DOE/ID/01799-1

MASTER

JOINT IRRIGATION DISTRICTS

HYDROPOWER ASSESSMENT STUDY

- FINAL FEASIBILITY ASSESSMENT REPORT -

VOLUME ONE

TURLOCK IRRIGATION DISTRICT
Turlock, Calif., 95380

DISCLAIMER

DISCLAIMER

The following pages are an exact representation of what is in the original document folder.

JOINT IRRIGATION DISTRICTS
HYDROPOWER ASSESSMENT STUDY

- FINAL FEASIBILITY ASSESSMENT REPORT -
VOLUME ONE

9510012

PREPARED BY:
FLUID ENERGY SYSTEMS, INC. FOR
TURLOCK IRRIGATION DISTRICT
UNDER A SUB-CONTRACT AGREEMENT

Date Published - February 1979

PREPARED FOR THE
DEPARTMENT OF ENERGY

Idaho Operations Office

Advanced Technology Branch

Work Performed Under Cooperative Agreement No. EW-78-F-07-1799

FES

PREFACE

In August, 1978, the United States Department of Energy and the Turlock Irrigation District entered into a cooperative agreement for a "Joint Districts Low-Head Hydropower Assessment Study". The purpose of the agreement was to carry out a study of the hydropower potential at sites within the borders of the Turlock, Merced, South San Joaquin and Oakdale Irrigation Districts.

Under a sub-contract agreement with the Turlock Irrigation District, Fluid Energy Systems, Inc. of Los Angeles, California, gathered and analyzed the required data and prepared the following Final Report.

The results of this Report indicate the total potential small hydropower capacity with the "Joint Districts" is 19,560 kilowatts installed with an annual energy generation of 68,561,800 kilowatt-hours. This is equivalent to oil-savings of 118,616 barrels per year.

TABLE OF CONTENTS

VOLUME I

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

SECTION 1.0

INTRODUCTION

America's search for alternative energy resources has been prompted by pressing energy needs, which most analysts feel will become even more critical in the years to come. Recently, small hydropower - domestic, clean and renewable - has emerged as an important alternative.

Small hydropower can be tapped virtually wherever water is in motion. Dams, irrigation canal structures and streams can all be developed by installing a hydroelectric facility at a "drop" and generating electric power from the energy of falling water.

In many parts of the world, small hydropower is a highly developed and valued part of energy planning. In the United States, however, interest has been renewed only recently.

When President Carter presented his National Energy Plan in 1977, he included small hydropower - the first Presidential initiative in this area. Accordingly, the new Department of Energy set aside funds for the assessment and construction of small hydropower facilities nationwide. Public and private groups all over the United States responded - and applied for funds. Fifty-four were funded. Most wanted to develop single sites and finance/develop/maintain them under their previous institutional structures. This assessment study, however, represents a unique innovation. As a result, it involves three irrigation districts in the co-dependent development of a system of sites in each district. This approach is unique on two levels: 1) A system of sites rather than a single site is studied; and 2) three irrigation districts are approaching the project in a cooperative fashion. These innovations can multiply the project potential, increase overall benefits-to-costs, reduce project system development element costs and provide overall project development management efficiency.

1.0 INTRODUCTION

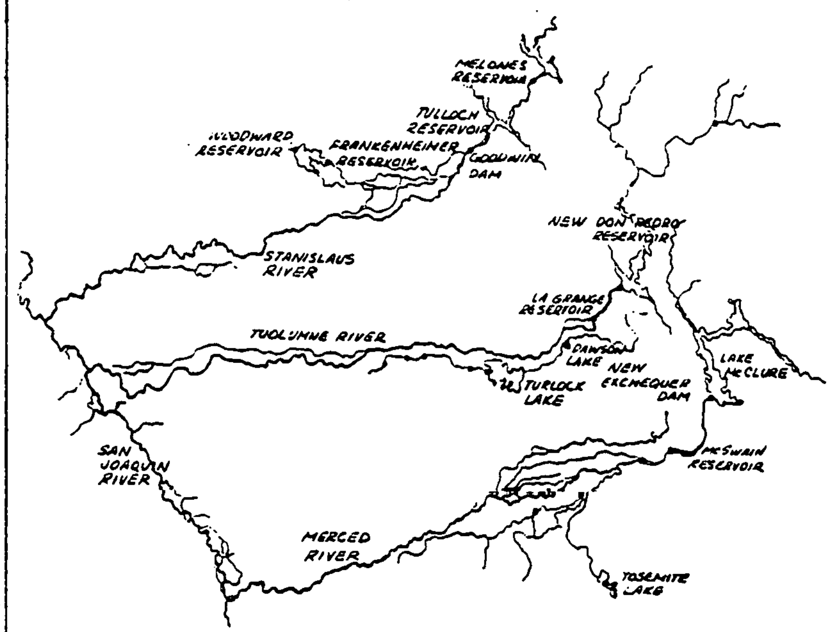
Even before the Federal Government became interested in small hydropower development, the irrigation districts in the San Joaquin Valley had been exploring its potential. In 1976, the Turlock Irrigation District (TID) began to study Drop Number One and Drop Number Nine of its Main Canal for possible hydropower installations. (At this writing, in February, 1979, the Department of Energy has awarded a cost-sharing construction contract to TID for development of the Drop Number One site.)

TID was spurred by increased need to purchase additional power, especially during the sustained drought of 1975-76, and by the need to provide lower-cost energy for industrial and commercial development. At the same time the small hydropower potential in the neighboring irrigation districts came under investigation.

In 1978, the Turlock, Merced, South San Joaquin and Oakdale Irrigation Districts joined together to submit a proposal to the Department of Energy for a "Joint District Low-Head Hydropower Assessment Study". The "Joint Districts" identified nineteen (19) sites within their borders for initial assessment. A site in Oakdale Irrigation District was quickly found to be infeasible; the study then became a three "Joint Districts" project at an early stage.

That proposal was funded in August of 1978. The Department of Energy entered into a Cooperative Agreement with TID, the lead agency of the "Joint Districts", to undertake the assessment study of twelve (12) of the available nineteen (19) sites. The study - conducted by the "Joint Districts" and Fluid Energy Systems, Inc. (FES) - assessed sites ranging from 50 kilowatts (kW) to 5,000 kilowatts (kW) capacity, to determine the economic feasibility of developing the sites within the co-dependent snow pack, rivers and canal systems. (See Figure 1-1.)

1.0 INTRODUCTION (CONT'D)



JOINT DISTRICTS CANAL AND RIVER SYSTEMS

Figure 1-1

The specific objectives of the "Joint Irrigation District Low-Head Hydropower Assessment Study" were:

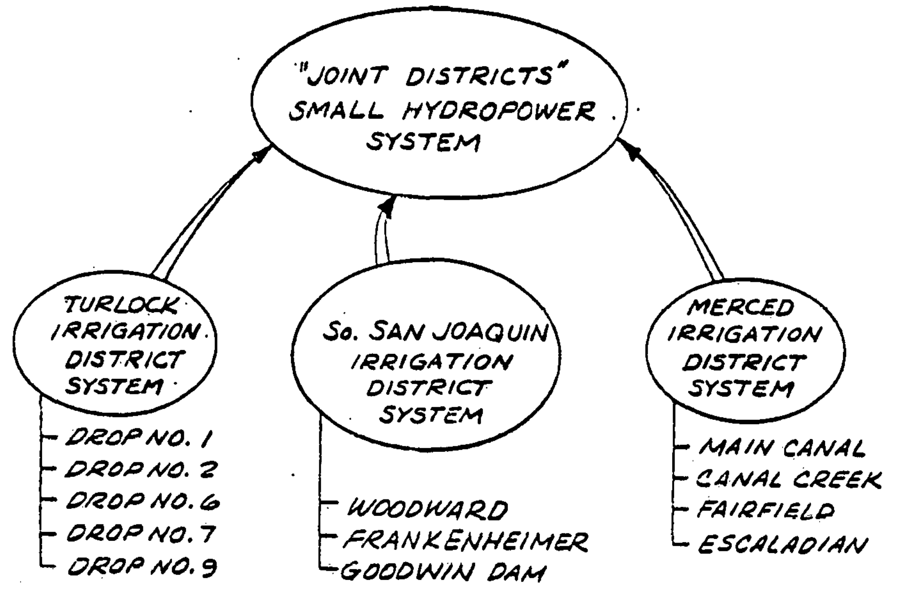
- To determine in detail the total undeveloped small hydropower potential at the identified sites in each of the four (4) irrigation districts' canal systems. (See Figure 1-2.)

- To develop unified data gathering and evaluation systems within the "Joint Districts" to provide a common language for small hydropower systems development.

- To determine if there are other sites in the four (4) canal systems at which small hydropower can be economically developed.

- To document an estimate of total usable small hydropower capacity of each of the systems that can be developed with a balanced framework of technical, demographic and economic factors.

- To analyze various financing and marketing options for small hydropower systems development, and to create a model for interagency cooperation for other local governments.



JOINT IRRIGATION DISTRICTS - SMALL HYDROPOWER SYSTEMS

Figure 1-2

The "Joint Districts" collective approach has several advantages:

- Application of the small hydropower systems development methodology.
- Avoidance of unnecessary duplication of efforts.
- A large number of combinations of head and flow variations within the systems for evaluation. This maximized the use of in-house computer system development programs.

1.0 INTRODUCTION (CONT'D)

- A single Department of Energy contact for assessing the feasibility of a significant sample of system sites within one area.

- The specialized small hydropower systems knowledge and expertise within the "Joint Districts" Assessment Study Team, multiplying the analytic power of the study.

- Opening the possibility for the "Joint Districts" to become a single:
  - small hydropower system developer,
  - financing entity,
  - developer of the overall project,
  - power purchaser,
  - operating and maintenance entity.

1.1 STUDY DESCRIPTION

The "Joint Districts" and FES established a feasibility study in four phases:

- Phase A - Turlock Irrigation District Main and Distribution Canal System Site Data.

- Phase B - Merced Irrigation District Main and Distribution Canal System Site Data.

- Phase C - South San Joaquin/Oakdale Irrigation Districts Main Canal System Site Data.

- Phase D - Assessment of the three (3) small hydropower systems and Final Report.

1.1 STUDY DESCRIPTION (CONT'D)

Phases A through C included a subphase for each of the identified sites and each site's subphase included twelve (12) tasks. As each phase and subphase (or site) was completed, the compiled system information was transmitted to Phase D for evaluation, analysis, assessment and documentation.

The results of the "Joint District" study are presented in this Final Assessment Report (Phase D) to the United States Department of Energy. The Report is divided into two volumes. Volume One contains two parts, the first of which is a project overview meant to be accessible to laypeople and professionals alike (Sections 1.0 and 2.0). Part Two of Volume One (Sections 3.0 through 8.0) contain the detailed technical analyses of the assessment. Volume Two contains Phases A, B and C detailed site reports.

The following table (Table 1-1) summarizes the process involved in assessing the "Joint Districts" sites. It gives all the sites identified as possibly feasible and shows the benefit-to-cost ratios for those sites finally recommended.

TABLE 1-1

IDENTIFIED, PROPOSED, FUNDED, ECONOMICAL SITES

IDENTIFIED SITES	PROPOSED TO DOE	FUNDED FOR STUDY	SITES ASSESSED	STUDY RESULTS SELECTED SITES BENEFIT-TO-COST*
1. Drop Number One	1. Drop Number Two	1. Drop Number Two	1. Drop Number Two	.960 to 1.0
2. Drop Number Two	2. Drop Number Six	2. Drop Number Seven	2. Drop Number Seven	.937 to 1.0
3. Drop Number Six	3. Drop Number Seven	3. Ceres Spillway	3. Ceres Spillway	Deleted
4. Drop Number Seven	4. Ceres Spillway	4. Main Canal	4. Main Canal	1.216 to 1.0
5. Drop Number Nine	5. Main Canal	5. Escaladian	5. Escaladian	.868 to 1.0
6. Ceres Spillway	6. Escaladian	6. Fisher	6. Canal Creek	1.243 to 1.0
7. Hickman Spillway	7. Fisher	7. Youd	7. Fairfield Drop	1.153 to 1.0
8. Dawson Lake	8. Buhach	8. Buhach	8. Goodwin Dam	1.500 to 1.0
9. Main Canal	9. Youd	9. Fairfield Drop	9. Frankenheimer	1.372 to 1.0
10. Canal Creek	10. Fairfield	10. Goodwin Dam		
11. Escaladian	11. Goodwin Dam	11. Frankenheimer		
12. Fisher	12. Frankenheimer	12. Parker Drop		*First year of operations
13. Buhach	13. Parker Drop			
14. Youd	14. Woodward Dam			
15. Fairfield Drop				
16. Goodwin Dam				
17. Frankenheimer				
18. Parker Drop				
19. Woodward				

SECTION 2.0

ASSESSMENT SUMMARY

2.1 CONCLUSIONS AND RECOMMENDATIONS

After six months of system development assessment study, Fluid Energy Systems, Inc. (FES), technical consultants to the "Joint Districts", offers the following conclusions and recommendations:

Conclusions:

- Installation of small hydropower system facilities is economically and technically feasible at twelve (12) of the nineteen (19) identified sites within the jurisdiction of the "Joint Districts".

- The total installed capacity of the recommended three (3) systems is 19,560 kilowatts.

- Development of the sites within each of the three (3) small hydropower systems would produce over 68.5 million kilowatt-hours per year.

- This electrical power is enough to replace 118,616 barrels of oil per year.

- Development of the three systems would make a significant contribution to meeting the economic development needs of the "Joint Districts'" service areas.

- No significant adverse environmental effects are foreseen in construction and operation of the systems assessed during this Study.

2.1 CONCLUSIONS AND RECOMMENDATIONS (CONT'D)

Recommendations:

- That the Districts proceed to develop the sites within the three (3) systems judged to be economically feasible during this study.
- That the three (3) system, twelve (12) site small hydropower development program of the "Joint Districts" be implemented based on the plans and schedules in Section 7.0
- That the Districts leave open the possibility of developing other sites should technological or financial developments, unforeseen at the present time, make them feasible.
- That the Districts, building on the options set forth in this Report, identify a financing and marketing program which will attain the maximum benefits of development.

2.2 HYDROPOWER CAPACITY

Table 2-1 is a breakdown by site and by District of the total small hydropower system capacity, the estimated annual energy, oil savings, and the approximate costs to develop the identified sites.

2.3 POWER MARKETING

Demand for electrical power is steadily increasing in the San Joaquin Valley. The Districts will be in the enviable position of producing a critically-needed resource at highly competitive cost. Marketing options, however, are limited to some degree because of the four irrigation districts, only TID is a retail distributor of electrical power. The other three districts only generate hydropower for wholesale.

TABLE 2-1

"JOINT DISTRICTS" SMALL HYDROPOWER CAPACITY

SITE	INSTALLED CAPACITY (kW)	ANNUAL ENERGY (kWh)	OIL SAVINGS (bbls/year)	DEVELOPMENT COST ($)
TID SYSTEM				
Drop One	3,260	12,200,000	21,107	3,560,493
Drop Two	660	2,073,400	3,587	1,048,247
Drop Six	920	2,902,000	5,020	1,313,712
Drop Seven	700	2,101,400	3,635	1,089,088
Drop Nine	1,070	4,700,000	8,131	1,786,400
MERCED SYSTEM				
Main Canal	2,800	9,169,000	15,863	3,660,690
Canal Creek	940	3,262,000	5,643	1,274,232
Fairfield	970	2,809,000	4,860	1,183,702
Escaladian	270	822,000	1,422	459,967
SSJID SYSTEM				
Woodward	2,300	6,906,000	11,948	2,537,193
Frankenheimer	4,700	16,962,000	29,346	6,006,110
Goodwin Dam	970	4,655,000	8,054	1,507,262
TOTALS	19,560	68,561,800	118,616	25,427,096

2.4 JOINT DISTRICTS SERVICE AREA SOCIO-ENVIRONMENTAL FACTORS

The Northern San Joaquin Valley in Central California is considered one of the nation's prime "breadbasket" areas. The 494,631 acres covered by the "Joint Districts" reach from Stockton, in central inland California, to a point some sixty (60) miles south through the center of the 200-mile long valley. There are approximately 250,000 people living within the boundaries of the combined districts, which falls within three counties.

Combined, the "Joint Districts" covers four of the valley's major population centers and nearly all of the prime agricultural land of this very fertile area, which produced $40 million in agricultural products last year. (See Figure 2-1).

2.4.1 Impacts

The impact that small hydropower development would have on the communities of San Joaquin, Stanislaus and Merced Counties is examined extensively in Section 5.0 of this Report. These impacts are: socio-economic, environmental and institutional.

Socio-economic

Development and operation of small hydropower facilities would have positive socio-economic effects on the three counties - both short term and long term. The counties have persistent unemployment and construction would create 315 direct jobs and 768 indirect jobs. In the long run, holding down energy costs through increased availability of small hydropower would buttress the economy because:

- more new industry will be attracted to the area,
- more stability will benefit existing industry,
- lower cost energy acts as a multiplier of local spending and helps keep development or income dollars in the local area,
- irrigation flows will be neither interrupted nor reduced,
- cost-of-living rises will be moderated.

Environmental

The construction and development of sites, outlined in this report, involves very little environmental impacts, since most sites are located at existing structures on irrigation canals. Addition of transmission lines where necessary and a small hydropower plant are the major physical changes. Attention will be paid to preservation of possible archaeological features and game fish migration pathways. Oil conservation, an environmental advantage, is also foreseen.

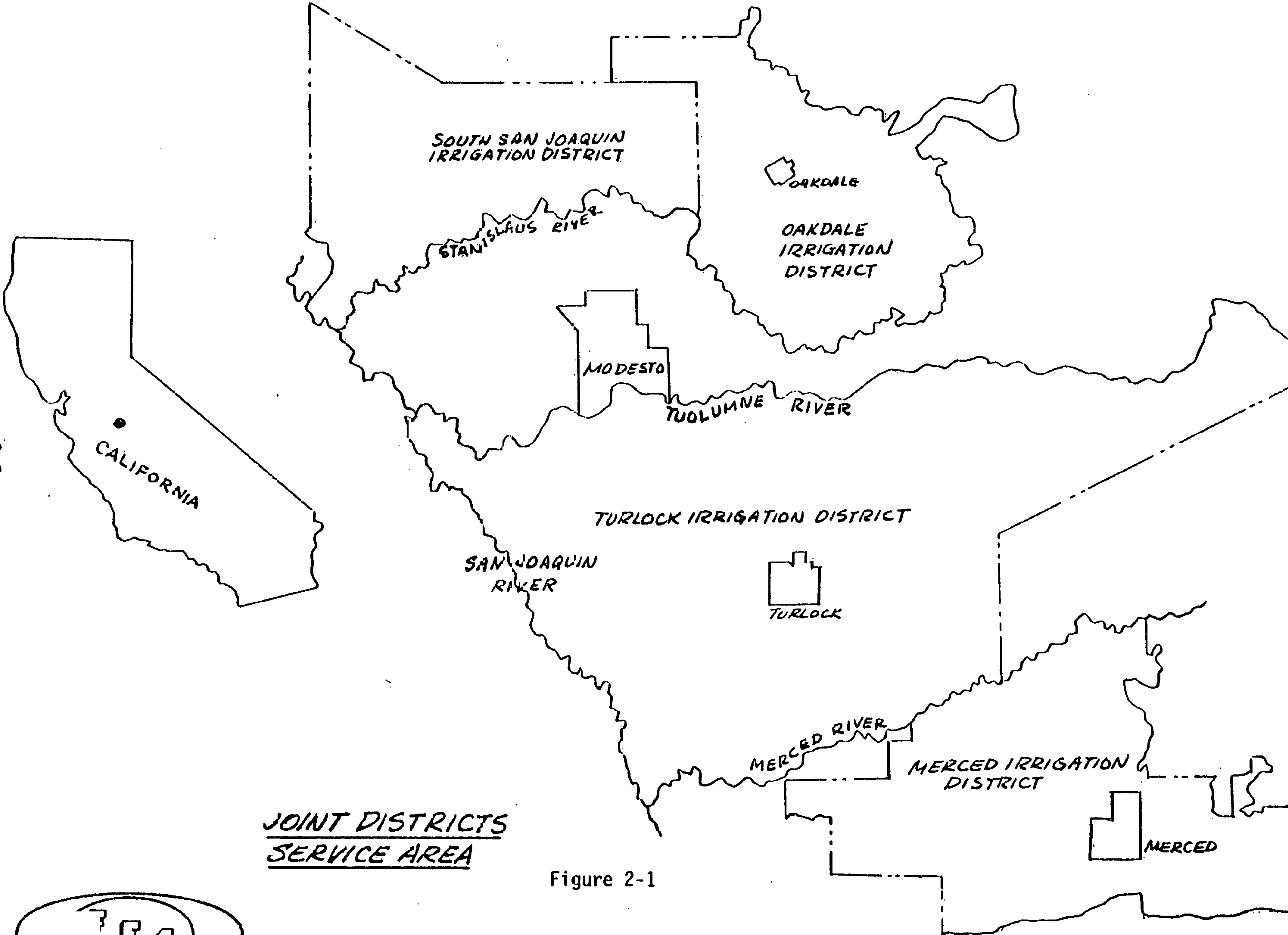

SOUTH SAN JOAQUIN IRRIGATION DISTRICT
OAKDALE
OAKDALE IRRIGATION DISTRICT
STANISLAUS RIVER
MODESTO
TUOLUMNE RIVER
CALIFORNIA
TURLOCK IRRIGATION DISTRICT
SAN JOAQUIN RIVER
TURLOCK
MERCED RIVER
MERCED IRRIGATION DISTRICT
MERCED
JOINT DISTRICTS
SERVICE AREA

Figure 2-1

2.4 JOINT DISTRICTS SERVICE AREA SOCIO-ENVIRONMENTAL FACTORS (CONT'D)

2.4.1 Impacts (Cont'd)

Institutional

In each of the "Joint Districts", implementation depends on the decision-making process of public agencies. This process will provide valuable checkpoints for public involvement and reactions. Turlock Irrigation District (TID) distributes power and the possibility exists that TID could become a single operating entity and power purchaser for the "Joint Districts".

2.5 ECONOMIC ANALYSIS

The economic viability of developing the identified sites depends on the terms and availability of financing. FES has analyzed two major types of financing, i.e., municipal tax-exempt vs. investor-owned utility financing. For detailed analysis, see Section 3.0. Municipal tax-exempt financing substantially raises the benefit-to-cost ratio of site development due to lower interest rates, longer terms and tax exemptions for public agencies.

Figures 3-2 through 3-4 in Section 3.0 show the project development fixed costs versus the revenues escalated at 6% per year. This indicates a pay-off for each of the three systems as:

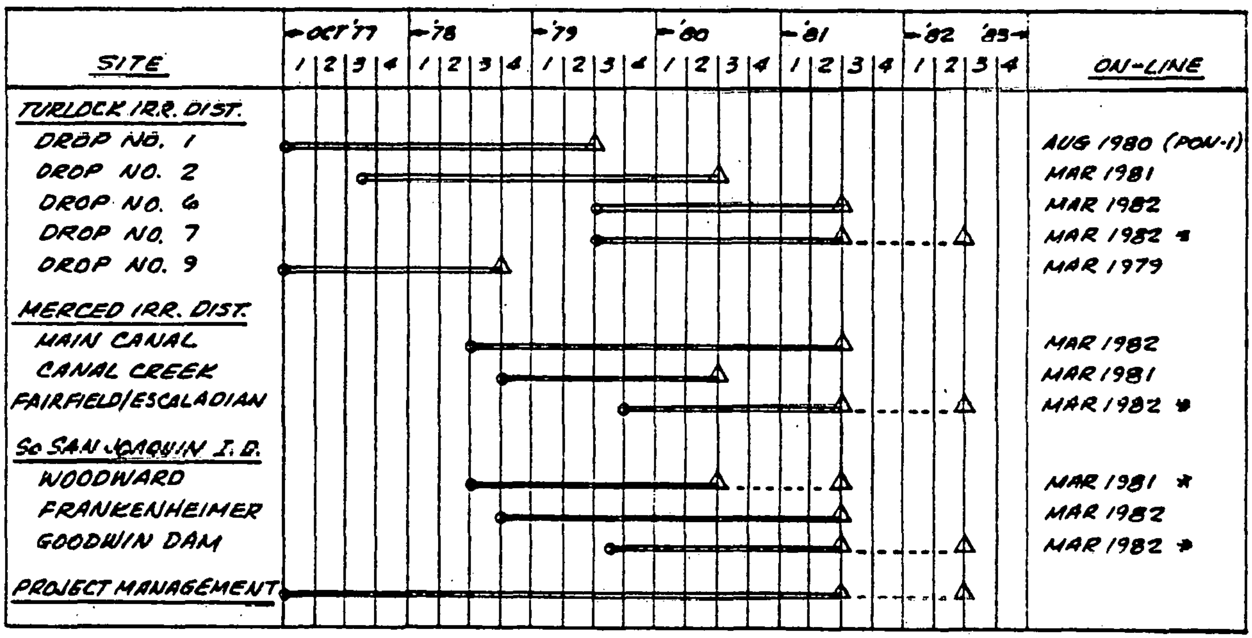
- 7 years for Turlock system
- 7 years for Merced system
- 6½ years for South San Joaquin system.

2.6 DEVELOPMENT PLANS AND SCHEDULES

As a result of the efforts of Phases A, B, C and D, an overall "Joint Districts" Hydropower Development Plan has been prepared. That Plan is discussed in detail in Section 7.0 of this Report.

The Development Plan includes four (4) additional sites that were not part of the Department of Energy funded effort. The overall Plan includes twelve (12) sites: five (5) in the Turlock Irrigation District (TID) small hydropower system; four (4) in the Merced Irrigation District (MERCED) small hydropower system; and three (3) in the South San Joaquin District (SSJID) small hydropower system.

The "Joint Districts" estimated on-line power development schedule is illustrated in Figure 2-2, based on estimated equipment and materials delivery schedules; weather contingencies; irrigation water operations and dry (no water delivery) seasons. It is estimated that all of the selected sites could be engineered, constructed, equipment installed and on-line by March, 1982. As shown in Figure 2-2, even with equipment and weather contingencies accounted for, all sites could be operational not later than March, 1983.



* INDICATES SLIPPAGE DUE TO EQUIPMENT DELIVERY OF 12 MONTHS.

"JOINT DISTRICTS" ESTIMATED ON-LINE POWER DEVELOPMENT SCHEDULE

Figure 2-2

2.7 REPORT METHODOLOGY AND PERSONNEL

This Study Report was prepared by Fluid Energy Systems, Inc. (FES), consultant to the "Joint Districts". The "Joint Irrigation Districts Hydropower Assessment Study" brought together the following data sources:

- Current Technical Literature and State-of-the-Art Information
  Interest in small hydropower has begun to generate a modest but valuable literature, which helped in framing research questions. A full bibliography appears in the Appendix, Section 8.4. Two books were especially useful: "Low-Head Hydro", edited by John S. Gladwell and Calvin C. Warnick, Idaho Water Resources Research Institute, 1978, and "Proceedings from the Midwest Regional Conference on Small Low-Head Hydroelectric Power", College of Engineering, Michigan State University, 1978. In addition, turbine manufacturers possess an immense range of data on the state-of-the-art. In order to enhance this study, FES invited turbine manufacturers to attend an information-gathering session on October 5, 1978, at which eight manufacturers were represented. (See Appendix, Section 8.2.)

- District Files
  The "Joint Districts" engineering staffs made available to FES all existing data on the project sites, including maps, profiles, drawings and functional descriptions. In addition, records of historical flows were transmitted to FES. Also, FES study personnel visited each site several times during the study period.

- Computer Systems
  TID made available to FES a computer program designed for equipment procurement for small turbines at its Drop Number One and Drop Number Nine. FES staff translated the program to PL/ONE for use in FES's IBM System/360 computer. With this program, FES was able to determine a range of potential energy generations at each site through simulation of testing of combinations of flow, head and equipment.

- Socio-Economic, Environmental
  FES directly contacted the County Economic Development Committees, or their equivalents, for each of the "Joint Districts" in order to ascertain the present situation and to estimate project impacts. Environmental research used site visits as well as substantial exploration on TID's Drop Number One and Drop Number Nine.

The Final Report was prepared by FES. A small business incorporated in California in 1975, FES is a multi-disciplinary consulting firm of highly skilled engineers, planners, administrators, writers and proposal managers who work together developing, implementing and evaluating energy-related projects.

FES's engineering support has been used in research, development and design of hydro, solar and wind systems; mechanical; electrical and hydraulic systems.

FES maintains the following active project teams:

- Technical Systems and Project Management: To assist the client in planning and directing hydro, solar and wind system projects.

- Civil and Hydraulic Engineering: To conduct all of the civil design engineering associated with penstocks, powerhouses, canals, dams, reservoirs, afterbays and solar and wind system installations.

- Mechanical and Electrical Engineering: To assess potential hydro, solar and wind energy recovery, outline feasibility and perform engineering design and specifications.

- Grantsmanship and Contract Procurement: To locate funding sources and prepare all required documentation and funding applications.

2.7 REPORT METHODOLOGY AND PERSONNEL (CONT'D)

The following personnel contributed to this Report:

FLUID ENERGY SYSTEMS, INC.

K. Thomas Miller, Engineering Manager
Patricia P. Miller, Project Coordinator
Thomas Cammarano, Design Engineer
Lee Royalty, Hydraulics/Civil/Computer Implementation
William O'Laughlin, P.E./Mechanical
Scot Stockton, Technical
Raphe Sonenshein, Editorial
Nicole Mosberg, Socio/Economic
Barbara Barker, Administrator/Repro Typing
Susanna Louie, Computer Design
Anthony L. Linhardt, P.E./Electrical

"JOINT DISTRICTS"

Ernest Geddes, General Manager, TID
A. K. Hagiwara, Project Manager, TID
Roger Masuda, Legal Counsel, TID

Jay Anderson, General Manager, Merced
Ken McSwain, Consultant, Merced

Noel Negley, General Manager, SSJID

Bob Isaacs, General Manager, Oakdale

SECTION 3.0

OVERALL ECONOMIC ANALYSIS

3.1 CONSIDERATIONS

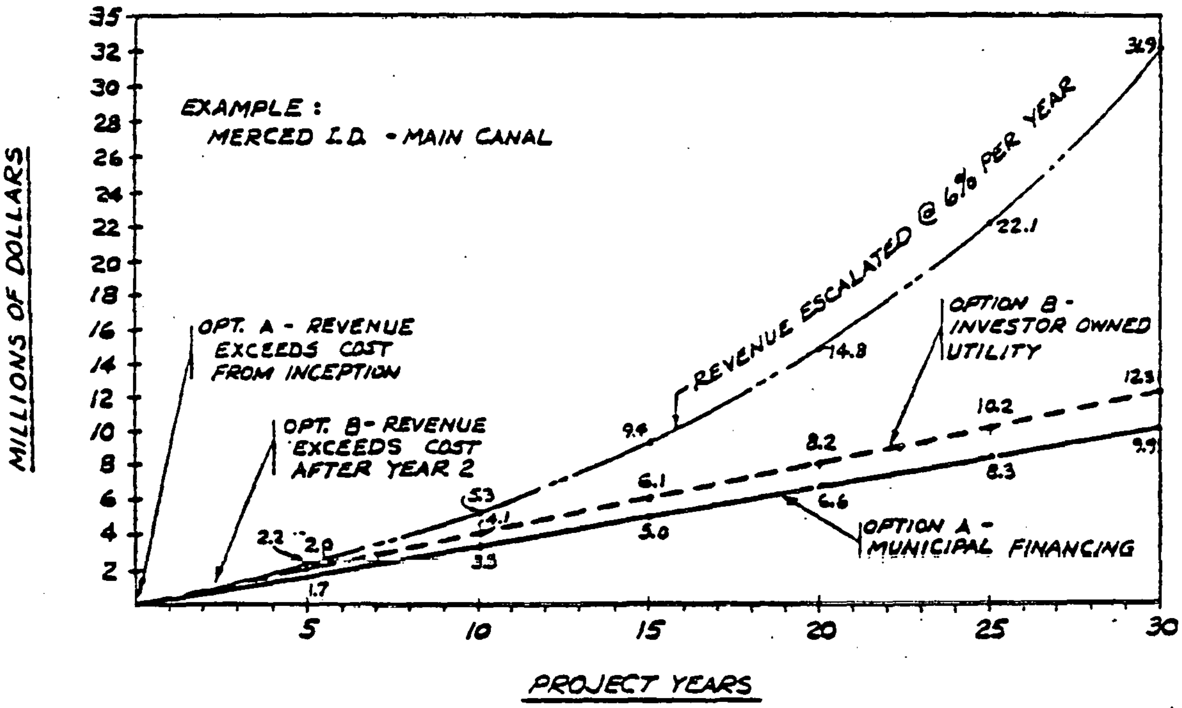
Economic analysis based on 1982 costs of the selected "Joint Districts" hydropower sites (for detailed economics of each selected site, see Section 7.0) indicates that all the sites are capital intensive. The variable annual costs of the project are only 9.5% to 11% of the total cost including debt service, operations and maintenance.

Municipal tax exempt financing is the more attractive source (i.e., 7% financing); it is more difficult for investor-owned utilities to finance projects because of their taxable rates. The effect of financing terms is amply demonstrated by Figure 3-1 showing two cases of financing for the Merced Main Canal site.

- Option A - Municipal tax exempt power revenue bond with 7% financing over 30 years (Table 3-1).
- Option B - Financing through investor-owned utility with 9% financing over 30 years (Table 3-2).

As tabulated in Tables 3-1 and 3-2 and as shown in Figure 3-1, Option A, Municipal Financing is clearly the best method of financing.

In Option A, Municipal Financing, the first year benefit-to-cost ratio for Merced Main Canal is 1.216 to 1.0 escalating at 6% per year for thirty years. The annual revenue exceeds the annual costs for this option from inception.



THIRTY YEAR COST COMPARISON OF FINANCING METHODS AND REVENUE

Figure 3-1

TABLE 3-1

TOTAL INVESTMENT COST:(1982):	
- Total Construction Cost	$ 3,115,481
- Net Interest During Construction* (7% for 2¼ years)	545,209
Total Investment Cost	$ 3,660,690
TOTAL ANNUAL COSTS:(1982):	
- Operations and Maintenance	$ 36,606
- Debt Service 7% for 30 years (.0805864)	295,002
Total Annual Costs	$ 331,608
- Bus Bar Energy 36.1 mills (1982)	
BENEFIT-TO-COST (First Year Operation)	
- 9,169,000 kWh/year X 44 mills** =	$ 403,436
- $403,436 ÷ 331,608/year = 1.216 to 1.0 escalating at 6%/year	

OPTION A, MERCED MAIN CANAL
MUNICIPAL FINANCING - 7% FOR 30 YEARS

* Estimated period overstated in order to allow for added construction and money market contingencies during project development.

** Based on State of California Energy Commission Values (Section 8.5).

TABLE 3-2

TOTAL INVESTMENT COST (1982):	
- Total Construction Cost	$ 3,115,481
- Net Interest During Construction* (9% for 2½ years)	700,983
Total Investment Cost	$ 3,816,464
TOTAL ANNUAL COSTS (1982):	
- Operations and Maintenance	$ 38,164
- Debt Service - 9% for 30 years (.0973363)	371,480
Total Annual Costs	$ 409,644
- Bus Bar Energy = 49.7 mills (1982)	
BENEFIT-TO-COST (First Year Operation)	
- 9,169,000 kWh/year X 44 mills** =	$ 403,436
- $403,436 ÷ 456,143/year = .985 to 1.0 escalating at 6%/year	

OPTION B, MERCED MAIN CANAL
INVESTOR-OWNED UTILITY FINANCING - 9% FOR 30 YEARS

* Estimated period overstated in order to allow for added construction and money market contingencies during project development.

** Based on State of California Energy Commission Values (Section 8.5).

In Option B, Investor-Owned Utility Financing, the first year benefit-to-cost ratio for Merced Main Canal is .985 to 1.0 escalating at 6% per year for thirty years. The annual revenue exceeds the annual costs for this option at the second year.

Over the same thirty year period, both methods of financing are cost effective. However if the power from the project was sold to another public entity, such as the Turlock Irrigation District, Option A could be used since it would be permissable to finance the project with tax-exempt bonds which normally carry a lower interest rate than taxable bonds. But if the power from the project was sold to a nonpublic entity, such as an investor-owned utility, Option B would have to be used since tax-exempt bonds could not be used to finance the project. Option A was used to calculate development costs discussed in Section 7.0, "Joint Districts Hydropower Development Plan."

3.2 SUMMARY

Summary economics for the three "Joint Districts" irrigation canal hydropower systems are shown in Table 3-3 through Table 3-5.

TABLE 3-3

ECONOMIC SUMMARY TURLOCK IRRIGATION DISTRICT SMALL HYDROPOWER SYSTEM

SITE	INSTALLED kW	PROJECT COST	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
DROP #1	3,260	$ 3,560,493	$ 322,531	$ 536,800	1.664 - 1.0
DROP #2	660	1,048,247	94,956	91,229	.960 - 1.0
DROP #6	920	1,313,712	119,004	127,688	1.072 - 1.0
DROP #7	700	1,089,088	98,655	92,461	.937 - 1.0
DROP #9	1,070	1,786,400	161,823	206,800	1.277 - 1.0
TOTALS	6,610 kW	$ 8,797,940	$ 796,969	$1,054,978	1.323 - 1.0
	COST/kW INSTALLED = $1,331.00/kW				

TABLE 3-4

ECONOMIC SUMMARY MERCED IRRIGATION DISTRICT SMALL HYDROPOWER SYSTEM

SITE	INSTALLED kW	PROJECT COST	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
MAIN CANAL	2,800	$ 3,660,690	$ 331,608	$ 403,436	1.216 - 1.0
CANAL CREEK	940	1,274,232	115,427	143,528	1.243 - 1.0
FAIRFIELD DROP	970	1,183,702	107,228	123,596	1.153 - 1.0
ESCALADIAN	270	459,967	41,666	36,168	.868 - 1.0
TOTALS	4,980 kW	$ 6,578,591	$ 595,929	$ 706,728	1.185 - 1.0
	COST/kW INSTALLED = $ 1,396.70/kW				

3.2 SUMMARY (CONT'D)

TABLE 3-5

ECONOMIC SUMMARY SOUTH SAN JOAQUIN IRRIGATION DISTRICT SMALL HYDROPOWER SYSTEM

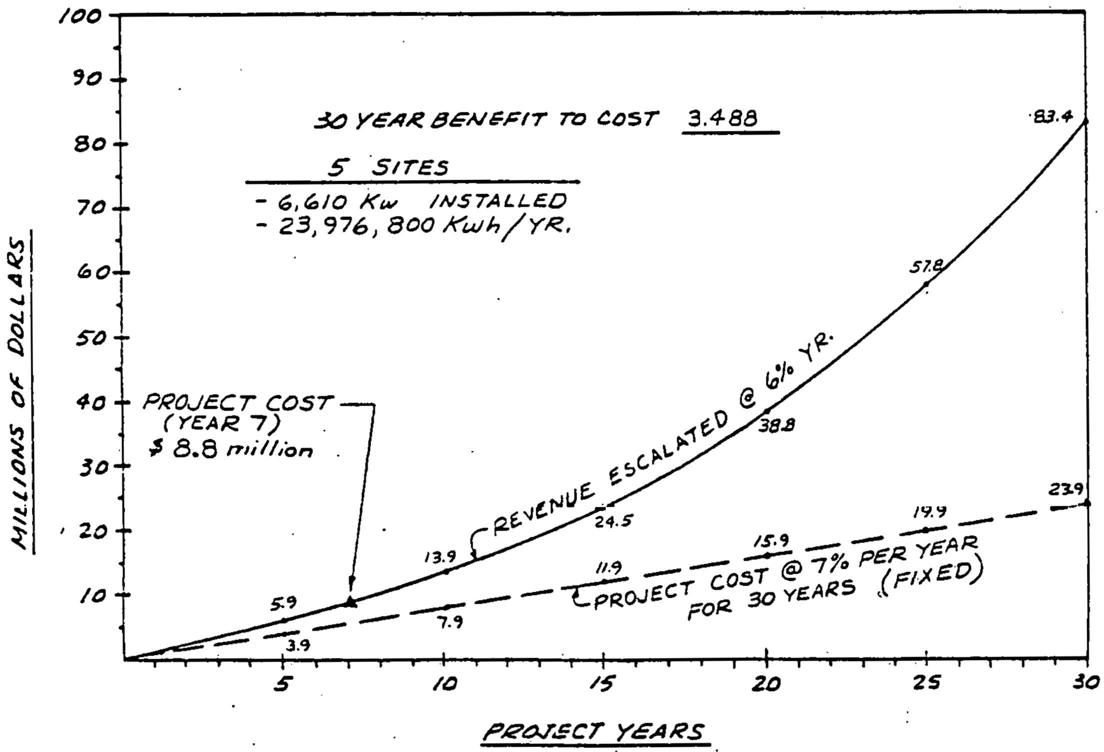
SITE	INSTALLED kW	PROJECT COST	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
WOODWARD DAM	2,300	$ 2,537,193	$ 229,835	$ 303,864	1.322 - 1.0
FRANKENHEIMER	4,700	6,006,110	544,071	746,328	1.372 - 1.0
GOODWIN DAM	970	1,507,262	136,537	204,820	1.500 - 1.0
TOTALS	7,970 kW	$ 10,050,565	$ 910,443	$ 1,255,012	1.378 - 1.0
	COST/kW INSTALLED = $ 1,261.05/kW				

Figures 3-2 through 3-4 show the project development fixed costs versus the revenue escalated at 6% per year and indicates revenue matches project costs for each of the three systems as:

- Turlock Irrigation District System - 7 years
- Merced Irrigation District System - 7 years
- South San Joaquin Irrigation District System - 6½ years.

