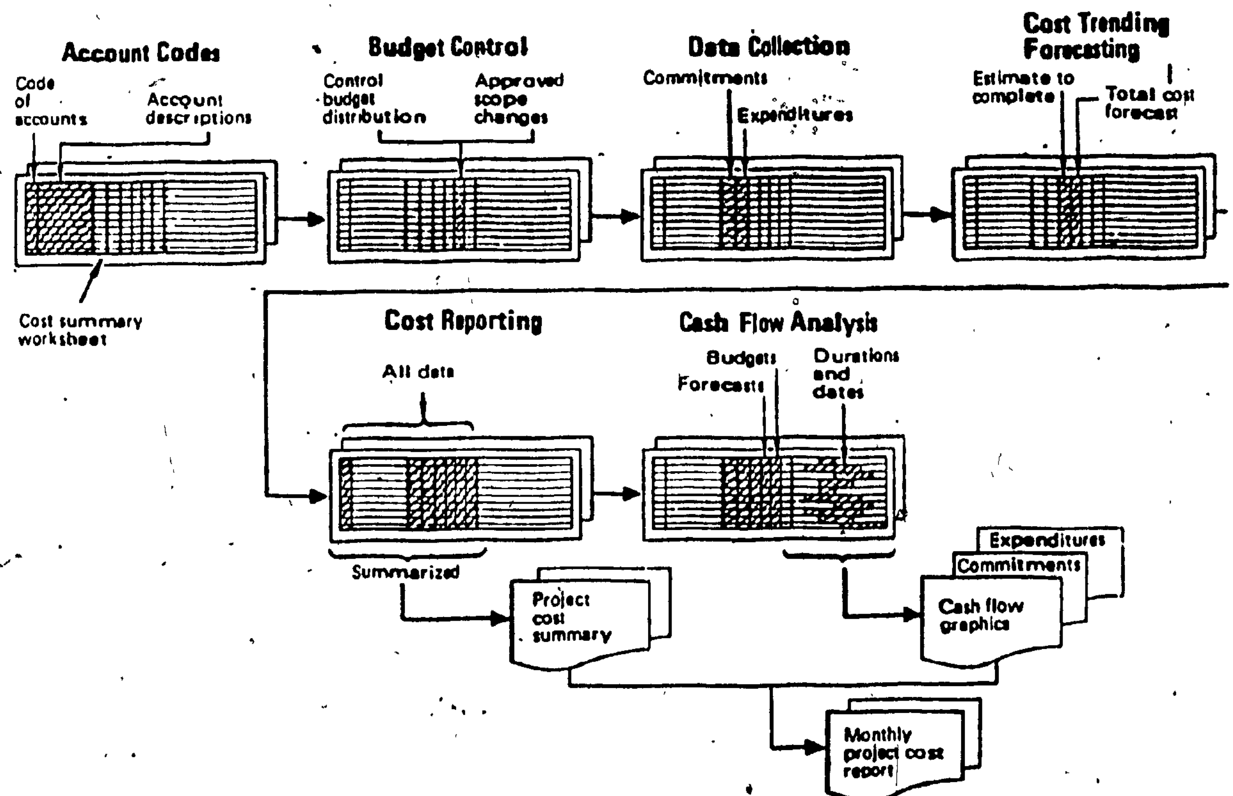
5- Cost reporting; and

6- Cash flow analysis.

The cost code structure is directly related to the funding organizational structure, accounting and reporting procedures established for each project. A code of accounts is developed for each project from the standard code of accounts within the cost structure and is used to allocate budgets, collect manhours, accrue costs and establish forecasts for each element.

Budget control is a method and documentation for developing and maintaining the project control budget. This includes converting the project estimate into a compatible breakdown within an established cost code structure, monitoring the budget to adjust for any authorized changes or revision.

The data collection system is used as a focal point to collect all




Source: *«Managing Capital Expenditures for Construction Projects» By Kenneth M. Guthrie, p. 148*

FIGURE 5.1.1

COST CONTROL

BASIC SYSTEM

the actual job costs as they occur on the project during the engineering, procurement, construction and commissioning phases. This data is collected or received in the form of reports from project accounting, engineering (consultant), procurement, field (contractor) and project management personnel. This data is used for trending, forecasting, and establishing cost status reports.

The cost trending/forecasting system aids in detecting and reporting deviations as they occur on the project, and analyzing all actual to date and trend information. This system helps estimate the cost of the work to be done and generate forecasts to complete the work. The forecasts are used by the cost reporting system and by the cash flow analysis system.

The cost reporting system is used to assemble all the major cost reports. All the data received from budget control, data collection, trend/forecast reporting can be recorded and used to generate the reports required for the project.

The cash flow system can be used to distribute budgets, commitments, expenditures and forecasts over time.

## 5.2 COST ACCOUNT CODING SYSTEM

### 5.2.1 Work Breakdown Structure

Before developing a standard code of accounts to be used on all projects, it is necessary to establish a typical WBS and related coding structure for most of the projects, as shown in figure 5.2.1.

We have seen in the third chapter that the typical WBS will have six levels:

Project - Level 1 : Project
Subdivision - Level 2 : Sub-projects
Subdivision - Level 3 : Areas or groups of systems
Subdivision - Level 4 : Buildings or systems
Subdivision - Level 5 : Sub-systems
Element - Level 6 : Cost elements

Figure 3.4.1 in the third chapter showed a typical WBS for main sewer construction. We will use in this section, the simplified format of the WBS as shown in figure 3.4.3.

Figures 5.2.2 to 5.2.7 show typical WBS's at the subdivision level (up to level 5) for each sub-project.

The typical WBS for the Epic studies is shown on figure 5.2.2. As previously mentioned, the Epic studies involve engineering services only. Most of the time, only one consultant is responsible for these studies for a municipality. These studies are broken down by phases and then by activities. Because of this reason, the 3rd, 4th and 5th levels of the WBS are not required, and the activities are identified at the element level. If more than one consultant is hired for the Epic studies in a municipality, the 3rd level would be used to identify the areas (or basins) covered

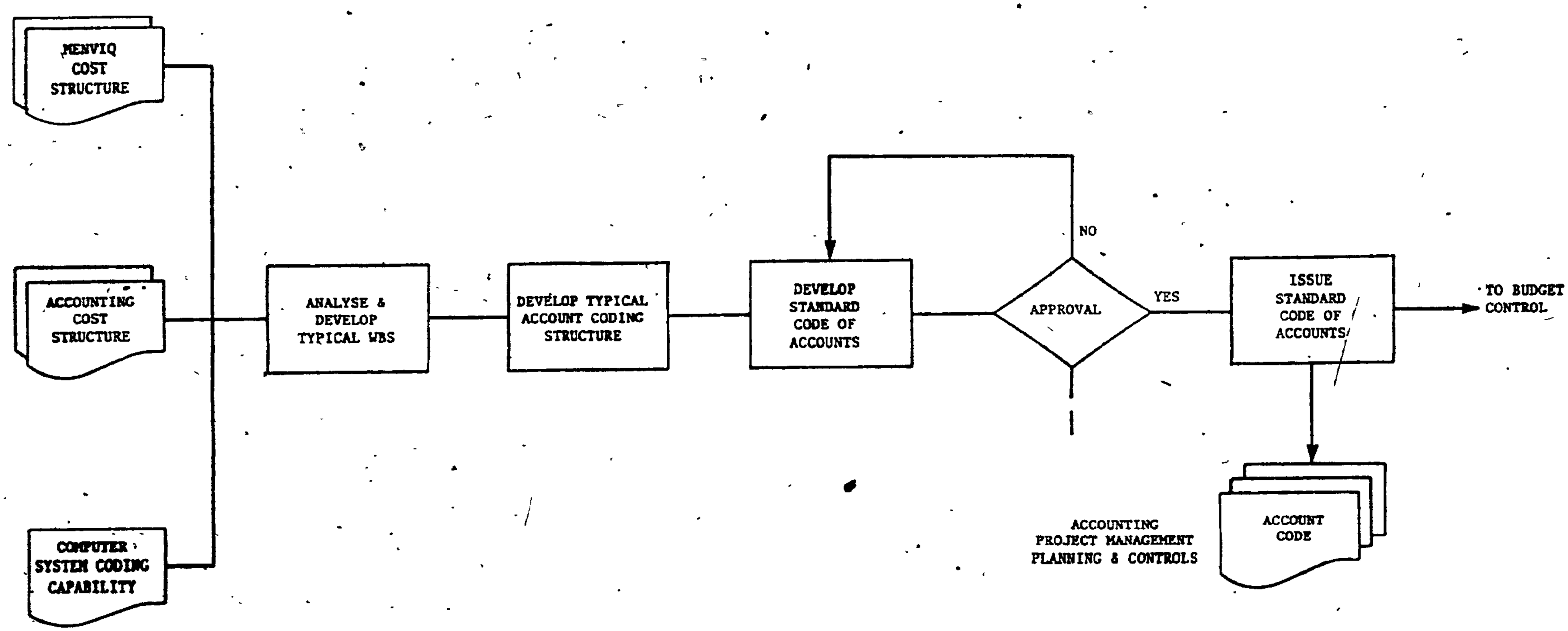



FIGURE 5.2.1

COST ACCOUNT CODING SYSTEM

DEFINITION

FIGURE 5.2.2

TYPICAL WBS

EPIC STUDIES

0000 PROJECT — LEVEL 1 PROJECT

- 1 EPIC STUDIES — LEVEL 2 SUB-PROJECT

FIGURE 5.2.3

TYPICAL WBS

RESTORATION

0000 PROJECT — 1 (LEVEL)

- 2 RESTORATION — 2
  - 20 GENERAL — 3 AREA OR GROUP OF SYSTEMS
  - 21 INFILTRATION — 3
    - 210 GENERAL — 4 BUILDINGS OR SYSTEMS
    - 211 SEWER 1
    - 212 SEWER 2
    - 213 SEWER 3
  - 22 COLLECTION — 3
    - 220 GENERAL — 4
    - 221 STREAM 1
    - 222 STREAM 2

by each consultant.

The typical WBS for the restoration of existing sewers is shown in figure 5.2.3. The restoration process can be broken down into two categories:

1- Infiltration of ground water in different sewers; and

2- Collection of running surface water from different streams.

The 3rd level is used to identify these categories, and the 4th level, for the different sewers and streams. The 5th level will not be used.

The typical WBS for sewerage is shown in figure 5.2.4. The sewer system can be broken down into three major sub-systems: main sewer systems, pumping systems, and stormwater retention systems. The main sewer systems (level 3) include the systems (level 4) located in different areas of the municipality; each system being formed of main sewer sections (level 5) of different sizes and/or material.

Typical WBS's for treatment are shown in figure 5.2.5 to 5.2.7. Figure 5.2.5 shows the WBS for an oxidation ditch type plant. The 3rd level is used to identify the group of systems: oxidations, secondary clarifier and sludge treatment. The 4th level shows the different systems; for example in the oxydation process, we have the oxidation ditch and the aeration system.

Figure 5.2.6 shows the WBS for an aerated lagoon type plant.

FIGURE 5.2.4

TYPICAL WBS

SEWERAGE

- 0000 PROJECT — 1
  - 3 SEWERAGE — 2
    - 30 GENERAL — 3
    - 31 MAIN SEWER SYSTEMS
      - 311 MAIN SEWER SYSTEM 1 — 4
        - 3111 MAIN SEWER 1 — 5
        - 3112 MAIN SEWER 2
        - 3113 MAIN SEWER 3
      - 312 MAIN SEWER SYSTEM 2
        - 3121 MAIN SEWER 1
        - 3122 MAIN SEWER 2
        - 3123 MAIN SEWER STRUCTURE
    - 32 PUMPING SYSTEMS
      - 321 PUMPIMG STATION 1
        - 3210 GENERAL
        - 3211 CIVIL
        - 3212 MECH., ELECT., INSTR.
    - 33 STORMWATER RETENTION SYSTEMS
      - 331 RETENTION BASIN 1
        - 3310 GENERAL
        - 3311 CIVIL
        - 3312 MECH., ELECT., INSTR.

FIGURE 5.2.5

TYPICAL WBS

TREATMENT
OXIDATION DITCH TYPE PLANT

- 0000 PROJECT — 1
  - 4 TREATMENT — 2
    - 41 PRE-TREATMENT — 3
      - 410 GENERAL — 4
      - 411 SCREENING
    - 42 OXIDATION
      - 420 GENERAL
      - 421 OXIDATION DITCH
      - 422 AERATION SYSTEM
    - 43 SECONDARY CLARIFIER
      - 430 GENERAL
      - 431 CLARIFIER TANK
    - 44 SLUDGE TREATMENT
      - 440 GENERAL
      - 441 SLUDGE PUMPING
      - 442 DEWATERING
      - 443 DISPOSAL

FIGURE 5.2.6

TYPICAL WBS

TREATMENT

AERATED LAGOON TYPE PLANT

- 0000 PROJECT
  - 4 TREATMENT
    - 40 GENERAL
      - 400 GENERAL
      - 401 ROADS
      - 402 EFFLUENT SEWERS OR DITCHES
    - 41 LAGOONING
      - 410 GENERAL
      - 411 LAGOON # 1
        - 4110 GENERAL
        - 4111 LINING
      - 412 LAGOON # 2
        - 4120 GENERAL
        - 4121 LINING
      - 413 LAGOON # 3
        - 4130 GENERAL
        - 4131 LINING
    - 42 AERATION (DIFFUSED AIR)
      - 420 GENERAL
      - 421 SYSTEM LAGOON # 1
      - 422 SYSTEM LAGOON # 2
      - 423 SYSTEM LAGOON # 3
      - 424 BOOSTER PUMP BUILDING
        - 4240 GENERAL
        - 4241 SERVICES
    - 43 CHLORINATION
      - 430 GENERATION
      - 431 CHLORINATION BLDG
        - 4310 GENERAL
        - 4312 SERVICES

The 3rd level shows the lagooning, aeration and chlorination major systems.

The 4th level shows the sub-systems of the third level, for example for lagooning, lagoons 1, 2 and 3.

Figure 5.2.7 illustrates the WBS of a much larger plant - a mechanical type plant. SQAE will be involved in the construction of a few plants of this nature. The major subdivision called "general" includes all the buildings and systems not related to the process. The pumping station, located close to the treatment plant, was included in the treatment sub-project rather than in the sewerage sub-project, since MENVIQ agreed to subsidize it at the same rate as the treatment plant.

FIGURE 5.2.7

TYPICAL WBS

TREATMENT

MECHANICAL TYPE PLANT

- 0000 PROJECT 1
  - 4 TREATMENT 2
    - 40 GENERAL 3
      - 400 GENERAL 4
        - 4000 GENERAL 5
      - 401 ROADS
        - 4010 GENERAL
      - 402 ADMINISTRATION BLDG
        - 4020 GENERAL
        - 4025 PLUMBING, HEATING
        - 4026 VENTILATING, AIR CONDITIONING
      - 403 HEATING BLDG
        - SEE 402 FOR BREAKDOWN
      - 404 CONTROL BLDG
        - SEE 402
      - 405 PUMPING STATION
        - 4050 GENERAL
        - 4051 CIVIL
        - 4052 MECH., ELECT., INSTR.
      - 406 ELECTRICAL SUB-STATION
        - 4060 GENERAL

FIGURE 5.2.7 (CONT'D)

TYPICAL WBS

TREATMENT

MECHANICAL TYPE PLANT

- 407 SERVICES 4
  - 407A GENERAL 5
  - 407B SANITARY SEWER
  - 407C STORM SEWER
  - 407D PROCESS SEWER
  - 407E WATER
  - 407F WATER PROCESS
  - 407G WATER FIRE PROTECTION
  - 407H GAS
  - 407I STEAM
  - 407J COMPRESSED AIR
  - 407K ELECTRICAL DISTRIBUTION
- 408 EFFLUENT SEWER
  - 4080 GENERAL

41 PRE-TREATMENT 3

- 410 GENERAL 4
  - 4100 GENERAL 5
- 411 SCREENING
  - 4110 GENERAL
- 412 GRIT CHAMBER
  - 4120 GENERAL
  - 4121 CHAMBER NO 1
  - 4122 CHAMBER NO 2

FIGURE 5.2.7 (CONT'D)

TYPICAL WBS

TREATMENT

MECHANICAL TYPE PLANT

- 42 PRIMARY SETTLING 3
  - 420 GENERAL 4
    - 4200 GENERAL 5
  - 421 SETTLING TANK # 1
    - 4210 GENERAL
  - 422 SETTLING TANK # 2
    - 4220 GENERAL
- 43 AERATION
  - 430 GENERAL
    - 4300 GENERAL
  - 431 AERATION TANK # 1
    - 4310 GENERAL
  - 432 AERATION TANK # 2
    - 4320 GENERAL
  - 433 BOOSTER PUMPS BUILDING
    - 4330 GENERAL
    - 4331 CIVIL
    - 4332 PROCESS SERVICES
    - 4333 BUILDING SERVICES
- 44 SECONDARY SETTLING
  - 440 GENERAL
    - 4400 GENERAL

FIGURE 5.2.7 (CONT'D)

TYPICAL WBS

TREATMENT

MECHANICAL TYPE PLANT

- 441 SETTLING TANK # 1
  - 4410 GENERAL
- 442 SETTLING TANK # 2
  - 4420 GENERAL

45 SLUDGE TREATMENT

- 450 GENERAL
  - 4500 GENERAL
- 451 PUMPING
  - 4510 GENERAL
- 452 CLARIFICATION
  - 4520 GENERAL
- 453 DIGESTION
  - 4530 GENERAL
  - 4531 PRIMARY
  - 4532 SECONDARY
- 454 DEWATERING
  - 4541 GENERAL
  - 4542 FILTER PRESS L
  - 4543 FILTER PRESS 2
- 455 DISPOSAL
  - 4550 GENERAL

### 5.2.2 Cost Account Coding Structure

#### 5.2.2.1 Standard Code of Accounts

The purpose of the cost account coding system is to establish an organized account code structure and develop a corresponding project code of accounts for each project. The code of accounts provides the means to collect project data at the lower levels and aggregate this data for use at higher levels, as required by the reporting functions.

The structure and elements of each code are based on the standard code of accounts which is included in this section. This standard code can be modified as required to suit specific project reporting, project visibility requirements and data collection techniques.

As shown in section 3.4, the cost account coding system is a thirteen digit code of which the last five are assigned to the construction (or service) elements. Figure 5.2.8 represents the coding system to be used.

. Positions 1, 2, 3, 4 are used for project number; it is expected that there should be less than a thousand projects (or municipality) at SQAE.

. Position 5 is used to identify the sub-project.

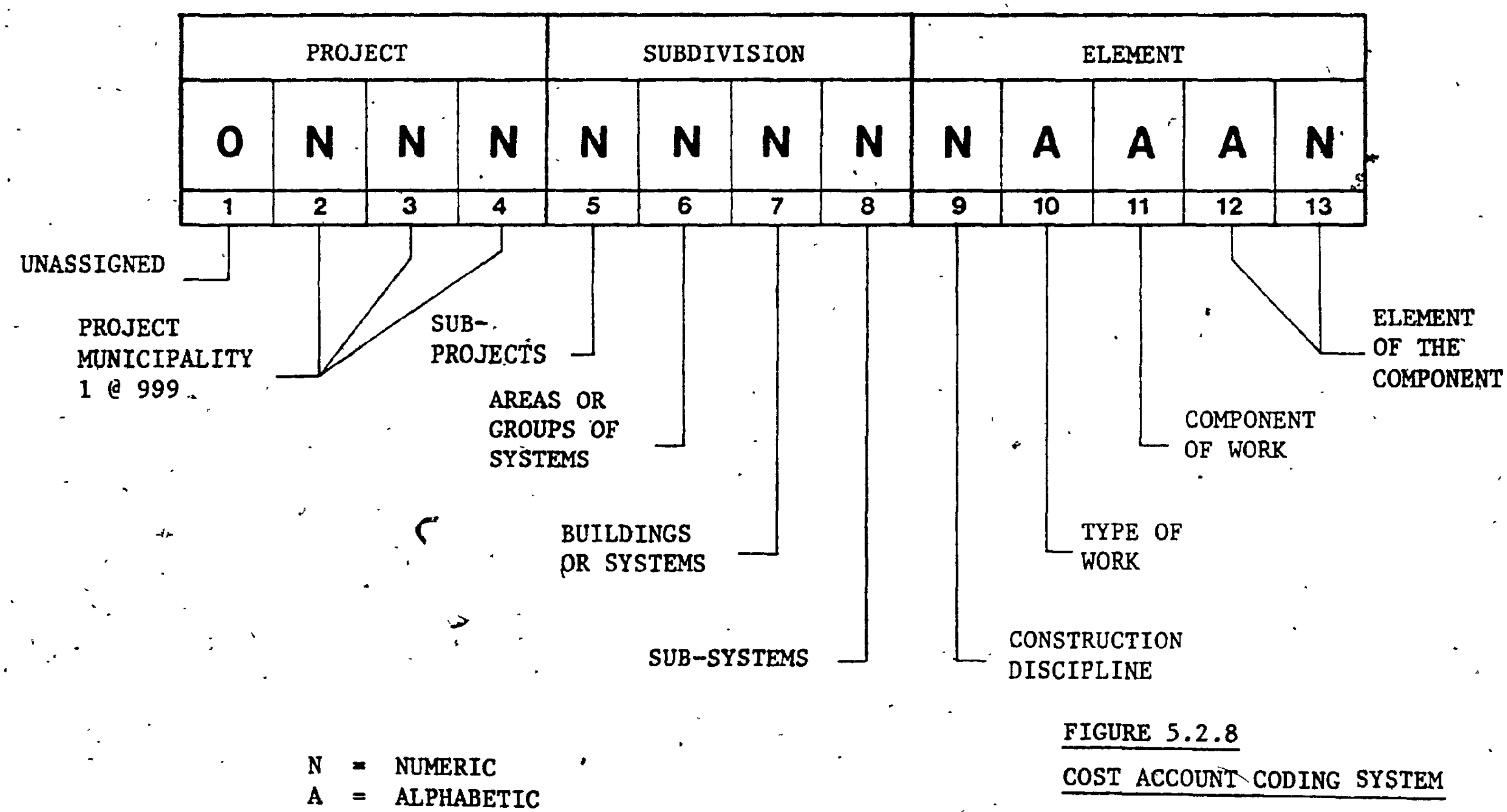



FIGURE 5.2.8

COST ACCOUNT CODING SYSTEM

CAPITAL ELEMENT

SQAE

. Positions 6, 7, 8 are used for system identification.

. Positions 9, 10, 11, 12, 13 are used for the construction (or service) elements code of accounts.

The standard code of accounts can now be develop to itemize all the construction and non-construction activities which generate charges during the execution of the project. This occupies the last five (5) positions in the account code structure and is denoted as the capital element for construction activities and the service element for non-construction activities (engineering, management...).

From figure 5.2.8, the five (5) positions for the capital element are:

. Position 9 : Construction discipline (numeric)
. Position 10 : Type of work (alphabetic)
. Position 11 : Component of work (alphabetic)
. Position 12 : Element of the component (alphabetic)
. Position 13 : Element of the component (numeric)

For most of the project, the structure will stop at the "type of work" (position 10) of the capital element which is the control level for most of the projects. Table 5.2.1 contains the list of code of accounts for the capital element up to position 10; this list is based on the integrated coding system used at SNC. (11)

## TABLE 5.2.1

## STANDARD CODE OF ACCOUNTS* (MAJOR ACCOUNTS)

## CAPITAL ELEMENT

* Based on SNC integrated coding system

CONSTRUCTION DISCIPLINE (column 9)

TYPE OF WORK (column 10)

| 9 | 10 | |
|---|---|---|
| 1 | | EARTHWORK |
| 1 | B | SITE PREPARATION |
| 1 | C | EXCAVATION EARTH |
| 1 | D | EXCAVATION ROCK |
| 1 | E | FILL & BACKFILLS |
| 1 | F | FILING |
| 1 | H | UNDERGROUND SITE SERVICE |
| 1 | J | ROAD ITEM |
| 1 | K | RAILROAD ITEM |
| 1 | M | FINISHING ITEM |
| 1 | N | SPECIAL ITEM |
| 1 | X | MISCELLANEOUS ITEM |
| | | |
| 2 | | CONCRETE |
| 2 | A | BULK ACCOUNT |
| 2 | B | CONCRETING FACILITIES |
| 2 | C | CONCRETE STRUCTURE |
| 2 | D | CONCRETE EQUIPMENT FOUNDATION |

TABLE 5.2.1 (CONT'D)

STANDARD CODE OF ACCOUNTS* (MAJOR ACCOUNTS)

CAPITAL ELEMENT

* Based on SNC integrated coding system

| | | |
|---|---|---|
| 3 | | STRUCTURAL STEEL |
| 3 | B | STRUCTURAL STEEL |
| 3 | C | MISCELLANEOUS STEEL |
| 3 | D | EQUIPMENT SUPPORT |
| 3 | E | MISCELLANEOUS STEEL STRUCTURE |
| 3 | F | WOODEN STRUCTURE |
| 3 | H | ORNAMENTAL METALS |
| 4 | | ARCHITECTURE |
| 4 | A | ROOFING & FLASHING |
| 4 | B | OUTSIDE WALL CLADDING |
| 4 | C | DECK/FLOOR & FINISHES |
| 4 | D | INSIDE WALL & CEILING |
| 4 | E | WINDOW |
| 4 | F | DOOR & FRAME |
| 4 | H | ARCHITECTURAL SPECIALTIES |
| 4 | J | DECORATION/FURNISHING |
| 4 | K | ARCHITECTURAL EQUIPMENT |
| 4 | X | INSUL / FIRE / PAINT |
| 5 | | EQUIPMENT |
| 5 | C | CONVEYORS |

TABLE 5.2.1 (CONT'D)

STANDARD CODE OF ACCOUNTS* (MAJOR ACCOUNTS)

CAPITAL ELEMENT

* Based on SNC integrated coding system

| | | |
|---|---|---|
| 5 | D | DRYING |
| 5 | F | FILTRATION |
| 5 | G | GRAVITY SEPARATIONS |
| 5 | I | INDUCTION HEAT EXCHANGER |
| 5 | M | MIXING |
| 5 | N | LIFTING EQUIPMENT & DUCTS |
| 5 | P | PUMP |
| 5 | Q | MOBILE EQUIPMENT |
| 5 | S | SEPARATORS |
| 5 | T | TANK - BIN |
| 5 | W | BUILDING SERVICE EQUIPMENT |
| | | |
| 6 | | PIPING |
| 6 | A | CAST IRON |
| 6 | B | CARBON STEEL |
| 6 | C | ALLOY STEEL |
| 6 | D | STAINLESS STEEL |
| 6 | E | CONCRETE |
| 6 | F | ASBESTOS FIBER |
| 6 | G | POLYETHYLENE |

TABLE 5.2.1 (CONT'D)

STANDARD CODE OF ACCOUNTS* (MAJOR ACCOUNTS)

CAPITAL ELEMENT

* Based on SNC integrated coding system

| | | | |
|---|---|---|---|
| 7 | | | ELECTRICAL |
| 7 | A | | OUTDOOR DISTRIBUTION |
| 7 | B | | TRANSFORMER |
| 7 | C | | MOTOR & GENERATOR |
| 7 | D | | RECTIFIER/CONVERTER |
| 7 | E | | SWITCHING EQUIPMENT |
| 7 | F | | PROTECTIVE EQUIPMENT |
| 7 | H | | PROTECTIVE RELAY |
| 7 | J | | CONTROL RELAY |
| 7 | K | | CONTROL DEVICE & EQUIPMENT |
| 7 | L | | LIGHTING EQUIPMENT |
| 7 | M | | INDICATING EQUIPMENT |
| 7 | N | | HEATING & COOLING EQUIPMENT |
| 7 | P | | CONDUCTOR & CONNECTOR |
| 7 | Q | | RACEWAY & FITTING |
| 7 | R | | WIRING DEVICE & BOX |
| 7 | S | | COMMUNICATION SIGNAL |
| | | | |
| 8 | | | AUTOMATION INSTRUMENT |
| 8 | A | | ALARM |
| 8 | C | | CONTROLLER |

TABLE 5.2.1 (CONT'D)

STANDARD CODE OF ACCOUNTS* (MAJOR ACCOUNTS)

CAPITAL ELEMENT

* Based on SNC integrated coding system

| | | | |
|---|---|---|---|
| 8 | D | | DATA PROCESSING |
| 8 | G | | GAUGE |
| 8 | I | | INDICATOR |
| 8 | R | | RECORDER |
| 8 | S | | SWITCH |
| 8 | T | | TRANSMITTER |
| 8 | V | | CONTROL VALVE/DAMPER |
| 8 | Y | | RELAY |
| 8 | Z | | DRIVE |
| 9 | | | CONSTRUCTION INDIRECTS |