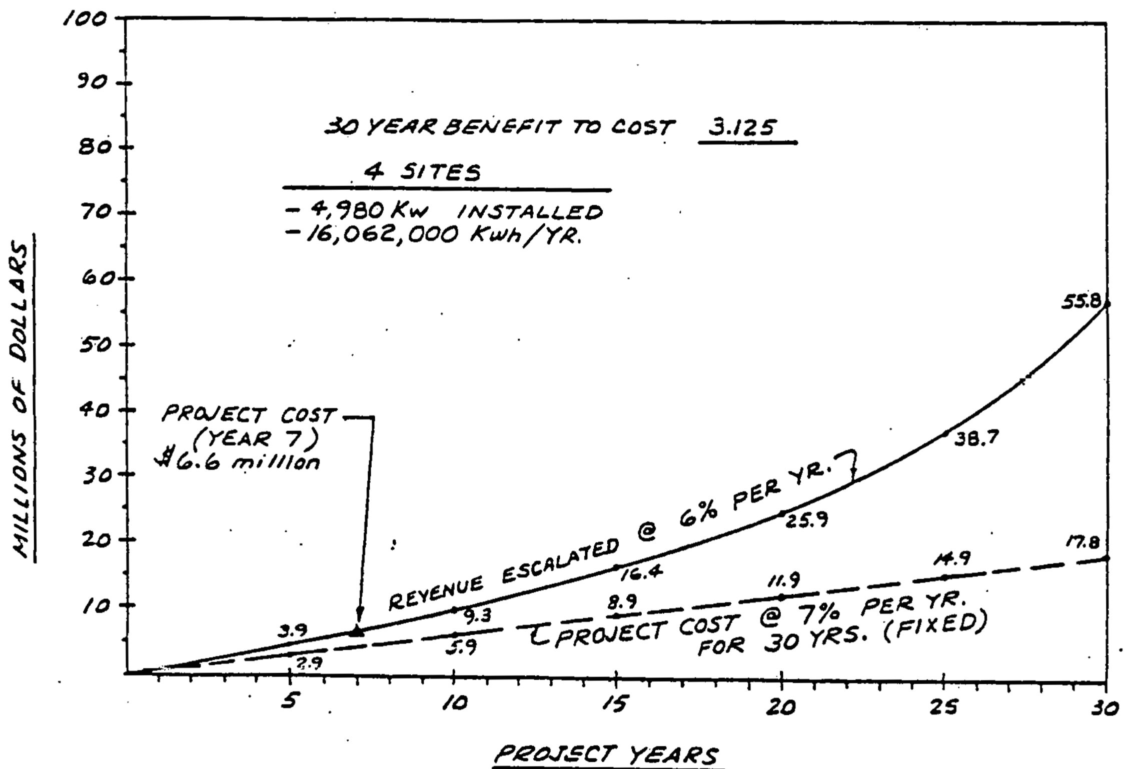
Figures 3-5 through 3-8 illustrate a series of cost comparison charts and curves of the selected sites to be developed and the associated cost elements. The cost curve figures are:

- Figure 3-5, Total Project Costs, dollars versus installed capacity.
- Figure 3-6, Cost per kW installed versus installed capacity.
- Figure 3-7, Civil costs, civil works versus installed capacity.
- Figure 3-8, Equipment Costs, equipment prices versus installed capacity.



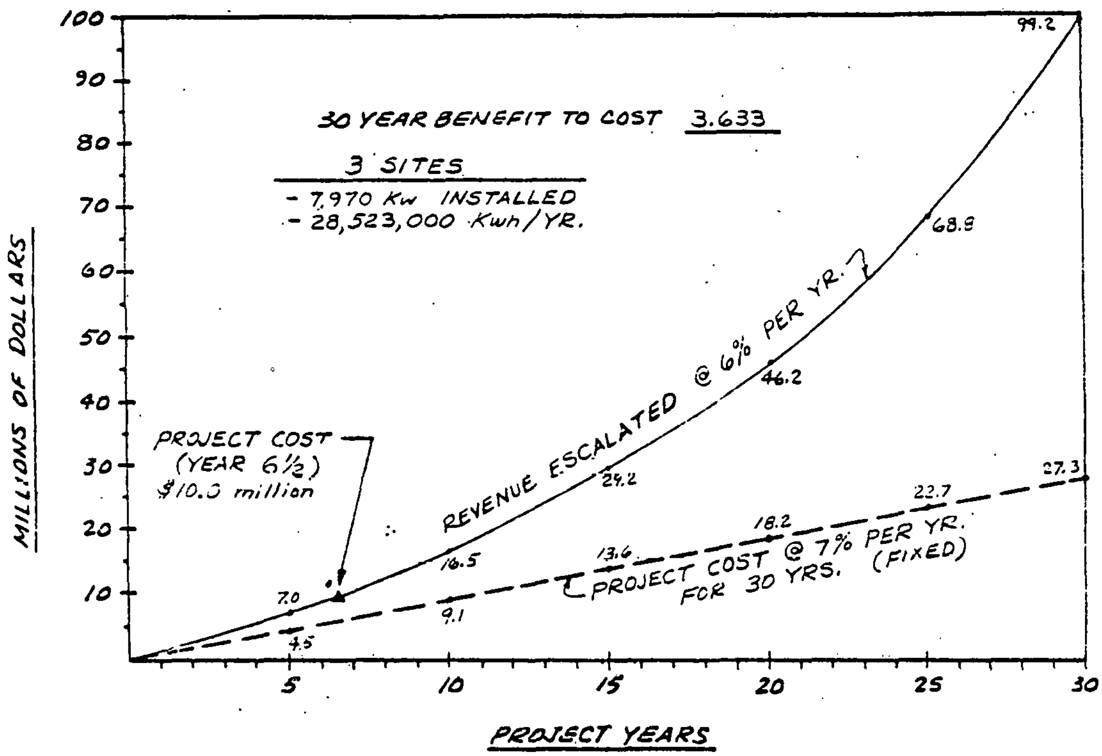
TID SYSTEM CUMULATIVE REVENUE VERSUS COST

Figure 3-2



MERCED SYSTEM CUMULATIVE REVENUE VERSUS COST

Figure 3-3



SSJID SYSTEM CUMULATIVE REVENUE VERSUS COST

Figure 3-4

A review of the companion charts will indicate the following findings that can be applied to any development project planning.

- Total Project Costs versus installed capacities appears to be a straight-line linear progression.
- Cost per kilowatt installed versus installed capacity becomes a diminishing curve, i.e., as the installed capacity increases the $/kW decreases.
- Equipment costs versus installed capacity becomes a series of increased progression curves for each of the three types of turbines.
- Civil Costs versus installed capacity becomes a very rapidly increasing progression as the installed capacity is increased.

3.2 SUMMARY (CONT'D)

The legend for Figures 3-5, 3-6, 3-7 and 3-8 is:

#1 = Drop Number One

#2 = Drop Number Two

#6 = Drop Number Six

#7 = Drop Number Seven

MC = Main Canal

CC = Canal Creek

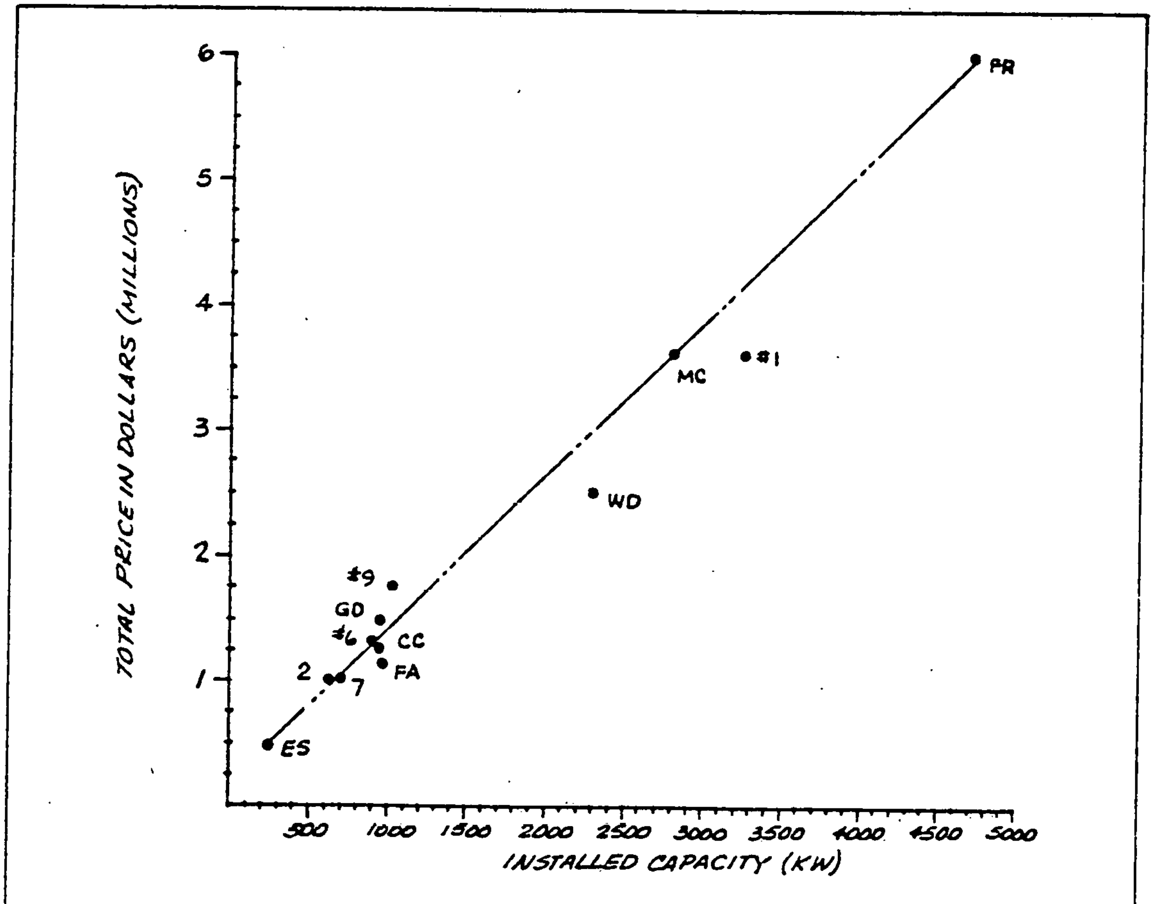
FA = Fairfield Drop

ES = Escaladian Headworks

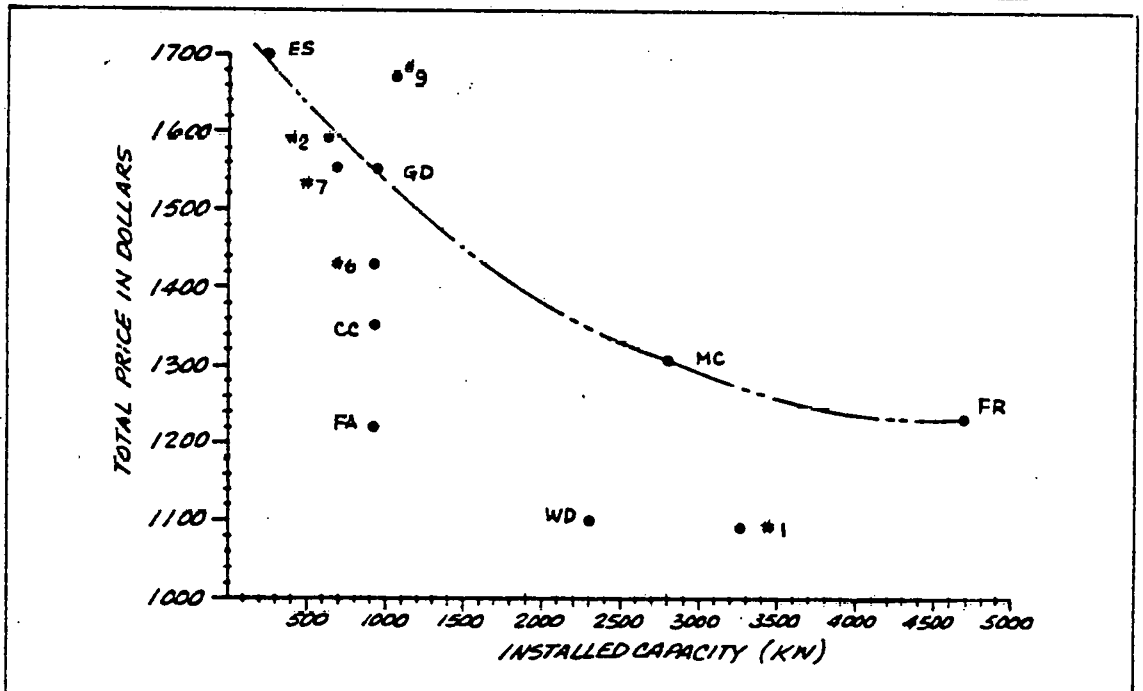
WD = Woodward Dam

FR = Frankenheimer

GD = Goodwin Dam.

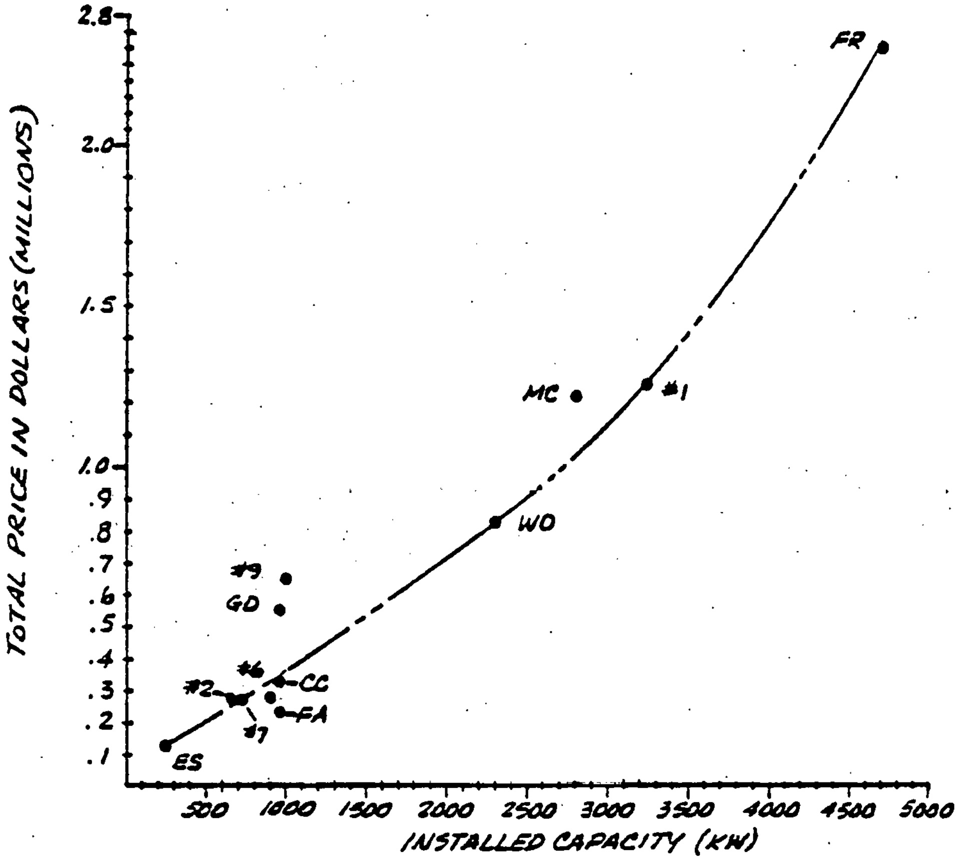


TOTAL PROJECT COSTS (1982)
FIGURE 3-5

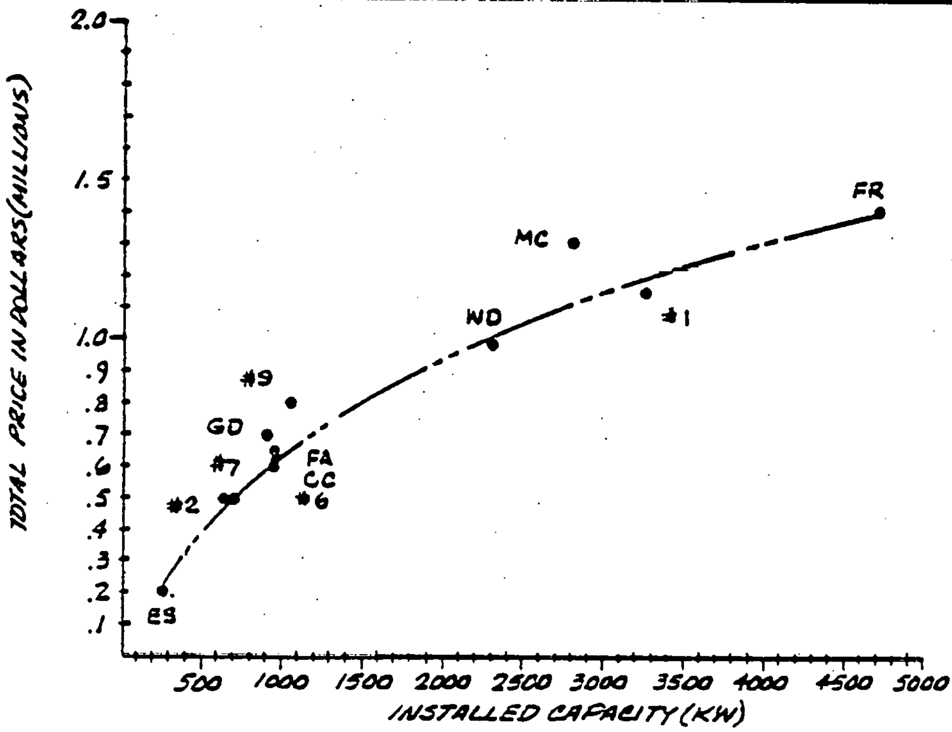


COST PER KW INSTALLED (1982)

FIGURE 3-6



CIVIL COSTS (1982)
FIGURE 3-7



EQUIPMENT COSTS (1982)
FIGURE 3-8

SECTION 4.0

POWER MARKETING ANALYSIS

Of the three (3) cooperative agencies, only Turlock Irrigation District (TID) distributes electrical energy. In the past, TID has used far more electrical energy than it has been capable of generating even during those years when there have been heavy or record rainfalls. The area is classified as a "demand" area with a substantial but not excessive peak-loading. All of the energy generated at various sites proposed can be locally used for residential, commercial or agricultural purposes. Five of the twelve sites are within TID's electrical service areas and the generated electricity at these sites can be fed directly into the TID power grid.

TID's generated power will be integrated into its own system, but Merced and South San Joaquin Irrigation Districts have the following options for the most economically advantageous sale of their generated power:

- Offsetting power presently purchased from Pacific Gas and Electric (PG&E),

- Wheeling the power over PG&E lines for sale to other buyers.

- Direct sale to PG&E.

In the areas of the Merced and South San Joaquin Irrigation Districts, where PG&E is the electrical supplier, the energy could be wheeled over the lines. Wheeling capability over privately-owned lines for minimal charges is a right that public agencies have by law. Initial approaches toward wheeling capabilities have been investigated. In this era of energy shortages such wheeling and mixing arrangements are not a roadblock. Transmission lines would have to be constructed from the generating facility to the nearest existing distribution facility. However, no environmental constraints have been found in implementing the construction of any transmission lines, since the area is very rural in nature and all present power and telephone facilities are constructed above ground. Most of the local transmission lines are relatively low-voltage so the cost of taking the generated voltages up or down to voltages that can be transmitted over the existing lines could be minimal.

4.1 TID POWER MARKETING

TID is unusual for an irrigation district in that it distributes electrical energy. Drops Numbers One, Two, Six, Seven and Nine are within TID's electrical service area and the generated electricity at these sites will be fed directly into the TID power grid and become part of TID's existing electrical power system.

The nearest electrical grid facility is an existing 12 kV, 3-phase electrical transmission line running along the Main Canal within three hundred feet of the planned power plants. The electrical output will be tied directly into this line and incorporated into the TID grid and distribution system via the Broadway Computerized Control Center.

4.2 MERCED POWER MARKETING

As stated at the beginning of this section, Merced has several options for the sale or use of the power generated by its small hydropower system.

However, Merced is presently considering a direct power sale. In that case, Merced would install 21 kV power lines from the planned Merced sites to PG&E's nearest power line tie-in. Table 4-1 shows the proposed power plant sites, size of the nearest transmission grid connection and the distance to that connection.

TABLE 4-1

MERCED SITES - GRID CONNECTION		
SITE	NEAREST LINE SIZE CONNECTION	DISTANCE
Main Canal	12 kV (1)	1.5 miles
Canal Creek	12 kV (1)	.2 mile
Fairfield Drop	12 kV (1)	.8 mile
Escaladian Headworks	12 kV (1)	.1 mile
TOTAL NEW TRANSMISSION LINES		2.6 miles

(1) Planned upgrading to 21 kV by PG&E.

Based on the average total energy generated annually by the selected Merced sites (16,062,000 kWh/year) and the amount of new 21 kV transmission lines, the cost to purchase Merced power would be:

- Transmission lines: 2.6 miles X $18,000/mile $ 46,800
- Wheeling Costs: 16,062,000 kWh X 1.5 mills/kWh 24,093/year*

In addition, the power purchaser would be responsible for debt service and operation and maintenance (O&M) costs of the sites (Section 7.2).

4.3 SOUTH SAN JOAQUIN POWER MARKETING

As stated in the beginning of this section, SSJID has several options for the sale or use of the power generated by its small hydropower system. However, SSJID is presently considering a direct power sale. In that case,

* Wheeling cost assumed from prior FES studies.

SSJID would install 17 kV power lines from the planned SSJID sites to PG&E's nearest power line tie-in. Table 4-2 shows the proposed power plant sites, size of the nearest transmission grid connection and the distance to that connection.

TABLE 4-2

SSJID SITES - GRID CONNECTION		
SITE	NEAREST LINE SIZE CONNECTION	DISTANCE
Woodward Dam	17 kV	.1 mile
Frankenheimer	17 kV	1.2 miles
Goodwin Dam	17 kV	.1 mile
Parker Drop	17 kV	.1 mile
TOTAL NEW TRANSMISSION LINES		1.5 miles

Based on the average total energy generated annually by the selected SSJID sites (28,523,000 kWh/year) and the amount of new 17 kV transmission lines, the cost to purchase SSJID power would be:

- Transmission lines: 1.5 miles X $18,000/mile $ 27,000
- Wheeling Costs: 28,523,000 kWh X 1.5 mills/kWh 42,785/year*

In addition, the power purchaser would be responsible for debt service and operation and maintenance (O&M) costs of the sites (Section 7.3).

* Wheeling cost assumed from prior FES studies.

SECTION 5.0

SOCIO-ENVIRONMENTAL ANALYSIS

The bulk of this Report is concerned with technical and economic feasibility. Here, Fluid Energy Systems, Inc. (FES) will examine the question of how the projects will affect the community.

There are three major areas of impact: socio-economic, environmental, and institutional. We have found the major impacts to be as follows:

- Socio-Economic
  - Direct jobs created.
  - Indirect jobs created.
  - The effect of the overall economy. Encourage new industries and maintain the industrial base; plus more local mileage from each development dollar.
  - No change or reduction of irrigation water supply.

- Environmental
  - The possibility of minor archaelogical findings existing at some project sites.
  - No significant impact on game fish migration.
  - Minor aesthetic impacts - e.g., construction of small power stations and additional transmission lines.
  - The effect of lowered demands for fossil fuel.

- Institutional
  - The effect of the decision-chain on project implementation.
  - The possible relationships among districts and utilities, i.e., future cost-sharing arrangements on energy production and sales.

5.0 SOCIO-ENVIRONMENTAL ANALYSIS (CONT'D)

This Study considered twelve (12) sites in four (4) irrigation districts, spanning three counties. Some impacts are particular to each site; some to each district; some to each county; and some are uniform for all sites. Each impact will be described accordingly.

5.1 SOCIO-ECONOMIC ASSESSMENT

The provisions of clean energy at lower cost will have an overall positive economic effect on the "Joint Districts". Development of small hydropower systems will create jobs, directly and indirectly. Long-term economic development will also be helped. And finally, since all sites are on irrigation waterways that serve areas heavily dependent on agriculture, development of small hydropower plants on these waterways must not impact scheduled irrigation flow releases.

- Direct Jobs

  Construction and maintenance of small hydropower facilities will create a total of 405 direct jobs (an average of 45 per site) in the counties. In addition, an estimated 1,012 indirect jobs (2.5 indirect for each direct job) will be created. While these jobs are insignificant in relation to the three counties' overall labor force, they do represent an increased payroll and new sales and purchases within the area.

- Effect on Overall Economy

  The "Joint Districts" are located in a three county area in California's San Joaquin Valley. Agriculture dominates the San Joaquin Valley; farming, food processing, packaging and related businesses are its economic backbone. The area encompassed by the "Joint Districts" retains great potential for economic development. Fundamental requirements for an industrial based economy include land, service facilities, transportation network and energy. The Districts have an abundance of all these with the exception of energy.

Effect on Overall Economy (cont'd)

An economic shift is occurring in the San Joaquin Valley as an agricultural-based economy is being augmented with an industrial-based economy. In the last ten years, new technologies have steadily mechanized agriculture while advances in food processing and manufacturing have spurred those businesses to greater industrialization. As the economy of the Valley shifts from a rural-based agricultural economy to a mixed agricultural-industrial economy, energy demands have substantially increased. As a result, local generating capabilities in the "Joint District" service areas have been surpassed.

Overall, a doubling of the area's population in the next half-century is anticipated which will increase housing and employment requirements as well as requirements for electrical power. For example, the population of Stanislaus County alone is expected to reach 235,400 by 1980, as shown in Table 5-1.

TABLE 5-1

	1950	1960	1970	1980	1990
Stanislaus County	127,300	157,300	194,500	235,400	278,300
Modesto	17,400	36,600	61,700	90,000	--
Turlock	6,200	9,100	14,000	19,000	--

Sources: Dept. of Finance, 6/74, Population Projections for California Counties, 1975-2020, Report 74 P-2; Series D-100, pp. 8-10.

Stanislaus County Dept. of Planning and Community Development, Census '75 (Book 1): p.5.

Bank of America, 1974, Focus on Stanislaus County, p.3.

ESTIMATES OF HISTORIC AND PROJECTED POPULATION
FOR STANISLAUS COUNTY AND SELECTED URBAN AREAS

Effect on Overall Economy (cont'd)

All of the counties wish to increase median family income, reduce unemployment, and enlarge the tax base. Merced County has, in its 1978 Overall Economic Development Program, identified key strategy steps to attract and hold industry to the area. Various public works programs are under study to develop and maintain facilities attractive to industry. Reduction of power costs will certainly help meet this economic goal.

Small hydropower development will go furthest toward slowing down the rising costs of energy, which have risen faster than other costs of living in the three-county area since 1967. Slowing this upward spiral is the key to the overall economic impact described in this section.

In Stanislaus County, development strategies are contemplated that would increase population - strategies like housing and neighborhood development. But although higher population increases revenues, in Stanislaus it increases the county deficit even faster - partly due to increased pupil load on the school district. This anticipated deficit will be eased by the availability of energy at lower cost.

In the counties, availability of lower-cost energy helps to keep dollars in the local area. This means that in-county transactions rise and the import of goods or services stays low. The result is a higher multiplier for the purchasing dollars generated by each additional income dollar that comes into the area. For example, in Stanislaus County each dollar generates from $.39 to $1.58 in additional county sales. The lower the cost of power in Stanislaus, the higher the "ripple effect" of local spending. Low-cost energy therefore represents an important coefficient in long-range economic planning, not just a base saving.

Effect on Overall Economy (cont'd)

A final economic consideration is that of irrigation. In a region as dependent on agriculture as the "Joint Districts" area, availability of irrigation water inevitably takes precedence over power generation. Therefore, small hydropower development must be built around the irrigation program of each of the Districts. Construction will be timed during non-irrigation months and during a time that has no impact on scheduled irrigation flow release schedules.

5.2 ENVIRONMENTAL ASSESSMENT

One of the leading advantages of small hydropower development, in contrast to nuclear power and major hydroelectric power production, is the absence of serious environmental impacts. The eight (8) sites deemed feasible during this study are all located at existing man-made structures on irrigation canals. The construction of a small hydropower plant, and in some cases transmission lines constitute the bulk of the physical change. Site environmental summaries appear in Figures 5-3 through 5-10. Several environmental topics however should be addressed.

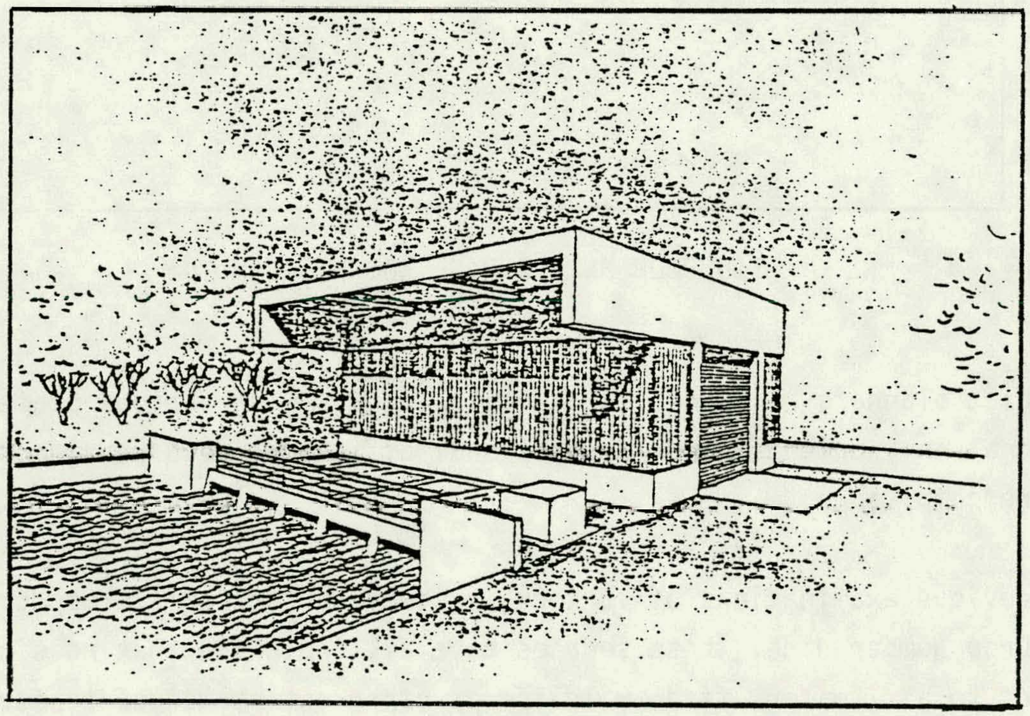
- Archaeology
  Preliminary analysis of Turlock Irrigation District's Drop Number One and Drop Number Nine indicated a very small possibility of the existence of minor archaeological materials. The review process for these sites by California State College, Stanislaus, indicated that should any archaeological finding be discovered during construction, the College should be notified.

- Aesthetics

  Small hydropower plants can be designed as an aesthetic enhancement as shown by the architectural renderings by Hardison and Komatsu Associates in Figures 5-1 and 5-2. The individual districts will need to consult with architects on the most functional and attractive structures.

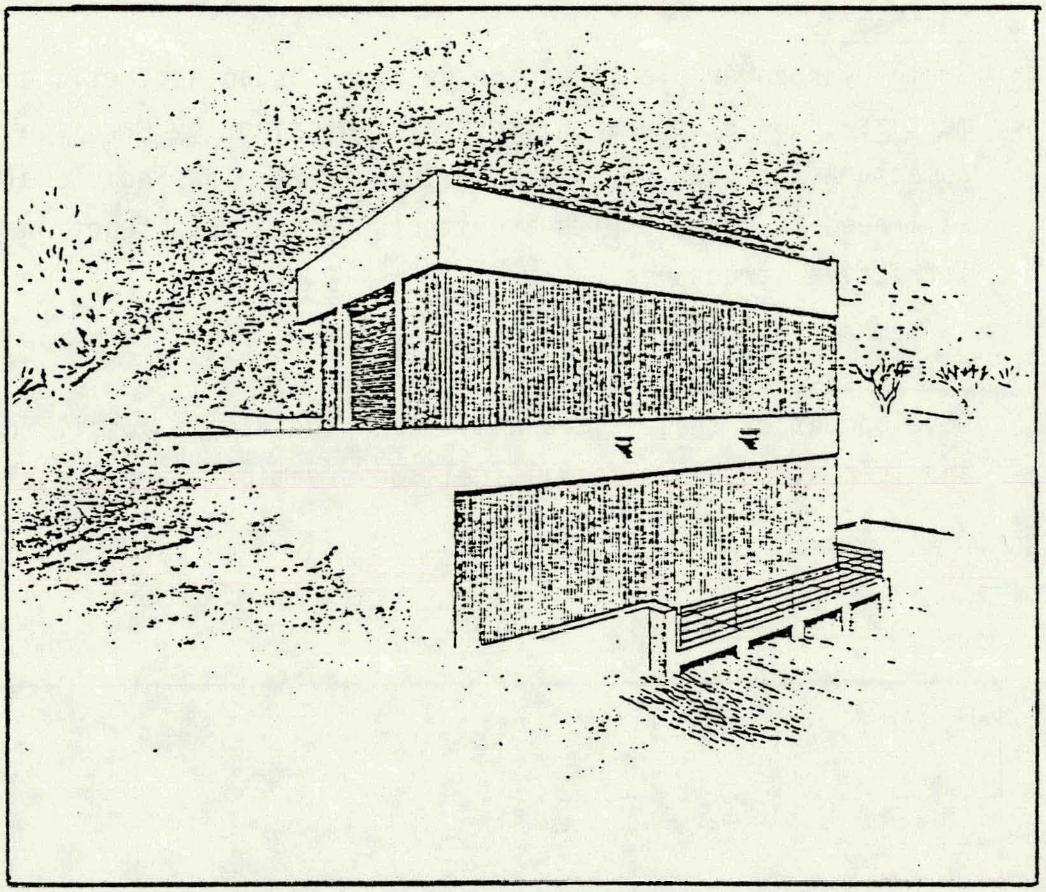
- Fossil Fuel Usage

  Development of these sites will lower the area's fossil fuel use and is a step toward fossil fuel conservation - a national goal.



TID DROP NUMBER NINE, UPSTREAM

Figure 5-1



TID DROP NUMBER NINE, DOWNSTREAM
Figure 5-2

District planners will need to maintain contact with various State and Regional environmental and institutional offices as required in order to ensure compliance.

In previous examinations of Turlock Irrigation District's Drop Number One and Drop Number Nine, these sources have all indicated that no significant impact to air, water, fish, wildlife or other environmental concerns are evident in such projects. However, all Districts realize that they will have to comply, when necessary, with the requirements of the California Environmental Quality Act of 1970 before any project can commence, see Section 8.6.

5.2 ENVIRONMENATL ASSESSMENT (CONT'D)

The "Joint Districts" are under the jurisdiction of the California Division of Safety of Dams and all alterations to an existing dam will have to be approved by that agency. Their attention would be focused on how the project would potentially affect the safety of the dam and they would not be concerned directly about the powerhouse portion.

Their prime attention would be on the alteration to the existing outlet works and how the operation of any existing reservoir would be affected. It is anticipated that the Safety of Dams review process would begin at the initiation of the final design process and continue until completion. They will also inspect the project construction to insure compliance with the approved plans.

No problems or potential delays are foreseen in dealing with the Division of Safety of Dams.

The Site Environmental Summaries, Figures 5-3 through 5-10, are for the following eight (8) sites:

- Drop Number Two - Figure 5-3
- Drop Number Seven - Figure 5-4
- Main Canal - Figure 5-5
- Canal Creek - Figure 5-6
- Fairfield - Figure 5-7
- Escaladian Headworks - Figure 5-8
- Frankenheimer Dam - Figure 5-9
- Goodwin Dam - Figure 5-10.

NAME OF PROJECT:	DROP NUMBER TWO POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a low-head hydroelectric power generating facility at the existing Turlock Irrigation District Main Canal Drop Number Two in Stanislaus County, California. The proposed project site is approximately 7-1/3 miles Northeast of the city of Turlock.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 2,073,400 kwh/year. Will eliminate the need to burn approximately 3,587 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Turlock Irrigation District in cost of providing power.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

TID DROP NUMBER TWO

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-3

NAME OF PROJECT:	DROP NUMBER SEVEN POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a low-head hydroelectric power generating facility at the existing Turlock Irrigation District Main Canal Drop Number Seven in Stanislaus County, California. The proposed project site is approximately 6 miles Northeast of the city of Turlock.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 2,101,400 kwh/year. Will eliminate the need to burn approximately 3,635 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Turlock Irrigation District in cost of providing power.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

TID - DROP NUMBER SEVEN

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-4

NAME OF PROJECT:	"MAIN CANAL" POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a small hydroelectric power generating facility at the existing Merced Irrigation District Main Canal in Merced County, California. The proposed project site is approximately 6-1/3 miles Northeast of the city of Merced.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 9,169,000 kwh/year. Will eliminate the need to burn approximately 15,863 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Merced Irrigation District in revenue offsets.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

MERCED - MAIN CANAL

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-5

5.2 ENVIRONMENTAL ASSESSMENT (CONT'D)

NAME OF PROJECT:	CANAL CREEK POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a small hydroelectric power generating facility at the Canal Creek Site existing on the Merced Irrigation District Main Canal in Merced County, California. The proposed project site is approximately 5-1/4 miles North of the city of Merced.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 3,262,000 kwh/year. Will eliminate the need to burn approximately 5,643 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Merced Irrigation District in revenue offsets.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

MERCED - CANAL CREEK SITE

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-6

NAME OF PROJECT:	FAIRFIELD DROP POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a small hydroelectric power generating facility at the Fairfield Site on the existing Merced Irrigation District Canal system in Merced County, California. The proposed project site is approximately 3 miles Northeast of the city of Merced .
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 2,809,000 kwh/year. Will eliminate the need to burn approximately 4,860 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Merced Irrigation District revenue offset.
Employment:	Increase in number of jobs druing construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

MERCED - FAIRFIELD SITE

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-7

5.2 ENVIRONMENTAL ASSESSMENT (CONT'D)

NAME OF PROJECT:	ESCALADIAN HEADWORKS POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a low-head hydroelectric power generating facility at the existing Merced Irrigation District Main Canal in Merced County, California. The proposed project site is approximately 6-1/3 miles Northeast of the city of Merced.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 822,000 kwh/year. Will eliminate the need to burn approximately 1,422 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to Merced Irrigation District in revenue offsets.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

MERCED - ESCALADIAN HEADWORKS

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-8

NAME OF PROJECT:	FRANKENHEIMER POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a small hydroelectric power generating facility at the Frankenheimer Site on the existing So. San Joaquin Irrigation District Main Canal, Stanislaus County, California. The proposed project site is approximately 2½ miles Northeast of the city of Oakdale.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 16,962,000 kwh/year. Will eliminate the need to burn approximately 29,346 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to So. San Joaquin Irrigation District in revenue offsets.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

SSJID - FRANKENHEIMER SITE

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-9

NAME OF PROJECT:	GOODWIN DAM POWER PLANT
BRIEF DESCRIPTION OF PROJECT:	The proposed project consists of the construction of a low-head hydroelectric power generating facility at the existing So. San Joaquin Irrigation District and Oakdale Irrigation District Joint Dam, Stanislaus County, CA. The proposed project site is approximately 5 miles Northeast of the city of Oakdale.
ENVIRONMENTAL IMPACTS:	The environmental assessment arrived at the following findings:
Water Flows:	The construction and operation of the power plant will have no impact on normal water flows.
Water Quality:	No adverse effect on water quality.
Air Quality:	Minor dust and increase in vehicle exhaust during construction. No effect on air quality during operation.
Noise:	Minor construction noise, no significant increase in noise during operation.
Vegetation:	Loss of approximately two (2) acres of grassland.
Terrestial Wildlife:	No significant effect on wildlife. Loss of less than three (3) acres of habitat would only result in loss or displacement of reptiles and small mammals such as squirrels and mice.
Aquatic Wildlife:	No significant effect on fish.
Rare and Endangered Species:	None at site or in immediate vicinity.
Power Resources:	Generation of approximately 4,655,000 kwh/year. Will eliminate the need to burn approximately 8,054 barrels of oil for electrical generation per year.
Land Use:	No effect on lands surrounding the site.
Solid Waste Disposal:	Dirt excavated from the project site will be disposed of in a manner which will result in no significant effect on the environment.
Recreation:	No effect on recreation facilities in area.
Water Use:	No effect on irrigation and recreation waters.
Economics:	Savings to So. San Joaquin Irrigation District in revenue offsets.
Employment:	Increase in number of jobs during construction to be employed from local job market.
Growth Inducing Impact:	None. Project will fill needs of growth which has already occurred.
Traffic:	Minor increase on local country roads.
Scenic Values:	Project site not readily visible. Small building structures introduced where they do not presently exist. Structures will be designed to blend with surroundings.
Archaeology:	No site of archaeological or historical interest will be affected by the project.