From figure 5.2.9, the (5) positions for the service element are:

. Position 9 : Zero (numeric)

. Position 10 : Service category (alphabetic)

. Position 11 : Service descipline (alphabetic)

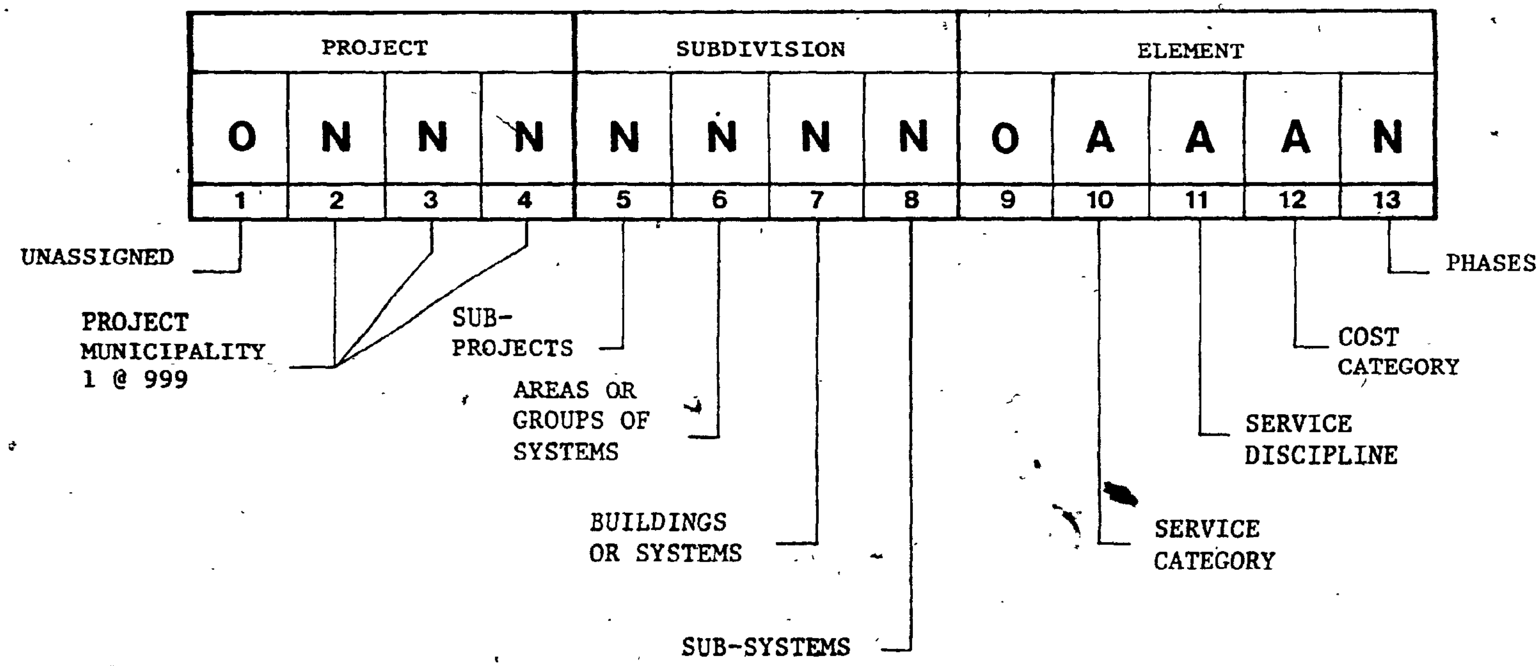
. Position 12 : Cost category (alphabetic)

. Position 13 : Phases (numeric)

As you can see, all the service elements were assigned to the construction discipline "zero" to be easily identified and the same type of characters (alphabetic or numeric) were used for practical purposes.

For most of the project, the structure will stop at the "service discipline" (position 11). Table 5.2.2 contains the list of code of accounts for the service element up to position 11.

If a project requires a code of accounts for the service element, up to the phase level (position 13), table 5.2.3 shows the methodology to be used. This example is based on the list of engineering activities given in table 3.4.1 for the municipal discipline. Separate account codes are set up for engineering fees and expenses and for each phase.




N = NUMERIC
A = ALPHABETIC

FIGURE 5.2.9

COST ACCOUNT CODING SYSTEM

SERVICE ELEMENT

SQAE

TABLE 5.2.2

STANDARD CODE OF ACCOUNTS (MAJOR ACCOUNTS)

SERVICE ELEMENT

10 — SERVICE CATEGORY
11 — SERVICE DISCIPLINE

| 9 | 10 | 11 | |
|---|---|---|---|
| Ø | D | | ENGINEERING & DESIGN |
| Ø | D | A | ARCHITECTURE |
| Ø | D | C | MUNICIPAL |
| Ø | D | E | ELECTRICAL |
| Ø | D | I | INSTRUMENTATION |
| Ø | D | M | MECHANICAL |
| Ø | D | P | PROCESS (ENVIRONMENT) |
| Ø | D | S | STRUCTURE |
| Ø | D | W | ELECTRICAL & INSTRUMENTATION |
| | | | |
| Ø | F | | FINANCING |
| Ø | F | C | SHORT TERM |
| | | | |
| Ø | G | | MANAGEMENT |
| Ø | G | C | CONTROL & PROCUREMENT DEPARTMENT |
| Ø | G | F | FINANCE |
| Ø | G | I | ENGINEERING |
| Ø | G | M | MARKETING |
| Ø | G | P | PROJECT MANAGEMENT |

TABLE 5.2.2 (CONT'D)

STANDARD CODE OF ACCOUNTS (MAJOR ACCOUNTS)

SERVICE ELEMENT

| | | | |
|---|---|---|---|
| Ø | L | | LABORATORY |
| Ø | L | E | WATERTIGHTNESS TEST |
| Ø | L | F | SOIL EXPLORATION |
| Ø | L | Q | QUALITY CONTROL |
| Ø | L | R | MEASURE RATE OF DISCHARGE & WATER SAMPLING |
| Ø | M | | COMMISSIONNING |
| Ø | M | C | CONSULTING |
| Ø | M | E | TRAINING |
| Ø | M | O | OPERATING & MAINTENANCE |
| Ø | M | P | SPARE PARTS |
| Ø | T | | LAND SERVICE |
| Ø | T | E | APPARAISER |
| Ø | T | G | SURVEYOR |
| Ø | T | N | NOTARY |

## TABLE 5.2.3

## STANDARD CODE OF ACCOUNTS

## SERVICE ELEMENT

SERVICE CATEGORY (10)
SERVICE DISCIPLINE (11)
COST CATEGORY (12)
PHASE (13)

| 9 | 10 | 11 | 12 | 13 | |
|---|---|---|---|---|---|
| Ø | D | | | | ENGINEERING & DESIGN |
| Ø | D | C | | | MUNICIPAL |
| Ø | D | C | H | | FEES |
| Ø | D | C | H | 1 | PRELIMINARY STUDIES |
| Ø | D | C | H | 2 | FINAL DESIGN |
| Ø | D | C | H | 3 | FIELD TECHNICAL SUPERVISION |
| | | | | | |
| Ø | D | C | D | | EXPENSES |
| Ø | D | C | D | 0 | GENERAL |
| Ø | D | C | D | 2 | TRAVELING EXPENSES |
| Ø | D | C | D | 3 | SALARIES MUNICIPALITY |
| Ø | D | C | D | 4 | OUTSIDE CONSULTANTS |
| Ø | D | C | D | 5 | PHOTOCOPIES |
| Ø | D | C | D | 6 | MATERIAL & EQUIPMENT |
| Ø | D | C | D | 7 | LABORATORY TESTS |
| Ø | D | C | D | 8 | COMPUTER PROCESSING |

Figure 5.2.10 illustrates the cost account coding structure for the capital element. This example is taken from the previous example shown in figure 5.2.7.

5.2.2.2 Other Codes

Additional coding is required to facilitate integration of the WBS with the project organization (packaging, contracts or purchase orders).

Figure 5.2.11 illustrates the coding to be used; the project is broken down into packages (service, procurement and construction) that become contracts and purchase orders which are performed by different firms (consultants, suppliers and contractors).

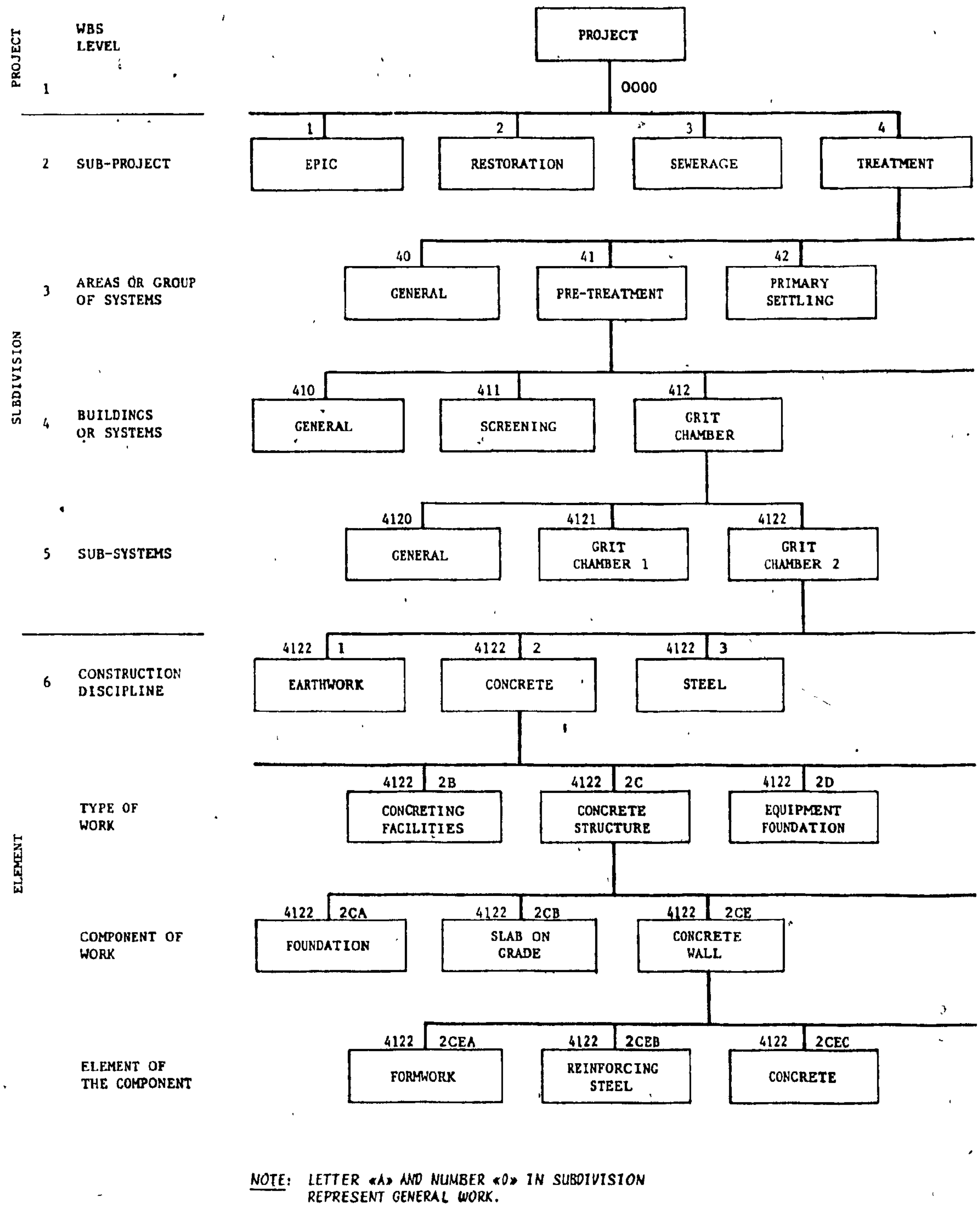



FIGURE 5.2.10

SQAE

COST ACCOUNT CODING STRUCTURE

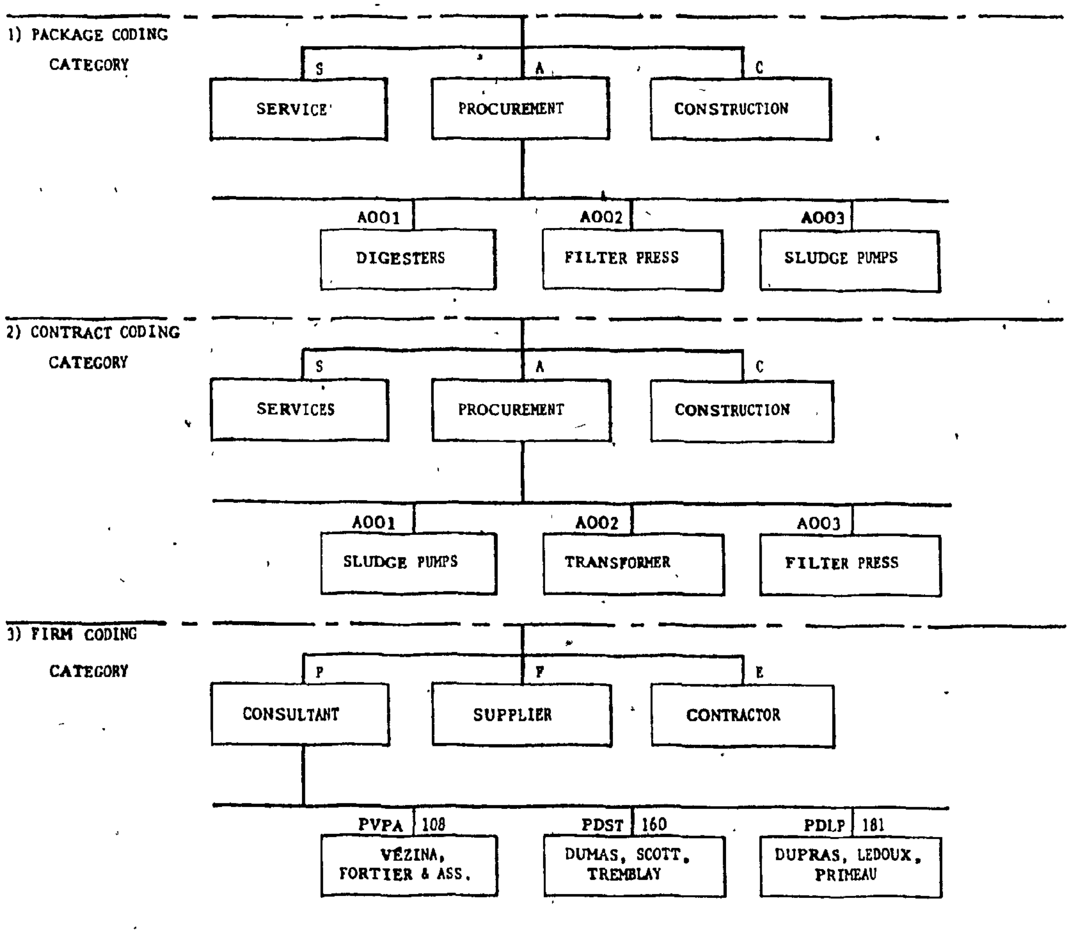



FIGURE 5.2.11

SQAE

COST ACCOUNT CODING STRUCTURE

OTHER CODES

## 5.3 BUDGET CONTROL SYSTEM

The purpose of the budget control system is to properly initiate and maintain an up-to-date control budget for the project according to the code of accounts (figure 5.3.1). This is accomplished by closely monitoring and incorporating change authorizations and budget transfer transactions.

The budget control system operates under three distinct phases for each element in the coding structure:

- The initial control budget or definitive budget;
- Approved project changes; and
- The current control budget or revised budget.

As the project cost estimate is the basis for preparing the control budget for the project, we will discuss the level of detail required and the methodology to prepare the cost estimate.

### 5.3.1 Definitive Budget

It was previously mentioned that the control level must be set at the "type of work" level of the WBS in order to permit adequate visibility and control over cost. The cost estimate must then be prepared at this level of detail.

Table 5.3.1 establishes the level of detail required for the

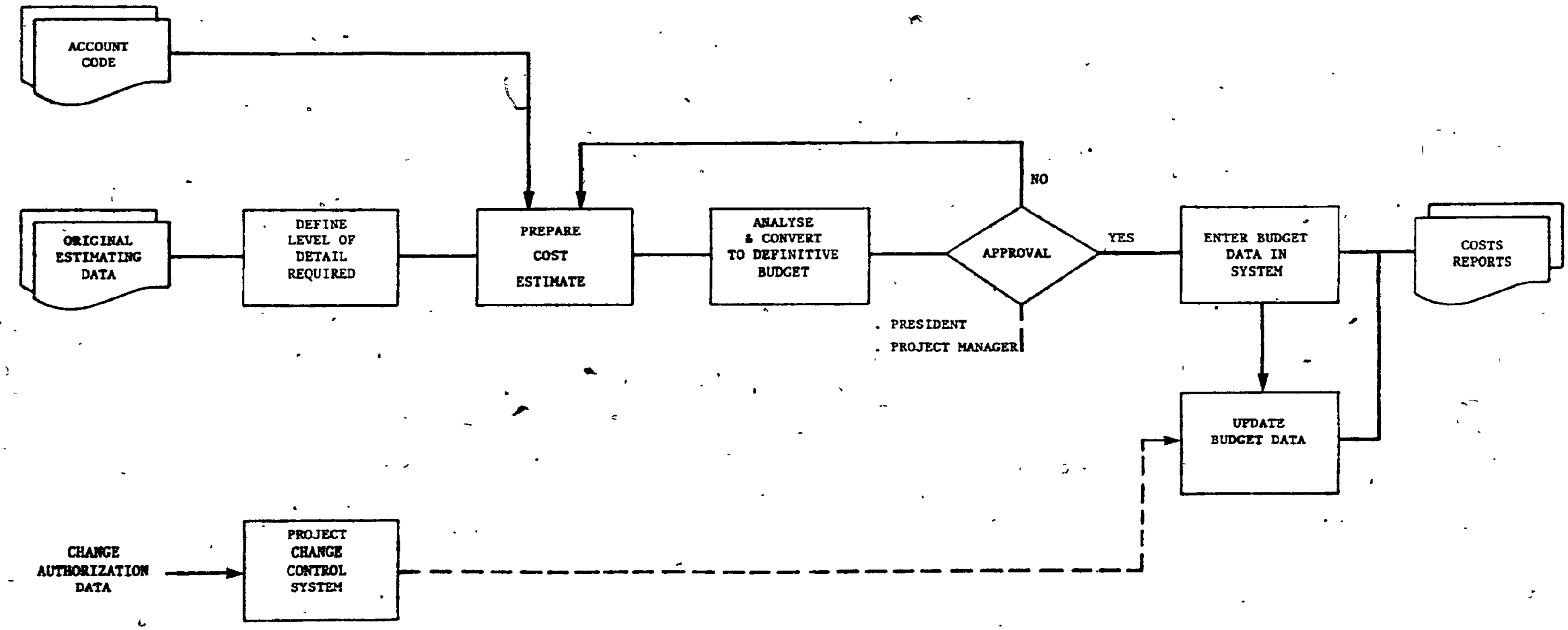



FIGURE 5.3.1

BUDGET CONTROL SYSTEM

TABLE 5.3.1

CONTROL BUDGET

COST ESTIMATE

DETAIL LEVEL

| COST CATEGORIES | W B S LEVEL | | | | | | SERVICE CATEGORY | SERVICE DISCIPLINE |
|---|---|---|---|---|---|---|---|---|
| | PROJECT | SUB-PROJECT | AREAS/GROUPS OF SYSTEMS | BUILDINGS OR SYSTEMS | SUB-SYSTEMS | CONSTRUCTION DISCIPLINE | TYPE OF WORK | |
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 1) CONSTRUCTION COSTS | X | X | X | X | X | X | X | |
| 2) SERVICE COSTS | | | | | | | | |
| 2.1 ENGINEERING & DESIGN (D) | | | | | | | | |
| - PRELIMINARY STUDIES | X | X | | | | N/A | X | X |
| - FINAL DESIGN | X | X | X | X | X | N/A | X | X |
| - FIELD SUPERVISION | X | X | X | | | N/A | X | X |
| 2.2 LABORATORIES (L) | | | | | | | | |
| - QUALITY CONTROL | X | X | X | | | N/A | X | X |
| - OTHERS | X | X | | | | N/A | X | X |
| 2.3 MANAGEMENT (G) | X | X | | | | N/A | X | X |
| 2.4 LAND SERVICES (T) | X | X | | | | N/A | X | X |
| 2.5 FINANCING (F) | X | X | | | | N/A | X | X |
| 2.6 COMMISSIONNING (M) | X | X | | | | N/A | X | X |

the different cost elements of the cost estimate. It is also at that level of detail that the actual costs will be collected and reported. It should be mentioned that the level of detail of all the cost elements must be at least at the sub-project level since government subsidies are different for each sub-project. For example, if a laboratory is hired on a project to perform soil exploration for the construction of the main sewers and the wastewater treatment plant, actual costs must be reported separately since the government grants are 90% of the total construction costs (and service costs) for the treatment plant, and 66-2/3% for the main sewers.

For the construction costs, each capital element of the WBS up to the "type of work" level has to be estimated.

For the service element "engineering and design" (D), estimates of the preliminary studies have to be prepared for each discipline, for each sub-project (level 2); it is not possible to break down the estimate by systems since the systems will only be defined at the end of the preliminary studies. For the final design, estimates are prepared for each discipline, for each element of the WBS. For the field supervision, the estimate must be broken down by discipline up to the areas or groups of systems level (level 3); recording the time spent in the field for each system (level 4) or sub-system (level 5) is not practical.

For the service element "Laboratories" (L), estimates for quality control will have the same level of detail as the field supervision. For the other specialties (soil exploration, measurement of rate of discharge and water sampling), estimates will be prepared for each specialty, for each sub-project.

For management services (G) or SQAE services, estimates at the sub-project level are required for each management discipline.

For the land services (T), estimates at the sub-project level for each specialty are sufficient; land purchasing is included in the capital elements.

For the financing costs (F), estimates at the sub-project level are sufficient since they can only be controlled at this level; short-term loans are raised for several projects at the time.

For the commissionning costs (M), estimates at the sub-project level are sufficient.

The cost estimate must be detailed by cost code element in the following categories:

. Material (supplied by SQAE only);
. Labour (supplied by SQAE only);
. Permanent equipment (supplied by SQAE only);
. Sub-contracts (material, labour and equipment supplied by

. contractor); and

. Non-construction costs: - Engineering and design

- Laboratories

- Land services

- Management services

- Financing

- Commissionning.

For most projects, the first two categories will not be used. Most of the labour, material and equipment will be supplied by the contractor. SQAE will purchase some major equipment for the wastewater treatment plant.

The cost estimate must be prepared in constant dollars; escalation allowance and contingency allowance must be calculated separately and added to the cost estimate to form the definitive budget.

5.3.2 Contingency and Escalation

5.3.2.1 Contingency Allowance

SQAE will use the same definition as the American Association of Cost Engineers for the contingency allowance. It is defined as follows: (12)

"An allowance for unforeseeable elements of cost, which from the relationship of previous estimates and actual costs have been shown to be statistically likely to occur."

Expressed in another way, the purpose of the contingency allowance is to cover items of work which will have to be performed or elements of cost which will be incurred, which although within the defined "scope of work" covered by the estimate, cannot be explicitly foreseen or described at the time the estimate is prepared because of the lack of complete, accurate and detailed information.

Therefore, it will cover design contingency, undefined items and refinement of defined items, but will not cover gross error in estimating, changes of scope, cost escalation and unforeseens such as labor strikes, acts of God, etc.

In determining the magnitude of the contingency allowance, each of the main elements of the estimate (subdivision) must be reviewed and the degree of uncertainty evaluated to establish the appropriate allowance for each element; the restoration and treatment works should have larger contingency allowances than sewerage works because the degree of uncertainty is greater. These individual allowances added together comprise the contingency allowance for the estimate as a whole.

A part of this allowance is kept as a reserve each month and the remaining portion is written-off at the rate of commitments:

$$\frac{\text{Commitment}}{\text{Forecast}} \times \text{Contingency}$$

It is assumed here that the relationship between the contingencies and the commitments is linear. In fact, this relationship will vary during the life of the project, depending on the amount and type of committed work. For a wastewater treatment plant, the civil work just committed may not be of a critical nature as compared to the work left to complete, such as process services; the degree of uncertainty is much greater for process services than for civil work.

This is an interesting and complex subject to examine but it is beyond the scope of this report.

The contingency allowance required for the definitive budget, when the final design is at 20 - 30%, should be within these guidelines:

| | |
|---|---|
| - Restoration | 10 - 15% |
| - Sewerage | 5 - 10% |
| - Treatment | 10 - 15% |

Contingency allowances for restoration and treatment should be higher because of their degree of uncertainty compared with the sewerage. There is a lack of historical cost data, lack of "known how" in these relatively new technical fields.

5.3.2.2 Escalation Allowance

The escalation allowance may be defined as the expected cost increase of the input elements of a project from the cost of these elements have been estimated to the time they will actually be incurred. It is suggested and agreed with MENVIQ that the escalation allowance be calculated using the escalation rates of Statistics Canada for non-residential construction. (13) The methodology suggested for dealing with escalation allowance is:

i) Breakdown the cost estimate (excluding contingency) by sub-project and then by major components of work:

1) Design ;
2) Construction, including the following service elements: - laboratory
   - land
   - commissionning;

3) Management.

The contingency allowance is excluded since it will be calculated as a global figure on the escalated estimate;

ii) Review the project schedule and establish the center of gravity for each component activity; and

iii) Calculate escalation by multiplying the cost of each component by the appropriate escalation rate per year and by the duration from the estimate date to the center of gravity.

The information given by Statistics Canada is broken down differently by construction labour and equipment/material for the overall construction industry. Judgment adjustment will be required to compensate for the type of construction and components.

This allowance will be distributed to the appropriate components in the estimate, once the definitive estimate have been approved in order to facilitate comparison of actual costs against estimated costs during the progress of the project.

It will be required to deescalate the components in the estimate in order to prepare MENVIQ quarterly reports. These reports are in constant dollars, for the year the reports are prepared, and escalation is added as a global figure for the project.

Figure 5.3.2 illustrates the depletion of contingency during the life of the project and its relation with the escalated definitive estimate.

As the total forecast (tangible costs) increases, the contingency in reserve decreases by the same amount.

### 5.3.3 Project Changes

Project changes here relate to all changes in the agreed scope, budget, and schedule for the project after approval of the definitive budget.

Project changes can be initiated for the following reasons:

1) Scope changes;
2) Design changes;
3) Market changes;
4) Quantity changes; and
5) Field changes.

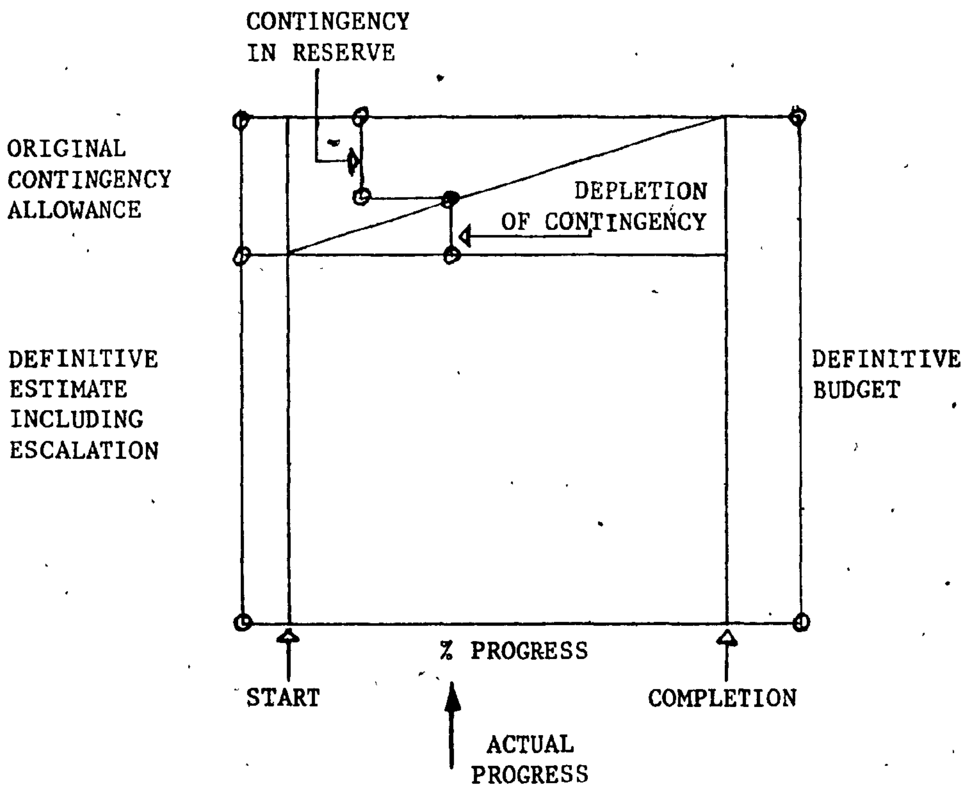
Scope changes relate to additional or reduced work not included in the scope of work approved by MENVIQ.