SSJID - GOODWIN DAM SITE

SITE ENVIRONMENTAL SUMMARY

FIGURE 5-10

FES

5.3 INSTITUTIONAL FACTORS

Planning, financing, building and maintaining small hydropower facilities at the assessed sites require cooperation among local government, irrigation districts, contractors, utilities and the public. Therefore, questions arise about the interplay between these institutions - questions that can be as important as technical feasibility.

Efficiency and effectiveness are keys to implementing this project. Thus the decision-making process has been assessed.

5.3.1 Discussion

The Districts are each governed by an elected Board of Directors. As elected officials, the Board members are directly accountable to the public. Public opinion has so far favored small hydropower development. It is generally perceived in the service areas as a clean source of energy which can help reduce power costs.

Directly under the Boards are the administrative staffs, followed by the technical staffs. All involved groups must be able to work together. Important technical recommendations must pass through an administrative process and finally be passed by the Boards. This may be slower than the process of a commercial firm, but it does provide valuable avenues for public involvement.

The projects' institutional structure will ultimately be determined by SSJID's and Merced's decision to set up a financing and sales arrangement with a power purchaser.

5.3.2 Federal Energy Regulatory Commission (FERC)

An additional institutional factor is the licensing process of the FERC. Initial inquiries to the San Francisco Office of the FERC indicate that any of the "Joint Districts" sites would come under FERC licensing procedures if it meets one of the following:

- A navigable waterway is involved.
- U.S. Government lands are involved.
- The transmission of energy ties into a transmission grid which distributes energy outside state boundaries.

5.3 INSTITUTIONAL FACTORS (CONT'D)

5.3.2 Federal Energy Regulatory Commission (FERC) (Cont'd)

If a facility should exceed the 2,000 horsepower (approximately 1,500 kW) installed capacity limitation of the minor project (short form) licensing procedure, then the major project (long form) licensing procedure is indicated.

Normal licensing time could be expected to be twelve (12) to eighteen (18) months.

FERC has discretionary authority to grant an exemption to Part I of the Federal Power Act, especially with respect to licensing requirements for any facility of less than 15 MW, which is located on non-Federal lands and uses hydroelectric potential of manmade conduits not primarily for the generation of electricity (Title IV, Section 6/b, PL 95-617, Public Utility Regulatory Policies Act of 1978).

SECTION 6.0

TECHNICAL ASSESSMENT

Phase D, Technical Feasibility of the "Joint Districts Hydropower Assessment Study", was conducted in the work flow manner shown in Figure 6-1.

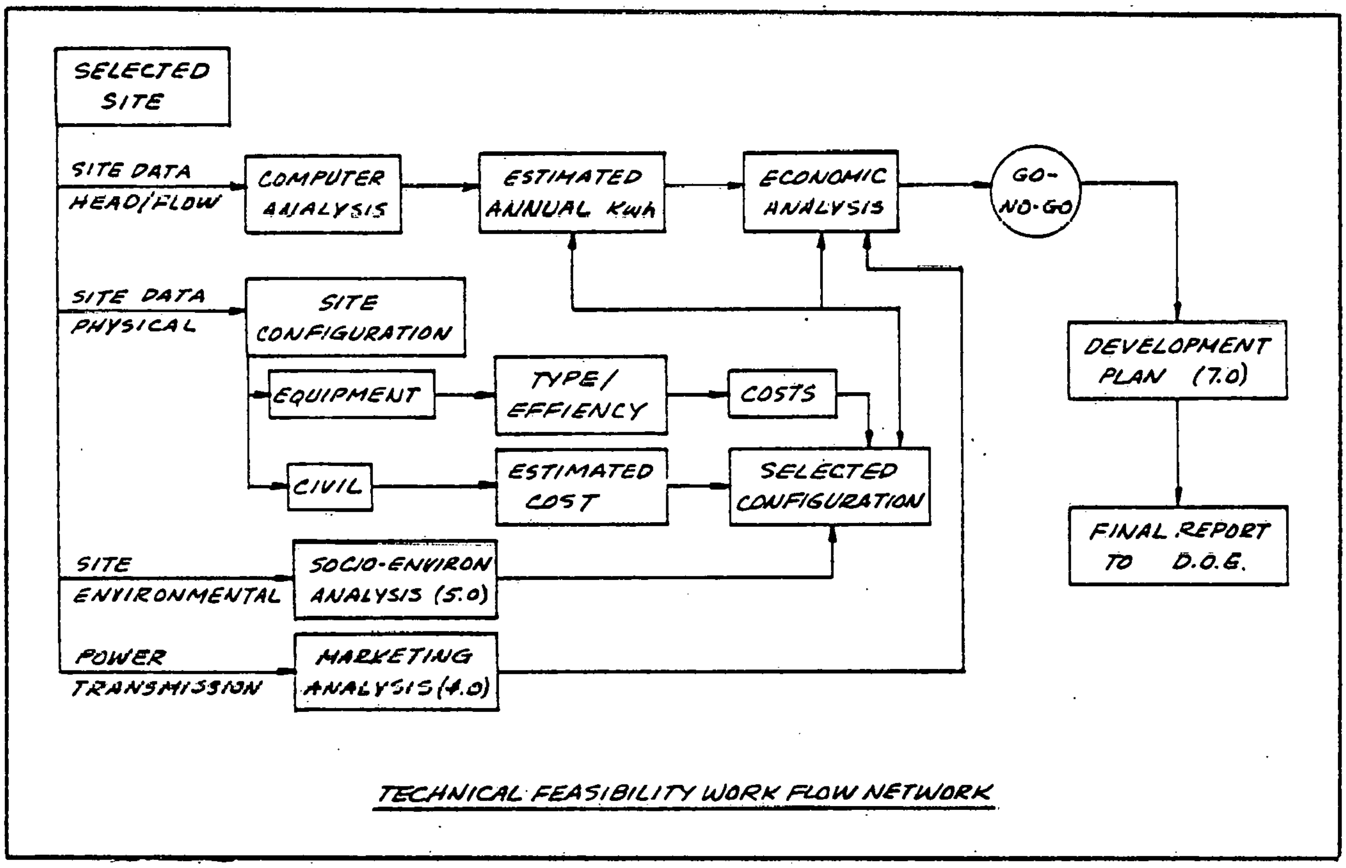


Figure 6-1

Using Turlock Irrigation District's (TID) computer program, the selected site data from the Phases A, B and C were analyzed for head, flow rate, potential power capacities (kW), and annual energy (kWh) output. Concurrently, the site physical conceptual designs were drawn for various equipment types. Civil works considerations, equipment efficiencies and costs were studied and preliminary arrangements were selected.

6.0 TECHNICAL ASSESSMENT (CONT'D)

Socio-Environmental Analysis (Section 5.0), the Marketing Analysis (Section 4.0), selected configurations and estimated annual energy (kWh) were then analyzed to determine the economics (Section 7.0) of each selected site. At the completion of the Economic Analysis, those sites with a benefit-to-cost ratio of less than .80 to 1.0 were deleted from consideration for the Project Development Plan (Section 7.0).

The results of all of the analyses and assessments conducted during the study are included in this "Final Feasibility Assessment Report".

6.1 TECHNICAL PARAMETERS AND REQUIREMENTS

Turlock Irrigation District (TID and the associated joint districts originally identified nineteen (19) possible sites for small hydropower development. Of these, fourteen (14) were proposed for assessment under Department of Energy (DOE) funding. Then eight (8) were selected during Phases A, B and C for detailed study during Phase D of the "Joint Districts Hydropower Assessment Study". These sites were selected based on the following factors:

- absence of major, obvious obstacles to feasibility, i.e., benefit-to-cost, environmental, water supply, etc.;
- high priority ranking by the owning irrigation district;
- congruence with DOE objectives; and
- availability of data.

Those eight (8) sites are:

- Turlock Irrigation District (TID)
  - Canal Drop Number Two
  - Canal Drop Number Seven

- Merced Irrigation District (Merced)
  - Main Canal
  - Canal Creek
  - Fairfield Drop
  - Escaladian Headworks

- South San Joaquin Irrigation District (SSJID)
  - Frankenheimer
  - Goodwin Dam Joint Canal Headworks (North Side)

The disposition of the remaining eleven (11) sites is as follows:

- Turlock Irrigation District (TID)

  - Canal Drop Number One - Engineering and design completed, scheduled construction start May 1, 1979 with 25% Department of Energy funding. This site is included in "Joint Districts Development Plan", Section 7.0.

  - Canal Drop Number Six - Deleted from study at DOE request; however, site is included in overall development plan as an alternative prototype low-head hydroelectric device.

  - Canal Drop Number Nine - Engineering completed, construction started, on-line operations scheduled for March, 1979. This site is also included in the "Joint Districts Development Plan".

  - Dawson Lake - This site has a very high potential and a complete assessment of this site will be conducted during TID's planned "Water/Energy Management Operations Study".

Turlock Irrigation District (TID) (cont'd)

- Ceres Spillway - Deleted from further assessment under this study effort. Winter only flows plus deletion of Woodward Dam by SSJID eliminated any possibility of equipment sharing sites in Phase D.

- Hickman Spillway - Not part of DOE-funded effort.

- Merced Irrigation District (Merced)

  - Buhach Road - deleted due to lack of available economical equipment (turbines/generators). Also there is no existing power line close to site. These two factors signified that the site is not economically feasible.

  - Fisher Road - same as Buhach Road.

  - Youd Road - same as Buhach Road.

- South San Joaquin/Oakdale Irrigation Districts (SSJID)

  - Woodward Dam - deleted from study by SSJID request. Based on proposal submitted to SSJID by Allis Chalmers, this site will be included in the "Joint Districts" overall development plan (Section 7.0).

  - Parker Drop - Disposition of this site same as for Buhach Road site for Merced.

6.1 TECHNICAL PARAMETERS AND REQUIREMENTS (CONT'D)

6.1.1 Assessment Parameters

During the assessment of the eight (8) selected sites, the following parameters for each site were applied:

- expected configurations,
- installed capacities,
- estimated performances,
- impact on water resources,
- marketing/sale of power,
- regulatory agency requirements,
- capital costs,
- annual operations and maintenance costs,
- project life,
- environmental considerations,
- safety considerations,
- site requirements,
- equipment investigation.

6.1.2 Assessment Requirements

Based on the above parameters, the assessment study team established a set of feasibility study technical requirements to be used for each of the eight (8) selected sites. The requirements for power generating technologies are:

- equipment parameters,
- site civil parameters,
- development and implementation time,
- existing levels of technology,
- turbine/generator equipment selection,
- powerhouse accessory equipment and facilities.

Estimates of cost requirements have been prepared for each site and considered for cost effectiveness. This cost assessment follows the Code of Accounts used in the Standard FERC Licensing Applications.

6.2 PHASE D, TECHNICAL ANALYSIS CRITERIA

The final analysis criteria for each of the eight (8) selected sites are:

- Expected configuration and capacity of the hydropower facility.
- Estimated performance characteristics of the hydroelectric power facility including the potential for peak power production and an estimate of average annual energy production.
- Expected impact of the hydropower installation on other perceived water resource needs of the area and the current use of the reservoir.
- Marketing potential of the power produced (from Section 4.0).
- The necessary requirements of the Federal Energy Regulatory Commission, the U.S. Army Corps of Engineers, and other appropriate Federal, State, regional and local agencies.
- Capital investment per installed kilowatt, total cost per kWh and return on investment.
- Anticipated annual operation and maintenance costs.
- Anticipated project life.
- An initial assessment of the environmental impact and socio-institutional factors (from Section 5.0).
- An initial assessment of the safety hazard, if any, introduced by the addition or rehabilitation of a power plant and other hydropower appurtenances.
- Appropriate analyses resulting in sound judgement as to the engineering acceptability of the proposed site for hydroelectric power development.

- Investigation of the availability of a suitable turbine(s), generator(s), and accessories required for the proposed hydroelectric power development.

- Development plan (schedule) for putting power on-line (identified in Section 7.0).

6.2.1 General Characteristics

The following factors applied to all sites and system designs in the study:

- Marketing of Generated Power
  The power generated by the installation of power plants at the various sites could be fed into the existing electrical systems of either TID or the private utility. The marketing analysis of this distribution is covered in Section 4.0.

- Water Resources Impact
  The primary function of each District is to supply its customers with irrigation water.. This function is so critical that it cannot be compromised; the adverse impact of a damaged crop, because of the District's failure to deliver water, would far exceed any power generation benefit. Therefore, outside of nominal modifications of water delivery operations to obtain peak-power output the impact of installing hydropower on the water delivery systems must be minimized. Since at each site the power plant will be located in or with by-pass arrangements or can be removed from the canal, the original function of the canal will not be altered.

6.2 PHASE D, TECHNICAL ANALYSIS CRITERIA (CONT'D)

6.2.1 General Characteristics (cont'd)

- Operation and Maintenance

  The operation of the power plants will be accomplished by remote control; therefore, no on-site operational employees will be required. As facilities are added to any system, they must be maintained. With the addition of a power plant, the dam and channels must be maintained somewhat more carefully than previously. Also, trash will have to be cleaned from the trash racks and various structural, mechanical and electrical equipment will have to be repaired, repainted, tightened, corrected, updated or even replaced. Present maintenence crews will have to be increased to accomplish these tasks. The manpower required can then be phased in as the need increases since the equipment, with the exception of the initial break-in period, will be new and relatively trouble-free. The annual costs for operation and maintenance estimated at one percent (1%) per year of the project cost for these power plants are used in Section 7.0, Cost Estimates.

- Capital Investment Requirements

  As with any capital investment project, the benefits must be economically justifiable within the limit deemed acceptable. The limit for a public service power project (where no profit rate is desired) may be defined as the highest monetary rate at which power can be marketed as compared to other available sources of power. The market price must include operation and maintenance costs as well as debt service. Additionally it must be based on realistic rates; this rate is assumed at seven percent (7%) for thirty (30) years in Section 7.0, Benefit-to-Cost Estimates.

6.2.1 General Characteristics (cont'd)

- Anticipated Project Life

  Project life is predicated upon costs of replacement of the various portions of the project; or abandonment when useful life has been reached, i.e., where operation, maintenance, and repair costs would exceed the return derived from the original capital investments. Such an abandonment of the agricultural potential and of the water and power delivery to the urban and rural population cannot be foreseen within the limits of technology that we know today. Therefore, the dams and canals or water channels should, with proper maintenance, last indefinitely, but, even though these items are not subject to flooding destruction, it will arbitrarily be said their project life is one hundred (100) years.

  With good specifications, proper control of steel fabrication, care in the placement of reinforced concrete, and good inspection during the process of construction or fabrication, the civil structures and the rotating equipment, such as turbine generators, shafts, etc., should have a minimum fifty (50) year project life. Many similar systems are operating more effectively now than when installed forty or fifty years ago. Items such as trash racks, gates, gear boxes, regulators, switchracks, pole lines and phone lines, etc., will be assumed to have a useful life of approximately thirty (30) years. The useful life of controls will be assumed to be twenty (20) years. The longevity of the project components are specifically set short assuming only average maintenance and care but also based on the effects of wind, dust, rodents, insects, vandalism and accidents.

6.2.1 General Characteristics (cont'd)

- Safety Assessment

The structures built, the rotating equipment and the mechanical parts and piping installed, and the electrical and transmission systems used will all be assembled and placed in compliance with applicable building and construction codes and in accordance with the highest design standards set forth by the ASCE, ASME, IEEE and others.

Modifying any environment or altering any geographic topography changes the "safety" of area residents or passers-by. In this case, we are adding civil structures and high voltage electrical systems, so even though those structures are protected in a reasonable manner by fences, heights, etc., they inherently add danger. Increased access to the areas of the dams, new power plants, switch yards, and the canals due to frequent inspection and maintenance adds to danger. Offsetting this increase in danger are two items: an increase of visual surveillance by the system operators and an increased use of fencing, "No Trespassing" signs and local police awareness.

A system of key control of gate locks will probably have to be developed. The programs of safety for area water and power systems have become quite sophisticated. All equipment purchased, the basic structural layouts, the electrical transfers and all other project features will be laid out and then reviewed by trained safety engineers to make the project parts and configurations as safe as possible, not only after they are constructed but during the construction period itself.

6.2.1 General Characteristics (cont'd)

Safety Assessment (cont'd)

It is anticipated that events of attempted vandalism will increase with the expected increased flow of traffic through the general locale. Therefore, the projects will be designed to be as vandal-proof as possible; to blend with the surrounding territory; will maintain a low profile and make significant use of fencing and other safety devices.

Whenever any dam, diversion works, or water control structure is appended to, modified, strengthened or otherwise changed, the work will be done with the full knowledge of the State of California, Division of Safety of Dams, if that Department has jurisdiction. The standards of design related to safety will be the highest possible. This assessment will not include the determination of the structural integrity of the dams, diversion works, etc., as they presently stand in the field. Such structural integrity is the responsibility of the "Joint Districts".

Sections 6.4, 6.5 and 6.6 contain more detailed data on the individual sites.

6.3 COMPUTER ANALYSIS

The task of determining the correct installed capacity and number of generating units at any site is one of the most crucial aspects of the Study. It is also perhaps the most complex and difficult task because there is no simple rule or relationship between the average flow rate of the site and its installed capacity. It may be quite possible for two sites to have the same installed capacity while their average flows are different because of variant flow patterns assuming a constant head. The TID computer analysis assumes a constant head size. TID desires to maintain a constant water elevation at all canal sections for irrigation water deliveries.

The correct installed capacity is a unique balance between the equipment/civil cost, the character of the canal flow rates (assuming a constant head), the equipment operating characteristics and the value which has been assigned to energy. The process of finding the correct balance by incrementing each site component is termed an optimization analysis.

Carrying out an optimization analysis by hand calculation would be a Herculean task. Fortunately, a computer can be utilized to dramatically reduce the effort and time required to complete the analysis. The computer utilized by Fluid Energy Systems, Inc. (FES) is a remotely located IBM 360/65 accessed on a time-sharing basis through FES's in-house CRT terminal.

A truly efficient computer analysis would require the writing and testing of a computer program tailored especially to the analysis problem presented by the study, as no such program is known to exist. This process would consume a substantial amount of time and financial resources and consequently is not within the scope of a specific project. However, a somewhat analogous program was developed by TID to evaluate equipment configurations submitted by turbine manufacturers for TID Main Canal Drop Number One and Drop Number Nine. TID agreed to make the program known as the "Mini-Hydro" program, available to FES. This program, originally written in BASIC language, was translated by FES to PL/ONE language so that it could be run on FES's computer facilities.

The Mini-Hydro program was developed by TID with a slightly different objective than presented by the "Joint Districts" Study. Consequently, the results produced by the program are not necessarily the optimum which would be produced by a more generalized, modified program developed for the objectives of this study. Rather than modify the basic logic of the Mini-Hydro program, and incur the risk of computer debugging problems, FES made the decision to utilize the program in the form received from TID. The result was that more computer runs were required to achieve an acceptable level of analysis. The results of the computer analysis are considered acceptable for an economic and technical feasibility assessment but further refinement is deemed necessary for design sizing should any of the sites continue to the design stage of development.

The characteristics of each site define the class of turbine runner most suitable to each site. With the exception of the Frankenheimer site, all sites are best suited to a propeller runner. Frankenheimer is best suited to a Francis runner. Both types fall into the general category of reaction turbines. The cross-flow runner could be utilized at any of the sites technically; however, the use of this type of runner may not be attractive because of the economics or site physical limitations. All of the sites in the study can be reasonably assessed by assuming either a propeller or Francis runner, and FES chose to analyze the sites utilizing the computer through one of these two runners. FES does not necessarily advocate the use of one type of runner over another at this level of analysis and development.

To simulate the performance of the turbines, FES selected performance curves considered typical for each type of runner. The performance of a runner, regardless of its full load capacity, can be expressed at any percentage of full load within its operating range. This non-dimensional performance characteristic makes it much simpler to analyze the energy potential of a site by submitting various station unit number/operating range combinations in trial and error fashion for computer simulation.

To evaluate any particular combination, the computer is given the maximum number of units for the configuration and the operating flow range of any one unit (all units are identical). For any given daily flow rate, the computer determines the correct number of units to run up to the maximum of the configuration, the operating efficiencies under the given flow/unit number combination, and then computes the daily energy generated. This process then continues iteratively for each month until the annual energy has been calculated. Once any particular configuration has been assessed, the unit size (installed capacity) is incremented, keeping the number of units constant, and the evaluation process continued with another computer run. This process is continued until the annual energy production is maximized for the number of units allowed. The installed capacity based on an energy criteria is thus established. The entire process is then repeated incrementing the number of units. Each station configuration of a certain number of units has its own unique station installed capacity.

The determination of the most desirable station configuration is then assessed with respect to economic and equipment availability factors. Three somewhat smaller generating units at a site may produce an increased amount of energy over two larger units but the additional energy revenue is not sufficient to offset the higher overall cost of three units. The most desirable station configuration then is a balance which produces the greatest benefit, both in terms of revenue and generation ability, for the least station cost. The computer permits the determination of this balance very rapidly and efficiently.

6.4 TID SMALL HYDROPOWER SYSTEM

This sub-section assesses the technical feasibility of various hydropower installations at two sites in the TID system. These are Drop Number Two and Drop Number Seven. The ultimate feasibility and disposition of the other sites considered in the overall assessment have been discussed in Section 6.I. The physical characteristics and hydrology for the individual sites in this sub-section can be found in the Phase A Report in Volume II.

6.4.1 Drop Number Two

The head and flow used for design purposes in this analysis are 4.86 feet and 1,700 cfs, respectively. The hydroelectric potential for this site as indicated by the computer analysis in Section 6.3 is a total installed capacity of 660 kW with 2,073,400 kWh annual production.

6.4.1 Drop Number Two (cont'd)

EQUIPMENT INSTALLATION CONSIDERATIONS

The selection of turbines for various operating conditions at low-head sites involves both total power output and turbine efficiency. The choice of units and configurations for this site from those presented in Appendix Section 8.3 are cross-flow, vertical Kaplan (propeller) or tube (propeller) type units(s).

The possibility of using a cross-flow type turbine was investigated and found to be unsuitable. The flow and head characteristics dictated the use of an available cross-flow turbine costing approximately $250,000 including the turbine, generator, controls and the necessary speed increaser. The efficiency would have been an acceptable 75%. However, a relatively low flow capacity of approximately 250 cfs each would have required the use of five units. This would bring the total installed cost in excess of $6,500/kW, several times the cost of other turbine installations.

The possibility of using a vertical Kaplan propeller reaction type turbine was eliminated for the following reasons: 1) the excessive cost of the civil works required to connect the unit between the two water levels (deep excavation for submergence or a cavitation-prone syphon arrangement would be required) and 2) hydraulic inefficiencies due to the change in direction of flow.

EQUIPMENT CONFIGURATION SELECTION

At this site two standard tube turbines were found to be best suited for the existing conditions. The runner diameters at this site are in the range of 1.5 meters. The unit would be placed in a by-pass configuration similar to that shown in Figure 6-2.(This figure shows an alternate installation of one unit with a larger runner.). These

6.4.1 Drop Number Two (cont'd)

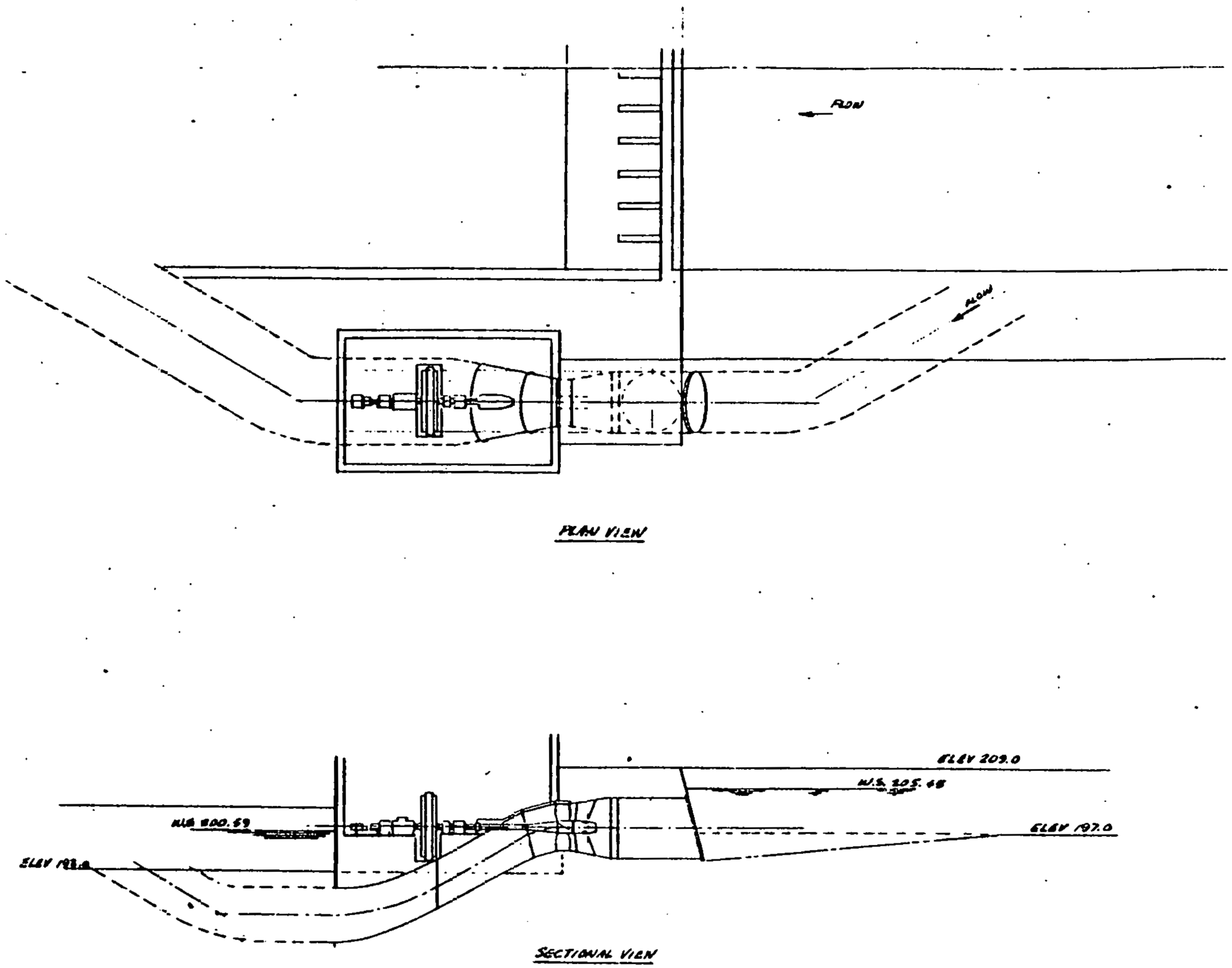
EQUIPMENT CONFIGURATION SELECTION (cont'd)

units would have a 3-bladed propeller to pass a maximum quantity of water. The propeller runners would be fixed on their shafts. The guide vanes used for propeller shaft support would also be fixed (i.e., non-adjustable). Valves will be located upstream of the turbines to regulate the flow.

Using a by-pass around the existing structure has two advantages. First, no demolition is required, which will save on construction costs. Secondly, the original dam can function as before in the event that repair is needed to the turbine or construction time lags into the irrigation season. This will help minimize the Water Resources Impact (See Section 6.2.1.).

The new power plant will be housed in a structure to protect the equipment from the weather and from vandalism or theft. The approximate installed cost/kW at this site is expected to be $1,600/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates a .960 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 6.7.

The generators will be of the conventional synchronous type and will be connected to the turbines by means of mechanical couplings and speed increasers. This type was selected over induction, or asynchronous generation because of its control over the power factor. The cost of the synchronous equipment is approximately 5 percent (5%) greater than that for an induction for this size unit.



VERY LOW HEAD - FIXED BLADE - TUBE TYPE TURBINE/GENERATOR CONCEPT
FOR CANAL DROPS NUMBER TWO, NUMBER SIX AND NUMBER SEVEN

Figure 6-2

6.4.2 Drop Number Seven

The head and flow used for design purposes in this analysis are 6.57 feet and 1,200 cfs respectively. The hydroelectric potential for this site as indicated by the computer analysis in Section 6.3 is a total installed capacity of 700 kW and 2,101,400 kWh annual production.

EQUIPMENT INSTALLATION CONSIDERATIONS AND CONFIGURATION SELECTION

The site data and flow characteristics for Drop Number Seven are similar to those of Drop Number Two. In order to simplify design, construction and maintenance, the choice of tube turbine similar to Drop Number Two would be most appropriate. Although the head and flow differ slightly, use of an identical turbine and generator will be recommended with necessary adjustments to the runner and switchgear. Figure 6-2 shows the installed configuration. The generators at this site will also be of the synchronous type.

The new power plant will be housed in a structure to protect the equipment from the weather, vandalism or theft. The approximate installed cost/kW at this site is expected to be $1,450/kW. This is slightly less than that for Drop Number Two due to the extra power that is generated by the higher head. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.072 to 1.0 benefit-to-cost in the first year of operations. Site electrical requirements are discussed in general in Section 8.7.

6.5 MERCED SMALL HYDROPOWER SYSTEM

This sub-section assesses the technical feasibility of various hydropower installations at four sites in the Merced Irrigation District system. These are the Main Canal, Canal Creek, Fairfield, and the Escaladian Headworks. The ultimate feasibility and disposition of the other sites considered in the overall assessment have been discussed in Section 6.1. The physical characteristics and hydrology for the individual sites in this sub-section can be found in the Phase B Report in Volume II.

6.5.1 Main Canal

The head and flow used for design purposes in this analysis are 19.4 feet and 1,900 cfs respectively. The head data was derived from the profile, Figure 6-3. The hydroelectric potential for this site as indicated by the computer analysis of Section 6.3 is a total installed capacity of 2,800 kW total energy with 9,169,000 kWh annual production. The power plant and drop structure are to be new at this site.

EQUIPMENT INSTALLATION CONSIDERATIONS

The site is located on the Main Canal Alignment and will require minimum civil design to maximize the existing developable head of 19.4 feet. The majority of the site improvements would involve channel excavation, lining, and support that would be done in the non-irrigation periods. The geological and structural integrity of the existing tunnel will be insured by not using a pressurized design, but rather maximizing the developable head.

The installation of a power facility at this location would allow an improvement in area safety by filling the deep approach channel with ponded waters and provide inlet protectional facilities at the inlet of the tunnel.

EQUIPMENT CONFIGURATION SELECTION

The turbine-generators chosen for this site are two (2) bulb-turbine units each mounted on a vertical gate. Figure 6-4 shows this arrangement, which would allow the turbine-generator to be removed from the canal and repaired or replaced without disruption of irrigation water

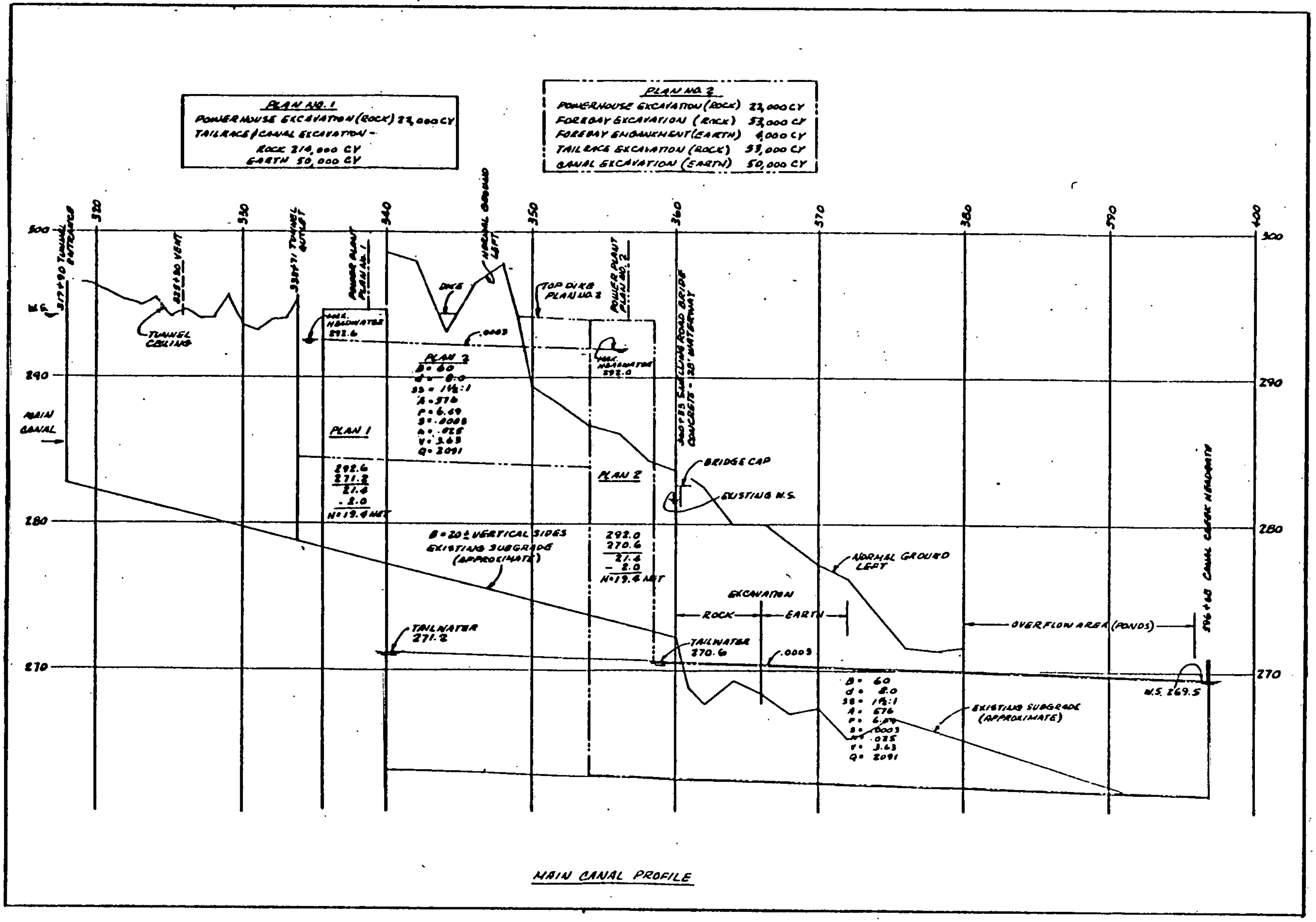
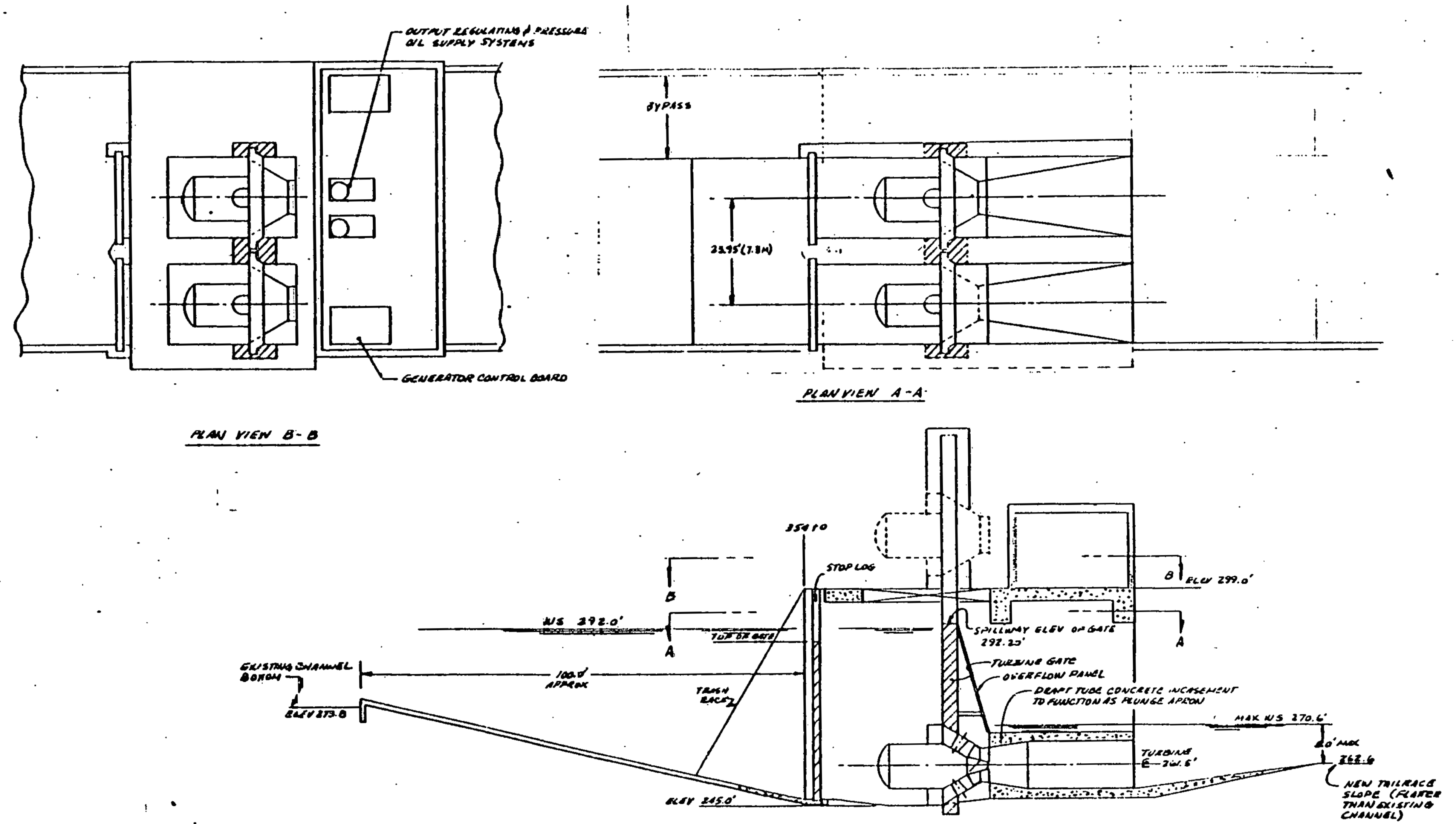

PLAN NO. 1
POWERHOUSE EXCAVATION (ROCK) 22,000 CY
TAILRACE/CANAL EXCAVATION -
ROCK 214,000 CY
EARTH 50,000 CY
PLAN NO. 2
POWERHOUSE EXCAVATION (ROCK) 22,000 CY
FOREBAY EXCAVATION (ROCK) 53,000 CY
FOREBAY EMBANKMENT (EARTH) 4,000 CY
TAILRACE EXCAVATION (ROCK) 53,000 CY
CANAL EXCAVATION (EARTH) 50,000 CY
300
290
280
270
MAIN CANAL
TUNNEL CEILING
DIKE
NORMAL GROUND LEFT
TOP DIKE PLAN NO. 2
PLAN 1
PLAN 2
BRIDGE CAP
EXISTING W.S.
B = 20± VERTICAL SIDES
EXISTING SUBGRADE (APPROXIMATE)
TAILWATER 271.2
TAILWATER 270.6
EXCAVATION
ROCK
EARTH
OVERFLOW AREA (PONDS)
W.S. 269.5
EXISTING SUBGRADE (APPROXIMATE)
MAIN CANAL PROFILE

Figure 6-3



CONCEPTUAL INSTALLATION OF GATE TYPE TURBINE/GENERATOR INSTALLATION

Figure 6-4

6.5.1 Main Canal (cont'd)

EQUIPMENT CONFIGURATION SELECTION (cont'd)

delivery. The gates may be raised and lowered by means of winches or by counter-weight. A by-pass around the turbine installation is also provided to allow for turbine shut-down conditions and for excess demand conditions. This will help minimize the water resources impact discussed in Section 6.2.1.

The turbine bulb outer casing is fixed with the gate along with four stay vanes used to support the turbine and direct the flow. The generator is completely submerged and contained within the inner casing. This generator is of the synchronous type. All auxiliary equipment, such as synchronizer, oil pressure supply system, lubricating oil system, feed water and drainage system, etc., are built in the gate and/or the bulb unit.

The draft tube liner is ribbed to fix on the bottom of the tailrace and on the sidewalls. Between the draft tube liner and discharge ring a specially designed loose flange is used. When the turbine-generator comes down to the specified position, they are joined with the loose flange automatically.

The propeller runner vanes are fixed, and wicket gates are movable. The operation mechanism of wicket gates is installed in the inner casing of the turbine. All of the control systems, lube oil pressure supply system, switchboard, etc. are installed in the auxiliary room above the gate.

The approximate installed cost/kW is expected to be $1,600. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.216 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 8.7.

6.5 MERCED SMALL HYDROPOWER SYSTEM (CONT'D)

6.5.2 Canal Creek

The head and flow used for design purposes in this analysis are 32.3 feet and 380 cfs respectively. The head data was derived from the profile, Figure 6-5. The hydroelectric potential for this site as indicated by the computer analysis of Section 6.3 is an installed capacity of 940 kW and 3,262,000 kWh annual production. The power plant and drop structure are to be new at this location.

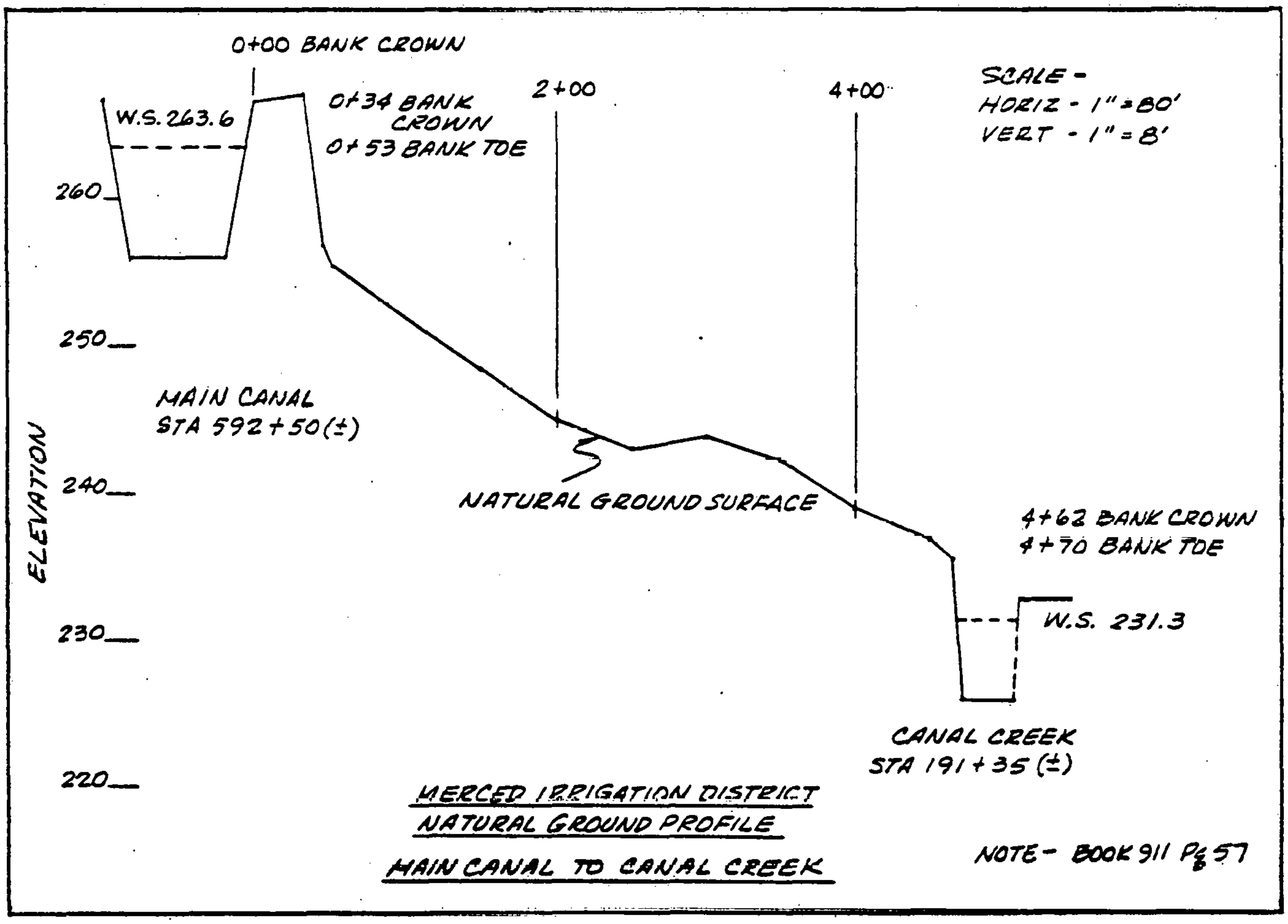


Figure 6-5

6.5.2 Canal Creek (Cont'd)

EQUIPMENT INSTALLATION CONSIDERATIONS

This location is considered a canal opportunity drop that allows 32.3 feet of head to be developed by dumping into a tributary canal adjoining the main canal system at this location. This drop can be developed without jeopardizing necessary irrigation deliveries because of the "Water Energy Management" opportunity at this portion of the canal delivery system.

The canal at the drop points will have to be modified to allow a penstock to take the flows into the lower existing branch canal. Figure 6-6 shows this site plan.

A possible environmental effect of the project would be the increase in the flow rate of the Main Canal from the existing Canal Creek Headworks to the new diversion point.

The Main Canal embankment will be modified to accept a new control gate and penstock transition. The penstock will then deliver the flow to the generating unit situated adjacent to the existing Canal Creek channel. The penstock is bifurcated ahead of the generating unit to provide a bypass capability.

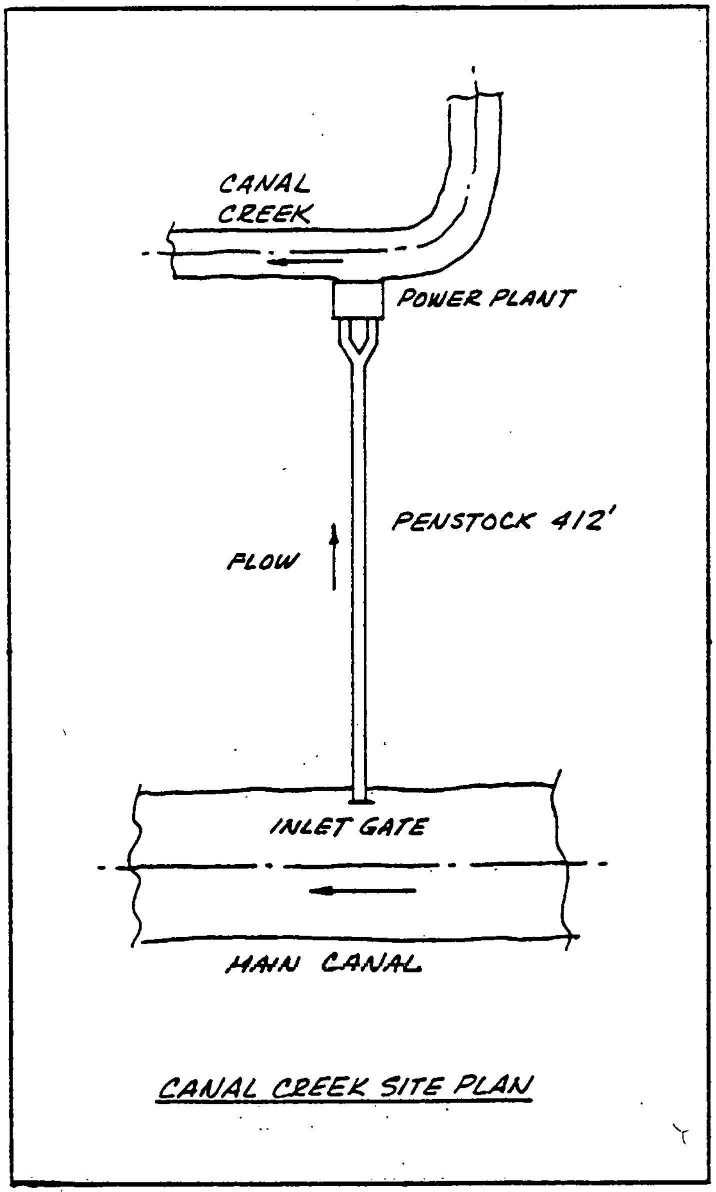


Figure 6-6

6.5.2 Canal Creek (Cont'd)

EQUIPMENT CONFIGURATION SELECTION

A turbine-generator selected from those presented in Section 8.3 is a single bulb type unit. Figure 6-7 shows the installation. The unit will require excavation at the site which is necessary for propeller submergence. A 1.4 meter diameter propeller runner would function with the highest efficiency under the existing head of 32.3 feet and design flow rate of 380 cfs.

The bulb turbine has definite hydraulic advantages over other turbine water passage configurations in that its water passage is nearly straight. This physical characteristic results in lower hydraulic energy losses and thereby provides higher operating efficiencies over some other propeller runner installation configurations.

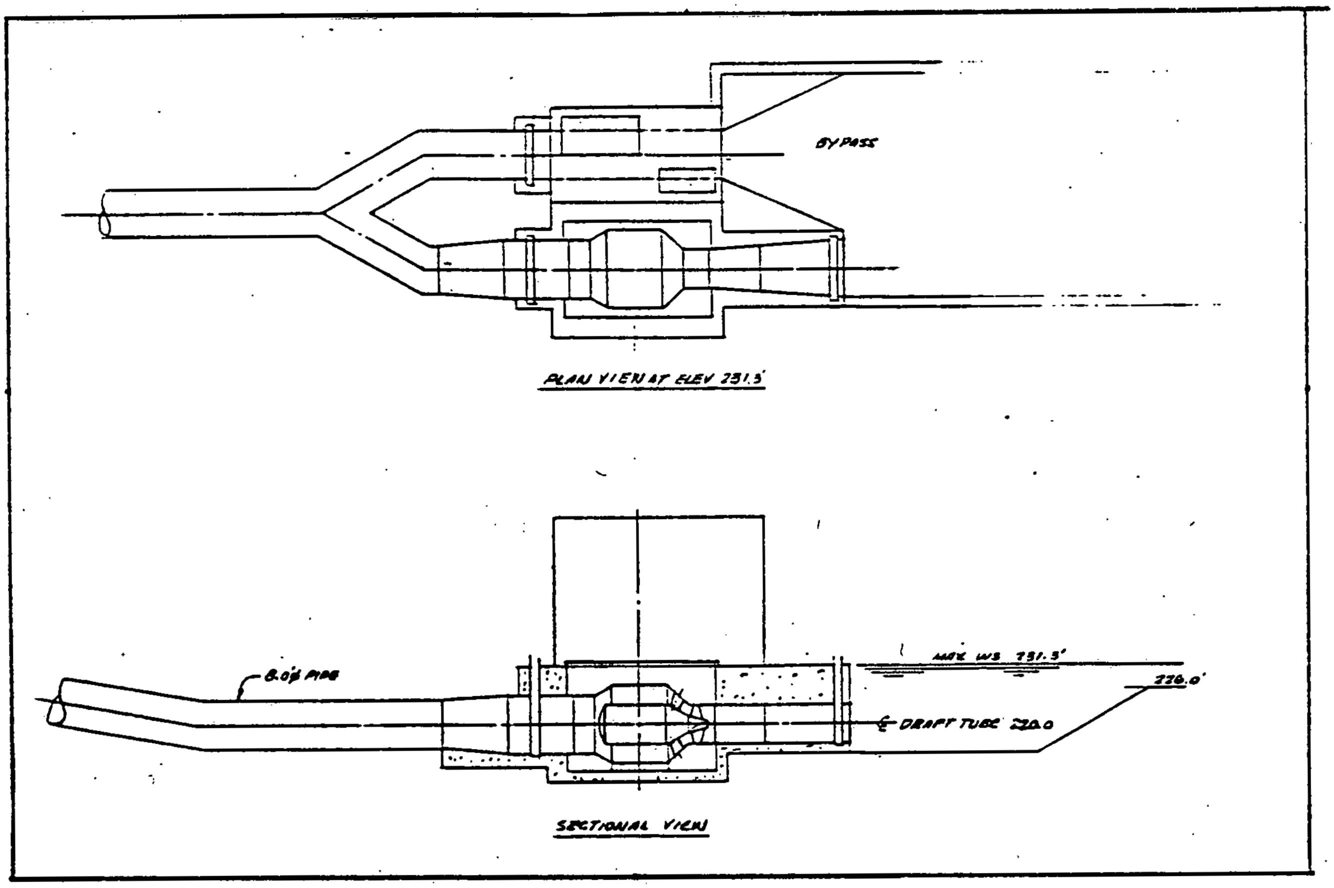
Although the equipment proposed at Canal Creek is similar to Main Canal in that both are bulb turbines, the overall Canal Creek configuration is quite different in that the site is not adaptable to the sliding "gate-bulb" concept. This is because of the horizontal distance between head and tailwaters and the existing topography over this distance.

The generator would be of the synchronous type. The synchronous generator would be advantageous over an induction generator by providing power factor control in an area with an inductive load.

The approximate installed cost/kW at this site is expected to be $1,350/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.243 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 8.7.

6.5 MERCED SMALL HYDROPOWER SYSTEM (CONT'D)

6.5.2 Canal Creek (Cont'd)



CONCEPTUAL INSTALLATION
CANAL CREEK AND FAIRFIELD DROP
Figure 6-7

6.5.3 Fairfield

The head and flow used for design purposes in this analysis are 30.2 feet and 420 cfs, respectively. The hydroelectric potential for this site as indicated by the computer analysis in Section 6.3 is an installed capacity of 970 kW and 2,809,000 kWh annual production. A new power plant and drop structure are to be built at this site.

6.5.3 Fairfield (Cont'd)

EQUIPMENT INSTALLATION CONSIDERATIONS

This is a canal opportunity drop like the previously-discussed Canal Creek site. Lake Yosemite, an intermediate storage reservoir in the system, feeds two separate canals - the Fairfield and the La Grange. The lower elevation Fairfield Canal has a reinforced concrete drop chute structure at a location approximately 700 feet from the upper La Grange canal. While the energy drop chute structure itself has good power potential, the total heads between the canals at this location will maximize the power potential. Again, the "Water Energy Management Plan" is flexible enough at this high elevation near the turnout of the canal system to allow this consideration. A penstock 8 feet in diameter will take flows into the Fairfield Canal in a manner similar to that for Canal Creek. Figure 6-8 shows this site plan. A penstock bifurcated ahead of the generating unit similar to the Canal Creek installation allows bypass capability.

EQUIPMENT CONFIGURATION SELECTION

The site data and flow characteristics for Fairfield are similar to Canal Creek. In order to simplify design, construction and annual maintenance, the choice of a single bulb turbine similar to Canal Creek would be most appropriate. Figure 6-7 shows the installation. Although the head and flow differ slightly the use of an identical bulb turbine generator will be used with the necessary adjustments to the runner and switchgear. The generator at this site will also be of the synchronous type.

The approximate installed cost/kW is expected to be $1,200/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.153 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 8.7.

6.5.3 Fairfield (Cont'd)

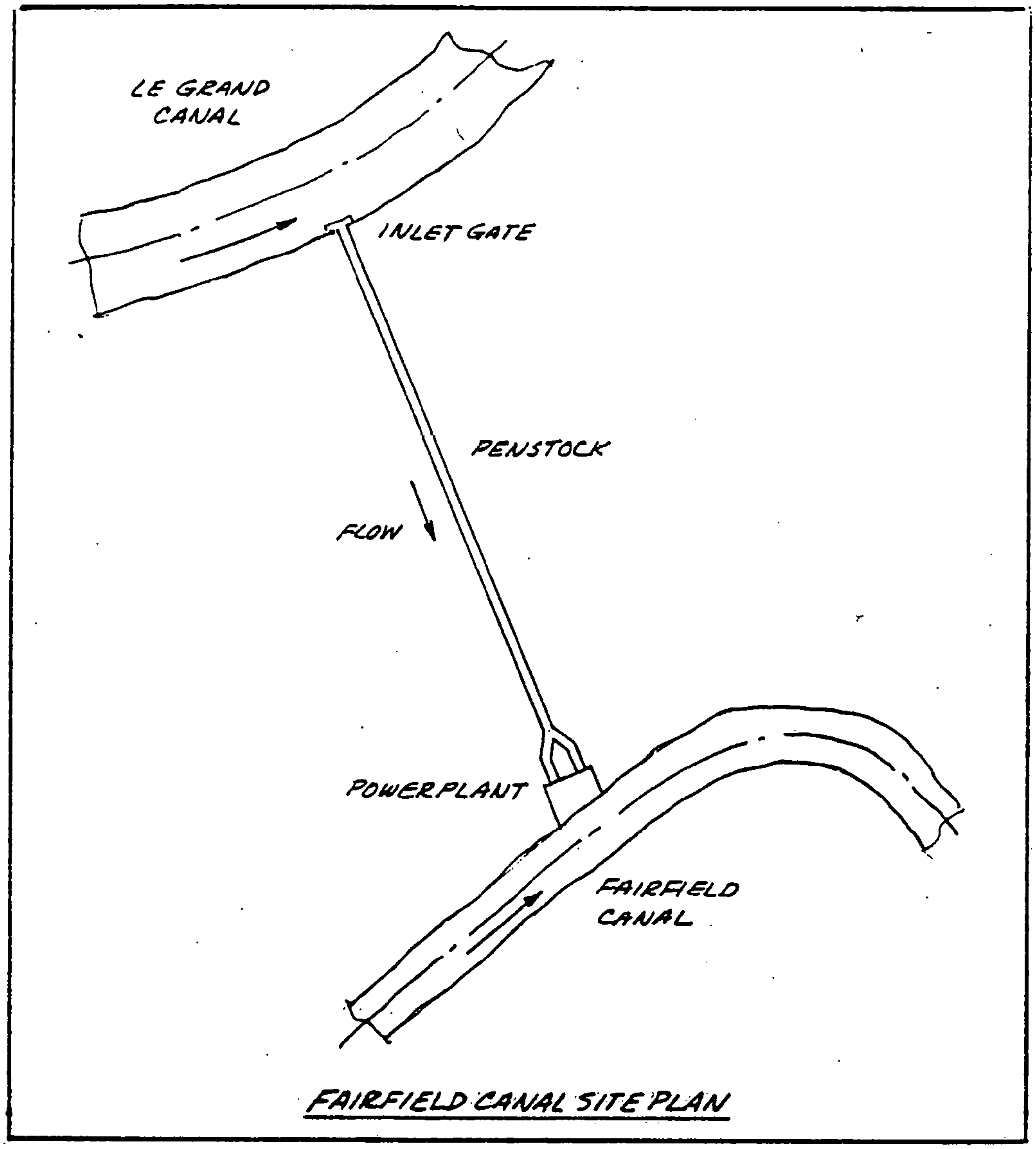


Figure 6-8

6.5.4 Escaladian Headworks

The head and flow used for design purposes in this analysis are 15.0 feet and 230 cfs respectively. The hydroelectric potential for this site as indicated by the computer analysis in Section 6.3 is an installed capacity of 270 kW and 822,000 annual production.

6.5.4 Escaladian Headworks (Cont'd)

EQUIPMENT INSTALLATION CONSIDERATIONS

This site is the first drop structure in a series of four structures in an unlined diversion canal. It serves as the diversion works at the main canal. With a head of 15 feet, the choice of units and configurations from those presented in Section 8.3 are cross-flow, vertical Kaplan or tube type (propeller) units.

EQUIPMENT CONFIGURATION SELECTION

The vertical Kaplan (propeller) configuration was eliminated for the same reasons as those for TID Drop Number Two (Section 6.4.1). The low flow at this site would allow the use of a cross-flow unit which has the advantage of a higher range of efficiencies under varying flow conditions. However, in order to simplify design, construction, operation and maintenance, a single tube type unit similar to those used at TID Drop Number Two and Drop Number Seven could be used. This could also allow the benefit of reduced cost to the purchase of a multiple tube-type unit in a "Joint Districts" equipment procurement.

The tube turbine runner diameter at this site will be in the range of 1.5 meters. The unit would be placed in a by-pass configuration similar to those for TID Drop Number Two and Drop Number Seven. This unit would have a 3-bladed fixed runner. The runner and guide vanes would be fixed. A slide gate valve will be located upstream of the turbine to regulate the flow.

Using a by-pass around the existing structure has two advantages. First, no demolition is required. Second, the original structure can function as before in the event that repair is needed to the turbine. This will help minimize the Water Resources Impact (See Section 6.2.1.).

6.5.4 Escaladian Headworks (Cont'd)

EQUIPMENT CONFIGURATION SELECTION (cont'd)

The new power plant will be housed in a structure to protect the equipment from the weather and from vandalism or theft. The approximate installed cost/kW at this site is expected to be $1,700/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates an .868 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 8.7.

The generator will be of the conventional synchronous type and will be connected to the turbine by means of mechanical coupling and speed increaser. This type was selected over induction, or asynchronous generation, because of its control over the power factor. The cost of the synchronous equipment is approximately five percent (5%) greater than that for an induction for this size unit.

6.6 SOUTH SAN JOAQUIN SMALL HYDROPOWER SYSTEM

This sub-section assesses the technical feasibility of various hydropower installations at two sites in the SSJID system. These are Frankenheimer (Main Canal) and Goodwin Dam (North Side). The ultimate feasibility and disposition of the other sites considered in the overall assessment have been discussed in Section 6.1. The physical characteristics and hydrology for the individual sites in this sub-section can be found in the Phase C Report in Volume II.

6.6.1 Frankenheimer (Main Canal)

The head and flow used for design purposes in this analysis are 78 feet and 900 cfs respectively. The hydroelectric potential for this site as indicated by the computer analysis in Section 6.3 is an installed capacity of 4,700 kW and 16,962,000 kWh annual production.

EQUIPMENT INSTALLATION CONSIDERATIONS

The location of this site is on a portion of the SSJID Main Canal with a relatively steep channel slope. The topography in the vicinity of the site is suitable to accommodate a relocation of the canal to a point where the canal could concentrate its drop over a short distance. The relocation would create approximately a seventy-eight (78) foot drop from a small forebay at the end of the relocated canal to the power plant adjacent to the existing canal. A penstock would deliver water from the forebay to the power plant. (See Figure 6-9.)

EQUIPMENT CONFIGURATION SELECTION

The relatively high head at this site (the highest of all sites in this Study) is best utilized through a Francis type turbine runner with a lower specific speed than a propeller runner.

The most suitable configuration would be a conventional vertical turbine/generator arrangement. Water would be directed to the runner through a conventional spiral casing and adjustable wicket gates. The wicket gates would provide the necessary irrigation flow regulation. It would be necessary, however, to bifurcate the penstock just ahead of the power plant and provide a plant shut-off valve to accommodate an irrigation bypass. The tailrace would return water to the existing canal channel. The unit should be protected by a trash rack.

The generator would be of the synchronous type and would be located above the runner. All equipment will be housed in an enclosed power

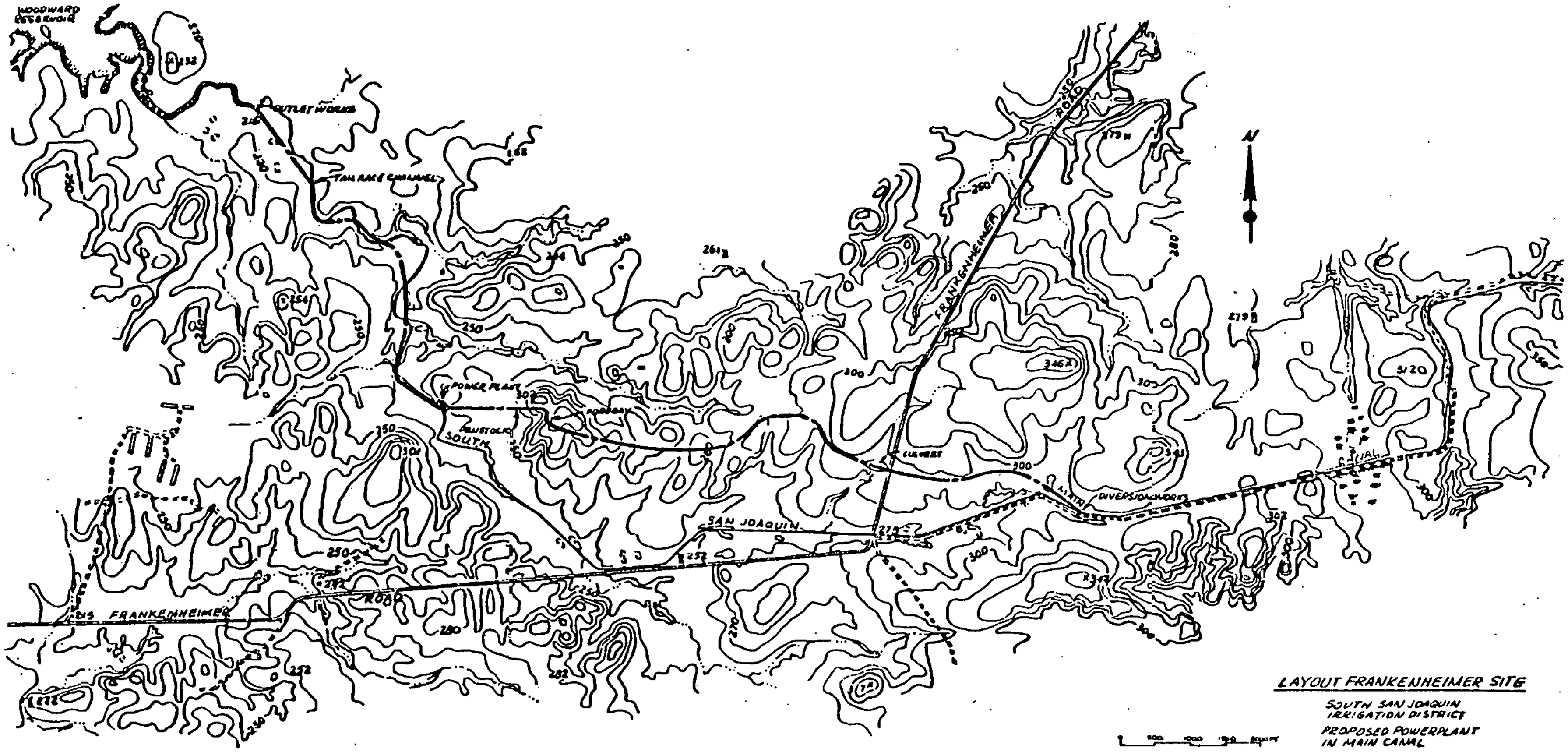

WOODWARD RESERVOIR
OUTLET WORKS
TAILRACE CHANNEL
POWER PLANT
PENSTOCK
SOUTH
SAN JOAQUIN
FRANKENHEIMER ROAD
FRANKENHEIMER
ROAD
CULVERT
DIVERSION WORKS
CANAL
N
LAYOUT FRANKENHEIMER SITE
SOUTH SAN JOAQUIN IRRIGATION DISTRICT
PROPOSED POWERPLANT IN MAIN CANAL

Figure 6-9

EQUIPMENT CONFIGURATION SELECTION (cont'd)

house. The amount of excavation and associated civil works is similar to that of the 1977 investigation in Section 8.3.

The approximate installed cost/kW is expected to be $1,300/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.372 to 1.0 benefit-to-cost in the first year of operation. Site electrical requirements are discussed in general in Section 8.7.

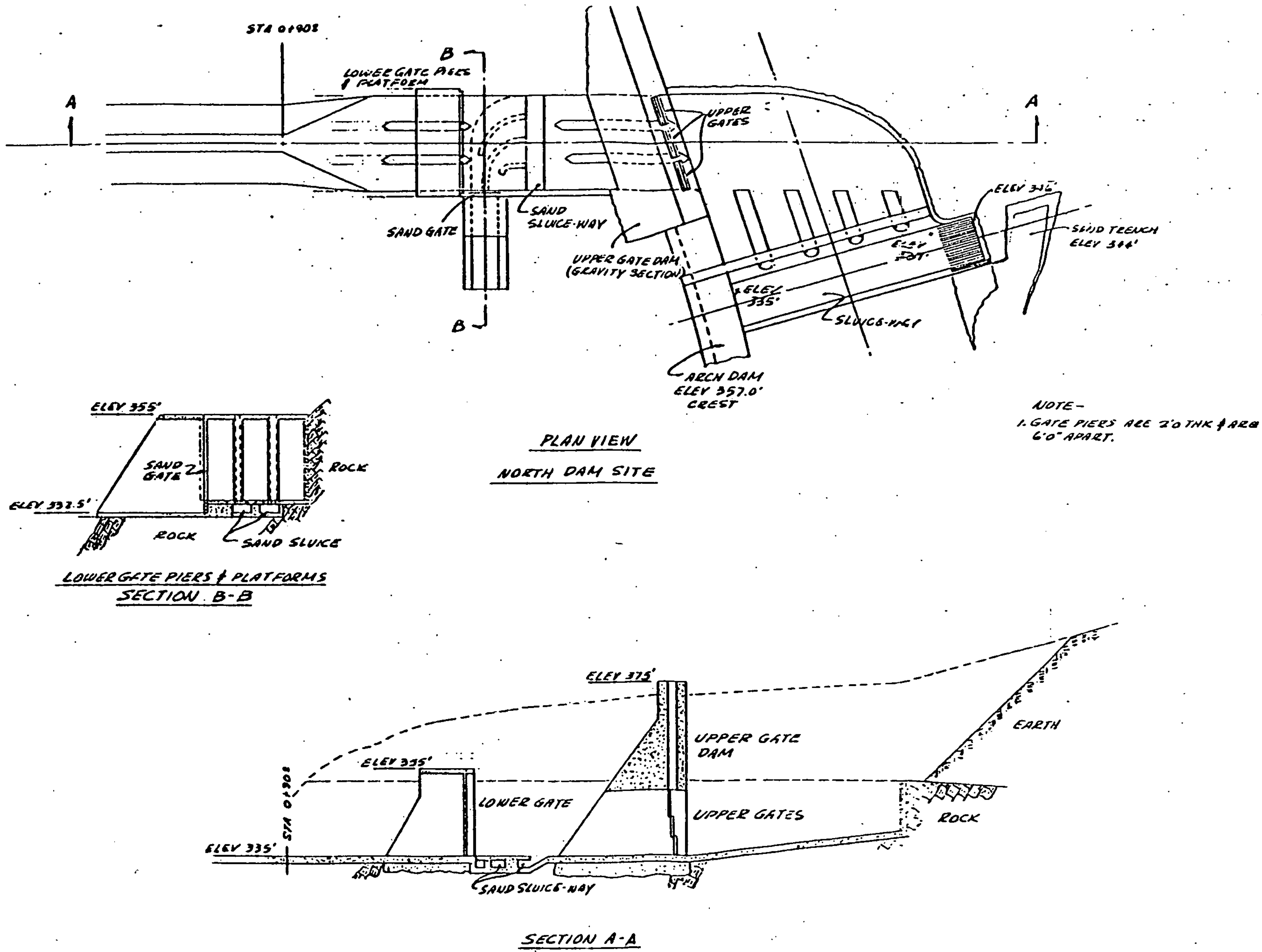
6.6.2 Goodwin Dam Joint Canal Headworks (North Side)

The head and flow used for design purposes in this analysis are 10 feet and 1,200 cfs respectively. The hydroelectric potential for this site as indicated by the computer analysis of Section 6.3 is an installed capacity of 970 kW total energy with 4,655,000 kWh annual production. The development of the site would require the construction of a new headwall immediately downstream of the existing lower headgates. This would relocate the head drop to a location which could accommodate generating equipment.

EQUIPMENT INSTALLATION CONSIDERATIONS

The site is located at the Goodwin Diversion Dam built in 1913 to divert water below Tulloch Reservoir into the South San Joaquin main canal. The joint canal headgates produce a head drop of 10 feet that can be used for power generation.

This site consists of several existing gate structures (Figure 6-10). The location best suited for a hydroelectric installation is approximately 100 feet downstream of the north diversion canal. The flow into



EXISTING STRUCTURE GOODWIN DAM (NORTH SIDE)

Figure 6-10

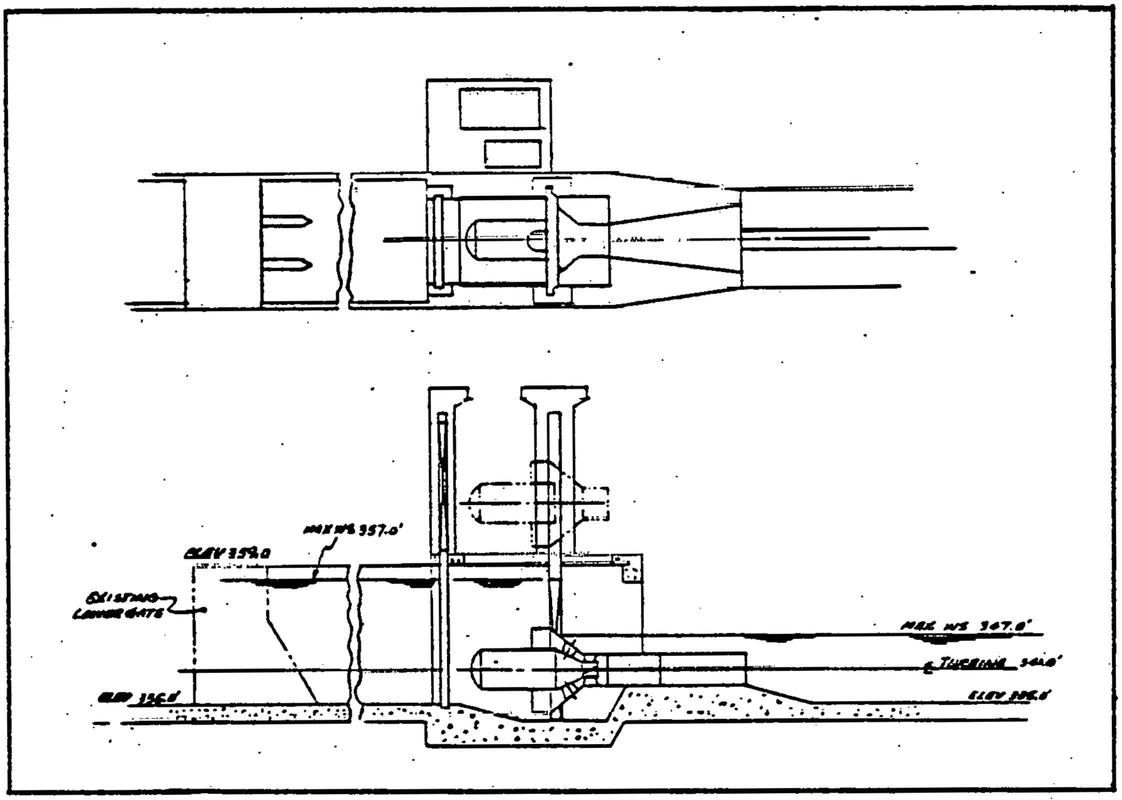
6.6.2 Goodwin Dam Joint Canal Headworks (North Side) (Cont'd)

EQUIPMENT INSTALLATION CONSIDERATIONS (cont'd)

the power plant and/or by-pass would continue to be regulated by existing gates.

EQUIPMENT CONFIGURATION SELECTION

The low head and flow characteristics for this site would best be utilized by a single bulb type unit. In order to allow full by-pass conditions for irrigation purposes and excess demand operation the bulb will be mounted on a gate similar to those used at the Merced sites (See Figure 6-11). This will also facilitate repair and maintenance.



CONCEPTUAL GATE TURBINE/GENERATOR INSTALLATION
GOODWIN DAM (NORTH SIDE)
Figure 6-11

6.6.2 Goodwin Dam Joint Canal Headworks (North Side) (Cont'd)

EQUIPMENT CONFIGURATION SELECTION (cont'd)

The turbine bulb is fixed with the gate along with four stay vanes used to support the turbine and direct the flow. The stator of the generator is installed on the inside of the casing. The generator is of the synchronous type. For a description of the equipment refer to the discussion in Section 6.5.1.

The approximate installed cost/kW is expected to be $1,550/kW. The benefit-to-cost analysis is covered in Section 7.0 and indicates a 1.500 to 1.0 benefit-to-cost in the first year of operations. Site electrical requirements are discussed in general in Section 8.7.

SECTION 7.0

"JOINT DISTRICTS" HYDROPOWER DEVELOPMENT PLAN

The results of the "Joint Irrigation Districts Hydropower Assessment Study" and the conclusions and recommendations of the "Final Feasibility Assessment Report" provide the basis for this development plan.

This plan includes the "Joint Districts" twelve (12) economically and environmentally feasible sites. These sites are divided into three (3) "small hydropower systems" for ease of project management and overall development control.

The three (3) small hydropower systems and their associated sites are:

- Turlock Irrigation District (TID) Small Hydropower System
  - Drop Number One
  - Drop Number Two
  - Drop Number Six
  - Drop Number Seven
  - Drop Number Nine

- Merced Irrigation District (Merced) Small Hydropower System
  - Main Canal Drop
  - Canal Creek Drop
  - Fairfield Drop
  - Escaladian Headworks

- South San Joaquin Irrigation District (SSJID) Small Hydropower System
  - Woodward Reservoir Outlet Works
  - Frankenheimer Drop
  - Goodwin Dam Joint Canal Headworks (North Side).

The Development Plan in this section provides the Joint Districts with a summary description of each system and each site within that system; project or system benefits, estimated costs and potential revenues; a phased site installation plan and schedule for each of the three (3) systems; and a financial plan and discussion of funding methods and sources.

7.1 TURLOCK IRRIGATION DISTRICT (TID)

The Turlock Irrigation District (TID) was founded in 1887 as a result of the drought of 1870-71. As California's first irrigation district, TID was established under the Wright Irrigation Act, which gave broad powers to such bodies.

TID is an irrigation district organized and existing under the laws of the State of California, having its principal office and place of business in the City of Turlock in the State of California. As an irrigation district, TID has two major functions:

- To conserve and distribute water for agricultural irrigation;
- To generate and provide electrical power for industrial, agricultural, commercial and residential use.