Design changes relate to changes in process equipment and material.

Market changes relate to price changes for the procurement of

FIGURE 5.3.2

DEPLETION OF CONTINGENCY




SOURCE: A major technical report "The Management of Contingency and Escalation in Construction" by W.E. Taylor, 1979, page 131.

equipment and material.

Quantity changes are initiated to cover quantity variances from the definitive estimate.

Field changes are initiated to cover changes in construction conditions.

This section will deal with the project change request and project change authorization procedures, also the project change request register is treated. Figure 5.3.3 show the data flow for the project change control system for scope changes and design changes.

For market changes, the data flow is similar but activities 6 to 12 are not required. For quantity changes, activities 6 to 9 are not required; activities 10 to 12 might not be required if the consultant's contract ~~is not~~ affected. ~~For field changes,~~ activities 6 to 12 might not be required, if it does not affect the design; a contract change order must be initiated to the contractor to cover the project change.

Table 5.3.2 contains the proposed format for project change requests and authorization. It is used by the project manager to obtain authorization from the client and MENVIQ to perform work not included in the scope of work and to control changes which affect the definitive budget.

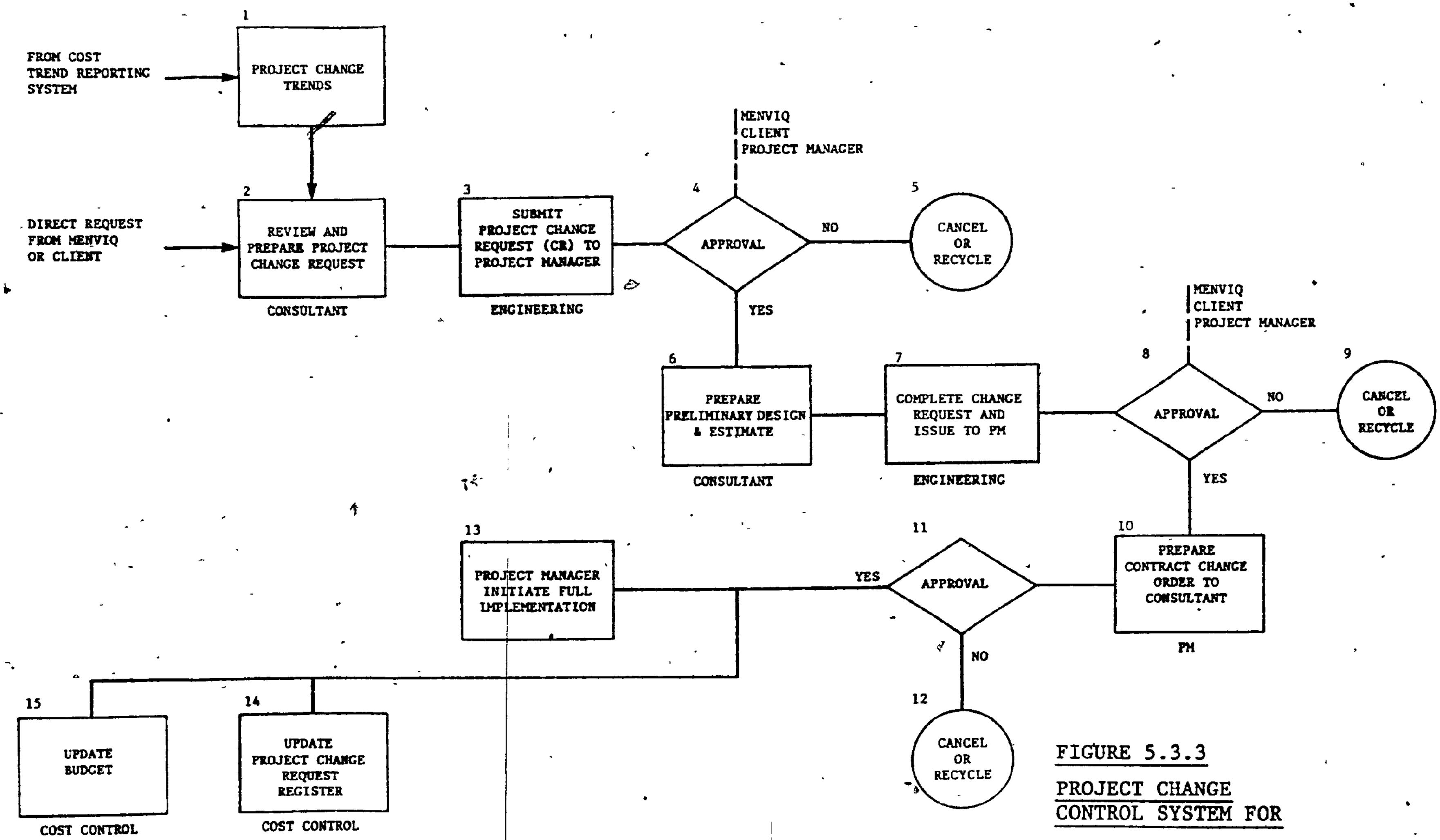



FIGURE 5.3.3

PROJECT CHANGE CONTROL SYSTEM FOR

1) SCOPE CHANGES
2) DESIGN CHANGES

**PROJECT CHANGE REQUEST**

| | | | |
|---|---|---|---|
| MUNICIPALITY: ______ | PROJECT NO | SUB-DIV. NO | C.R. NO |
| CONSULTANT: ______ | SUBJECT NO: | | Rev. |
| ORIGINATOR: ______ | DATE: ______ | | |

DESCRIPTION OF PROPOSED CHANGE:

REASON FOR CHANGE:

IMPACT ON SCHEDULE:

SUMMARY ESTIMATE OF COST

| THIS REQUEST | Machinery Equip. | Field Cost | TOTAL |
|---|---|---|---|
| A Direct cost | $ ____ | $ ____ | $ ____ |
| ~~B Indirect cost~~ | | $ ____ | $ ____ |
| C Sub-total constr. | $ ____ | $ ____ | $ ____ |
| D Services (eng., lab.) | | | $ ____ |
| E Sub-total | | | $ ____ |
| F Contingency | | | $ ____ |
| G Escalation | | | $ ____ |
| H Total estimated cost | | | $ ____ |

| | |
|---|---|
| A Original Budget | $ ____ |
| B Requests Previously approved No ____ | $ ____ |
| C Requests in Process No ____ | $ ____ |
| D THIS REQUEST | $ ____ |
| TOTAL | $ ____ |

APPROVALS

| | |
|---|---|
| SQAE PROJECT MANAGER | DATE |
| MENVIQ PROJECT COORDINATOR | DATE |
| MUNICIPALITY REPRESENTATIVE | DATE |

SUBJECTS FOR CHANGE:

1 Scope change
2 Design change
3 Market change
4 Quantity change
5 Field change

TABLE 5.3.2

PROJECT CHANGE REQUEST

The changes request (CR) is prepared by the engineering consultant for the engineering department. The engineering coordinator issues the CR to the project manager and the cost controller registers the CR on a form as shown in Table 5.3.3.

If the change is "out of scope", the project manager alerts the client's representative and MENVIQ's project coordinator of the impending change and requests approval to proceed with sufficient preliminary design in order to evaluate the monatery effect of the change. If approval is given, limited Engineering/Design is performed and a preliminary estimate is prepared by the consultant and it is completed by the control and procurement department. The cost controller records the preliminary estimate of cost.

The engineering department then completes the CR form including all necessary attachments to be sent to the project manager for approval. Once the client's and MENVIQ's approvals have been obtained, the project manager then authorizes the consultant to proceed by issuing a contract change order. Cost control enters the approved change request into the system to obtain the revised budget.

The project manager located in remote areas should have the authority to accept project changes on urgent matters, involving the proper specialists on the project team, the client, and MENVIQ if required.

| WORK AND MANPOWER CONTROL | CLIENT: | CONTR. | SUBDIV | SUBJECT | ACTIVITY | LEGEND. |
|---|---|---|---|---|---|---|
| | PROJECT. | | | | | |
| FOURTH LEVEL SUMMARY | SNC STATUS SUMMARY PROJECT CHANGES | IN CHARGE | | SHEET | UPDATED | |

| Trend forecast No. | Change order No. | TITLE | Submitted for approval date | Approved date | Not approved date | Estimated capital cost | Estimated services cost | Estimated total cost | Estimated Man/Hours |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| TOTAL APPROVED THIS MONTH | | | | | | | | | |
| TOTAL UNDECIDED | | | | | | | | | |
| TOTAL TRENDS | | | | | | | | | |

3100 - 09E/0

*Source*: SNC, SNC *Project Guide for Project Change*, p. 15

TABLE 5.3.3

PROJECT CHANGE REQUEST REGISTER

Therefore, telex or other communication facilities should be used to get the information and approvals. The project manager should then initiate the normal project change procedure.

5.3.4 Revised Budget

The revised budget represents the definitive budget plus the value of all approved changes issued to date.

The cost report and forecast shown in Table 5.3.4 is the basic control document. The columns of the cost report and forecast are completed as follows:

1) Expenditure: expended to date;
2) Commitments: total commitments, by purchase order, contract or change order;
3) Estimate to complete: the estimated cost to complete the work covered by the cost item over and above the commitments;
4) Total forecast: best forecast to date when "commitments" are added to "estimate to complete";
   This is the expected final cost of the project based on the information available to date.
5) Revised budget: the definitive estimate revised for all changes of scope approved and adjustments in scope of work between cost code items (without changing overall amounts);
6) Variance: the forecast is compared with the revised budget to identify any overrun or underrun; and
7) Definitive budget.

TABLE 5.3.4

COST REPORT & FORECAST

SUMMARY BY MAJOR SUBDIVISION

| PROJECT CODE | DESCRIPTION | EXPEN-DITURES | COMMIT-MENTS | ESTIMATE TO COMPLETE | TOTAL FORECAST | REVISED BUDGET | VARIANCE | DEFINITIVE BUDGET |
|---|---|---|---|---|---|---|---|---|
| 1 | EPIC STUDIES | | | | | | | |
| 2 | RESTORATION | | | | | | | |
| 3 | SEWERAGE | | | | | | | |
| 4 | TREATMENT | | | | | | | |
| | SUB-TOTAL | | | | | | | |
| | CONTINGENCY | | | | | | | |
| | TOTAL | | | | | | | |

These figures are in current dollars; the contingency allowance is added in the summary report.

5.3.5 Dual Control

We have seen that two entities must be involved in any decision-making process related to financial transactions. We will examine here the mechanism put in place to meet this basic need.

5.3.5.1 Budgetary Transactions

i) Order of magnitude estimate: the cost controller has the authority to load the order of magnitude estimate in the cost control system;

ii) Preliminary estimate: the director of control and procurement has the authority to accept any transaction related to the loading of the preliminary budget;

iii) Definitive estimate: only the president can authorize the transactions related to the loading of the definitive budget.

The project manager in these transactions must approve the estimates.

5.3.5.2 Commitments

i) Consultant's contracts: the cost controller can authorize a commitment of money up to 100 000 $; the cost control manager, up to 200 000 $, and the control and procurement director has full authority;

ii) Contractor's contracts: the cost controller can authorize a commitment of money up to 200 000 $; the cost control manager up to 1 500 000 $ and the control and procurement director has full authority.

The project manager's role in these transactions is to approve the contract clauses and value.

5.3.5.3 Commitment Changes

These commitment changes are either change orders issued to consultants or contractors or addenda to a contract.

Table 5.3.5 and Table 5.3.6 list the maximum authorized for the cost controller or the cost control manager, for consultant's contracts and contractor's contracts. It should be noted that there is a maximum per change order and that the cumulative commitment allowed in percentage is much lower for large contracts. Both tables are identical, except for the initial commitments that are larger for contractor's contract. The control and

TABLE 5.3.5

DUAL CONTROL
COMMITMENT CHANGES
CONSULTANT'S CONTRACT

| INITIAL COMMITMENT | AUTHORIZED PERSONNEL | MAXIMUM CUMULATIVE % | MAXIMUM PER CHANGE |
|---|---|---|---|
| 1 to 100,000 | Cost Control Manager<br>Cost Controller | 15<br>7.5 | 5,000<br>2,500 |
| 100,001 to 200,000 | Cost Control Manager<br>Cost Controller | 10<br>5 | 10,000<br>5,000 |
| 200,001 and up | Cost Control Manager<br>Cost Controller | 5<br>2.5 | 15,000<br>7,500 |

TABLE 5.3.6

DUAL CONTROL
COMMITMENT CHANGES
CONTRACTOR'S CONTRACT

| INITIAL COMMITMENT | AUTHORIZED PERSONNEL | MAXIMUM CUMULATIVE % | MAXIMUM PER CHANGE |
|---|---|---|---|
| 1 to 100,000 | Cost Control Manager<br>Cost Controller | 15<br>7.5 | 5,000<br>2,500 |
| 100,001 to 400,000 | Cost Control Manager<br>Cost Controller | 10<br>5 | 10,000<br>5,000 |
| 400,001 and up | Cost Control Manager<br>Cost Controller | 5<br>2.5 | 15,000<br>7,500 |

procurement director has full authority.

The project manager's role here is to approve the change.

5.3.5.4 Approval of Invoices and Progress Payments

i) Consultant's invoices: the cost controller can authorize the payment of invoices up to 25 000 $, and the cost control manager up to 50 000 $; the director of control and procurement has full authority;

ii) Contractor's contracts: the cost controller can authorize progress payments up to 100 000 $, and the cost control manager up to 200 000 $; the director of control and procurement has full authority.

The project manager's role here is to approve the expenditure.

## 5.4 DATA COLLECTION SYSTEM

The purpose of the data collection system is to provide an organized and efficient method to capture and periodically summarize all cost accounts to date for engineering, procurement and construction activities. (14)

The data flow for the data collection system is shown in figure 5.4.1

The prime objective here is to collect the data rapidly at the end of each period so to inform management as soon as possible on the status of the project.