Because of its dual responsibility for two key resources - water and power - TID plays a pivotal role in the economic development of its service area. Serving a population of 78,000 (many dependent on agriculture), the District provides water to 161,000 acres of land and electrical power to 40,000 metered customers.

TID is governed by a publicly-elected, five-member Board of Directors. The District is administered by a full-time General Manager selected by the Board of Directors.

TID has a gross area of 195,892 acres located in Merced, Stanislaus and Tuolumne Counties. TID includes the incorporated cities of Turlock, Ceres, Hughson and a portion of Modesto, and the unincorporated communities of Hickman, Keyes, Denair, Delhi and Hilmar.

TID and the adjoining Modesto Irrigation District are joint owners of the New Don Pedro Dam and Reservoir and power facilities on the Tuolumne River located in Tuolumne County. TID also wholly owns the 4,700 kW La Grange Power Plant.

The District owns approximately 114,000 kilowatts of hydroelectric generation and purchases the balance of its power requirements from the City and County of San Francisco's Hetch-Hetchy Project and the Pacific Gas and Electric Company (PG&E). The drought of 1976-77 caused TID to purchase over 90% of its electrical power from PG&E, the largest share of which was generated from fossil fuel fired power plants.

7.1.1 TID Small Hydropower System

The sites which constitute the TID "Small Hydropower System" are situated on the TID Main Canal from Turlock Lake to the Ceres Main Canal and consist of five (5) economically and environmentally feasible sites. The five (5) sites will have a total installed capacity of 6,610 kilowatts (kW) providing an average of 23,976,800 kilowatthours (kWh) of energy annually during the seven (7) month irrigation season. This annual energy would be equal to saving 41,480 barrels of oil per year.

Table 7-1 presents a summary of essential site parameters: installed capacity (kW), annual energy (kWh) and barrels of oil which would be saved.

7.1 TURLOCK IRRIGATION DISTRICT (TID) (CONT'D)

7.1.1 TID Small Hydropower System (Cont'd)

TABLE 7-1

TID SMALL HYDROPOWER SYSTEM			
SITE	INSTALLED CAPACITY (kW)	ANNUAL ENERGY (kWh)	OIL SAVING (BBLS/YEAR)
Drop One	3,260	12,200,000	21,107
Drop Two	660	2,073,400	3,587
Drop Six	920	2,902,000	5,020
Drop Seven	700	2,101,400	3,635
Drop Nine	1,070	4,700,000	8,131
TOTALS	6,610	23,976,800	41,480*
* at $18.75/BBL, this would equal $777,750/year savings			

DROP NUMBER ONE

Drop Number One was assessed for technical and economic feasibility by TID in November, 1977. The results of this assessment indicated the site would be feasible and TID therefore advanced to the next stage of development by obtaining a power plant design.

The planned small hydroelectric power plant will consist of three (3) hydroelectric generating units next to the existing outlet structure for Turlock Lake. Each of the three (3) generating units will consist of a Leffel turbine in a flume arrangement coupled to a General Electric Company generator. Each unit will be rated at 1,086 kW for a total output of 3,260 kW at a flow of 1,608 cubic feet per second, which is eighty percent (80%) of canal capacity.

The transformer, electrical switching equipment and other auxiliary equipment will be located on a raised pad as close to the power plant as possible without blocking access. Ladders and hatches will be built into all structures to allow access to equipment for inspection and repairs.

7.1.1 TID Small Hydropower System (Cont'd)

DROP NUMBER ONE (cont'd)

The power plant will have stoplogs upstream of the generating units. The stoplogs will be used to isolate the power plant during shutdown for inspection or for repairs. The units will be protected by trash racks. Two hydraulically controlled slide gates will be used to bypass water for irrigation purposes whenever units are shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

The power plant will be remotely monitored and controlled from TID's Broadway Control Center in Turlock. Close coordination will be maintained between the operation of the power plant and operation of TID's irrigation system. The plant can not function as a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual energy production is 12,200,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

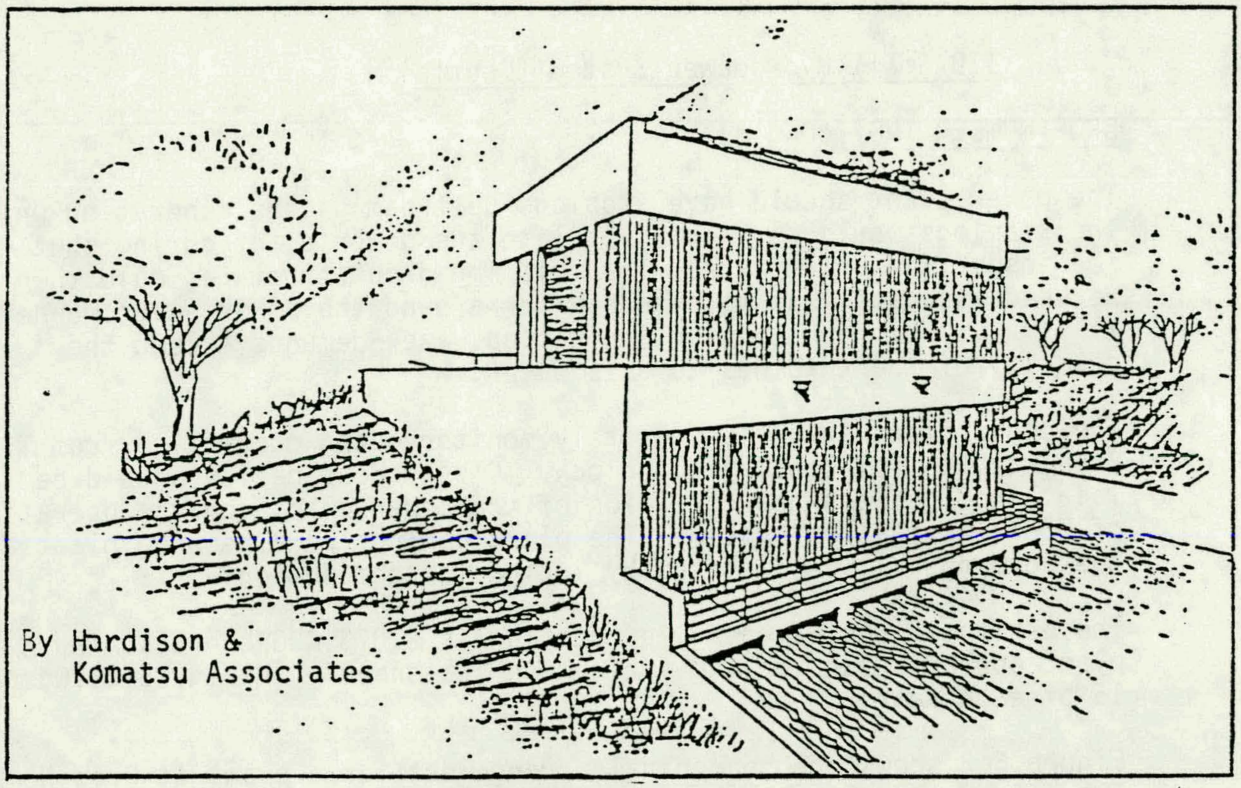
The engineering design work is complete and TID is preparing to go into the construction phase. Construction is scheduled to begin in the spring of 1979 with on-line operation scheduled for March, 1980.

Figure 7-1 shows an architectural rendering of the completed power plant. Figure 7-2 shows a typical cross-section through the power plant illustrating the arrangement of the turbines, generators, draft tubes and stop logs.

DROP NUMBER TWO

A suitable small hydroelectric power plant would most likely consist of two generating units located adjacent to the existing structure and outside of the existing canal. Each generating unit would consist of a single turbine coupled to a single generator rated at 330 kW for a total station installed capacity of 660 kW. The rated capacity would occur at a canal flow of 1,700 cubic feet per second which represents eighty-five percent (85%) of canal capacity.

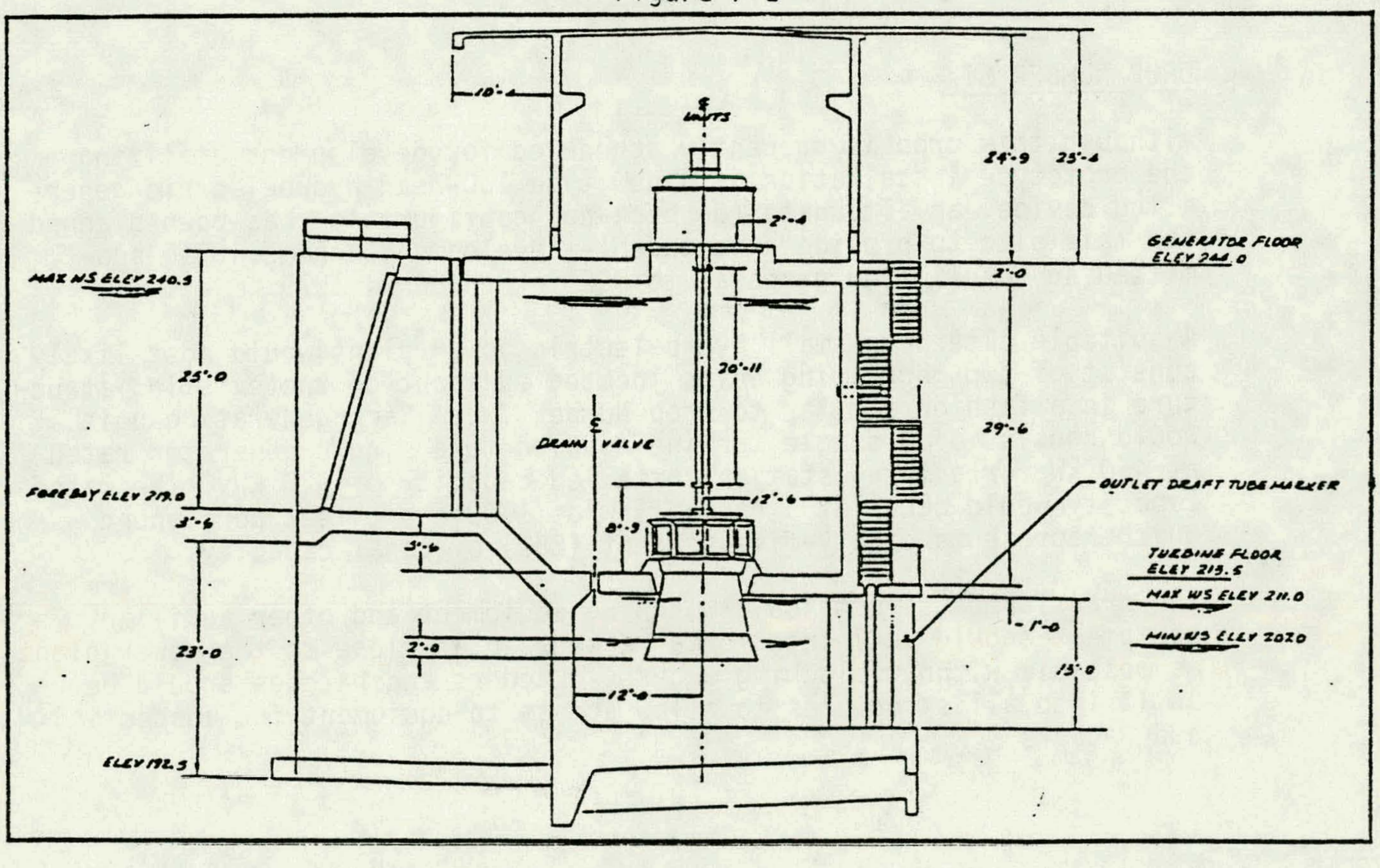
The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow for convenient, unrestricted inspection and repair of equipment.



ARCHITECTURAL RENDERING

TID MAIN CANAL DROP NUMBER ONE SMALL HYDROPOWER PLANT

Figure 7-1



CROSS SECTION, DROP NUMBER ONE POWER PLANT

Figure 7-2

7.1.1 TID Small Hydropower System (Cont'd)

DROP NUMBER TWO (cont'd)

The power plant should have stoplogs upstream of the generating units. The stoplogs would be used to isolate the power plant during shut down for inspection or repairs. The existing drop structure could then be used as a spillway to bypass water around the power plant whenever it is shut down or whenever irrigation water demands exceed the capacity of the turbines to pass water.

The power plant should be remotely monitored and controlled from TID's Broadway Control Center in Turlock. Close coordination should be maintained between the operation of the power plant and the operation of TID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual energy production is 2,073,400 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

Figure 6-2 shows the conceptual arrangement for a plant at Drop Number Two. As noted on the drawing, this arrangement could also be utilized for Drop Number Six and Drop Number Seven, thereby achieving a uniformity of site improvements and equipment.

DROP NUMBER SIX

Although this drop is presently scheduled for development utilizing the prototype installation of a new type low-head hydroelectric generating device, an alternate (or back-up) configuration has been planned for this site to provide a dependable development scheme. TID submitted an unsolicited proposal to DOE in February, 1979.

A suitable alternate small hydroelectric power plant would most likely consist of two generating units located adjacent to the existing structure in a fashion similar to Drop Number Two. Each generating unit would consist of a single turbine coupled to a single generator rated at 460 kW for a total station installed capacity of 920 kW. The rated capacity would occur at a canal flow of 1700 cubic feet per second which represents eighty-five percent (85%) of canal capacity.

The transformer, electrical switching equipment and other auxiliary equipment should be located on a raised pad as close to the power plant as possible without blocking access. Ladders and hatches should be built into all structures to allow access to equipment for inspection and repairs.

7.1 TURLOCK IRRIGATION DISTRICT (TID) (CONT'D)

7.1.1 TID Small Hydropower System (Cont'd)

DROP NUMBER SIX (cont'd)

The power plant should have stoplogs upstream of the generating units. The stoplogs would be used to isolate the power plant during shut down for inspection or repairs. The existing drop structure could then be used as a spillway to bypass water around the power plant whenever it is shut down or whenever irrigation water demands exceed the capacity of the turbines to pass water.

The power plant should be remotely monitored and controlled from TID's Broadway Control Center in Turlock. Close coordination should be maintained between the operation of the power plant and the operation of TID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual energy production is 2,902,000 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

The arrangement and configuration for this site would be similar to that for Drop Number Two as shown in Figure 6-2.

DROP NUMBER SEVEN

A suitable small hydroelectric power plant would most likely consist of two generating units located adjacent to the existing structure and outside of the existing canal. Each generating unit would consist of a single turbine coupled to a single generator rated at 350 kW for a total station installed capacity of 700 kW. The rated capacity would occur at a canal flow of 1,300 cubic feet per second which represents eighty-seven percent (87%) of canal capacity.

The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow for convenient, unrestricted inspection and repair of equipment.

The power plant should have stoplogs upstream of the generating units. The stoplogs would be used to isolate the power plant during shut down for inspection or repairs. The existing drop structure could then be used as a spillway to bypass water around the power plant whenever it is shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

7.1.1 TID Small Hydropower System (Cont'd)

DROP NUMBER SEVEN (cont'd)

The power plant will be remotely monitored and controlled from TID's Broadway Control Center in Turlock. Close coordination will be maintained between the operation of the power plant and operation of TID's irrigation system. The plant can not function as a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual energy production is 2,101,400 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

The configuration for this site would be similar to that shown for Drop Number Two in Figure 6-2.

DROP NUMBER NINE

As was done at Drop Number One, Drop Number Nine was assessed for technical and economic feasibility by TID in November, 1977. The results of this assessment indicated the site would be feasible and TID therefore advanced to the next stage of development by obtaining a power plant design.

The planned small hydroelectric power plant will consist of two hydroelectric generating units installed in a new structure for Drop Number Nine. Each of the two generating units will consist of a Leffel turbine in a flume arrangement coupled to a General Electric Company generator. Each unit will be rated at 550 kW for a total output of 1,070 kW at a flow of 1,000 cubic feet per second, which is sixty-six percent (66%) of canal capacity.

The power plant will be remotely monitored and controlled from TID's Broadway Control Center in Turlock. Close coordination will be maintained between the operation of the power plant and operation of TID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual energy production is 4,700,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

The transformer, electrical switching equipment and other auxiliary equipment will be located on a raised pad as close to the power plant as possible without blocking access. Ladders and hatches will be built into all structures to allow access to equipment for inspection and repairs.

7.1.1 TID Small Hydropower System (Cont'd)

DROP NUMBER NINE (cont'd)

The power plant will have stoplogs upstream of the generating units. The stoplogs will be used to isolate the power plant during shut down for inspection or for repairs. The units will be protected by trash racks. One hydraulically controlled slide gate will be used to by-pass water through a new by-pass conduit for irrigation purposes whenever units are shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

Construction on Drop Number Nine was started in September of 1978 and is scheduled for on-line operations beginning in July, 1979.

Figure 7-3 shows an architectural rendering of the completed power plant.

7.1.2 TID System Features

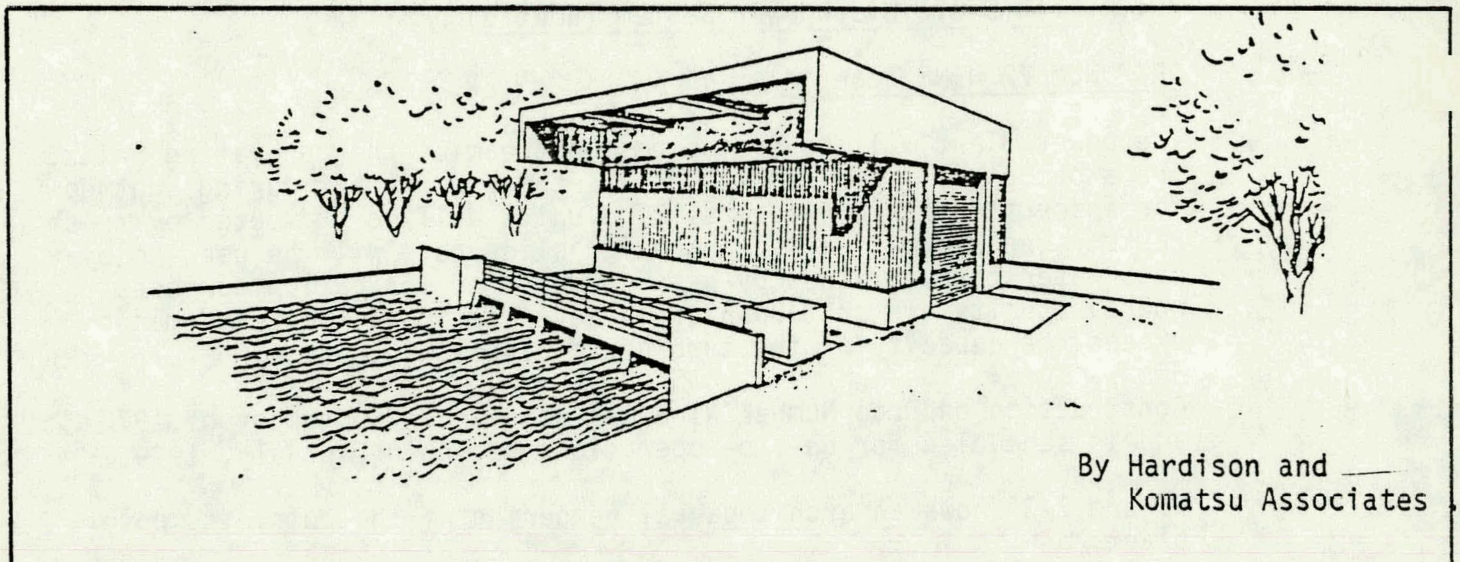
Based on the technical analysis conducted during the assessment study (Section 6.0), the project system features to TID are:

- Total installed capacity - 6,610 kW
- Total annual energy - 23,976,800 kWh
- Estimated Total Project Cost - $8,797,940
- Average Cost/kW installed - $1,331.00/kW
- Assumed Revenue @ 44 mills - $1,054,978/year
- Assumed Annual Costs - $796,969/year
- Bus Bar Energy (1982) - 33.2 mills
- Benefit-to-Cost (first year) - 1.323 to 1.0
- 30 Year Benefit-to-Cost - 3.488 to 1.0
- Annual Oil Savings - 41,480 BBLS/year.

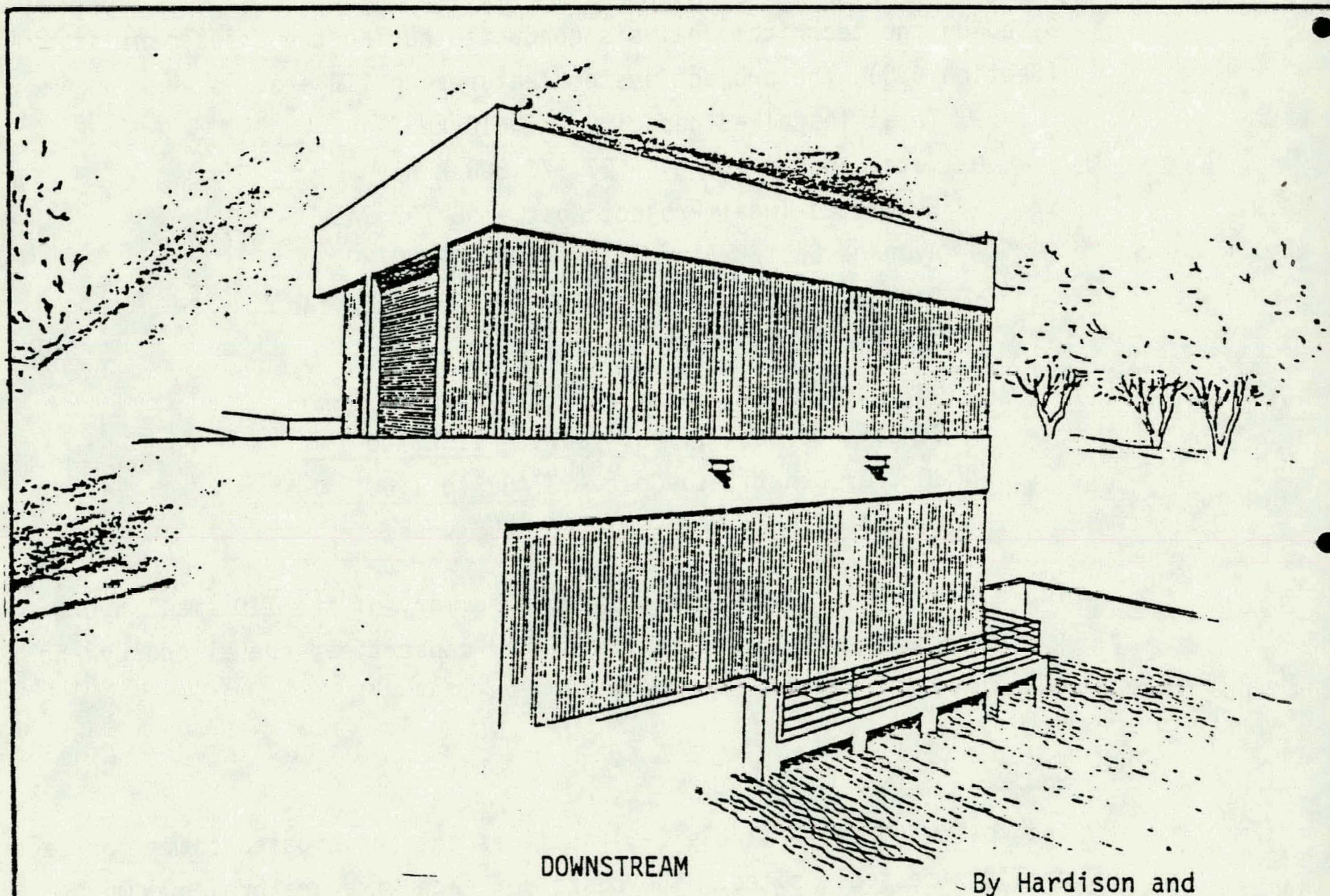
Table 7-2 is a site-by-site breakdown summary of the TID small hydropower system benefits, costs, installed capacities, annual energy and estimated oil savings.

COSTS

The following table (Table 7-3) outlines the anticipated costs for each of TID's feasible sites. The costs for each site are broken down by cost element and are given in the table. All costs and revenue are calculated on escalated 1982 prices.



UPSTREAM



DOWNSTREAM

TID DROP NUMBER NINE SMALL HYDROPOWER PLANT

Figure 7-3

TABLE 7- 2

TID SMALL HYDROPOWER SYSTEM - BREAKDOWN SUMMARY BY SITE

SITE	INSTALLED CAPACITY (KW)	ANNUAL ENERGY (KWH)	SITE COST $	COST $/KW	ANNUAL REVENUE	ANNUAL COSTS	MILLS PER KWH	BENEFIT-TO-COST	ANNUAL OIL SAVINGS
DROP NUMBER ONE	3260	12,200,000	$3,560,493	$1,092.17	$ 536,800	$322,531	26.4	1.664	21,107 BBLS/YR
DROP NUMBER TWO	660	2,073,400	1,048,247	1,588.25	91,229	94,956	45.7	.960	3,587 " "
DROP NUMBER SIX	920	2,902,000	1,313,712	1,427.95	127,688	119,004	41.0	1.072	5,020 " "
DROP NUMBER SEVEN	700	2,101,400	1,089,088	1,555.84	92,461	98,655	46.9	.937	3,635 " "
DROP NUMBER NINE	1070	4,700,000	1,786,400	1,669.53	206,800	161,823	34.4	1.277	8,131 " "
TOTALS	6610	23,976,800	$8,797,940	*	$1,054,978	$796,969	**	***	41,480 BBLS/YR

* AVERAGE COST/KW INSTALLED = $1,331.00 /KW

** AVERAGE BUS BAR ENERGY = 33.2 MILLS

*** OVERALL SYSTEM BENEFIT-TO-COST = 1.323 TO 1.0 FIRST YEAR OF OPERATION

FES

TABLE 7-3

TID SMALL HYDROPOWER SYSTEM

PROJECT COSTS AND COST ELEMENTS

SITE	INSTALLED CAPACITY (kW)	EQUIPMENT (ELECT'L/MECH'L) A	CONSTRUCTION (CIVIL/INST'L) B	ENGINEERING/ MANAGEMENT C	CONTINGENCIES (1) D	I.D.C.* (2) E	TOTAL
DROP NUMBER ONE	3260	$1,160,000	$1,252,442	$342,292	$275,473	$530,286 (3)	$3,560,493
DROP NUMBER TWO	660	495,000	275,000	92,400	86,240	99,607 (4)	1,048,247
DROP NUMBER SIX	920	690,000	275,000	115,800	108,080	124,832 (4)	1,313,712
DROP NUMBER SEVEN	700	525,000	275,000	96,000	89,600	103,488 (4)	1,089,088
DROP NUMBER NINE	1070	805,000	645,000	174,000	162,400	-0-	1,786,400
TOTALS	6610 kW	$3,675,000	$2,722,442	$820,492	$721,793	$858,213	$8,797,940

(1) CONTINGENCIES = 10% OF SUB-TOTAL OF ITEMS A + B + C.

(2) INTEREST DURING CONSTRUCTION = 7% OF SUB-TOTAL OF ITEMS A + B + C + D.

(3) FOR 2½ YEARS.

(4) FOR 1½ YEARS.

* ESTIMATED PERIOD OVERSTATED IN ORDER TO ALLOW FOR ADDED CONSTRUCTION AND MONEY MARKET CONTINGENCIES DURING PROJECT DEVELOPMENT.

7.1.2 TID System Features (Cont'd)

REVENUES/BENEFIT-TO-COST

Anticipated revenues and the calculations for the benefit-to-cost ratios are given in this section. Table 7-4 shows the escalated benefit-to-cost ratios for all TID sites combined over 30 years.

- Benefit-to-Cost Analysis

Drop Number One

- Annual Revenue
  12.2 million kWh/year X 44 mills** = $536,800
- Annual Cost
  $3,560,493 X .0805864 = $286,927
  Operation and Maintenance = 35,604
  Annual Costs $322,531
- Bus Bar Energy (1982) = 26.4 mills
- Benefit-to-Cost = 1.664 to 1.0

Drop Number Two

- Annual Revenue
  2,073,400 kWh/year X 44 mills** = $ 91,229
- Annual Cost
  $1,048,247 X .0805864 $ 84,474
  Operation and Maintenance = 10,482
  Annual Costs $ 94,956
- Bus Bar Energy (1982) = 45.7 mills
- Benefit-to-Cost = .960 to 1.0

** Based on State of California Energy Commission values (See Section 8.5).

TABLE 7-4

TID ESCALATED BENEFIT-TO-COST TOTAL PROJECT COST = $8,797,940 @ 7% FOR 30 YEARS			
YEAR	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
	796,969	escalated @ 6%/yr.	
1		1,054,978	1.324 to 1.000
2		1,118,277	
3		1,185,373	
4		1,256,496	
5		1,331,885	
5-YR TOTAL	3,984,845	5,947,009	1.492 to 1.000
6		1,411,799	
7		1,496,506	
8		1,586,297	
9		1,681,475	
10		1,782,363	
10-YR TOTAL	7,969,690	13,905,449	1.745 to 1.000
11		1,889,305	
12		2,002,663	
13		2,122,823	
14		2,250,192	
15		2,385,264	
15-YR TOTAL	11,954,535	24,555,636	2.054 to 1.000
16		2,528,316	
17		2,680,015	
18		2,840,816	
19		3,011,265	
20		3,191,941	
20-YR TOTAL	15,939,380	38,807,989	2.435 to 1.000
21		3,383,457	
22		3,586,465	
23		3,801,653	
24		4,029,752	
25		4,271,537	
25-YR TOTAL	19,924,225	57,880,853	2.905 to 1.000
26		4,527,829	
27		4,799,499	
28		5,087,469	
29		5,392,717	
30		5,716,280	
30-YR TOTAL	23,909,070	83,404,647	3.488 to 1.000

7.1.2 TID System Features (Cont'd)

REVENUES/BENEFIT-TO-COST (cont'd)

Benefit-to-Cost Analysis (cont'd)

Drop Number Six

- Annual Revenue
  2,902,000 kWh/year X 44 mills** = $127,688

- Annual Cost

$1,313,712 X .0805864 =	$105,867
Operation and Maintenance =	13,137
Annual Costs	$119,004

- Bus Bar Energy (1982) = 41.0 mills

- Benefit-to-Cost = 1.072 to 1.0

Drop Number Seven

- Annual Revenue
  2,101,400 kWh/year X 44 mills** = $ 92,461

- Annual Cost

$1,089,088 X .0805864 =	$ 87,765
Operation and Maintenance =	10,890
Annual Costs	$ 98,655

- Bus Bar Energy (1982) = 46.9 mills

- Benefit-to-Cost = .937 to 1.0

Drop Number Nine

- Annual Revenue
  4,700,000 kWh/year X 44 mills** = $206,800

- Annual Cost

$1,786,400 X .0805864 =	$143,959
Operation and Maintenance =	17,864
Annual Costs	$161,823

- Bus Bar Energy (1982) = 34.4 mills

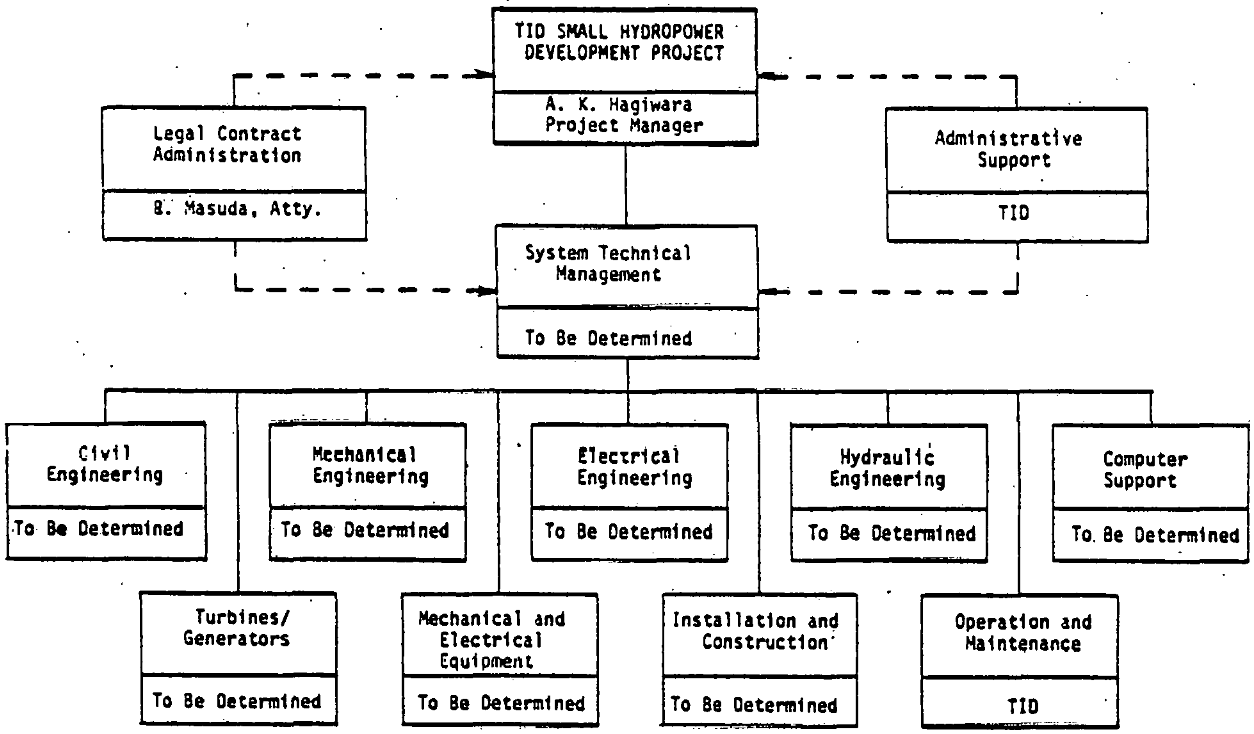
- Benefit-to-Cost = 1.277 to 1.0

** Based on State of California Energy Commission values (See Section 8.5).

7.1.3 Phased Site Installation Plan

TID has established a phased site installation procedure for those sites which demonstrate economic and environmental feasibility. This installation plan is based on the "Typical Site Development Project Management Plan" described in Appendix 8.1.

TID has established a small hydropower development project office with Mr. A. K. Hagiwara designated as the Project Manager (see Figure 7-4). The Project Office and Project Manager will be supported by legal and administrative support from within TID's staff.



TURLOCK IRRIGATION DISTRICT • SMALL HYDROPOWER DEVELOPMENT PROJECT ORGANIZATION

Figure 7-4

7.1.3 Phased Site Installation Plan (Cont'd)

The Plan has proposed that:

- All civil, mechanical, electrical and hydraulic engineering be conducted by selected outside engineering consultants;
- Turbines and generators, plus mechanical/electrical equipment and controls, be purchased through the competitive bidding process;
- Civil works construction and equipment installation contractors be selected by the competitive bid process; and
- The on-line operations and maintenance be conducted by TID which presently operates the New Don Pedro power plant, the La Grange power plant and the Broadway Control Center for electrical power distribution.

Development Schedules

The estimated TID on-line power development schedule is illustrated in Figure 7-5. This schedule calls for the following site/on-line operations:

- Drop Number Nine
  Construction started September 1978
  On-line operations - July 1979.

- Drop Number One
  Engineering completed - April 1979
  Construction started - May 1979
  On-line operations - August 1980.

7.1.3 Phased Site Installation Plan (Cont'd)

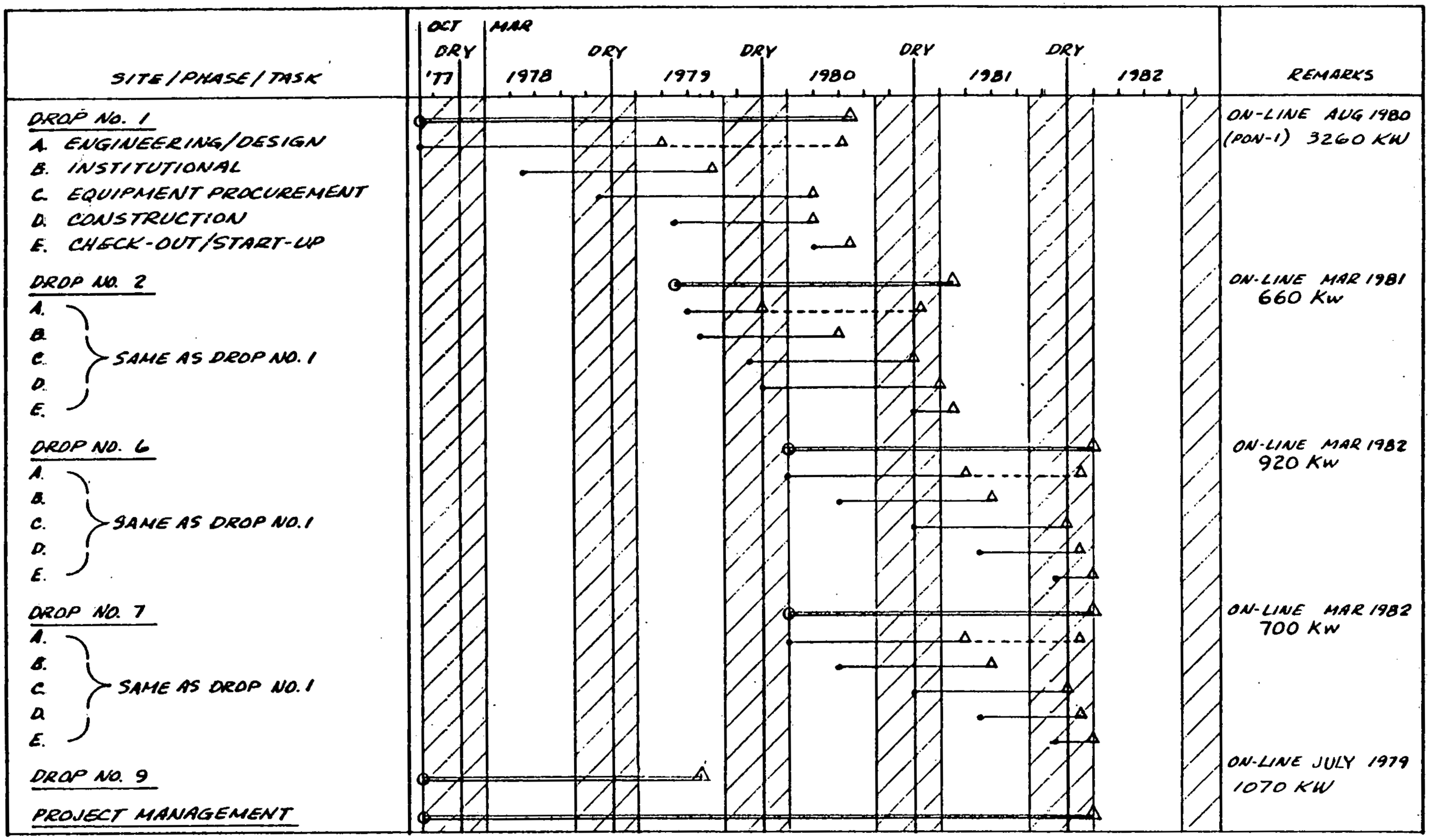
Development Schedules (cont'd)

- Drop Number Two
  Project Start - April 1979
  Construction Start - January 1980
  On-line operations - March 1981

- Drops Numbers Six[1] and Seven
  Project Start - March 1980
  Construction Start - January 1981
  On-line operations - March 1982

This development schedule is based on estimated equipment and materials delivery schedules, weather contingencies, and irrigation water operations. It is planned that all of the selected TID sites can be engineered, constructed, equipment installed and on-line operation started by March, 1982.

1 This schedule to be considered alternate for planned prototype installation of new type low-head hydroelectric generating device at Drop Number Six.



TURLOCK IRRIGATION DISTRICT

HYDROPOWER SYSTEM DEVELOPMENT SCHEDULE

Figure 7-5

7.2 MERCED IRRIGATION DISTRICT (MERCED)

The Merced Irrigation District is an irrigation district organized in 1919 under the California Water Code. Controlled by a Board of Dirctors elected by the registered voters of the district, its primary function is to supply irrigation water to the 154,394 acres within its boundaries. Additionally, the irrigation district takes part in operating and maintaining drainage, power generation, flood control and recreation facilities. Unlike Turlock Irrigation District, Merced does not provide electrical service within its service area on a retail basis.