The data collected must be unbiased; engineering performance data must be collected by management personnel not involved in the design itself.

### 5.4.1 Management Manhours and Expenses

The finance and administration department should provide, to cost control, management information reports detailing the direct labor hours by department and by project. The reports should also break the project down by sub-project accounts.

The reports should be issued on a monthly basis and list for each project and sub-project, the department budgets, total

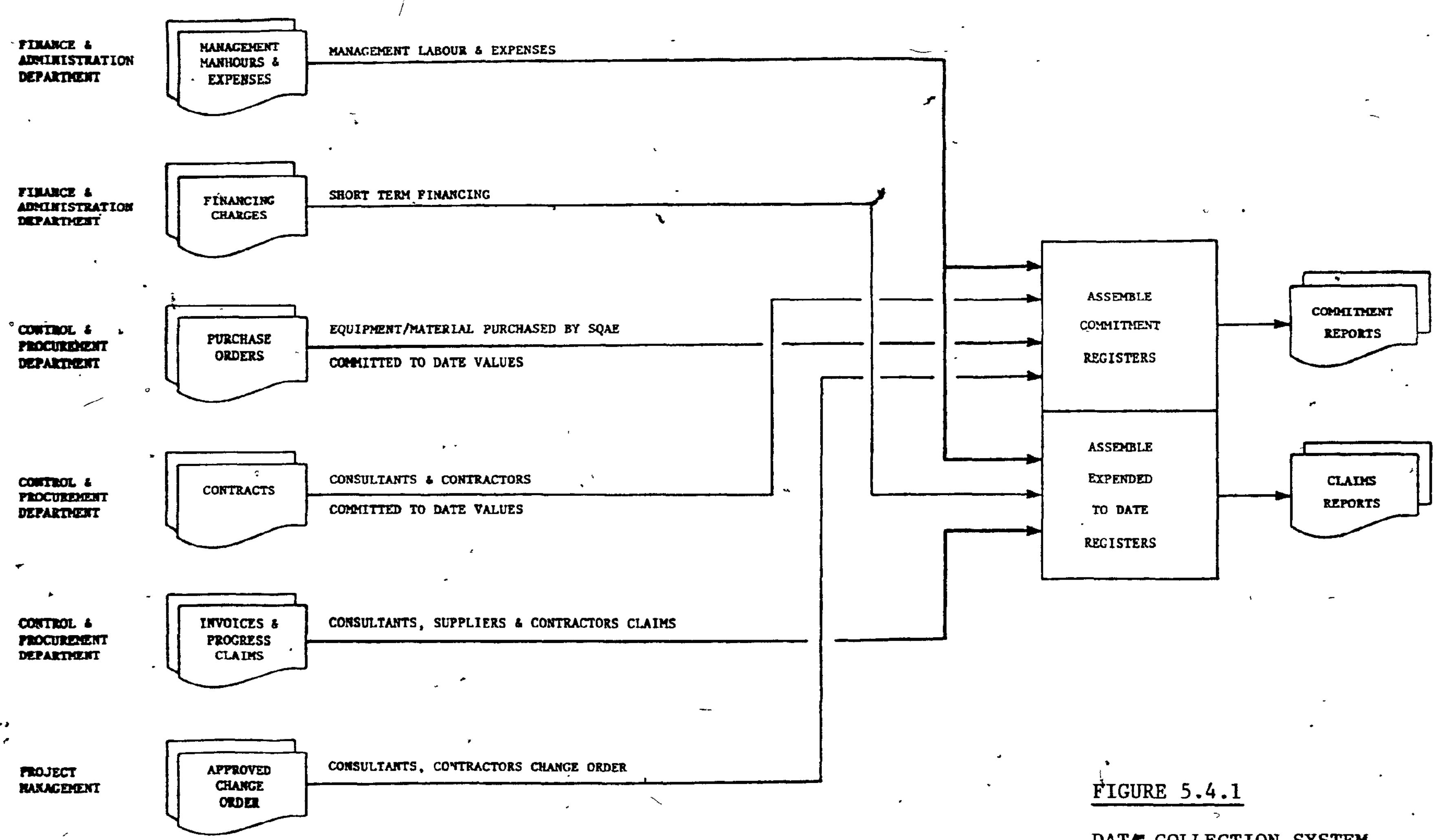



FIGURE 5.4.1

DATA COLLECTION SYSTEM

department hours to date, percent of completion, estimate to complete and total manhour forecast.

The reports should also include the related direct labor dollars and expenses per project. The hours are extended by the hourly rates to arrive at direct labor dollars. Direct labor dollars are extended by a standard overhead rate to arrive at indirect labor dollars.

### 5.4.2 Financing Charges

The finance and administration department should also provide to cost control, reports detailing the financing charges per project. The reports should also break the charges down by sub-project accounts.

### 5.4.3 Purchase Orders

After vendor selection has been made, the procurement group should forward a copy of the purchase order to cost control; the purchase requisition issued to procurement prior to the issual of the P.O. must be checked by cost control to assure proper coding of the material and equipment. The purchase requisitions as well as the bid evaluations and the quotations are issued to cost control to prepare new forecasts.

### 5.4.4 Contracts

After contract signature, the procurement group should forward a copy of a contract summary to cost control; the contract requisition must be checked by cost control to assure proper coding and breakdown of contractor lump sum prices (if any) and engineering manhours. The contract requisition, the consultant's proposals and contractor's bids as well as their evaluation are issued to cost control to prepare new forecasts.

### 5.4.5 Invoices and Progress Claims

#### 5.4.5.1 Invoices

Consultant's invoices are sent to control to verify hours (and labor dollars) charged to the various sub-projects and disciplines and total expenses against the contract conditions and to forecast the remaining hours (and labor dollars) and expenses.

The consultant includes with his invoice, a progress report per discipline showing the authorized budgets, total discipline hours to date, estimated manhour to complete, total manhour forecast and percent of completion. The report also includes the related labor dollars and total expenses.

Cost control records the expenditures and the new forecast in the system and authorizes payment.

Suppliers invoices are checked by the engineering consultant to certify that the material/equipment was received in good condition and according to P.O. and specifications. The project manager forwards the invoices to cost control to check the prices and quantities against the P.O. and records the expenditures against the material/equipment accounts.

Consultant's invoices should not be sent to the project manager located in remote areas but to the cost controller at the head office; a copy of the transmittal letter should be sent to the project manager for information. The progress report included with the invoices should be verified in the consultant's office by the engineering coordinator or the project manager and approved prior to being sent.

5.4.5.2 Contractor's Claims

The contractor's claims are checked by the engineering consultant, to certify that the work claimed was completed according to the contract conditions. The project manager forwards the claims to cost control to check the prices, and quantities and the breakdown of the contractor bid against the contract.

Cost control records the expenditures in the system for each cost item and authorizes payment.

The same procedure as for consultant's invoices should apply for the project manager located in remote areas; the engineering consultant should send the progress claims to the cost controller at the head office.

### 5.4.6 Change Orders

Once a project change request has been approved, contract change orders are issued to the consultant to proceed with the changes; a copy of the change order should be sent to cost control when it is initiated to check the coding and once approved to revise the commitments. The same approach should be used for contractor change orders.

## 5.5 COST TRENDING/FORECASTING SYSTEMS

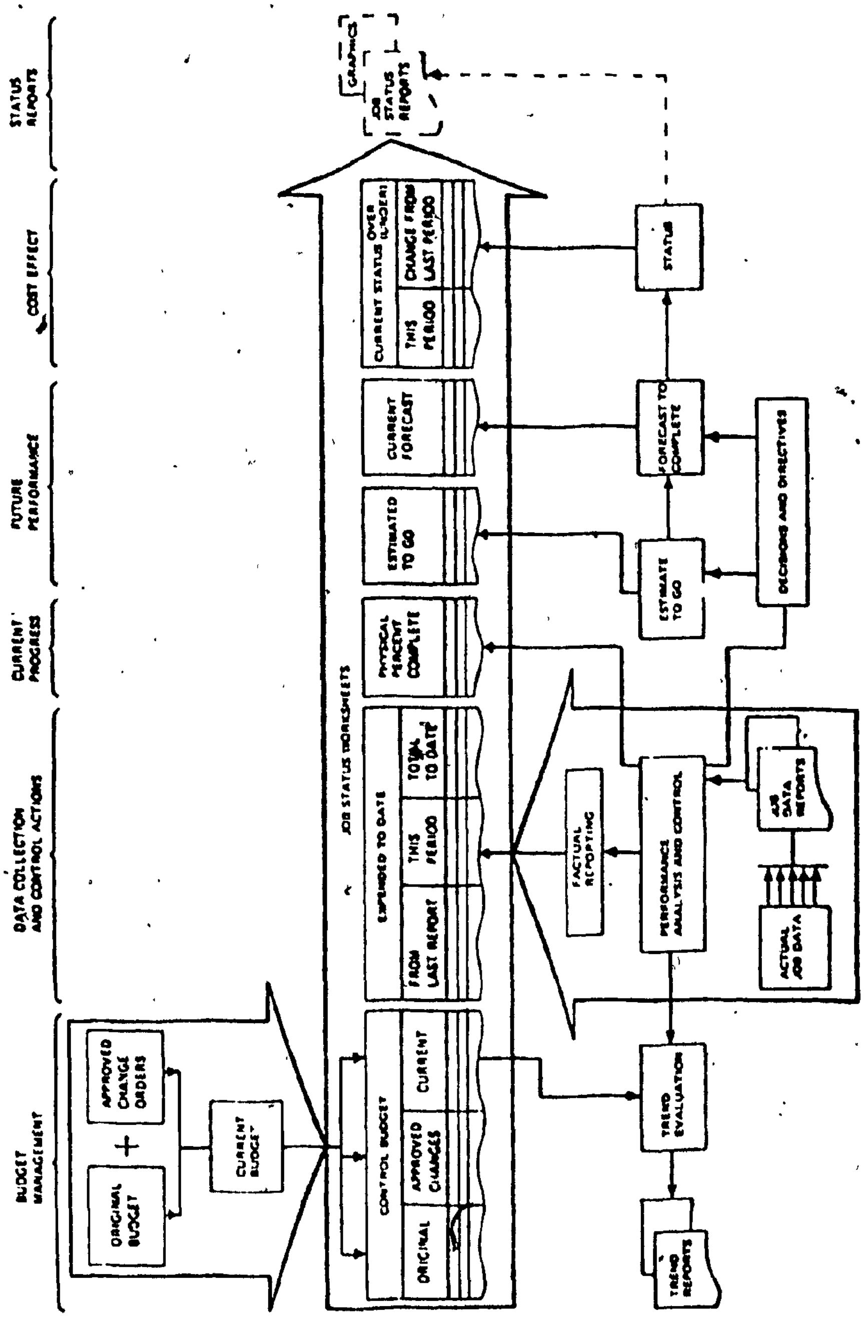
Cost trending and forecasting are part of the performance analysis and control actions necessary to keep the project progressing according to plan. The diagram on figure 5.5.1 shows the data flow and formats which are used to capture and display cost development. Budget management maintains current budgets using the budget control system previously defined. Actual job data on expenditures and commitments obtained from the data collection system and performance are analysed and reported as current progress. Forecasts on future performance are made using the cost trending and forecasting system and the current status reported to management.

The trend of progress in relation to the plan is obtained from current progress and performance data. This data is captured, sorted, summarized, and analysed before it can be used for control or as the basis of forecasting the future.

This section discusses performance measurement and trending and forecasting procedures.

### 5.5.1 Cost Trending

A trend is defined as any deviation from a planned project or schedule which can seriously affect the outcome of the project. Cost trending is the technique used to give early visibility of




Source: «Managing Capital Expenditures for Construction Projects» By Kenneth M. Guthrie, p. 120

**FIGURE 5.5.1**

**ANALYSIS AND CONTROL**

these deviations during the engineering,procurement, and construction phases of a project. (15)

The basic trend program must be consistent on all projects and follow the cost trend reporting system illustrated in figure 5.5.2.

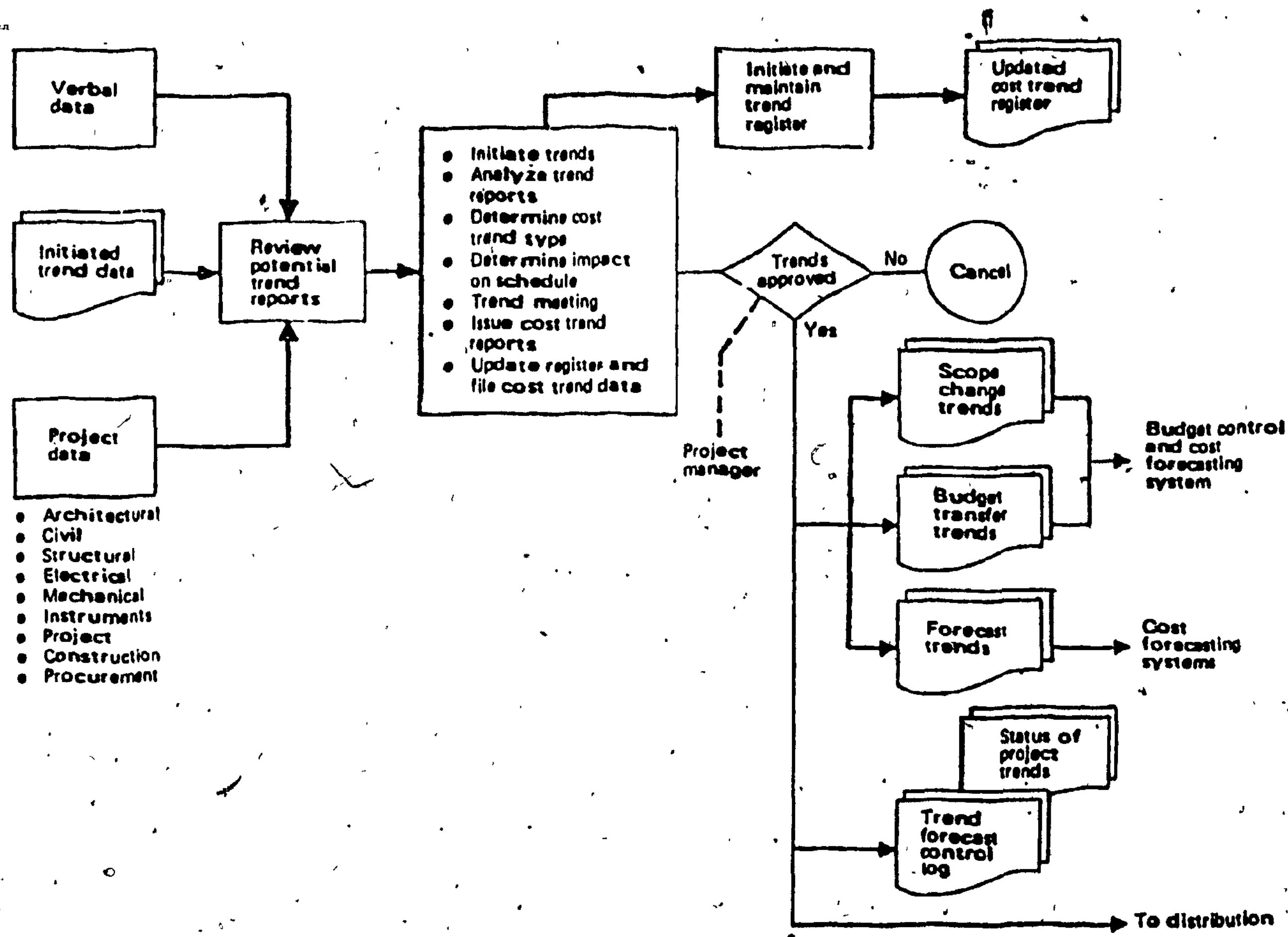
Trends are devided into three (3) basic types: (16)

Scope trends: These are client-authorized deviations and directly affect the definitive budget.