The Merced Irrigation District's principal source of revenue is a combination of taxation of real property without improvements and water sales.

Water for the District is supplied by the Merced River. Merced Irrigation District is the sole owner of New Exchequer Dam completed in 1967 and McSwain Dam completed in 1966 on the Merced River. Facilities at both dams include power plants, the energy from which is wholesaled to the area's electrical utility, PG&E.

The annual costs of Merced's storage and power facilities are recovered through the energy revenue received from PG&E.

7.2.1 Merced Small Hydropower System

The sites which constitute the Merced "Small Hydropower System" are situated on the Merced Main Canal and consist of four (4) economically and environmenatlly feasible sites. The four (4) sites will have a total installed capacity of 4,980 kilowatts (kW) providing an average of 16,062,000 kilowatthours (kWh) of energy annually during the seven (7) month irrigation season. This annual energy would be equal to saving 27,788 barrels of oil per year. Table 7-5 presents a summary of essential site parameters: installed capacity (kW), annual energy (kWh) and barrels of oils which would be saved.

7.2.1 Merced Small Hydropower System (Cont'd)

TABLE 7-5

MERCED SMALL HYDROPOWER SYSTEM

SITE	INSTALLED CAPACITY (kW)	ANNUAL ENERGY (kWh)	OIL SAVINGS (BBLS/Year)
Main Canal	2,800	9,169,000	15,863
Canal Creek	940	3,262,000	5,643
Fairfield Drop	970	2,809,000	4,860
Escaladian	270	822,000	1,422
TOTALS	4,980	16,062,000	27,788*

* at $18.75/BBL., this would equal $521,025/year savings.

MAIN CANAL

A suitable small hydroelectric power plant would most likely consist of two hydroelectric generating units in a new drop structure for the Main Canal. Each of the two generating units would consist of a sliding gate bulb type turbine coupled to a generator. Each unit will be rated at 1,400 kW for a total station installed capacity of 2,800 kW at a canal flow rate of 1,900 cubic feet per second, which is ninety-one percent (91%) of canal capacity.

The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow convenient, unrestricted inspection and repair of equipment.

The power plant would have stoplogs upstream of the generating units. The stoplogs would be used to isolate the power plant during shut down for inspection and repairs. The units would be protected by trash racks. The power plant would utilize a peripheral spillway to bypass water whenever units are shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

7.2.1 Merced Small Hydropower System (Cont'd)

MAIN CANAL (cont'd)

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and the operation of Merced's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 9,169,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

Figure 6-4 shows a conceptual installation scheme for a sliding gate-bulb type turbine and generator, with a by-pass and associated power house and equipment.

CANAL CREEK

A suitable small hydroelectric power plant would most likely consist of one hydroelectric generating unit installed at the terminus of a new penstock connecting Canal Creek to the Main Canal. The generating unit could consist of an in-line bulb-type turbine/generator. The unit would be rated at 940 kW at a flow of 380 cubic feet per second.

The transformer, electrical switching equipment and other auxiliary equipment will be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow convenient, unrestricted inspection and repair of equipment.

The power plant should have a flow regulation device upstream of the generating units. The regulation device could also be used then to isolate the equipment during shutdown for inspection or repairs. The unit should be protected by trash racks. The power plant should incorporate a bypass feature. One hydraulically controlled slide gate will bypass water for irrigation purposes whenever the unit is shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination will be maintained between the operation of the power plant and operation of Merced's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 3,262,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

CANAL CREEK (cont'd)

Figure 6-6 shows the site plan for the Canal Creek site including the diversion works location, pipeline, and power plant locations. Figure 6-7 shows the conceptual installation of a bulb-type turbine and generator with a bypass and associated power house equipment.

FAIRFIELD DROP

A suitable small hydroelectric power plant could be identical in its configuration to the configuration proposed at Canal Creek, the only difference being its rated capacity; the two sites are extremely similar. The generating unit would be rated at 970 kW at a flow of 420 cubic feet per second.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and the operation of Merced's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 2,809,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

Figure 6-8 shows the site plan for the Fairfield Drop site including the diversion works location, penstock and power plant location. The turbine/generator, by-pass and associated power house would be identical to Canal Creek as shown in Figure 6-7.

ESCALADIAN HEADWORKS

A suitable small hydroelectric power plant would most likely consist of one hydroelectric generating unit next to the existing Escaladian Headworks control structure. The generating unit would consist of a single turbine coupled to a single generator. The unit would be rated at 270 kW at a flow rate of 230 cubic feet per second.

Electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow convenient, unrestricted inspection and repair of equipment.

The power plant would require a flow regulation device upstream of the generating unit. The unit would be protected by trash racks. The power plant would utilize the existing control structure to bypass water around the generating unit for irrigation purposes whenever

7.2.1 Merced Small Hydropower System (Cont'd)

ESCALADIAN HEADWORKS (cont'd)

irrigation water demands exceed the capacity of the turbine to pass water.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and the operation of Merced's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 822,000 kWh assuming plant operation during the irrigation season only (March 15 through October 15 of each year).

Figure 6-2 shows a conceptual arrangement of a planned power plant at Drop Number Two. The configuration at Escaladian Headworks would be somewhat similar.

7.2.2 Merced System Features

Based on the technical analysis conducted during the Assessment Study (Section 6.0), the Project's major features and benefits to Merced are:

- Total installed capacity - 4,980 kW
- Total annual energy - 16,062,000 kWh
- Estimated total project cost - $6,578,591
- Average Cost/kW installed - $1,396.70/kW
- Assumed Revenue @ 44 mills = $706,728/year
- Assumed Annual Costs - $595,929/year
- Bus Bar Energy (1982) - 37.1 mills
- Benefit-to-Cost (First Year) - 1.185 to 1.0
- 30-Year Benefit-to-Cost - 3.125 to 1.0
- Annual Oil Savings - 27,788 barrels/year.

Table 7-6 is a site-by-site breakdown summary of the Merced small hydropower system benefits, costs, installed capacities, annual energy and estimated oil savings for the nation.

TABLE 7-6

MERCED SMALL HYDROPOWER SYSTEM - BREAKDOWN SUMMARY BY SITE

SITE	INSTALLED CAPACITY (KW)	ANNUAL ENERGY (KWH)	SITE COST $	COST $/KW	ANNUAL REVENUE	ANNUAL COSTS	MILLS PER KWH	BENEFIT-TO-COST	ANNUAL OIL SAVINGS
MAIN CANAL	2800	9,169,000	$3,660,690	$1,307.38	$403,436	$331,608	36.1	1.216	15,863 BBLS/YR
CANAL CREEK	940	3,262,000	1,274,232	1,355.56	143,528	115,427	35.3	1.243	5,643 " "
FAIRFIELD DROP	970	2,809,000	1,183,702	1,220.31	123,596	107,228	38.1	1.153	4,860 " "
ESCALADIAN HEADWORKS	270	822,000	459,967	1,703.58	36,168	41,666	50.6	.868	1,422 " "
TOTALS	4980	16,062,000	$6,578,591	*	$706,728	$595,929	**	***	27,788 BBLS/YR

* AVERAGE COST/KW INSTALLED = $1,396.70/KW

** AVERAGE BUS BAR ENERGY = 37.1 MILLS

*** OVERALL SYSTEM BENEFIT-TO-COST = 1.185 TO 1.0 FIRST YEAR OF OPERATION

7.2.2 Merced System Features (Cont'd)

COSTS

The following table (Table 7-7) outlines the anticipated costs for each of Merced's feasible sites. The costs for each site are broken down by cost element and are given in the table. All costs and revenues are calculated on escalated 1982 prices.

REVENUES/BENEFIT-TO-COST

Anticipated revenues and the calculations for the benefit-to-cost ratios are given in this section. Table 7-8 shows the escalated benefit-to-cost ratios for all Merced sites combined over 30 years.

- Benefit-to-Cost Analysis

Main Canal

- Annual Revenue
  9,169,000 kWh/year X 44 mills** = $403,436
- Annual Cost
  $3,660,690 X .0805864 = $295,002
  Operation and Maintenance = 36,606
  Annual Costs $331,608
- Bus Bar Energy (1982) = 36.1 mills
- Benefit-to-Cost = 1.216 to 1.0

Canal Creek

- Annual Revenue
  3,262,000 kWh/year X 44 mills** = $143,528
- Annual Cost
  $1,274,232 X .0805864 = $102,685
  Operation and Maintenance = 12,742
  Annual Costs $115,427
- Bus Bar Energy (1982) = 35.3 mills
- Benefit-to-Cost = 1.243 to 1.0

** Based on State of California Energy Commission values (Section 8.5).

FES

TABLE 7-7

MERCED SMALL HYDROPOWER SYSTEM

PROJECT COSTS AND COST ELEMENTS

SITE	INSTALLED CAPACITY (kW)	EQUIPMENT (ELECT'L/MECH'L) A	CONSTRUCTION (CIVIL/INST'L) B	ENGINEERING/ MANAGEMENT C	CONTINGENCIES (1) D	I.D.C.* (2) E	TOTAL
MAIN CANAL	2800	$1,313,200	$1,215,600	$303,456	$283,225	$545,209 (3)	$3,660,690
CANAL CREEK	940	611,000	325,000	112,320	104,832	121,080 (4)	1,274,232
FAIRFIELD DROP	970	630,500	239,000	104,340	97,384	112,478 (4)	1,183,702
ESCALADIAN HEADWORKS	270	202,500	125,000	39,300	36,680	56,487 (5)	459,967
TOTALS	4980 kW	$2,757,200	$1,904,600	$559,416	$522,121	$835,254	$6,578,591

(1) CONTINGENCIES = 10% OF SUB-TOTAL OF ITEMS A + B + C.

(2) INTEREST DURING CONSTRUCTION = 7% OF SUB-TOTAL OF ITEMS A + B + C + D.

(3) FOR 2½ YEARS.

(4) FOR 1½ YEARS.

(5) FOR 2 YEARS.

* ESTIMATED PERIOD OVERSTATED IN ORDER TO ALLOW FOR ADDED CONSTRUCTION AND MONEY MARKET CONTINGENCIES DURING PROJECT DEVELOPMENT

TABLE 7-8

MERCED ESCALATED BENEFIT-TO-COST TOTAL PROJECT COST - $6,578,591 @ 7% FOR 30 YEARS			
YEAR	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
	595,929	escalated @ 6%/yr.	
1		706,728	1.186 to 1.000
2		749,132	
3		794,080	
4		841,724	
5		892,228	
5-YR TOTAL	2,979,645	3,983,891	1.337 to 1.000
6		945,761	
7		1,002,507	
8		1,062,658	
9		1,126,417	
10		1,194,002	
10-YR TOTAL	5,959,290	9,315,237	1.563 to 1.000
11		1,265,642	
12		1,341,581	
13		1,422,076	
14		1,507,400	
15		1,597,844	
15-YR TOTAL	8,938,935	16,449,780	1.840 to 1.000
16		1,693,715	
17		1,795,338	
18		1,903,058	
19		2,017,241	
20		2,138,276	
20-YR TOTAL	11,918,580	25,997,407	2.181 to 1.000
21		2,266,572	
22		2,402,567	
23		2,546,721	
24		2,699,524	
25		2,861,495	
25-YR TOTAL	14,898,225	38,774,287	2.603 to 1.000
26		3,033,185	
27		3,215,176	
28		3,408,087	
29		3,612,572	
30		3,829,326	
30-YR TOTAL	17,877,870	55,872,634	3.125 to 1.000

7.2 MERCED IRRIGATION DISTRICT (MERCED) CONT'D)

7.2.2 Merced System Features (Cont'd)

REVENUES/BENEFIT-TO-COST (cont'd)

Benefit-to-Cost Analysis (cont'd)

Fairfield Drop

- Annual Revenue
  2,809,000 kWh/year X 44 mills** = $123,596

- Annual Cost

$1,183,702 X .0805864 =	$ 95,391
Operation and Maintenance =	11,837
Annual Costs	$107,228

- Bus Bar Energy (1982) = 38.1 mills

- Benefit-to-Cost = 1.153 to 1.0

Escaladian Headworks

- Annual Revenue
  822,00 kWh/year X 44 mills** = $ 36,168

- Annual Cost

$459,967 X .0805864 =	$ 37,067
Operation and Maintenance =	4,599
Annual Costs	$ 41,666

- Bus Bar Energy (1982) = 50.6 mills

- Benefit-to-Cost = .868 to 1.0

** Based on State of California Energy Commission values (Section 8.5).

7.2.3 Phased Site Installation Plan

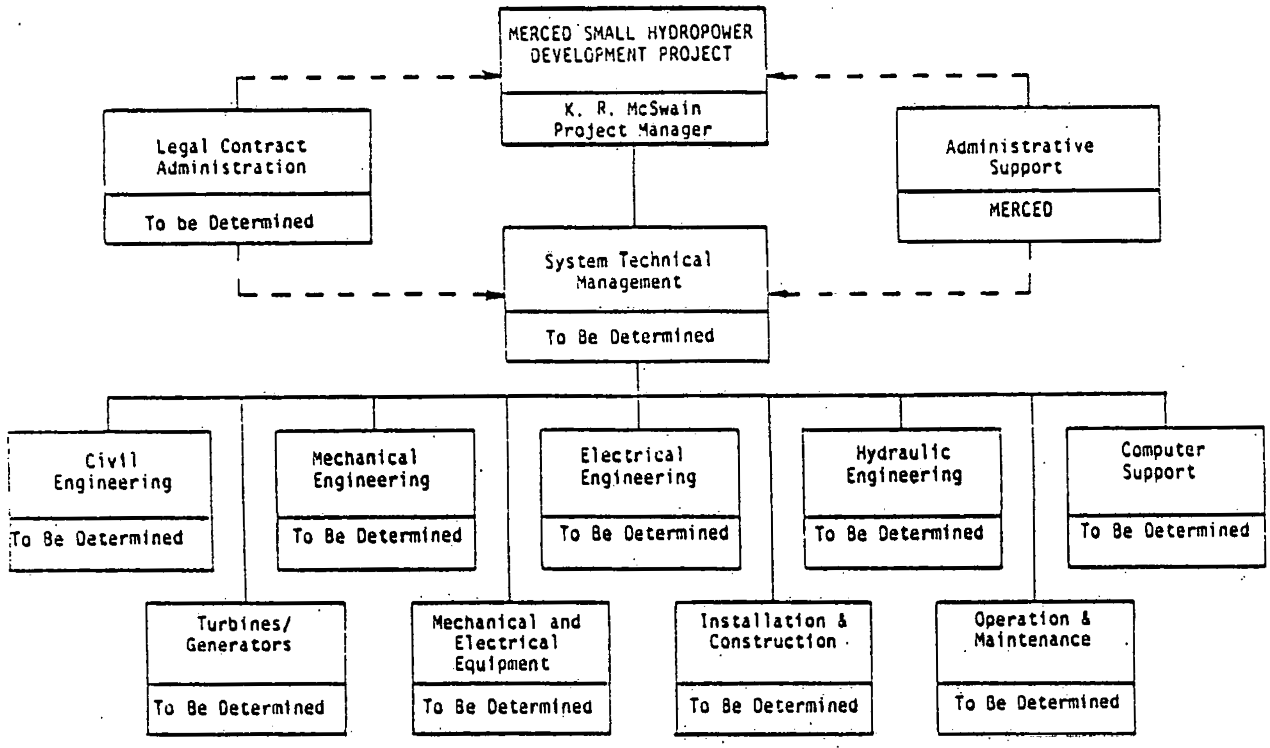
Merced has established a phased site installation procedure for those sites which demonstrate economic and environmental feasibility. This installation plan is based on the "Typical Site Development Project Management Plan" described in Appendix 8.1.

Merced has established a small hydropower development project office with Mr. K. R. McSwain designated as the Project Manager (See Figure 7-6). The project office and project manager will be supported by

FES

7.2.3 Phased Site Installation Plan (Cont'd)

legal and administrative support from within Merced's staff.



MERCED IRRIGATION DISTRICT - SMALL HYDROPOWER DEVELOPMENT PROJECT ORGANIZATION

Figure 7-6

The plan proposes that:

- All civil, mechanical, electrical and hydraulic engineering be conducted by selected outside engineering consultants;

- Turbines and generators plus mechanical/electrical equipment and controls be purchased through the competitive bidding process;

- Civil works construction and equipment installation contractors be selected by the competitive bid process; and

7.2 MERCED IRRIGATION DISTRICT (MERCED) (CONT'D)

7.2.3 Phased Site Installation Plan (Cont'd)

- The on-line operations and maintenance be conducted by the power purchaser's work force.

Development Schedules

The Merced estimated on-line power development schedule is illustrated in Figure 7-7. This schedule calls for the following site/on-line operations:

- Main Canal
  Project Start - March 1979
  Construction Start - October 1980
  On-line operation - March 1982

- Canal Creek
  Project Start - June 1979
  Construction Start - October 1979
  On-line operations - March 1981

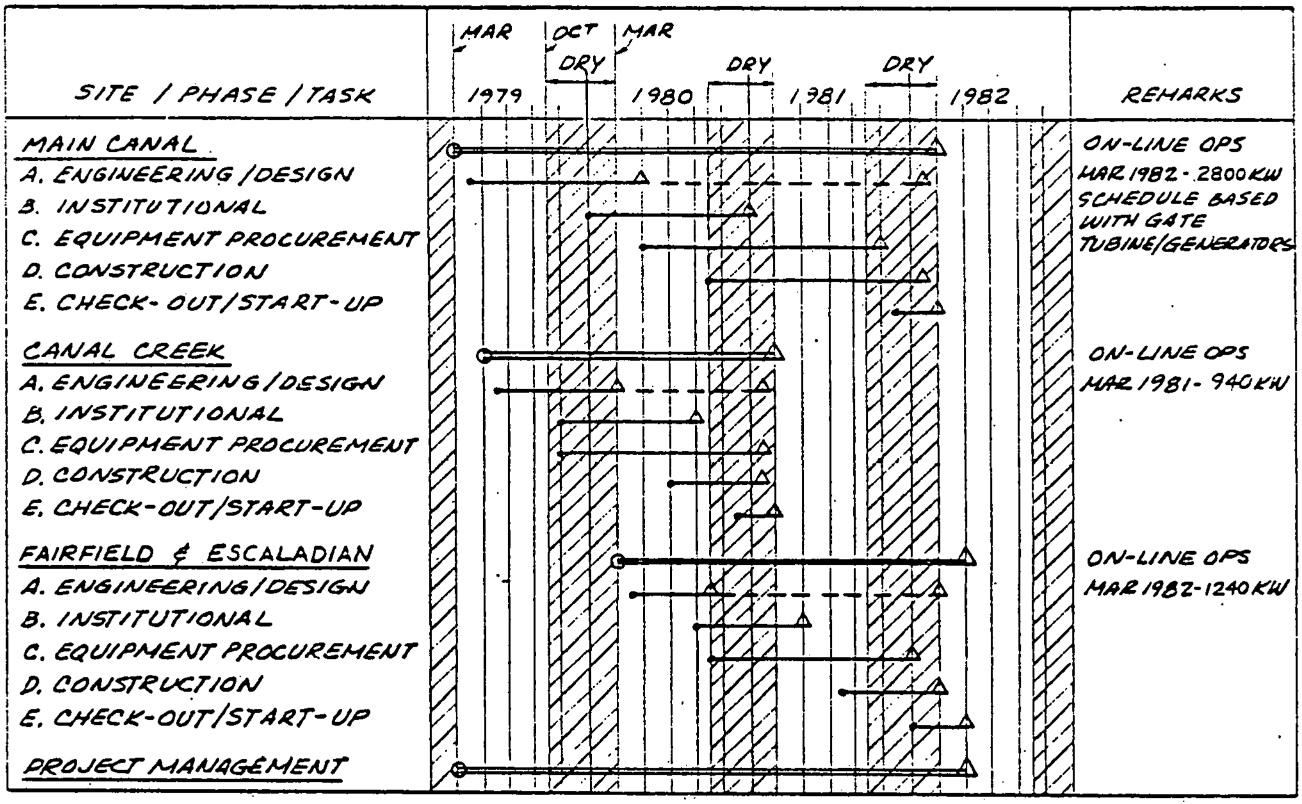
- Fairfield Drop
  Project Start - March 1980
  Construction Start - October 1981
  On-line operations - March 1982

- Escaladian Headworks
  Project Start - March 1980
  Construction Start - October 1981
  On-line operations - March 1982

This development schedule is based on estimated equipment and material delivery schedules, weather contingencies and irrigation water operations. It is planned that all of the selected Merced sites could be engineered, constructed, equipment installed and on-line operations started by March 1982.

7.2 MERCED IRRIGATION DISTRICT (MERCED) (CONT'D)

7.2.3 Phased Site Installation Plan (Cont'd)



MERCED IRRIGATION DISTRICT

HYDRO POWER SYSTEM DEVELOPMENT SCHEDULE

Figure 7-7

7.3 SOUTH SAN JOAQUIN IRRIGATION DISTRICT (SSJID)

Established in 1909 as an irrigation district by the Water Code of the State of California, governed by a locally elected five-member Board of Directors, the District provides irrigation water for 72,000 acres of farmland in the northern section of the San Joaquin Valley.

The District has constructed an irrigation system consisting of three (3) major storage reservoirs, a major regulating reservoir, four hydroelectric plants, a diversion dam and reservoir, a canal transmission system and a pipeline distribution system. Water supplied by the Stanislaus River is controlled by the Tri-Dam Project (Tulloch, Beardsley and Donnells Dams) and Goodwin Diversion Dam, all of which are jointly owned by the South San Joaquin and Oakdale Irrigation Districts.

7.3.1 SSJID Small Hydropower System

The SSJID "Small Hydropower System" on the Main Canal from Goodwin Dam to the Woodward Reservoir outlet consists of three (3) economically and environmentally feasible sites. The three (3) sites would have a total installed capacity of 7,970 kilowatts (kW) providing an average of 28,523,000 kilowatthours (kWh) of energy annually during the seven (7) month irrigation season. This annual energy would be equal to saving 49,348 barrels of oil per year.

Table 7-9 presents a summary of essential site parameters: installed capacity (kW), annual energy (kWh) and barrels of oil which would be saved.

WOODWARD RESERVOIR

A suitable small hydroelectric power plant would most likely consist of one hydroelectric generating unit at the existing outlet structure for Woodward Reservoir. The generating unit would consist of an in-line bulb-type turbine/generator. The unit would be rated at 2,300 kW.

7.3.1 SSJID Small Hydropower System (Cont'd)

TABLE 7-9

SSJID SMALL HYDROPOWER SYSTEM			
SITE	INSTALLED CAPACITY (kW)	ANNUAL ENERGY (kWh)	OIL SAVINGS (BBLS./YEAR)
Woodward Reservoir	2,300	6,906,000	11,948
Frankenheimer	4,700	16,962,000	29,346
Goodwin Dam	970	4,655,000	8,054
TOTALS	7,970	27,523,000	49,348*
* at $18.75/BBL., this would equal $925,275/year savings.			

WOODWARD RESERVOIR (cont'd)

The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be provided in all structures to allow for convenient, unrestricted inspection and repairs of equipment.

The power plant flow would be regulated by the controls of the existing reservoir outlet tower. A bifurcation of the outlet penstock immediately ahead of the power plant would be used to bypass water for irrigation purposes whenever the unit is shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and operation of SSJID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 6,906,000 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

Appendix 8.3 shows the conceptual arrangement of a single bulb-type turbine/generator power plant at Woodward Reservoir. Section 8.3 also illustrates an alternate two-tube turbine/generator configuration and site plan.

7.3.1 SSJID Small Hydropower System (Cont'd)

WOODWARD RESERVOIR (cont'd)

All data on Woodward Reservoir is based on a proposal report submitted to SSJID in June, 1978.

ERANKENHEIMER

A suitable small hydroelectric power plant would most likely consist of one hydroelectric generating unit on a relocated portion of the Main Canal above Woodward Reservoir. The generating unit would consist of a standard vertical Francis type turbine coupled to an overhead generator. The unit would be rated at 4,700 kW at a flow of 900 cubic feet per second.

Development of the site would require the relocation of a portion of the existing canal to a power plant forebay at a suitable site. A penstock would deliver water from the forebay to the power house located near the existing canal. A tailrace would then conduct water from the power plant back to the main canal.

The power plant structure and associated equipment would be of conventional vertical Francis turbine configuration similar to that shown in Section 8.3. The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned as close to the power plant as possible without blocking access. Adequate access should be built into all structures to allow convenient, unrestricted inspection and repair of equipment.

The unit will be protected by trash racks. A bifurcation of the penstock ahead of the power plant would be used to bypass water for irrigation purposes whenever the unit is shut down or whenever irrigation water demands exceed the capacity of the turbine to pass water.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and the operation of SSJID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 16,962,000 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

GOODWIN DAM JOINT CANAL HEADWORKS (NORTH SIDE)

A suitable small hydroelectric power plant would most likely consist of one hydroelectric generating unit at the existing irrigation outlet structure at the north side of Goodwin Dam. The generating unit would consist of a sliding gate-bulb type turbine generator. The unit would be rated at 970 kW at a flow of 1,200 cubic feet per second.

The transformer, electrical switching equipment and other auxiliary equipment should be located on a concrete pad positioned close to the power plant if possible. Adequate access should be provided in all structures to allow convenient, unrestricted inspection and repair of equipment.

The unit will be protected by trash racks. The turbine/generator would be an integral part of a large slide gate which could be raised to pass water for irrigation purposes whenever the unit is inoperative.

The power plant should be remotely monitored and controlled from the power purchaser's control center. Close coordination should be maintained between the operation of the power plant and the operation of SSJID's irrigation system. The plant can not be a peaking plant as the loading will be dictated by irrigation demands only.

The estimated annual kilowatthour output is 4,655,000 kWh assuming plant operation during the irrigation season only (March 15 to October 15 of each year).

Figure 6-11 shows a planned conceptual power plant arrangement, including the sliding gate bulb turbine/generator, gate mechanism, power plant structure and associated equipment.

7.3.2 SSJID System Features

Based on the technical analysis conducted during the Assessment Study (Section 6.0), the project benefits to SSJID are:

- Total installed capacity - 7,970 kW
- Total annual energy - 28,523,000 kWh
- Estimated Total Project Cost - $10,050,565
- Average Cost/kW installed - $1,261.05/kW
- Assumed Revenue @ 44 mills - $1,255,012/year
- Assumed Annual Costs - $910,443/year
- Bus Bar Energy (1982) - 31.9 mills
- Benefit-to-Cost (First Year) - 1.378 to 1.0
- 30-Year Benefit-to-Cost - 3.633 to 1.0
- Annual Oil Savings - 49,348 barrels/year

7.3.2 SSJID System Features (Cont'd)

Table 7-10 is a site-by-site breakdown summary of the SSJID small hydropower system benefits, costs, installed capacities, annual energy, and estimated oil savings for the nation.

COSTS

The following table (Table 7-11) outlines the anticipated costs for each of SSJID's feasible sites. The costs for each site are broken down by cost element and are given in the table. All costs and revenue are calculated on escalated 1982 prices.

REVENUES/BENEFIT-TO-COST

Anticipated revenues and the calculations for the Benefit-to-Cost ratios are given in this section. Table 7-12 shows the escalated benefit-to-cost ratios for all SSJID sites combined over 30 years.

- Benefit-to-Cost Analysis

Woodward Dam

- Annual Revenue
  6,906,000 kWh/year X 44 mills** = $303,864
- Annual Cost
  $2,537,193 X .0805864 = $204,463
  Operation and Maintenance = 25,372
  Annual Costs $229,835
- Bus Bar Energy (1982) = 33.3 mills
- Benefit-to-Cost = 1.322 to 1.0

** Based on State of California Energy Commission values (Section 8.5).

TABLE 7-10

SSJID SMALL HYDROPOWER SYSTEM - BREAKDOWN SUMMARY BY SITE

SITE	INSTALLED CAPACITY (KW)	ANNUAL ENERGY(KWH)	SITE COST $	COST $/KW	ANNUAL REVENUE	ANNUAL COSTS	MILLS PER KWH	BENEFIT-TO-COST	ANNUAL OIL SAVINGS
WOODWARD DAM	2300	6,906,000	$ 2,537,193	$1,103.12	$303,864	$229,835	33.3	1.322	11,948 BBLS/YR
FRANKENHEIMER	4700	16,962,000	6,006,110	1,277.89	746,328	544,071	32.0	1.372	29,346 " "
GOODWIN DAM	970	4,655,000	1,507,262	1,553.88	204,820	136,537	29.3	1.500	8,054 " "
TOTALS	7970	28,523,000	$10,050,565	*	$1,255,012	$910,443	**	***	49,348 BBLS/YR

* AVERAGE COST/KW INSTALLED = $1,261.05/KW

** AVERAGE BUS BAR ENERGY = 31.9 MILLS

*** OVERALL SYSTEM BENEFIT-TO-COST = 1.378 TO 1.0 FIRST YEAR OF OPERATION

TABLE 7-11

SSJID SMALL HYDROPOWER SYSTEM

PROJECT COSTS AND COST ELEMENTS

SITE	INSTALLED CAPACITY (kW)	EQUIPMENT (ELECT'L/MECH'L) A	CONSTRUCTION (CIVIL/INST'L) B	ENGINEERING/ MANAGEMENT C	CONTINGENCIES (1) D	I.D.C.* (2) E	TOTAL
WOODWARD DAM	2300	$ 981,500	$ 825,000	$216,780	$202,328	$ 311,585 (3)	$ 2,537,193
FRANKENHEIMER	4700	1,410,000	2,619,000	483,480	451,248	1,042,382 (4)	6,006,110
GOODWIN DAM	970	630,500	550,000	141,660	(5)	185,102 (3)	1,507,262
TOTALS	7970 kW	$3,022,000	$3,994,000	$841,920	$653,576	$1,539,069	$10,050,565

(1) CONTINGENCIES = 10% OF SUB-TOTAL OF ITEMS A + B + C.

(2) INTEREST DURING CONSTRUCTION = 7% OF SUB-TOTAL OF ITEMS A + B + C + D.

(3) FOR 2 YEARS.

(4) FOR 3 YEARS.

(5) FIGURED INTO ITEM B.

* ESTIMATED PERIOD OVERSTATED IN ORDER TO ALLOW FOR ADDED CONSTRUCTION AND MONEY MARKET CONTINGENCIES DURING PROJECT DEVELOPMENT.

TABLE 7-12

SSJID ESCALATED BENEFIT-TO-COST

TOTAL PROJECT COST = $10,050,565 @ 7% FOR 30 YEARS

YEAR	ANNUAL COST	REVENUE/YEAR	BENEFIT-TO-COST
	910,443	escalated @ 6%/yr.	
1		1,255,012	1.378 to 1.000
2		1,330,313	
3		1,410,131	
4		1,494,739	
5		1,584,424	
5-YR TOTAL	4,552,215	7,074,619	1.554 to 1.000
6		1,679,489	
7		1,780,259	
8		1,887,074	
9		2,000,298	
10		2,120,316	
10-YR TOTAL	9,104,430	16,542,056	1.817 to 1.000
11		2,247,535	
12		2,382,387	
13		2,525,331	
14		2,676,851	
15		2,837,462	
15-YR TOTAL	13,656,645	29,211,622	2.139 to 1.000
16		3,007,709	
17		3,188,172	
18		3,379,462	
19		3,582,230	
20		3,797,164	
20-YR TOTAL	18,208,860	46,166,358	2.535 to 1.000
21		4,024,994	
22		4,266,493	
23		4,522,483	
24		4,793,832	
25		5,081,462	
25-YR TOTAL	22,761,075	68,855,621	3.025 to 1.000
26		5,386,349	
27		5,709,530	
28		6,052,102	
29		6,415,228	
30		6,800,142	
30-YR TOTAL	27,313,290	99,218,972	3.633 to 1.000

7.3.2 SSJID System Features (Cont'd)

REVENUES/BENEFIT-TO-COST (cont'd)

Benefit-to-Cost Analysis (cont'd)

Frankenheimer

- Annual Revenue
  16,962,000 kWh/year X 44 mills** = $746,328

- Annual Cost

$6,006,110 X .0805864 =	$484,010
Operations and Maintenance	60,061
Annual Costs	$544,071

- Bus Bar Energy (1982) = 32.0 mills

- Benefit-to-Cost = 1.372 to 1.0

Goodwin Dam Joint Canal Headworks (North Side)

- Assume 12 month operations with plant capacity of 70% flow rate.

- Annual Revenue
  4,655,000 kWh/year X 44 mills** = $204,820

- Annual Cost

$1,507,262 X .0805864 =	$121,465
Operations and Maintenance	15,072
Annual Costs	$136,537

- Bus Bar Energy (1982) = 29.3 mills

- Benefit-to-Cost = 1.500 to 1.0

7.3.3 Phased Site Installation Plan

SSJID has established a phased site installation procedure for the three (3) economically and environmentally feasible sites. This installation plan is based on the "Typical Site Development Project Management Plan" efforts and tasks as described in Appendix 8.1.

** Based on State of California Energy Commission values (Section 8.5).

7.3.3 Phased Site Installation Plan (Cont'd)

SSJID has established a small hydropower development project office with Mr. Noel Negley designated as the Project Manager (see Figure 7-8). The project office and project manager will be supported by legal and administrative support from within SSJID's staff.

The plan proposes that:

- All civil, mechanical, electrical and hydraulic engineering be conducted by selected outside engineering consultants;

- Turbines and generators plus mechanical/electrical equipment and controls be purchased through the competitive bidding process.

- Civil works construction and equipment installation contracts be selected by the competitive bid process; and

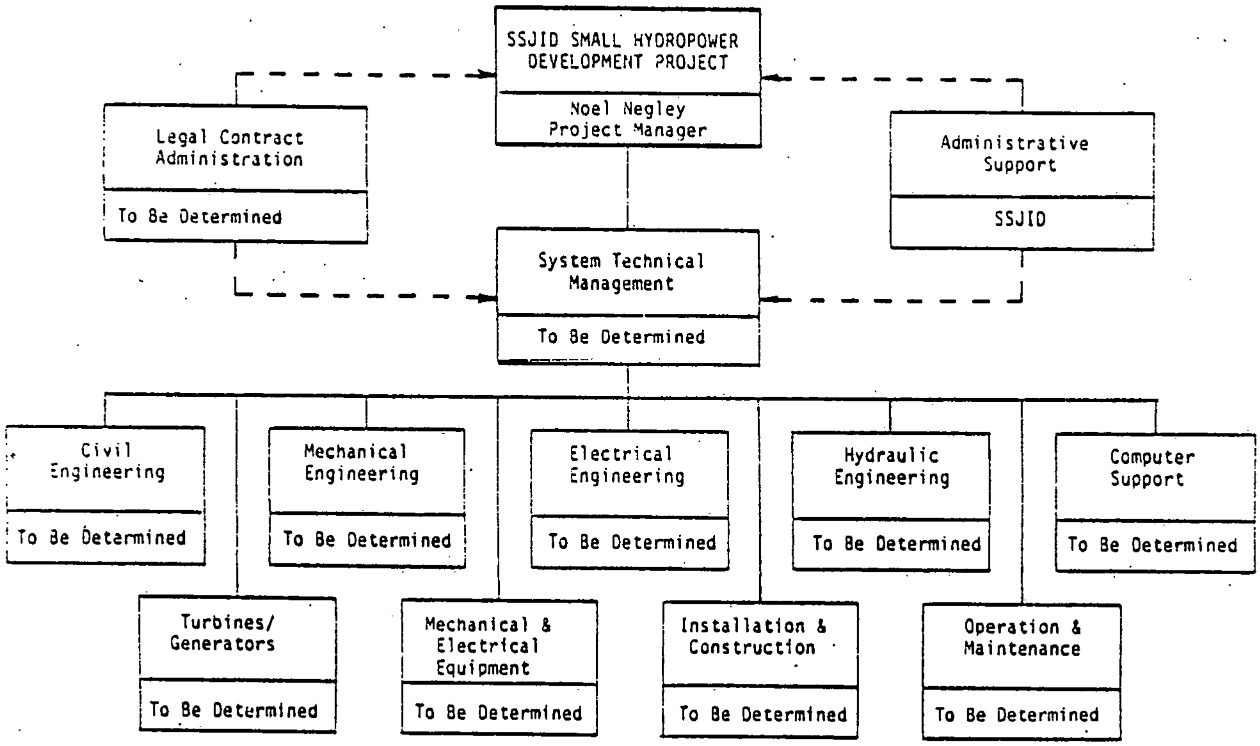
- The on-line operations and maintenance be conducted by the power purchaser's work force.

Development Schedules

The SSJID estimated on-line power development schedule is illustrated in Figure 7-9. This schedule calls for the following site/on-line operations:

- Woodward Dam
  Project start - March 1979
  Construction start - June 1980
  On-line operations - March 1981

7.3.3 Phased Site Installation Plan (Cont'd)



SOUTH SAN JOAQUIN IRRIGATION DISTRICT - SMALL HYDROPOWER DEVELOPMENT

PROJECT ORGANIZATION

Figure 7-8

Development Schedules (cont'd)

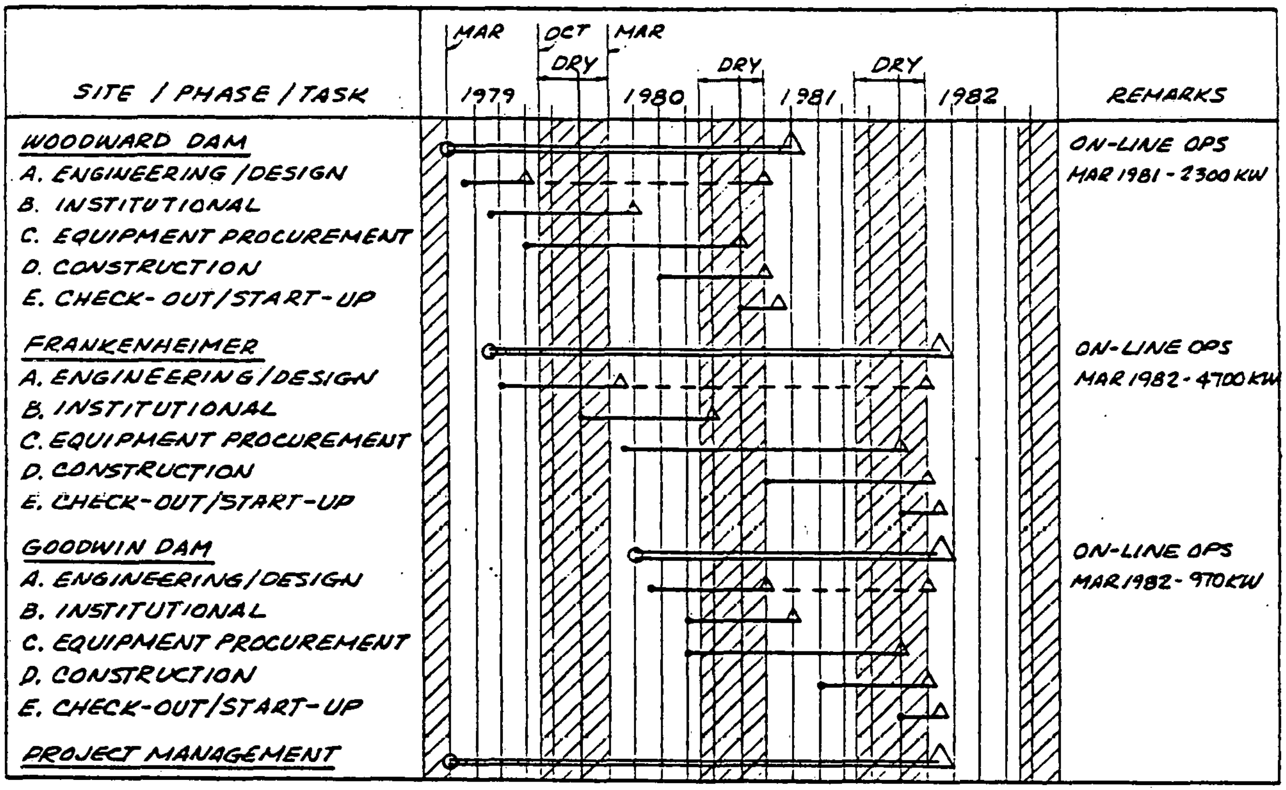
- Frankenheimer
  Project start - June 1979
  Construction start - March 1981
  On-line operations - March 1982

- Goodwin Dam
  Project start - May 1980
  Construction start - July 1981
  On-line operations - March 1982

7.3.3 Phased Site Installation Plan (Cont'd)

Development Schedules (cont'd)

This development schedule is based on estimated equipment and materials delivery schedules, weather contingencies, and irrigation water operations. It is planned that all of the selected SSJID sites could be engineered, constructed, equipment installed and on-line operations started by March 1982.



SO. SAN JOAQUIN IRRIGATION DISTRICT

HYDRO POWER SYSTEM DEVELOPMENT SCHEDULE

Figure 7-9

7.4 PROJECT DEVELOPMENT FINANCIAL PLAN

The "Joint Districts Small Hydropower System Development Financial Plan" includes the project costs of the twelve (12) sites previously discussed in this section. Additionally, the cost of any required new transmission lines, wheeling costs, operation and maintenance, debt service and costs for securing a "Joint Districts" tax exempt Power Revenue Bond issue have been included.

As discussed in Section 3.4, Economic Analysis, the obvious advantage of the "Joint Districts" being the project developer and power purchaser is the availability of low cost Project Development Funds, i.e., 6½% or 7% versus 9% financing.

Other advantages to establishment of the "Joint Districts" as the Project Developer are:

- single financing entity,
- single operating entity,
- single point of project management control,
- single point for project engineering control,
- single procurement control for equipment, materials and services,
- single point of construction management and development schedule control.

7.4.1 Development of Funding Sources

Development funds would come from three sources. They are:

- General District funds.
- Revenue Bonds.
- Department of Energy (DOE)
  - * Assessment Study $79,687, Cooperative Agreement awarded August 1978.
  - * Demonstration Project (PON-1) $719,000, Contract announced February 1979.

7.4 PROJECT DEVELOPMENT FINANCIAL PLAN (CONT'D)

7.4.1 Development of funding Sources (Cont'd)

In November, 1977, TID retained the services of Fluid Energy Systems, Inc. (FES) and Stone and Youngberg Municipal Financing Consultants, Inc. (S&Y) to assist in preparing long range development plans to identify and solicit federal, state and institutional funding sources for the financing of the potential small hydropower sites within the Districts.

7.4.2 Project Costs - 1982

Assuming that the "Joint Districts" become the single project developer, financing and operating entity, the total project costs would be:

- TID five (5) site system	$ 7,939,727
- Merced four (4) site system	5,743,337
- SSJID three (3) site system	8,511,496
- 4.1 miles of new 21 kV transmission lines	73,800
- Subtotal of engineering, equipment construction and installation	$ 22,268,360
- Interest during construction $22,268,360 X 7% X 2½ years	3,896,963
Subtotal	$ 26,165,323
- Minus DOE funding	(798,687)
TOTAL PROJECT COST 1982	$ 25,366,636

7.4.3 Revenues/Benefit-to-Costs - 1982

The revenues and benefits to a single project developer, financing and operating entity would be:

7.4 PROJECT DEVELOPMENT FINANCIAL PLAN (CONT'D)

7.4.3 Revenues/Benefit-to-Costs - 1982 (Cont'd)

Annual Revenues

- TID System	23,976,800 kWh	
- Merced System	16,062,000 kWh	
- SSJID System	28,523,000 kWh	
- Total Annual Energy	68,561,800 kWh	
- Revenue @ 44 mills/kWh		$ 3,016,719/year

Annual Costs

- Debt Service - 7% for 30 years or $25,366,636 X .0805864	$ 2,044,205
- Operations and Maintenance (O&M)	253,666
- Wheeling by PG&E or 44,585 kWh at 1.5 mills	668,775
- Total Annual Costs	$ 2,966,646/year
- Benefit-to-Cost (First Year) $3,016,719 ÷ $2,966,646 = 1.106 to 1.0	

Table 7-13 shows the 30-year costs and benefits of the project using 6% escalation for power revenue, operations and maintenance. The summary benefit-to-cost of the project at the end of 30 years is 2.931 to 1.0.

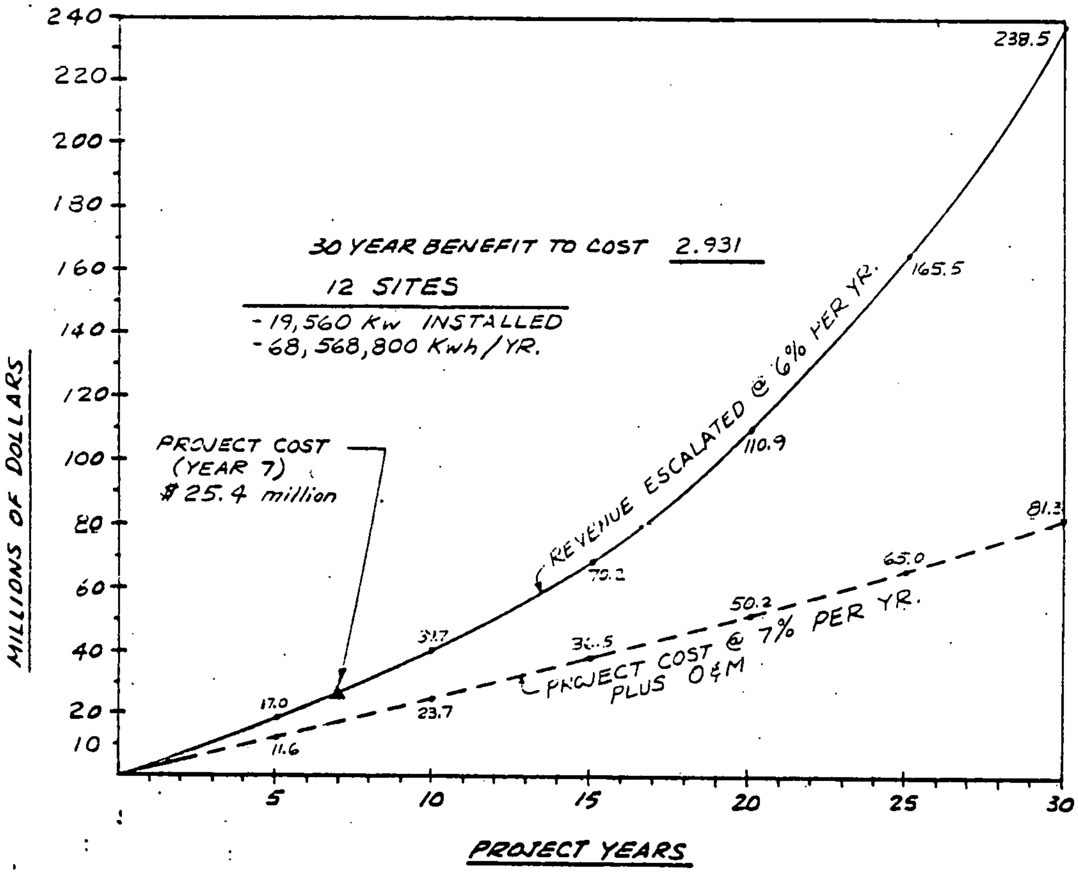
Figure 7-10 shows project cost versus revenue over the project's 30-year period. The graph also indicates project pay-back would occur in seven (7) years.

TOTAL PROJECT COST - $25,427,006 @ 7% FOR 30 YEARS.

YEAR	DEBT SERVICE	O&M ESCALATED @ 6% PER YEAR	TOTAL ANNUAL COSTS	REVENUE/YEAR ESCALATED @ 6% PER YEAR	BENEFIT-TO-COST
1	$ 2,044,205	$ 253,666	$ 2,297,871	$ 3,016,719	1.313 TO 1.000
2		268,886	2,313,091	3,197,722	
3		285,019	2,329,224	3,389,585	
4		302,120	2,346,325	3,592,961	
5		320,247	2,364,452	3,808,538	
TOTAL	10,221,025	1,429,939	11,650,964	17,005,525	1.460 TO 1.000
6		339,462	2,383,667	4,037,051	
7		359,830	2,404,035	4,279,274	
8		381,420	2,425,625	4,536,030	
9		404,305	2,448,510	4,808,192	
10		428,563	2,472,768	5,096,683	
TOTAL	20,442,050	3,343,520	23,785,570	39,762,755	1.672 TO 1.000
11		454,277	2,498,482	5,402,484	
12		481,534	2,525,739	5,726,633	
13		510,426	2,554,631	6,070,231	
14		541,051	2,585,256	6,434,445	
15		573,514	2,617,719	6,820,512	
TOTAL	30,663,075	5,904,322	36,567,397	70,217,061	1.920 TO 1.000
16		607,925	2,652,130	7,229,743	
17		644,401	2,688,606	7,663,527	
18		683,065	2,727,270	8,123,339	
19		724,049	2,768,254	8,610,739	
20		767,492	2,811,697	9,129,384	
TOTAL	40,884,100	9,331,254	50,215,354	110,971,792	2.210 TO 1.000
21		813,541	2,857,746	9,675,027	
22		862,354	2,906,559	10,255,528	
23		914,095	2,958,300	10,870,860	
24		968,941	3,013,146	11,523,111	
25		1,027,077	3,071,282	12,214,498	
TOTAL	51,105,125	13,917,261	65,022,386	165,510,816	2.545 TO 1.000
26		1,088,702	3,132,907	12,947,368	
27		1,154,024	3,198,229	13,724,210	
28		1,223,265	3,267,470	14,547,663	
29		1,296,661	3,340,866	15,420,522	
30		1,374,461	3,418,666	16,345,754	
TOTAL	$61,326,150	$20,054,374	$85,380,524	$238,496,333	2.931 TO 1.000

TOTAL PROJECT ESCALATED BENEFIT-TO-COST

FES



CUMULATIVE REVENUE VERSUS COST

Figure 7-10

SECTION 8.0

APPENDIX

FES

APPENDIX 8.1

TYPICAL SITE DEVELOPMENT PROJECT

MANAGEMENT PLAN

Prepared By:

FLUID ENERGY SYSTEMS, INC.
LOS ANGELES, CALIFORNIA

FES

TYPICAL SITE DEVELOPMENT

PROJECT MANAGEMENT PLAN

1.0 MANAGEMENT PLAN

The Turlock Irrigation District is a governmental unit chartered by the State of California to provide water and electric power. The District is governed by an elected five-member Board and is managed by a General Manager and an experienced staff.

The District will be fully responsible for achieving the goals of the Small Hydropower Program through its control of management and operation. Several of the project tasks will be directly fulfilled by District staff. Where appropriate, outside consultants will be retained.

District direction will be exercised by a Project Manager whose tasks will include supervising all work performed, maintain consistency and provide all required reports. The Manager will be the one person to whom all involved personnel will report throughout the life of this Project.

Under the direction of the Project Manager, the District will implement four major program plans to achieve project goals, with full control over quality, time and cost of work performed.

1.1 TECHNICAL MANAGEMENT PLAN

The goals of the Technical Management Plan are to:

- establish controls;
- track all Project activities;
- prepare all Monthly and Quarterly Reports;
- Prepare Project Reviews and supervise Project functions; and
- maintain adherence to Project Schedule.

The District will utilize the Project Management form of organization. This system establishes levels of management responsibility, defines organizational relationships and identifies tools and techniques for Project planning, direction and control. Since the organization is tailored to the Project, only those controls necessary to the successful completion of the Project will be imposed.

In order to implement this plan, a central Project Office will be established within the headquarters of the District. From this location, the Project Manager will supervise and control design, development, analysis, procurement, construction and installation liaison.

1.2 TECHNICAL PLAN

The goals of the Technical Plan are to:

- control, track, and integrate all field activities and data collections;
- conduct all analyses and technology transfers; and
- compile and prepare documentation in support of reports on project results.

This Technical Plan will apply the best available skills in a wide range of disciplines in order to take into account the technical economic, operational and logistics factors involved in the site development. All functions will be directed by the applications of systems integration to maximize effectiveness.

1.3 ADMINISTRATIVE PLAN

The goals of the Administrative Plan are to control and coordinate:

- accounting and costs;
- personnel requirements; and
- equipment and facility needs.

This Plan will also track and monitor contract and sub-contract matters involved in the project. Cost control will be provided by the implementation of the Work Breakdown Structure System.

1.4 PROCUREMENT PLAN

The goal of the Procurement Plan is to assure that all fabrication and construction is accomplished in accord with approved design and specifications.

The District Procurement Staff and consultants have experience in procuring equipment for hydroelectric projects. In this project, as in other projects, maximum use will be made of the competitive marketplace to achieve maximum results at the lowest feasible cost.

The Planning Staff will compile the requirements from all sources to establish a material support plan to meet schedule needs. Effective management is accomplished by use of uniform methods of classification and coding, using commercial designations guidelines.

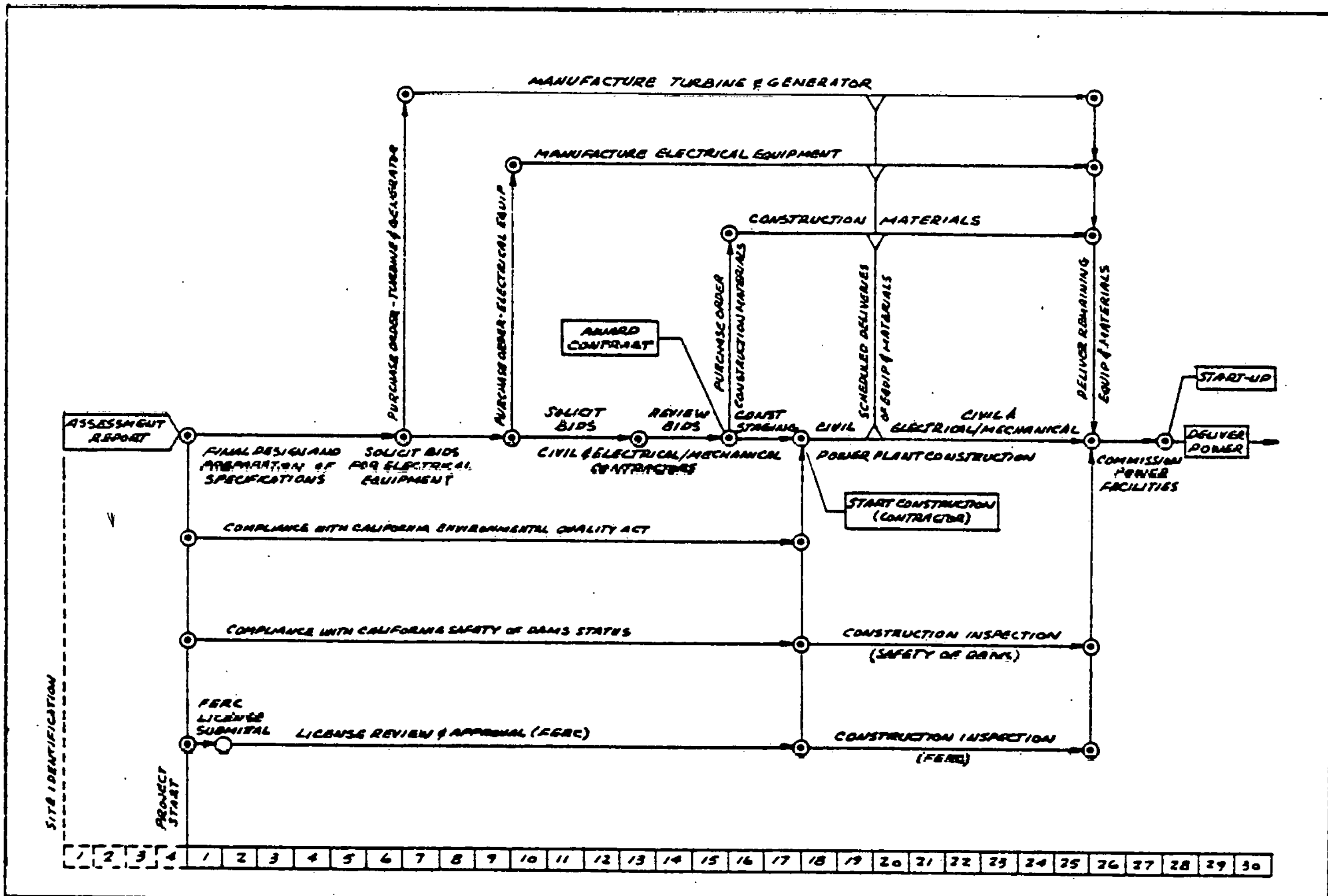
Materials and off-the-shelf equipment are procured on a purchase order system. Specialty items and major procurements are handled by sub-contract administrators who, in addition, are responsible for monitoring and controlling

1.4 PROCUREMENT PLAN (CONT'D)

all subcontractor-generated data. Subcontract administrators receive vendor data and distribute it to engineering; coordinate and review comments and technical responses; and consolidate them for transmittal to the vendor.

1.5 CRITICAL PATH MODE

Figure A is a typical Critical Path Mode (CPM) for a small hydropower project. It shows the phasing and interrelationships of the various tasks. The CPM shows the integration of work, time and resources necessary to complete the project within the proposed time frame.



TYPICAL SITE DEVELOPMENT CRITICAL PATH MODE (CPM)

Figure A

2.0 PROJECT TASKS

The Project Tasks are structured to assure the timely, complete and cost-effective fulfillment of all tasks and sub-tasks of the project.

The Project Site Development is structured into five (5) tasks. The tasks are identified as follows:

- Task 1 - Engineering Design and Specifications
- Task 2 - Equipment and Materials Procurement
- Task 3 - Civil Construction
- Task 4 - Equipment Installation
- Task 5 - Equipment Check-Out and Start-Up.

2.1 TASK 1: ENGINEERING DESIGN AND SPECIFICATIONS

Within this task, the preliminary engineering assessment, engineering design drawings and specifications, permit and license applications will be prepared. The relevant engineering disciplines are hydraulic, civil, mechanical, and electrical. This task is most active early in the development. Upon start of construction, most of the engineering has been completed and the project emphasis is shifted from engineering to construction. However, the engineering function will be actively supporting the construction and procurement efforts and later the start-up and check-out operations. The engineering function also has the responsibility of monitoring the manufacturing and construction efforts for compliance with the drawings and specifications.

- Preliminary Engineering: During this sub-task the following will be completed:

    - collect all basic data associated with the canal system, water supplies, area electrical requirements;
    - conduct soils investigation and geology;
    - develop site and power plant configurations;
    - develop the installed capacities;
    - develop power plant/water release operations;
    - identify specific concerns which must be worked out with regulatory agencies.

  The task utilizes civil, mechanical, electrical and geotechnical inputs in addition to the hydrology studies.

- Civil Engineering: During this sub-task, the project civil engineering will be completed in accordance with the concepts and guidelines established in the feasibility assessment. This includes, but is not limited to:

    - site layout;

2.1 TASK 1: ENGINEERING DESIGN AND SPECIFICATIONS (CONT'D)

Civil Engineering (cont'd)

- site design and engineering;
- civil construction sequence and CPM;
- site layout drawings;
- preparation of site excavation drawings;
- disposition of excavation soil;
- preparation of civil structure drawings;
- preparation of civil specificatons; and
- construction monitoring to assure conformance to the drawings and specifications.

• Mechanical Engineering: During this sub-task, the project mechanical engineering will be completed in accordance with the concepts and guidelines established in the feasibility assessment. This includes, but is not limited to:

  - layout and location of mechanical equipment;
  - machinery installation sequence and CPM;
  - preparaton of mechanical drawings;
  - selection of equipment;
  - preparation of mechanical specifications; and
  - monitoring machinery manufacture and installation to assure compliance with drawings and specifications.

• Electrical Engineering: During this sub-task, the project electrical engineering will be completed in accordance with the concepts and guidelines established in the feasibility assessment. This includes, but is not limited to:

  - layout and location of electrical equipment;
  - location of transmission lines;
  - electrical equipment installation sequence and CPM;
  - selection of electrical equipment;
  - preparation of electrical specifications; and
  - monitoring electrical equipment manufacture and installation to assure compliance with drawings and specifications.

2.1 TASK 1: ENGINEERING DESIGN AND SPECIFICATIONS (CONT'D)

- Legal and Institutional: During this sub-task, the District will file with the Federal Energy Regulatory Commission (FERC) and obtain the necessary license to generate, distribute and sell the electrical power produced by the site development.

  Also during this sub-task, determination from the State of California, Division of Safety of Dams, as to the structural design integrity of the existing structure and new power plant configuration will be requested.

  The District's Board of Directors will file an environmental statement with the State of California that there is no environmental impact caused by the proposed construction at the site.

2.2 TASK 2: EQUIPMENT AND MATERIALS PROCUREMENT

The function of this task is to have the appropriate materials and equipment on the site when required by the construction schedule. This will include the preparation of invitations to bid; evaluation of the suppliers and contractors' bids; the preparation and placement of purchase orders; expedition of the equipment and materials; recording of receipt of equipment and materials; and notification of the financial staff that the purchase order has been fulfilled and is approved for payment.

Some of the key items of particular concern to this task are turbines, generators, controls, switch gear, and construction materials. The equipment and materials are commercially available; therefore, no identified or foreseen problems are associated with this task.

- Purchasing: During this sub-task, all of the materials and equipment identified within the civil, mechanical and electrical drawings and specifications will be purchased. This includes, but is not limited to:

  - preparing equipment and material lists;
  - preparing invitations to bid;
  - soliciting bids;
  - evaluating bids;
  - preparing and placing purchase orders; and
  - authorizing payment upon successfully fullfilling purchase orders.

- Expediting: During this sub-task, the purchased equipment and material availability on site or in the warehouse when required in the production schedule will be assured. This includes, but

Expediting (Cont'd)

is not limited to:

- communication and coordination with the equipment and material suppliers to assure that the purchased items will be available when specified in the purchase orders; and

- working out and coordinating shipping schedules.

- Communications: The Procurement Task Group will be the funnel through which all technical and business communications will pass. Problems or inquiries developed by the engineering, construction or installation efforts associated with equipment or material supplies will be directed to the suppliers or contractors by the Procurement Task Group.

- Manufacturers' Conformance Inspection: During this sub-task, the District will assure that the electrical and mechanical equipment manufactured is in conformance with the:

  - drawings;
  - specifications;
  - ASME specifications;
  - ASCE specifications;
  - IEEE specifications;
  - OSHA specifications; and
  - local and state codes.

  Periodic inspection visits will be made to the manufacturers' shops for review and inspection of the contracted work in progress. Materials, fabrication, and fabricator's inspection hold points will be checked. The final inspection and equipment operation will be witnessed in the fabricator's shop prior to shipping.

2.3 TASK 3: SITE CONSTRUCTION

Site construction includes all of the work on the site except the installation of the mechanical and electrical equipment. It does include, but is not limited to: building and relocation of roads; site survey and layout; power plant excavation; forebay excavation and lining; tailrace excavation and lining; concrete and steel structures; and mechanical and electrical foundations and embedments.

2.3 TASK 3: SITE CONSTRUCTION (CONT'D)

- Construction Period: The construction period is unique in these projects. The primary function of the District's Canal System is to deliver agricultural irrigation water within the District. The canal system is flooded during the irrigation period of March 15 through October 15 and dry during the non-irrigation period of October 15 through March 15. Therefore, the construction period is dictated by the irrigation schedule and limited to the non-irrigation period. To gain more time for site construction, a two and one-half (2½) month period prior to water shut-off will be set aside for construction staging and starting those civil works which can be accomplished while the canals are filled with water.

- Site Layout: Early in the site construction sequence, the site will be surveyed and laid out in conformance with the civil drawings and specifications. Throughout the excavation and construction period, the various civil construction features will be monitored by survey to assure their location and characteristics.

2.4 TASK 4: EQUIPMENT INSTALLATION

Equipment installation includes all of the work associated with the installation of the mechanical and electrical equipment. It includes, but is not limited to, installation of the turbines, generators, gates, lifting devices, transformers, switch gear, electronic controls and power transmission lines on the foundations provided in the civil works.

The equipment is commercially known and proven and the design and layout are simple and straightforward. Therefore, there are no identified or foreseen problems associated with this task. The installation of equipment is not excessively dependent on the irrigation period. Much of the work can be accomplished after water release.

- Equipment Installation Plan: The installation of the mechanical equipment is dependent on, and will be coordinated with, the concrete works. Specific embedments and/or foundations for the mechanical equipment will be required at specific times for incorporation in the concrete works. As the civil construction progresses, the installation of mechanical and electrical equipment will be accomplished in a coordinated effort. It is anticipated that the equipment installation effort will extend beyond the water release date. By that time, the site construction will have reached a stage where water in the canal will not interfere with the construction work.

  Installation of equipment is to be accomplished with the assistance of the manufacturing representatives as required.

2.5 TASK 5: EQUIPMENT CHECK-OUT AND START-UP

This task involves equipment start-up and check-out. It includes, but is not limited to, preparing the power plant operation, starting all of the installed equipment for the first time, checking the operation of all the installed equipment, integrating the operations of the various systems, resolving all start-up and equipment problems, and operating the power plant under full load. The power plant can then be turned over to the operations group for electric power generation.

The equipment is commercially known and proven and no difficulties are anticipated in the design and layout. The start-up and check-out of the power plant equipment are scheduled to coincide with the release of water at the beginning of the irrigation period.

- Turbine-Generator: During this sub-task, the turbine-generator is started up, run out, checks are performed, and machinery or operational problems are resolved, and the equipment and operations are accepted.

- Gates and Operating Devices: During this sub-task, the gates and their operating devices are started up, the machinery and its operations are checked out, any machinery or operational problems are resolved, and the equipment and operations are accepted.

- Transformer, Switch Gear and Electrical Transmission Equipment: During this sub-task, the transformer, switchgear and electrical transmission equipment are activated, operational checks are performed, any equipment or operational problems are resolved, and the equipment and operations are accepted.

- Power Plant Operation Controls: During this sub-task, the power plant operation controls are activated, operational checks are performed, any equipment or operational problems are resolved, and the equipment and operations are accepted.

- Power Plant Operational: Upon completion of all equipment and operational checks and commissioning, the power plant is made operational, power is generated, and the operation of the power plant is turned over to the District's Operating Department. During this sub-task, the work is coordinated between the installation contractor, the equipment manufacturer's representative, and the District's operating personnel.

APPENDIX 8.2

EQUIPMENT SUPPLIER

INFORMATION

FES

CONTENTS

FLUID ENERGY SYSTEMS, INC.

4241 REDWOOD AVENUE
LOS ANGELES, CA. 90066
Telephone: (213) 822-5062
September 12, 1978

Gentlemen:

This letter is an invitation for a representative from your company to attend a manufacturers' briefing on the potential and progress of the Department of Energy's (DOE) Funded Turlock Irrigation District (TID) "Joint Districts" Hydropower Assessment Study. This meeting will be hosted by Fluid Energy Systems, Inc. (FES) at its new facilities in Los Angeles. As the Prime Sub-Contractor for TID, FES will conduct the briefing for the TID Project Manager, Mr. A. K. (Al) Hagiwara.

The purpose of the meeting will be to brief interested manufacturers on the overall "Joint Districts" Hydropower potential. Additionally, FES will outline the DOE/TID Project milestones, specific site potentials, and solicit equipment manufacturers' support and data information. This information will be used during the Assessment to determine:

A. Civil versus Equipment Trade-Offs;
B. Equipment Efficiencies versus Heads and Flow Rates; and
C. Estimated Project Costs and Economic Analyses.

Enclosed please find the following information:

A. Meeting Agenda;
B. Map of FES location; and
C. Table 1-1, Hydropower Recovery Program Summary.

It is requested that all interested manufacturers respond to this invitation either to the writer or Ms. Barbara Barker by September 29, 1978.

On behalf of the "Joint Districts", we thank you and look forward to your reply.

Yours truly,

FLUID ENERGY SYSTEMS, INC.

K. Thomas Miller

K. Thomas Miller
President/Director of Operations

KTM:bjb

encl.

MANUFACTURERS' MEETING

"JOINT DISTRICTS" HYDROPOWER ASSESSMENT STUDY

LIST OF INVITED MANUFACTURERS

Mr. Roger King
Aerojet Manufacturing Company
601 South Placentia Avenue
Fullerton, California 96231

Mr. J. D. Kiser
Empire Company
Route 1, Box 182 A
Vulcan, Michigan 49892

Mr. William H. Delp, II
Post Office Box 1467
Noxon, Montana 59853

Mr. Sahir Erispaha, P.E.
Voest-Alpine International Corp.
60 East 42nd Street
New York, New York 10017

Mr. J. Robert Groff
The James Leffel and Company
Springfield, Ohio 45501

Mr. Joseph M. Keating
Keating Associates
2449 Giovanni Drive
Placerville, California 95667

Mr. Erwin A. Rungaldier
Voest-Alpine
1923 Magellan Drive
Oakland, California 94611

Mr. Yoichi Saji
Hitachi America, Ltd.
100 California Street
San Francisco, California 94111

Mr. W. Jon Versteeg
General Electric Company
9350 East Flair Drive
El Monte, California 91734

Mr. Mark Barandy
Post Office Box 712
York, Pennsylvania 17405

Mr. E. Sennhauser
Sulzer Bros., Inc.
1255 Post Street, Suite 911
San Francisco, California 94109

Nissho-Iwai American Corporation
Broadway Plaze, Suite 1900
700 South Flower Street
Los Angeles, California 90017
Attention: Mr. William V. Slocum

Border Electric Company
4600 Shipyard Road
Blaine, Washington 89203

Ateliers Des Charmilles S.A. Geneve
Cse Postale, 83
CH-1211 Geneve 13, Switzerland
Attention: Mr. E. Combe

Sorumsand Versted A/S
N-1920 Sorumsand, Norway

Brown Boveri Corporation
1460 Livingston Avenue
North Brunswick, New Jersey 08902

Mr. Arthur Mieland
Bofors-Nohab
One World Trade Center, Suite 10225
New York, New York 10048

Mr. Daniel W. Loughlin
Chromalloy
17400 East Chestnut Street
City of Industry, California 91749

MANUFACTURERS' MEETING

"JOINT DISTRICTS" HYDROPOWER ASSESSMENT STUDY

DATE: OCTOBER 5, 1978

TIME: 10:00 A.M.

PLACE: FLUID ENERGY SYSTEMS, INC.
4241 Redwood Avenue
Los Angeles, California 90066
(213) 822-5062

AGENDA

10:00 A.M. - 10:15 A.M.	-	SIGN-IN/INTRODUCTIONS
10:15 A.M. - 10:45 A.M.	-	STUDY SCOPE
10:45 A.M. - 11:15 A.M.	-	SITE SPECIFIC DATA
11:15 A.M. - 11:45 A.M.	-	MANUFACTURER'S ROLE
11:45 A.M. - 1:15 P.M.	-	LUNCH (HOSTED BY FES)
1:15 P.M. - 2:15 P.M.	-	DISCUSSION, QUESTIONS/ANSWERS

FES

FLUID ENERGY SYSTEMS, INC.

4241 REDWOOD AVENUE
LOS ANGELES, CA. 90066
Telephone: (213) 822-5062

KTM/FES/0278
October 10, 1978

Gentlemen:

We were sorry you could not attend the scheduled Manufacturers' Meeting for the "Joint Districts" Hydropower Assessment Study on October 5, 1978. Enclosed please find a copy of the handout that was distributed to those manufacturers who did attend.

Should you elect to assist in this study, or have further questions, please contact myself at (213)822-5062 or Mr. Al Hagiwara at (209) 632-3861.

Thank you for your interest.

Yours truly,

FLUID ENERGY SYSTEMS, INC.

K. Thomas Miller

K. Thomas Miller
President/Assessment Study
Coordinator

KTM:bjb

encl.

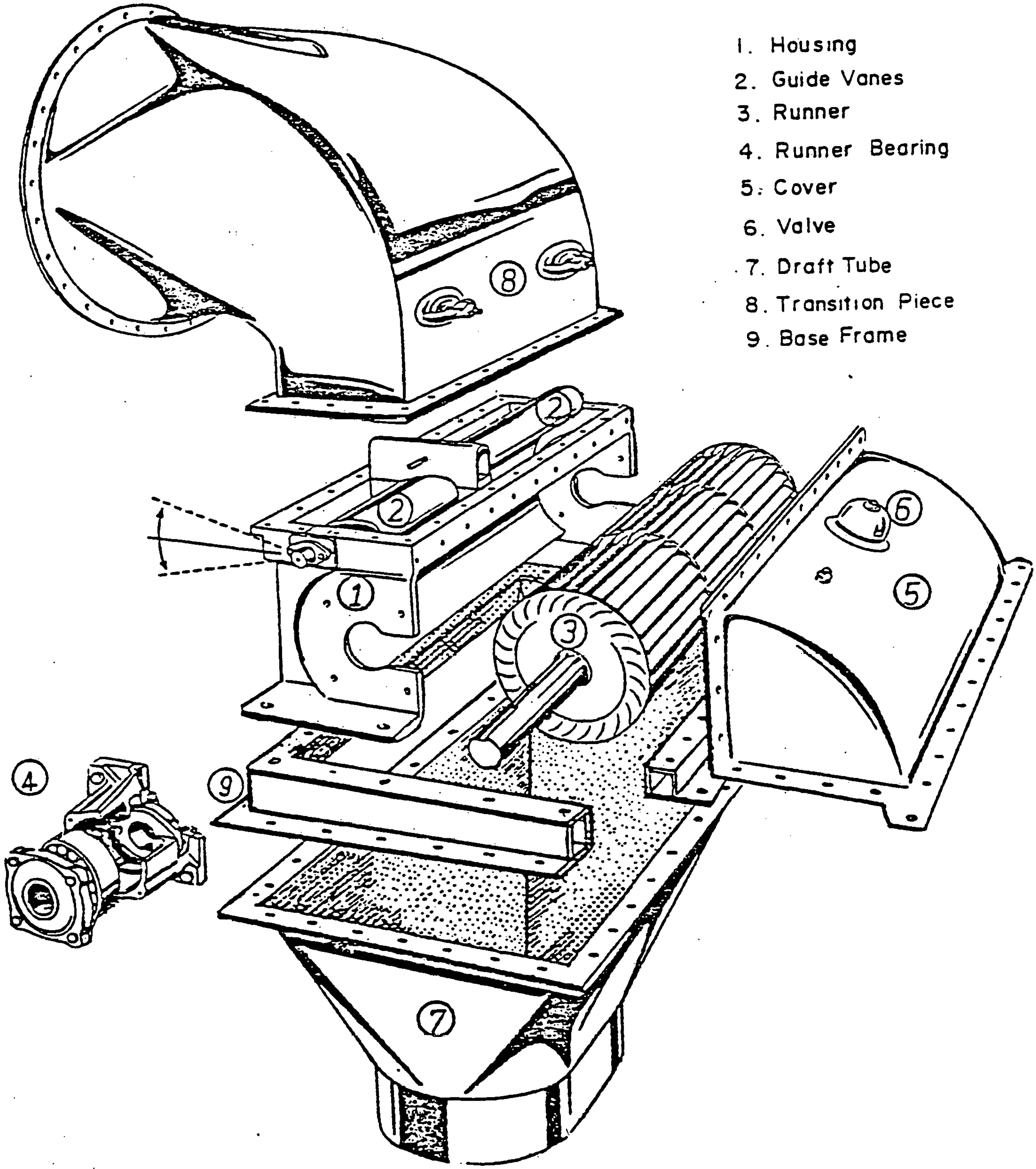
cc: Al Hagiwara, TID
Project Manager

OSSBERGER

(CROSS FLOW)

INFORMATION

(GERMANY)



View of Typical OSSBERGER Turbine Assembly

FUJI ELECTRIC

INFORMATION

(JAPAN)

Small Hydro Development as Energy Resources

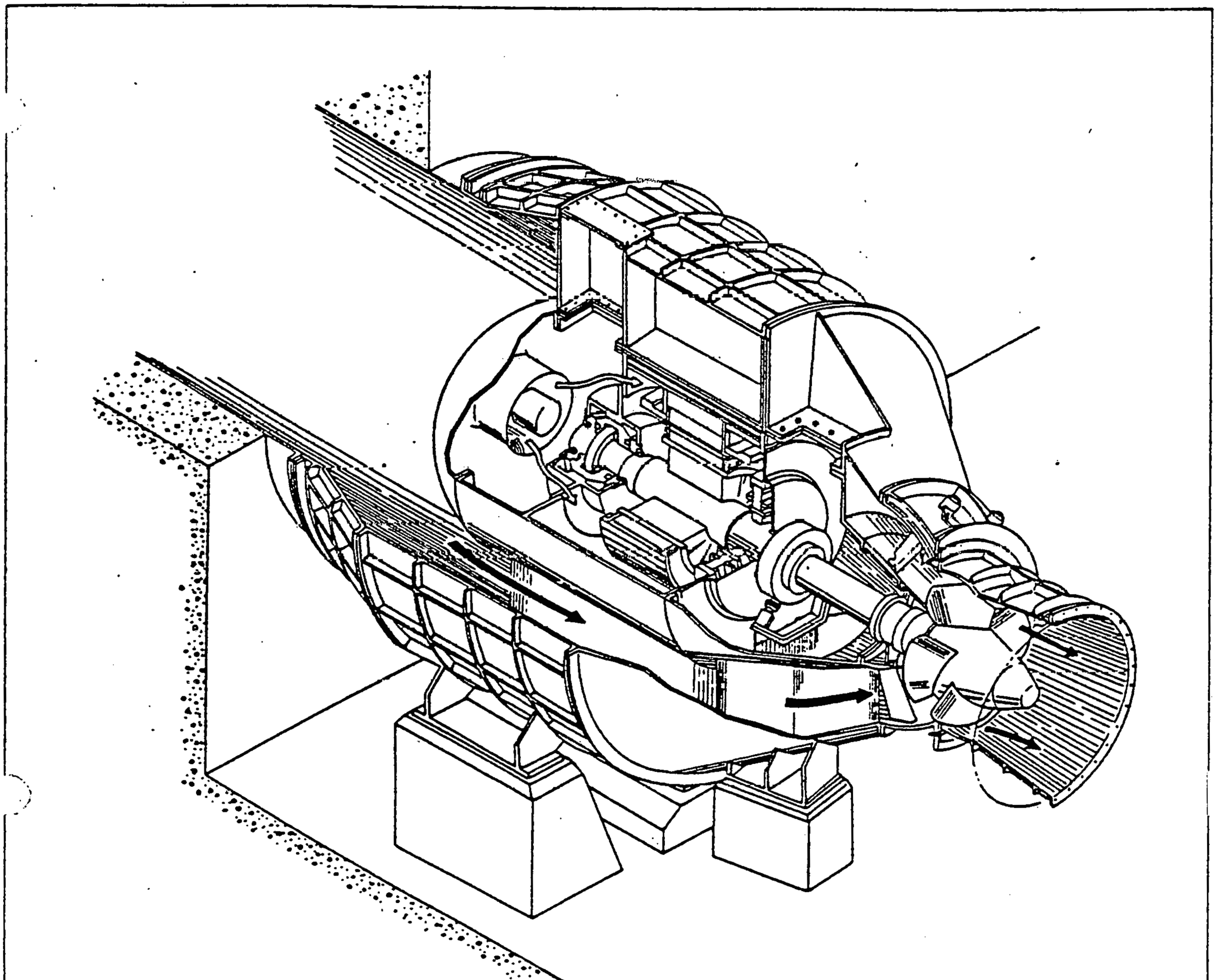
Every kind of energy resources in the world has its limit of reserve, and the effective utilization of energy resources which we may possibly develop is required in every country in the world. Hydro power is an endless circulating energy resource and it is quite natural that this hydropower has received keen attention once again.

There are many sites for hydro power of low head and relatively smaller flow in the world and they are generally left undeveloped. If those smaller hydro sites are developed under economical basis and in a rather short period, then such development of small and low head hydro could, to some extent, be an answer to the requirement of energy development.