Forecast trends: Where the cost is affected due to deviations between actual and budget, or where unauthorized deviations to scope have occurred. Forecast trends do not change the definitive budget.

Budget transfer trends: Transfer of individual items within the control budget such as changing equipment to be purchased by SQAE to sub-contract or vice versa. These revisions are reflected in the budget and forecast of cost centers affected.

The cost trend report as shown on Table 5.5.1 is the only formal document for initiating the processing of a trend. This document can be initiated by the consultant or by any member of the project team and must be approved by the project manager.




*Source*: «Managing Capital Expenditures for Construction Projects» By Kenneth M. Guthrie, p. 180

FIGURE 5.5.2

COST TREND

REPORTING SYSTEM

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**HOLMES & NARVER, INC.**

**COST TREND REPORT**

CLIENT ______ CONTRACT ______
LOCATION ______ DATE ______
PROJECT ______ REVISION ______

TRENDNO 11 TREND TYPE Forecast

DESCRIPTION OF TREND

Add to the Subcontract for Earthwork & Site Preparation (S/C 3027-5-46 NX)

| | |
|---|---|
| 1. Removal of Fill Mat'l | $1,200 |
| 2. Install Water Line | 3,100 |
| 3. Added Drain Line | 2,600 |
| Total | $7,300 |

SOURCE OF TREND

Estimate versus Purchase Order

COST IMPACT

Direct Field Subcontract $7,300

Type of Estimate Factored☐ Semi-definitive☑ Definitive☐

SCHEDULE IMPACT

None

INITIATED BY C. Wells DATE 7/1/75

APPROVED BY ICH DATE 7/29/75

Source: «Managing Capital Expenditures for Construction Projects» By Kenneth M. Guthrie, p. 184

TABLE 5.5.1

COST TREND REPORT

The change request register previously shown in Table 5:3.3 also serves as the trend forecast register. This document serves as a basis to revise the total forecast each month. Project change requests and cost trend reports must be issued to identify the reasons for revising the total forecast and to make sure that the total forecast is approved by the project manager before it is issued.

5.2.5 Cost Forecasting

A cost forecast is a periodic estimate of the anticipated final job cost which takes into account all of the factors which have developed during the progress of the job. A common cutoff date is necessary for proper coordination and reconciliation of data. Differences between periodic forecasts should be expected and covered by the trending system.

Cost forecasting can be further defined by the following relationships:

1) Revised Budget + Cost Trends To Date = Total Forecast

2) Commitments To Date + Estimate To Complete = Total Forecast

There are no relationship between 1 and 2 above; they illustrate different approach in forecasting.

A cost forecast can also be defined in terms of a complete re-evaluation of a project. In this case, the current cost forecast is established independently from either 1 or 2 above and can be related as:

3) Revised Budget + Cost Trends To date + Compensating Trend (if any) = Total Forecast

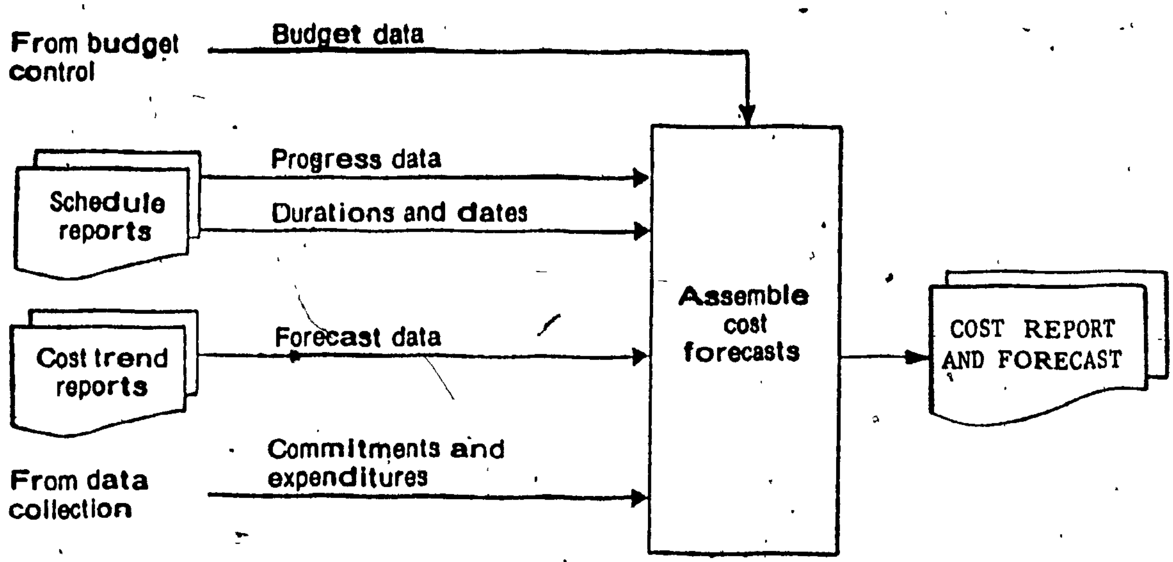
4) Commitments To Date + To go (Current Cost Forecast Less Commitments To Date) = Total Forecast (Complete Reevaluation)

The compensating trend is developed from the cost trend to date and is a prediction of the cost trends to complete the project.

The purpose of the cost forecasting system is to constantly analyse cost trends, actual cost accruals, job progress and provide an accurate prediction for the cost of work to be done to complete the project. From these analyses and predictions, the cost forecasting system can be used to assemble the total cost forecast for all elements in the project plan as illustrated in Figure 5.5.3.

5.5.2.1 Consultant Manhours and Cost

Forecasting consultant manhours and cost will be developed from the earned value method. Engineering performance will be measured in term of physical percentage complete for each activity: actual percentage complete multiplied by the manhour budget allocated to the activity will give the earned hours for that activity. The earned hours are compared with the expended hours for the same




Source: «Managing Capital Expenditures for Construction Projects» By Kenneth M. Guthrie, p. 202

FIGURE 5.5.3

COST FORECASTING SYSTEM

activity to estimate the manhours to complete.

Table 5.5.2 shows the format used to evaluate engineering progress and to prepare the total forecast. This example is taken from Figure 5.2.4, assuming that the consultant was awarded the design package D01 including the main sewer system and the pumping station. The cost item would be listed by subdivision and by engineering discipline with their authorized budgets (including approved change orders). The consultant will evaluate its progress for each item and calculate the earned manhours. The expended hours will be calculated from the time sheets coded accordingly. The consultant must compare the expended manhours with the earned manhours to estimate the manhours required to complete.

The engineering coordinator at SQAE must check and approve the progress and the forecasted hours evaluated by the consultant. The cost controller at SQAE must check the budget hours to certify that they were actually authorized. He must also issue a cost trend report and a project change request to cover the new forecast. The cost forecast is calculated using an average wage rate for the cost code item for the work yet to be accomplished.

The total forecast manhours evaluated by the consultant can be checked using the following formula: (17)

MANHOUR FORECAST
FOR: ENGINEERING & DESIGN

| | | | |
|---|---|---|---|
| CONSULTANT: | FILE NO. | INVOICE NO. / ISSUAL DATE / PAGE OF | |
| MUNICIPALITY: | | PERIOD COVERED BY THIS REPORT | |
| PROJECT: | PROJECT NO. | FROM | TO |

| CODE | | | DESCRIPTION | AUTHORIZED BUDGET * | | EARNED HOURS | | | | EXPENDED HOURS | | ESTIMATE TO COMPLETE | | TOTAL FORECAST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PACK | SUBD. | ELEM. | | | | THIS PERIOD | | CUMULATIVE TO DATE | | CUMULATIVE TO DATE | | | | |
| | | | | HOURS | DATE | % PRO. | HOURS | % PRO. | HOURS | % BUD. | HOURS | HOURS | DATE | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 = 5 x 7 | 9 | 10 = 5 x 9 | 11 | 12 | 13 | 14 | 15 = 12 + 13 |
| D01 | 3110 | ØDC | Main Sewer Syst. 1 Mun. | | | | | | | | | | | |
| D01 | 3111 | ØDC | Main Sewer 1 Mun. | | | | | | | | | | | |
| D01 | 3112 | ØDC | Main Sewer 2 Mun. | | | | | | | | | | | |
| D01 | 3113 | ØDC | Main Sewer 3 Mun. | | | | | | | | | | | |
| D01 | 3210 | ØDC | Pump Stat 1 Mun. | | | | | | | | | | | |
| D01 | 3210 | ØDS | Struct. | | | | | | | | | | | |
| D01 | 3210 | ØDM | Mech. | | | | | | | | | | | |
| D01 | 3210 | ØDW | Electr. & Instr. | | | | | | | | | | | |
| | | | TOTAL | | | | | | | | | | | |

NOTE:
* including approved change orders

| | | |
|---|---|---|
| | PROGRESS APPROVED FORECASTED HOURS | AUTHORIZED BUDGET EXPENDED HOURS |
| CONSULTANT'S REPRESENTATIVE | ENGINEERING COORDINATOR | COST CONTROLLER |

TABLE 5.5.2
MANHOUR FORECAST
ENGINEERING & DESIGN

$$\text{Authorized Budget} \times \frac{\text{\% Expended To Date}}{\text{\% Progress}} \times \text{Variance Factor} = \text{Trend Forecast}$$

From Table 5.5.2:

$$\text{Column 5} \times \frac{\text{Column 11}}{\text{Column 9}} \times \text{Variance Factor} = \text{Column 15}$$

The formula is a straightline forecast modified by the variance factor which is the product of an historical curve based on the accuracy of a straightline forecast.

The variance factor was developed in the following manner:

By using series of completed jobs, a straightline forecast was prepared at different points of progress throughout each job. The forecast was then compared to the actual expenditure at the job completion point. The variance between the straightline forecast vs actual expenditure was translated into a statistical curve, illustrated in Table 5.5.3.

~~The trend forecast is calculated~~ after 15% progress is reported until 100% job completion is reported.

5.5.2.2 Management Manhours and Cost

Forecasts for managements manhours are developed using the same approach as the consultant manhours.

The forecasts will be developed by sub-project only (Epic, resto-

| % | FACTOR | % | FACTOR | % | FACTOR | % | FACTOR | % | FACTOR | % | FACTOR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 1.25 | 29 | 1.21 | 43 | 1.16 | 57 | 1.11 | 72 | 1.10 | 86 | 1.07 |
| 16 | 1.25 | 30 | 1.20 | 44 | 1.16 | 58 | 1.11 | 73 | 1.10 | 87 | 1.07 |
| 17 | 1.25 | 31 | 1.20 | 45 | 1.15 | 59 | 1.11 | 74 | 1.10 | 88 | 1.06 |
| 18 | 1.24 | 32 | 1.20 | 46 | 1.15 | 60 | 1.10 | 75 | 1.10 | 89 | 1.06 |
| 19 | 1.24 | 33 | 1.19 | 47 | 1.15 | 61 | 1.10 | 76 | 1.10 | 90 | 1.05 |
| 20 | 1.24 | 34 | 1.19 | 48 | 1.14 | 62 | 1.10 | 77 | 1.10 | 91 | 1.05 |
| 21 | 1.23 | 35 | 1.19 | 49 | 1.14 | 63 | 1.10 | 78 | 1.10 | 92 | 1.04 |
| 22 | 1.23 | 36 | 1.18 | 50 | 1.14 | 64 | 1.10 | 79 | 1.10 | 93 | 1.04 |
| 23 | 1.23 | 37 | 1.18 | 51 | 1.13 | 65 | 1.10 | 80 | 1.10 | 94 | 1.03 |
| 24 | 1.22 | 38 | 1.18 | 52 | 1.13 | 66 | 1.10 | 81 | 1.10 | 95 | 1.03 |
| 25 | 1.22 | 39 | 1.17 | 53 | 1.13 | 68 | 1.10 | 82 | 1.09 | 96 | 1.02 |
| 26 | 1.22 | 40 | 1.17 | 54 | 1.12 | 69 | 1.10 | 83 | 1.09 | 97 | 1.02 |
| 27 | 1.21 | 41 | 1.17 | 55 | 1.12 | 70 | 1.10 | 84 | 1.08 | 98 | 1.01 |
| 28 | 1.21 | 42 | 1.16 | 56 | 1.12 | 71 | 1.10 | 85 | 1.08 | 99 | 1.01 |
| | | | | | | | | | | 100 | 1.00 |

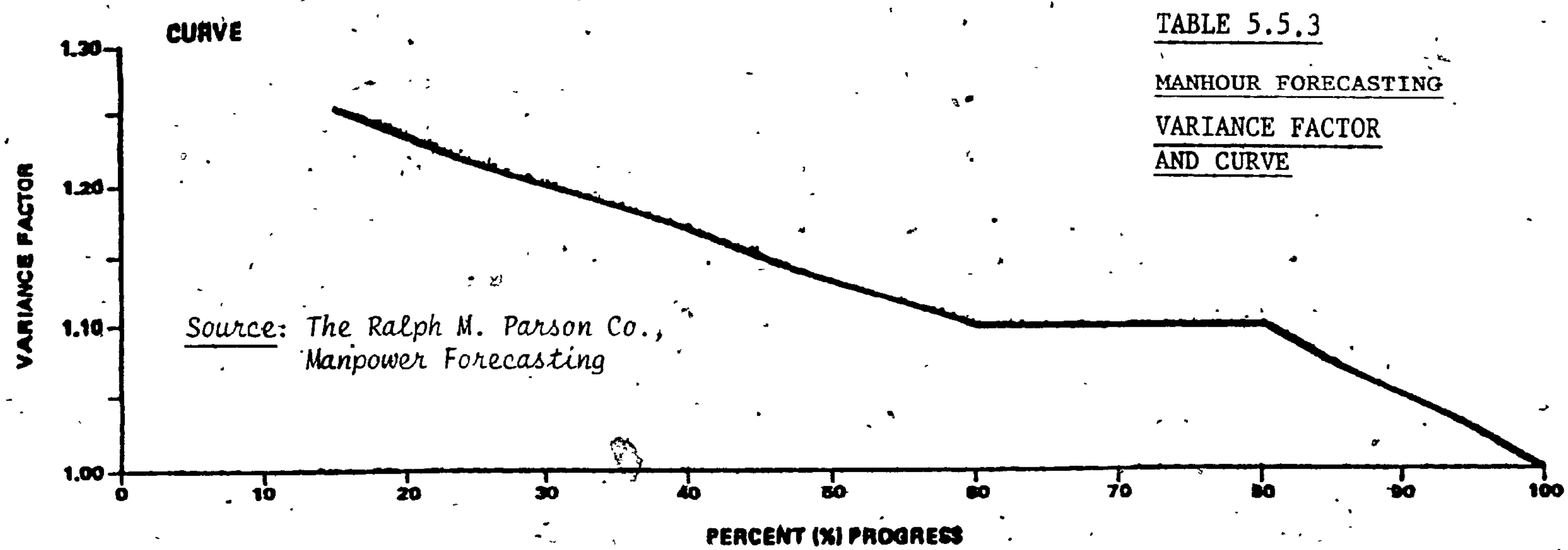



TABLE 5.5.3

MANHOUR FORECASTING

VARIANCE FACTOR AND CURVE

ration, sewerage, treatment) and then by management discipline.

5.5.2.3 Material/Equipment Costs

Material costs will not comprise a large portion of the total project costs; most of the material/equipment will be purchased by the contractors.

Forecasts will be developed from the trending reports issued during the design process, when quotations are received and once the bids are being analysed.

5.5.2.4 Sub-contract Costs

Most of the contracts will fall into two categories:

. Fixed price contract; or

. Unit price contract.

All the sewer construction contracts will be unit price, since the length of the sewer may vary depending on site constraints.

For fixed price contracts, forecasts will be developed from the spot check estimates during the final design and from the tender check estimates. It will also be developed from the estimate of project change and possible claims from the contractor.

For unit price contracts, forecasts are developed using the same approach. During the construction, the cost controller must compare the actual quantities with the quantities stated in the contract, and develop forecast with the consultant on the site. The project manager located in remote areas should assume this responsibility; he would then send the information to the cost controller at the head office.

## 5.6 COST REPORTING SYSTEM

Cost reporting is the end product of all data collection, data analysis, and cost forecasting activities in the cost control system. It can be defined as a monetary synopsis report of progress to date, work to be done and the total anticipated cost to complete the project. Cost reporting is also a narrative analysis of all significant cost developments during the reporting period. (18)

The cost reporting system (Figure 5.6.1) is used to summarize and assemble data in clear, concise formats which display definitive budgets, cost accruals to date, cost forecasts, and a monetary status of the project relative to authorized budgets.

Three types of reports will be required:

- . Client's monthly status reports;
- . Management monthly status reports; and
- . Control reports.

### 5.6.1 Client's Monthly Status Reports

As previously mentioned in 3.4.8, the cost control progress report must contain a status report on the overall financial aspect of the project, a variance report for each sub-project and cash flow projections.

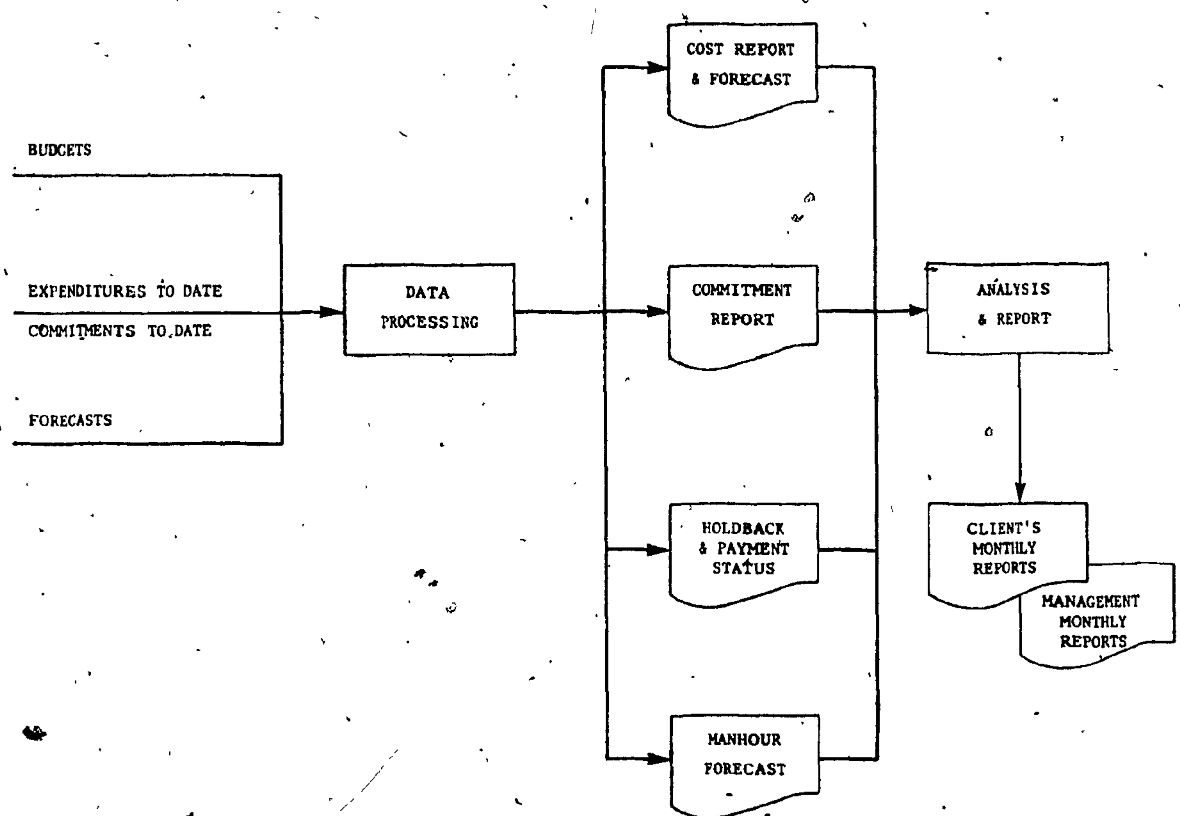



FIGURE 5.6.1

COST REPORTING SYSTEM

Table 5.3.4 in section 5.3 showed the format of the cost summary report and forecast. The summary report is broken down by major subdivisions (or sub-projects) and all the cost figures are in current dollars. The contingency allowance is treated separately and added at the bottom. The definition of each column title was given in section 5.3. The status report will give the reasons for the budget change, listing the project change requests approved during the month.

The format of the forecast variance report is shown in Table 5.6.1. This summary report compares the forecast of the previous report with the present forecast and the revised budget. Trend reports should be issued during the month to explain the variances.

The cash flow projections for the next quarter will be given as well as cash flow curves showing planned and actual expenditures for the duration of the project. This item will be discussed in the next section.

### 5.6.2 Management Monthly Status Report

The management report is prepared by the cost controller and is intended for the project managers and functional directors.

Cost summary reports and forecast must be prepared highlighting the variances at different levels of the WBS. The following

| CODE | DESCRIPTION | ESTIMATION RÉVISÉE | PRÉVISIONS PRÉCÉDENTES | PRÉVISIONS ACTUELLES | CHANGEMENT | RAISONS |
|---|---|---|---|---|---|---|
| | | REVISED BUDGET | PREVIOUS FORECAST | PRESENT FORECAST | VARIANCE | REASONS |

| | | | |
|---|---|---|---|
| | PRÉPARÉ PAR | MUNICIPALITÉ: | DATE DE LA MISE À JOUR: |
| | | TABLEAU NO<br>SOMMAIRE DES CHANGEMENTS AUX PRÉVISIONS | |

TABLE 5.6.1

FORECAST VARIANCE REPORT

reports should be produced:

- Cost report and forecast (summary by subdivision)

  This report summarizes at level 3 of the WBS, the area or group of system level; it would advise the project manager of forecasted cost variances in the main sewer systems or in the pumping systems for example.

- Cost report and forecast (summary by discipline)

  This report summarizes at the construction discipline level (element level) and alerts the engineering to the need for corrective measures to be taken by the consultant in the design.

- Cost report and forecast (summary by package)

  This report summarizes at the construction package level and advises the project manager of forecasted cost variance in a particular package.

- Manhour forecast (summary by engineering discipline)

  This report is prepared by engineering discipline and alerts the engineering group to the need for corrective measures to be taken by the consultant in the manhour expenditures and engineering progress.

### 5.6.3 Control Reports

Control reports are the detailed reports used by the cost controller.

The major reports to be used are described below:

- <u>Cost report and forecast</u>

  This report lists all the cost items according to the cost structure.

- <u>Commitment report</u>

  This report provides cost information on all commitments for the supply of goods and services, that have actually been made against each cost code to date:

  - Purchase order/contract number, supplier, description, amount;
  - Gross claim;
  - Balance outstanding.

- <u>Holdback & payment status report</u>

  This report gives information against each purchase order or contract number for each supplier under the following headings:

  - P.O. amount;
  - Gross claims;
  - Holdback deducted;
  - Payment to date;
  - Unpaid balance.

## 5.7 CASH FLOW ANALYSIS

Cash flow analysis in the cost control system serves as a review and analysis of cost and schedule data for the purpose of accurately distributing costs over time and generating various incremental and cumulative graphics to display the profile of this data over the duration of the project. The cost control system establishes three elements to be displayed on each set of graphics: (19)

- Planned profile;
- Actual profile; and
- Forecast profile.

The basic type of cash flow profiles required are:

- Commitment distribution; and
- Cash expenditure distribution.

Commitment represents the value of signed purchase orders (or letters of intent), contracts (or letters of intent) and change orders, and cash expenditures represent the value of monies at the time the expenditure is made; it is not at the time the invoice will be received or paid.

The purpose of the cash flow analysis system (Figure 5.7.1) is to provide graphic profiles of the distribution of monies over the duration of the project. Cash flow worksheets will be prepared per sub-project according to the following breakdown:

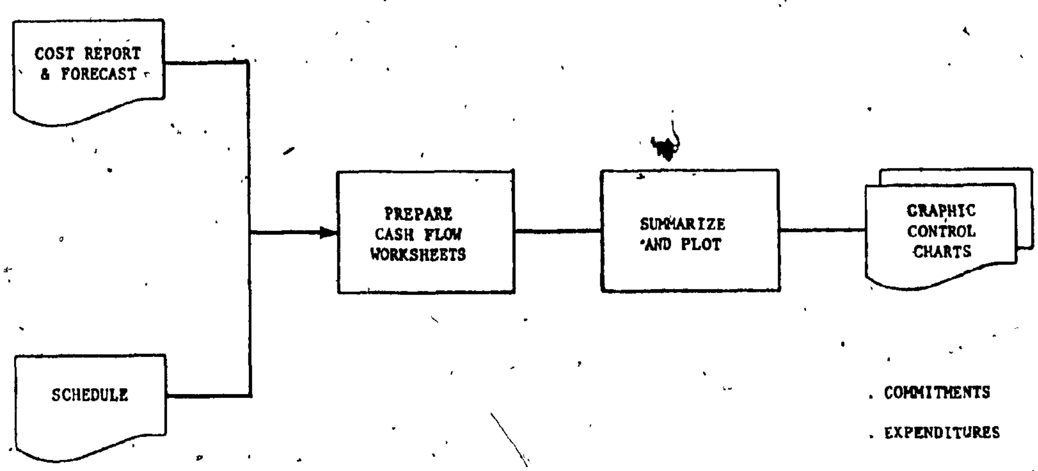



FIGURE 5.7.1

CASH FLOW

ANALYSIS SYSTEM

1) <u>Non-construction costs</u>:

1.1 Engineering & design;

1.2 Laboratories;

1.3 Land services;

1.4 Commisionning;

1.5 Management;

1.6 Financing; and

1.7 Others.

2) Construction costs.

# CHAPTER SIX

## CONCLUSION

# CHAPTER 6

## CONCLUSION

The implementation of a cost control system must be carefully planned. It cannot succeed without an absolute commitment from top management. Top management must make sure that the entire organization is sold on the need for it.

The multi-project environment creates a major constraint for the implementation of a cost control system. Top management must define the extent to which the firm must control the cost of all these projects. The value placed by the firm on cost control or management's belief in the concepts of cost control will assure the successful implementation of the cost control system.

One of the basic concepts for an effective cost control system is to have accurate cost baselines from estimating. If the baselines are not valid, there is no cost control. Another basic concept is to break down the total project into sufficiently small subdivisions, using the work breakdown structure (WBS) technique, to permit accurate cost estimates and adequate visibility and control over cost and time limits. The WBS must be developed at the appropriate level of control with the project organization structure to allow reporting by responsibility level. A third concept is to assign each element of the WBS to an engineering, procurement and construction package to be able to compare the actual costs with the cost estimates.

The control function for each project must be provided through a consistent and constant point of leadership, the project manager. The project manager must be provided with the authority necessary to get the job done on time, within budget, and to the satisfaction of the client. He must have the veto power to refuse project changes affecting his budget for the good of the project.

Cost control should be the active tool of the project manager. The control group is not there to control the project manager, but to support him or guide him on the project to stay within budget and to meet the schedule. The prime function of cost control is not to record committed and expended costs, but to forecast final project costs. The accounting group is involved after the facts, but the cost control group must be involved before the facts.

The opinions expressed in this report are the sole responsibility of the author. This report was written to highlight the problems related to the planning and implementation of a cost control system and to serve as a constructive tool to improve the existing system at SQAE.

## REFERENCES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