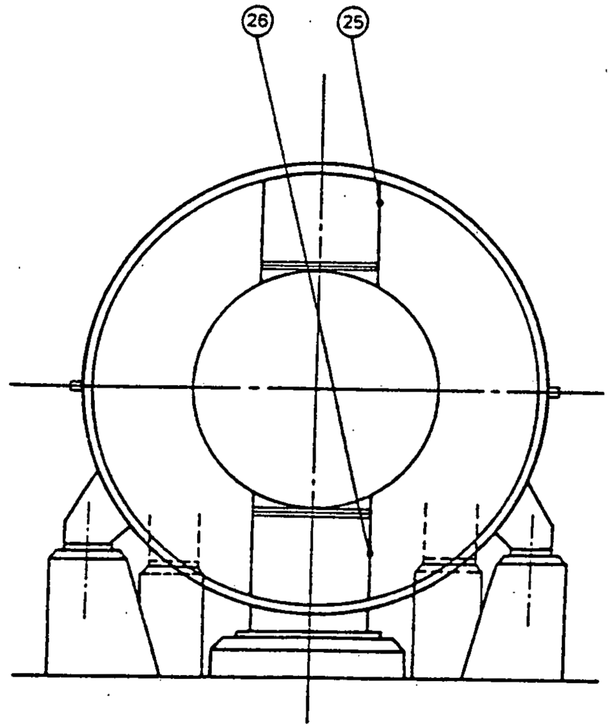
In order to proceed with the development of such small hydro, we have to find a solution to the following points.

- Project to stand on economical basis
- Less engineering work
- Shorter period of installation
- Maintenance free operation

As an answer meeting with the above requirements, FUJI ELECTRIC has completed the standard series of "PACKAGE TYPE BULB TURBINE-GENERATOR".



1 RUNNER
2 DISCHARGE RING
3 TURBINE SHAFT
4 CONIC RING
5 OUTER WICKET GATE RING
6 INNER WICKET GATE RING
7 BULB FOR TURBINE
8 GUIDE BEARING FOR TURBINE
9 SHAFT SEAL
10 REGULATING RING
11 WICKET GATE
12 STATOR
13 ROTOR
14 GENERATOR SHAFT
15 GUIDE (THRUST) BEARING FOR GENERATOR
16 EXCITER
17 OUTER CASING FOR GENERATOR
18 CONNECTING TUBE LINER
19 BULB NOSE
20 COOLING FAN
21 BRAKE
22 PENSTOCK
23 DRAFT TUBE
24 BULB FOR GENERATOR
25 UPPER STAY VANE
26 LOWER STAY VANE



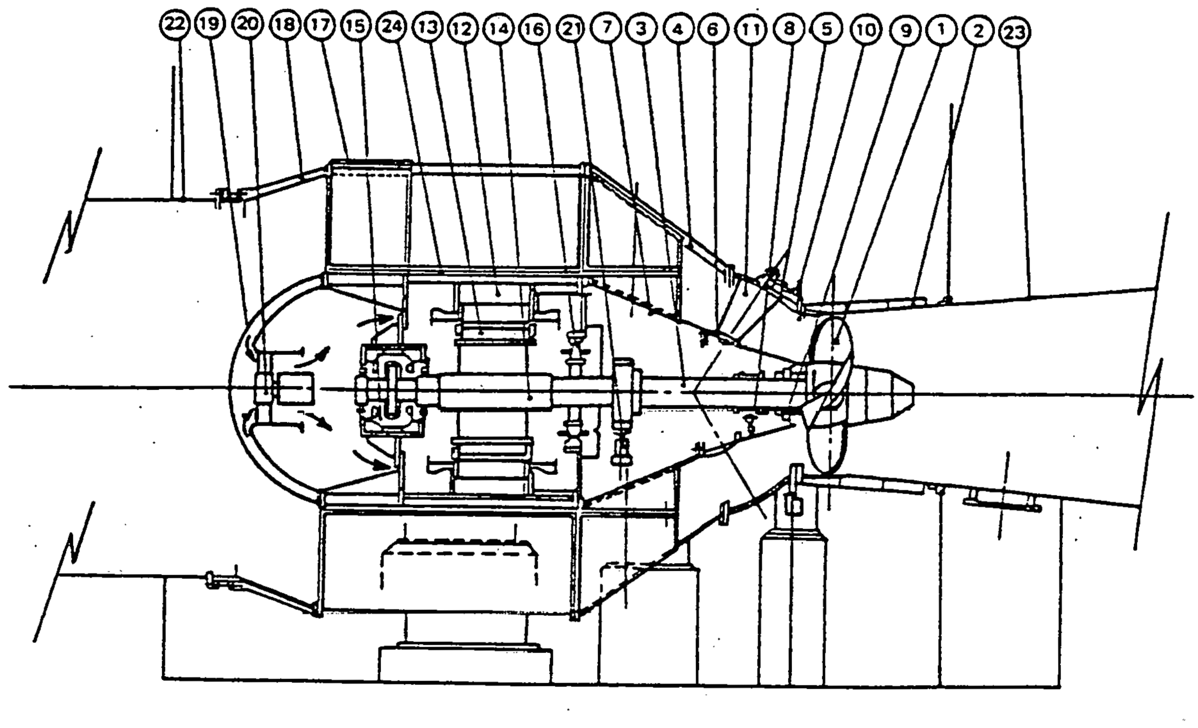


Fig. 6 Sectional Drawing of Bulb Turbine-Generator

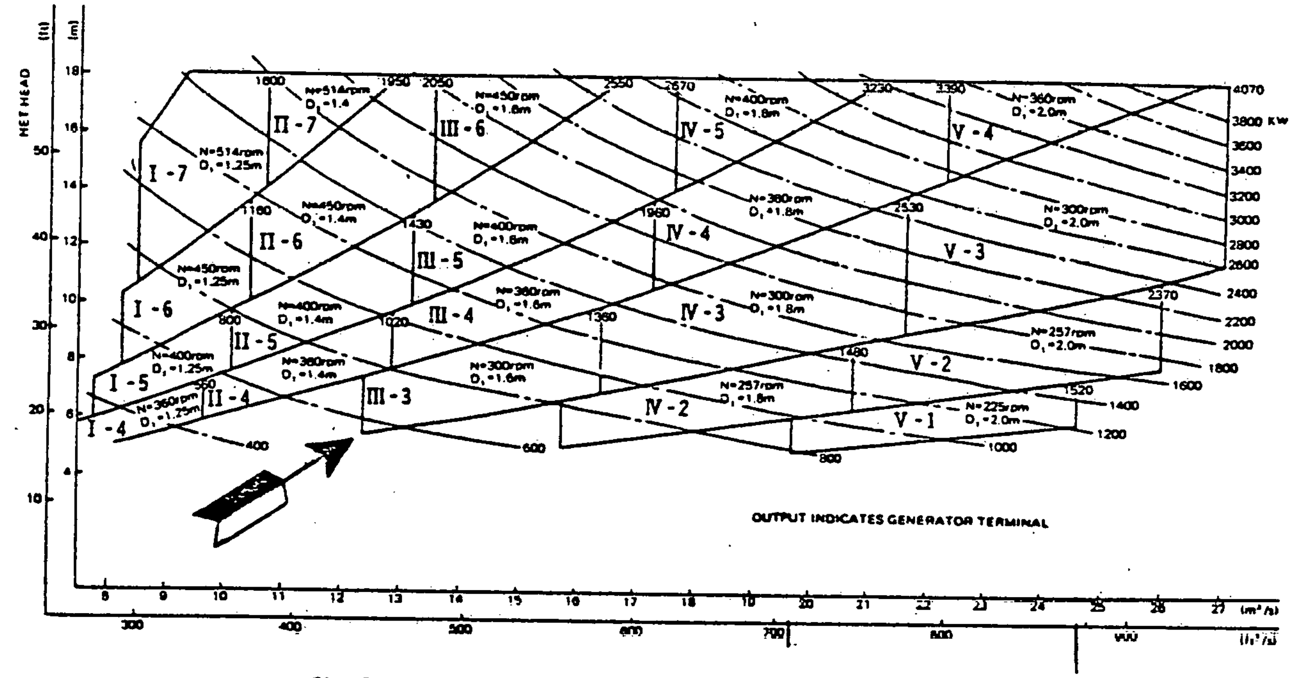


Fig. 1 Model No. of Fuji Package Type Bulb Turbine-Generator (60Hz)

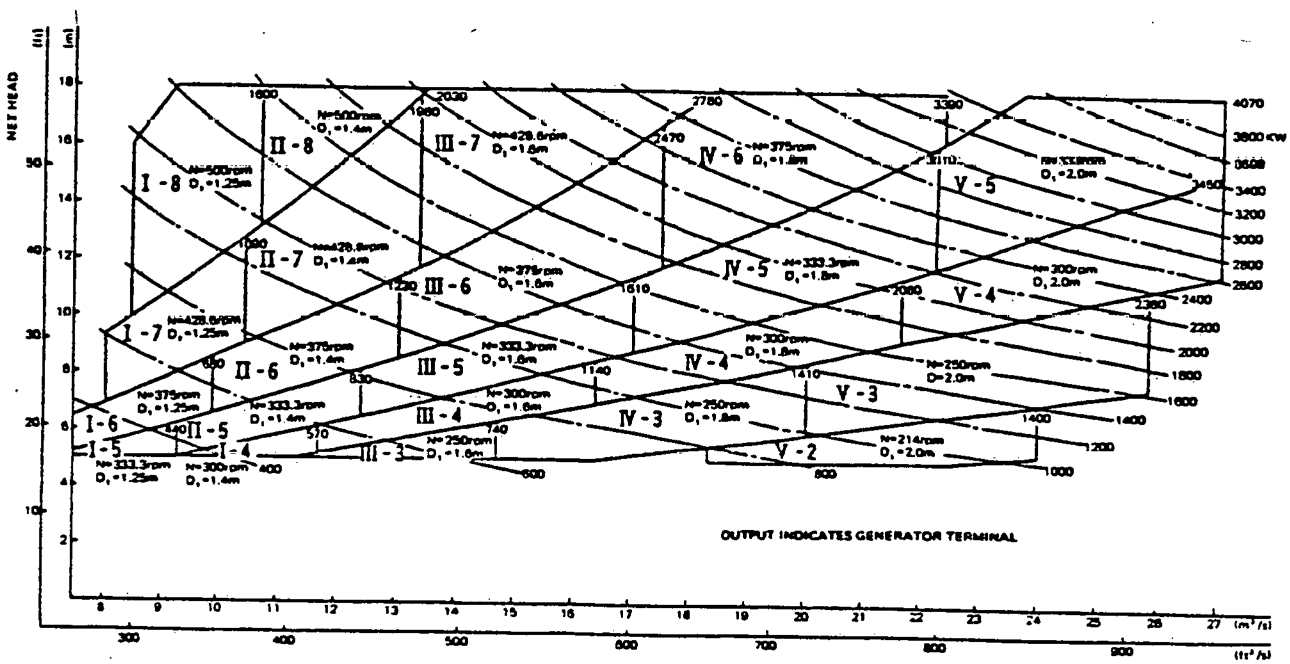
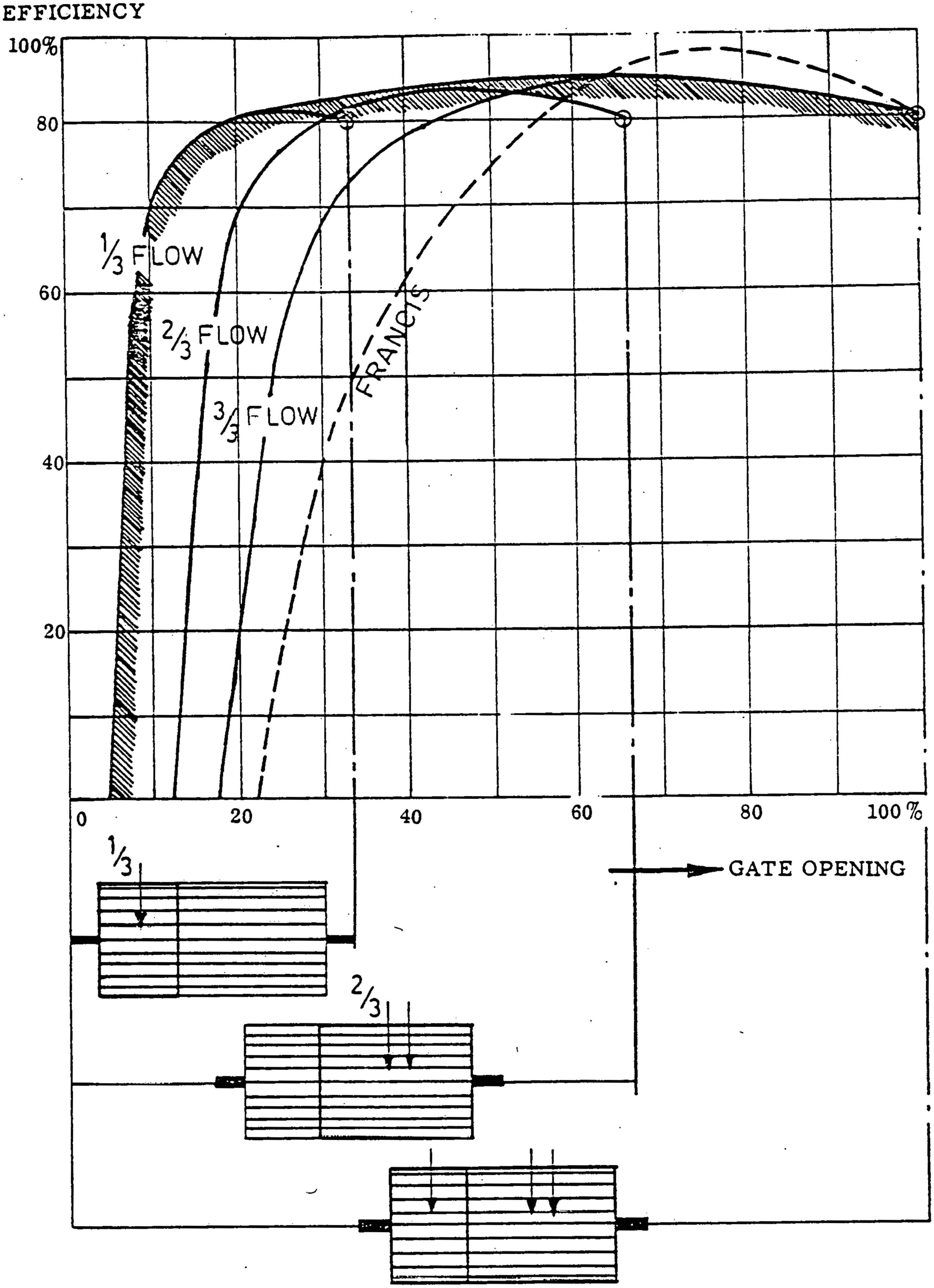
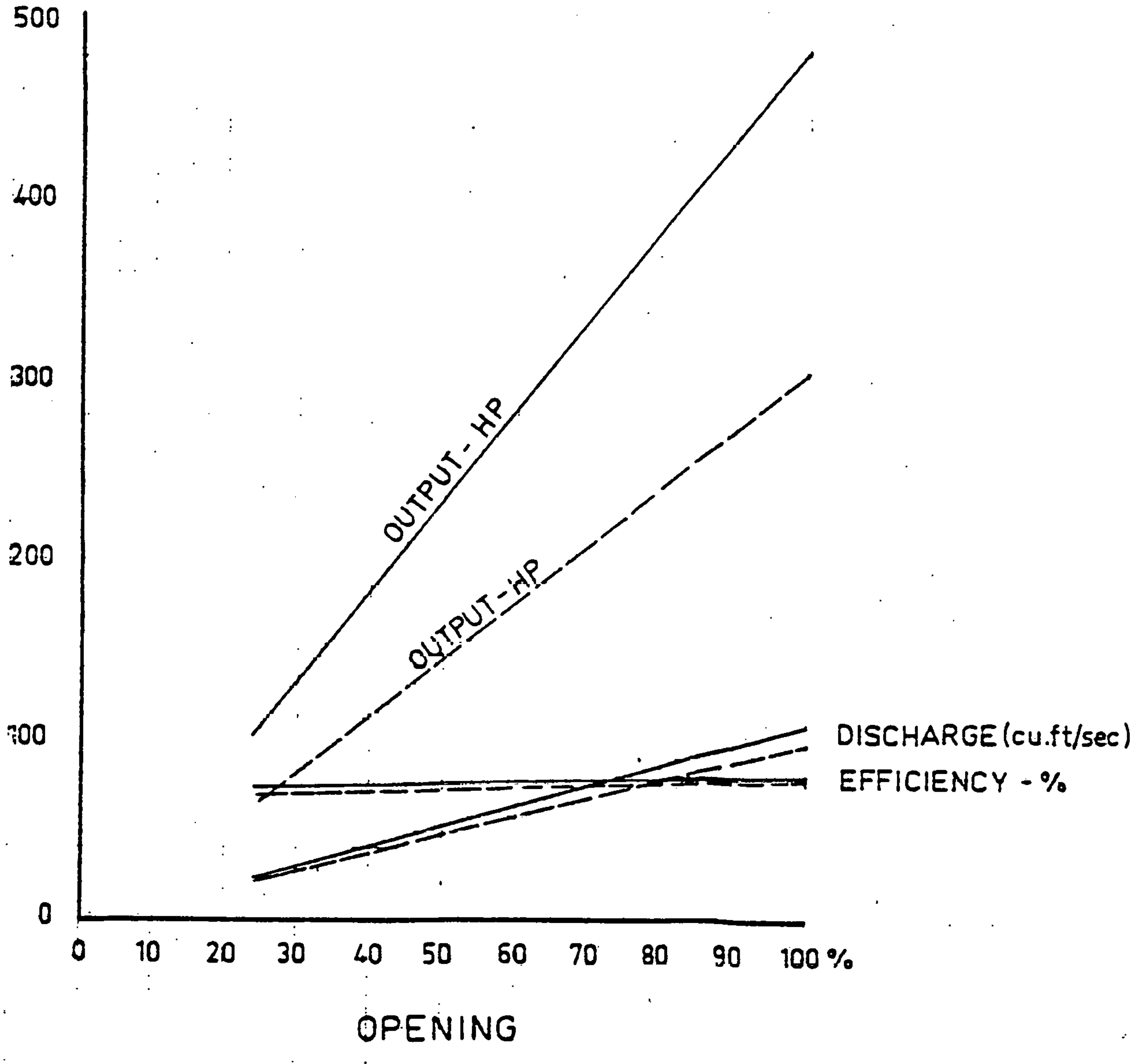


Fig. 2 Model No. of Fuji Package Type [illegible]



Gate Opening: Ossberger vs Francis

PERFORMANCE OF TYPICAL OSSBERGER TURBINE AT VARIOUS HEAD AND WATER CONSUMPTION (SAME UNIT)



——— FOR MAX. NET HEAD OF 47 FEET

– – – FOR MIN. NET HEAD OF 35 FEET

MAX DISCHARGE – 113 cu.ft/sec.

MIN DISCHARGE – 24.5 cu.ft/sec

<u>BROWN BOVERI</u>

<u>CORPORATION</u>

<u>INFORMATION</u>

(NORWAY)

BBC BROWN BOVERI
Brown Boveri Corporation

MECHANICAL AND ELECTRICAL POWER EQUIPMENT • SINCE 1891

NORTH BRUNSWICK, N.J. 08902

IN REPLY PLEASE
REFER TO File 0304 EL

AREA CODE 201 · 932-6000
MY DIRECT DIAL NUMBER IS 932- 6117

November 28, 1978

Mr. K. Thomas Miller
President/Director
Fluid Energy Systems, Inc.
4241 Redwood Avenue
Los Angeles, CA 90066

Dear Mr. Miller:

Reference: Mini-Hydro Power Project
Turlock Irrigation System

In response to your request for information concerning application of our mini-hydro package plants for the Turlock Irrigation system, we have the pleasure in enclosing herewith a list of budgetary prices for the different types of units we feel will be most suitable.

Please note that for some locations we feel the head is too low to be accommodated in our production range of turbines. Apart from two locations, namely Hukman Spillway and Frankenheimer, where the high head calls for a Francis Turbine, all other locations are best served with our tubular type turbines.

For drop 1 and for Dawson Lake we have suggested the use of tubular turbine with a runner diameter of 2.4 meters, the largest standard size manufactured; however, it is then only possible to utilize approximately 1910 cfs. The full flow can, of course, be utilized by using three units, each with a runner diameter of 2 meters. In this case the solution would be more expensive.

For general information on the tubular turbine, please refer to the enclosed brochure from Sørumsand.

The generator is a strongly-built machine and consists of a conventional stator and a salient pole system. The generator is further of the brushless type, having rotating rectifiers and an AC-exciter mounted on the shaft.

The machine is capable of withstanding short circuit and equipped with our modern thyristor regulator it may be run in parallel with the grid.

The generator is self-ventilated, air cooled, and the output terminals are arranged for easy access from either side.

For further information please refer to the enclosed WAB brochure.

Furthermore, the control gear consists of the following main components:

- Turbine and generator cubicle
- Power transformer
- Station supply
- High voltage cubicles
- Circuit breaker

Necessary protection equipment to ensure a safe running of the plant. If a fault is detected the set will be brought to a standstill.

The plant may be operated unmanned but requires a manual start-up.

Our prices are budgetary, delivered F.O.B., job site, inclusive of customs duty, freight charges, clearance costs, etc., but exclusive of local sales and other taxes.

The prices are based on an exchange rate of 5 Norwegian kroners to one U.S. dollar.

Based on the present factory loading, deliveries are estimated to be 14-16 months from the date of a clear-cut order.

We trust the above information is of assistance to you. Should you need further clarifications, we are always at your service.

Very truly yours,

BROWN BOVERI CORPORATION

S. Mookerjee
Sales Manager
Electrical Division

SM:ms
cc: G. Palka

Enclosures:

Francis Type Turbines
Tubular Turbines
Budgetary Prices
WAB - N-O-5551.3E

BBC BROWN BOVERI

BUDGETARY PRICES

	Installed Capacity KW	No. of Units	Type of Turbine	Diameter of Turbine Runner	Total Inst. Gen. Rating (KVA)	Total Price as Specified U.S.$
Drop 1	3600	2	RTRL	2.4	4000 (2 X 2000)	1,950,000.
Drop 2	Too Low Head					
Drop 6	Too Low Head					
Drop 9	1800	2	RTRL	2.0	2000 (2 X 1000)	910,000.
Dawson Lake	2900	2	RTRL	2.4	3200 (2 X 1600)	1,560,000.
Ceres Spillway	2200	1	RTRL	2.2	2400 (2 x 1200)	955,500.
Hukman Spillway	2100	1	Francis		2300	598,000.
Canal Creek	3000	2	RTRL	2.4	3300 (2 x 1650)	1,586,000.
Fairfield	600	1	RTRL	1.6	660	611,000.
Escaladian	280	1	RTRL	1.6	330	546,000.
Butrack	Too Low Head					
Fusher	-	-	-			
Youd	Too Low Head					
Woodward	2300	1	RTRL	2.4	2500	981,500.
Frankenheimer	3600	1	Francis		4000	1,040,000.
Goodwin Dam	1100	1	RTRL	2.4	1200	715,000.
Parker Drop	Too Low Head					

ALLIS-CHALMERS

INFORMATION

(U. S. A.)

ALLIS-CHALMERS
STANDARD

tube units

SIZING
CHART

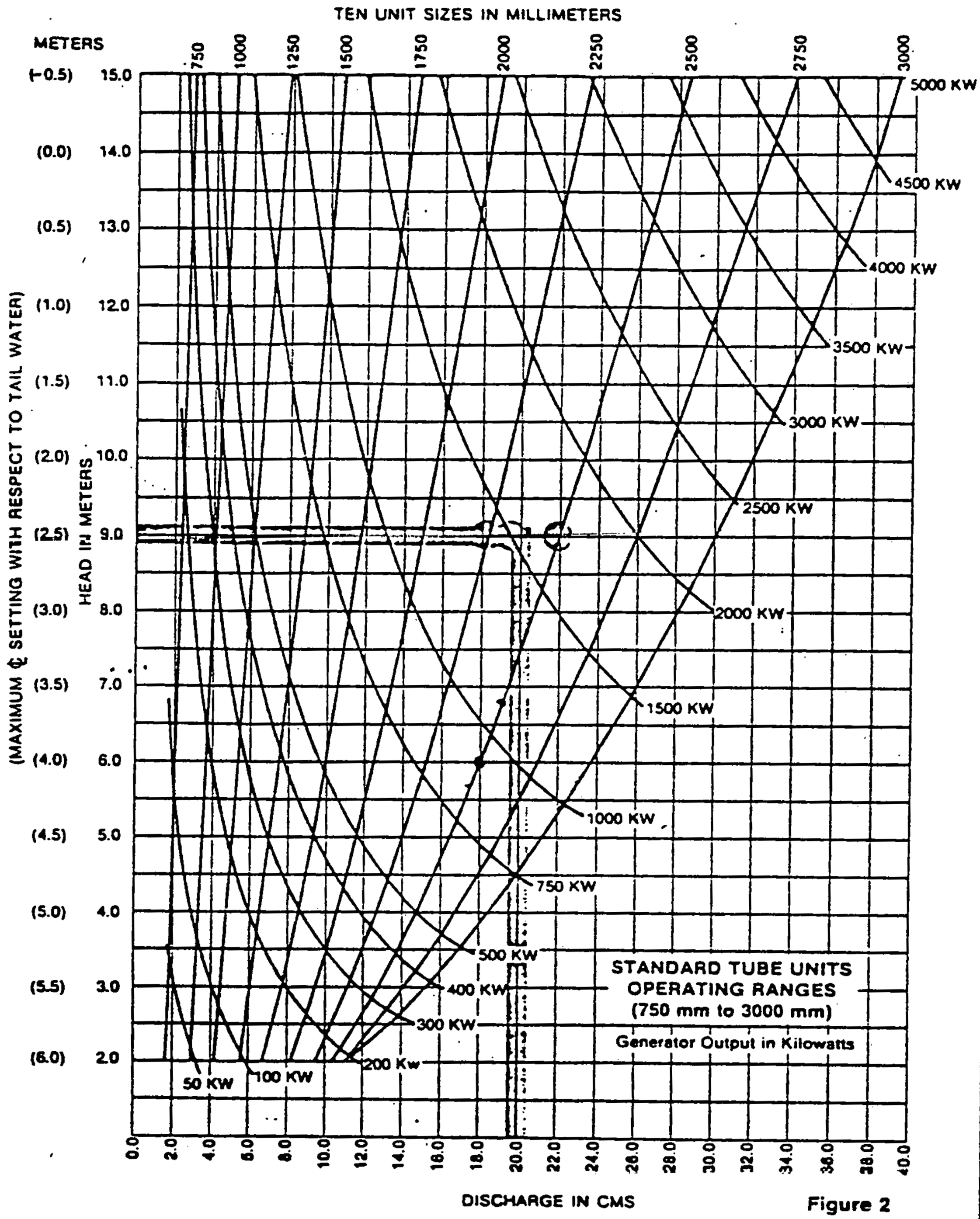


Figure 2

EXAMPLE (colored line) using operating range curve

Site characteristics:

- Head 9 m;
- Discharge 40 cms
- Set at sea level

(Turbine shaft is located not more than 2.8 m above full load tailwater elevation. This height must be reduced by differences in vapor pressure due to altitude of turbine above sea level.)

1. Since 40 cfs is beyond sizing curve capacity at 9 m head, at least two units are required, at 20 cms each.
2. Intersection of 9 m and 20 cms is between 2250 and 2500 mm sizes and slightly above 1500 kw.
3. A 2250 mm unit provides slightly less output and has a lower cost.

   $$\frac{18.4 \text{ cms}}{19.5 \text{ cms}} \times 1500 \text{ kw} = 1400 \text{ kw}$$

   Output at maximum blade angle
4. A 2500 mm unit provides a higher output at maximum blade angle and discharges the required amount of water at better efficiency

   $$\frac{19 \text{ cms}}{22 \text{ cms}} = 86\% \text{ full load.}$$

   $$\frac{22.0 \text{ cms}}{19.5 \text{ cms}} \times 1500 \text{ kw} = 1690 \text{ kw}$$

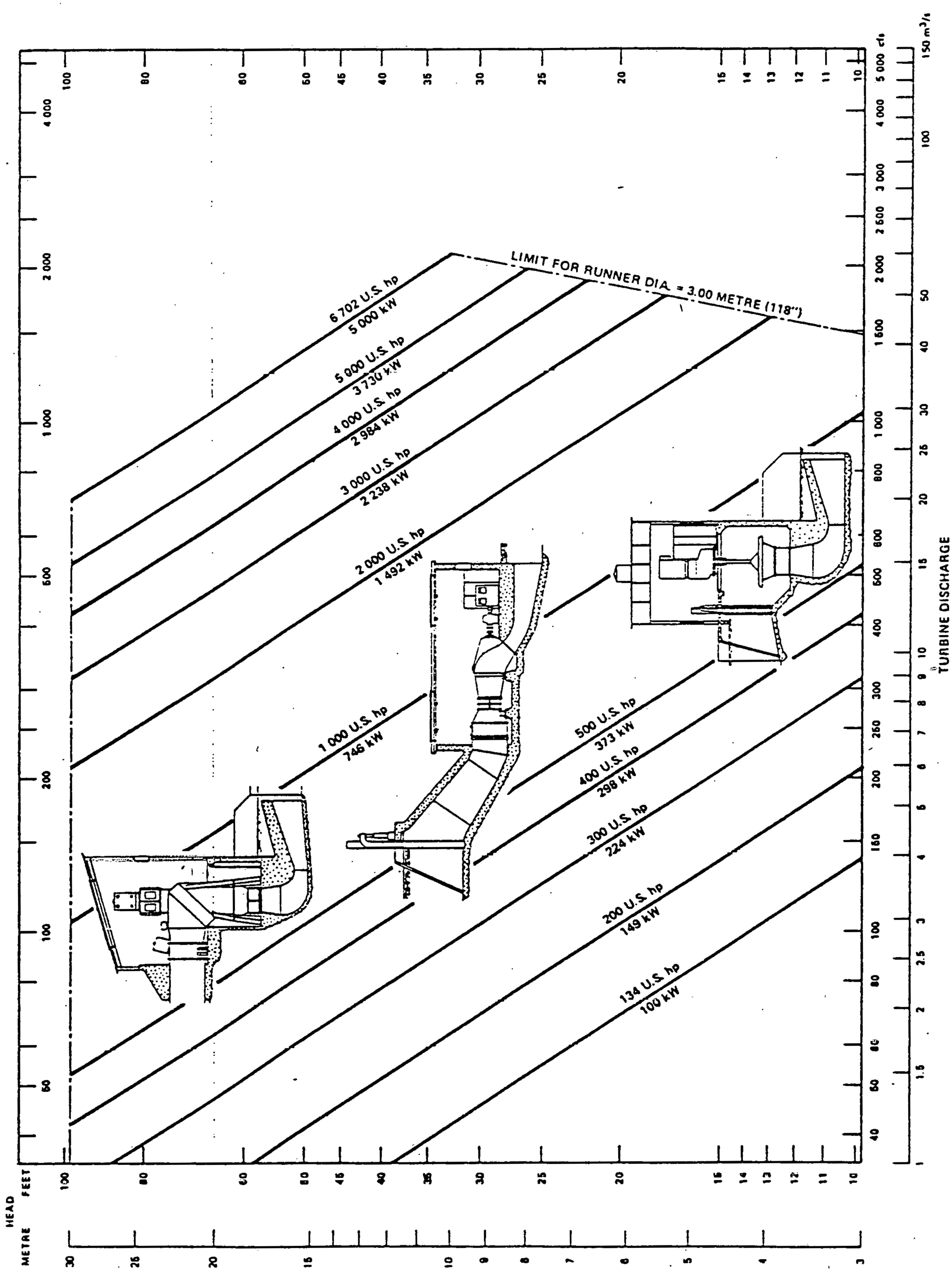
   Output at maximum blade angle

BOFORS-NOHAB

INFORMATION

(SWEDEN)

HYDRO TURBINE PROGRAM



APPLICATION DIAGRAM FOR BOFORS-NOHAB STANDARD TURBINES

APPENDIX 8.3

SITE CONFIGURATION

CRITERIA

CONTENTS

8.3 CONFIGURATIONS

EXPECTED GENERATION CONFIGURATIONS

A wide variety of turbine-generator characteristics can be examined for use at the various sites.

Hydropower generation is, of course, accomplished by the use of various types of turbine-generator combinations, with turbine selection basically dependent upon the combination of flow, head and site characteristics. General classification of turbines are:

- Pelton (Impulse): Used with heads normally exceeding 300 feet, Figure 1.
- Francis (Reaction): Used with heads from 75 to 1,000 feet, Figure 2.
- Kaplan (Propeller): Used with heads from 10 to 120 feet, Figure 3.
- Axial Flow (Tube Type): (Horizontal or Vertical Kaplan) used with heads from 6 to 60 feet, Figure 4.
- Axial Flow (Bulb Type): (Horizontal Kaplan) used with heads up to 100 feet, Figure 5.
- Fuji (Gate Type Bulb): Used with heads from 17 to 59 feet, Figure 6.
- Cross-Flow Types: Used with heads from 3 to 650 feet, Figure 7.

With small flows, impulse turbines are usually used with minimum heads of one hundred feet or higher, but with larger flows, they are not used below two hundred feet of head. They are not practical for low-head installations. For those sites that have heads from fifteen feet up to several times the sixty-six foot limit set for this assessment, reaction turbines or cross-flow turbines are the most appropriate choice. We know that on sites or applications where the head is less than twenty feet, the runner equipment to be selected will be some type of fixed propeller.

With an effective head range of 4.8 to 78 feet and relatively small flows, the turbines most appropriate for the various Districts' sites appear to be Francis, Kaplan (Propeller types), gate types bulbs and cross-flow types. These types have been assessed in Section 6.0 for suitability at each site.

Synchronous versus induction generation will be investigated as a specific subject. The basic information developed from this investigation will then be used to determine the possibility fo using a simplified induction generation scheme. Distribution or transmission lines, if available, at specific

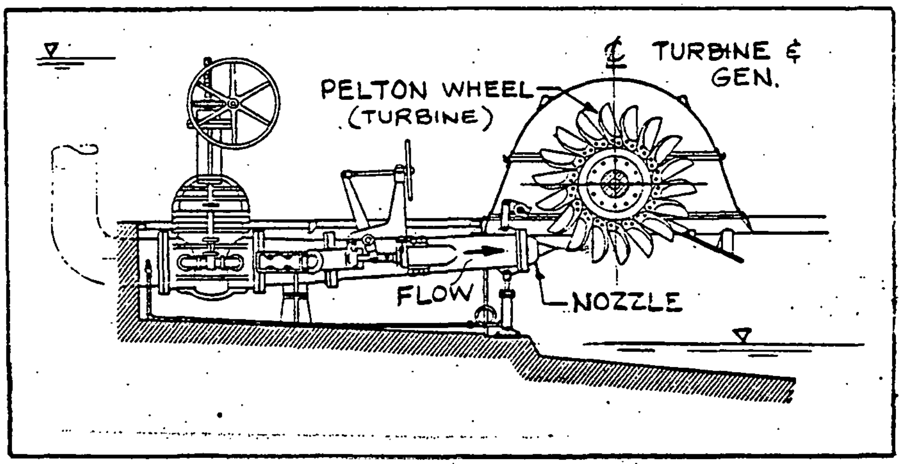
8.3 CONFIGURATIONS (CONT'D)

EXPECTED GENERATION CONFIGURATIONS (Cont'd)

locations, can apply the wattless component for excitation current required or can economically be controlled to allow this type of generation. Additional advantages achieved with induction generation are:

- Reduced capital equipment costs.
- Overall operation and maintenance savings.
- 33-50% installation costs saving.
- Reduced technical qualifications of power house operators.
- Less control and protection equipment required.

TURBINE GENERATOR CONFIGURATIONS

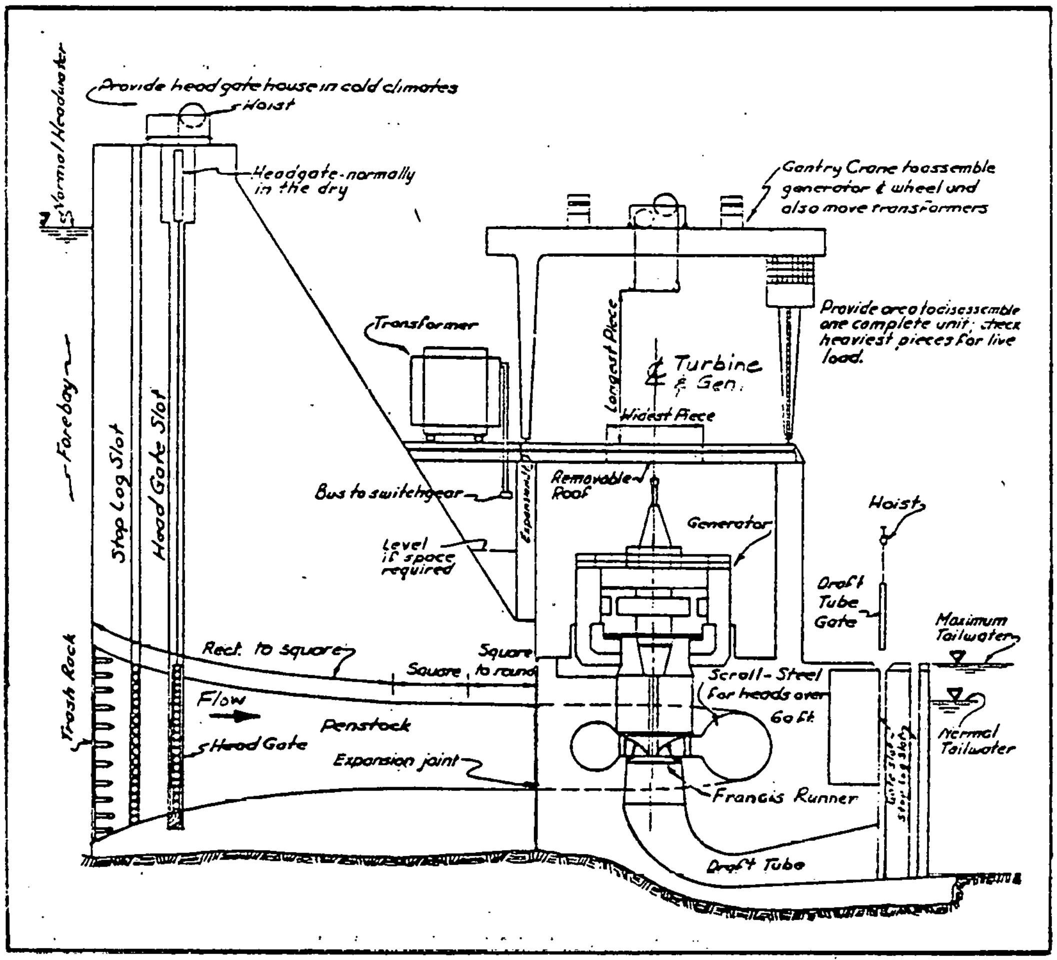


PELTON (IMPULSE)

Figure 1

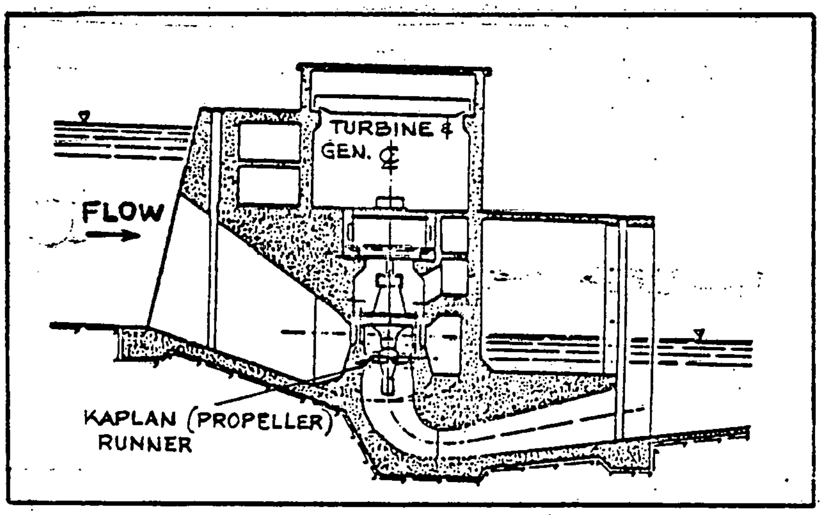
8.3 CONFIGURATIONS (CONT'D)

TURBINE GENERATOR CONFIGURATIONS



FRANCIS (REACTION)

Figure 2

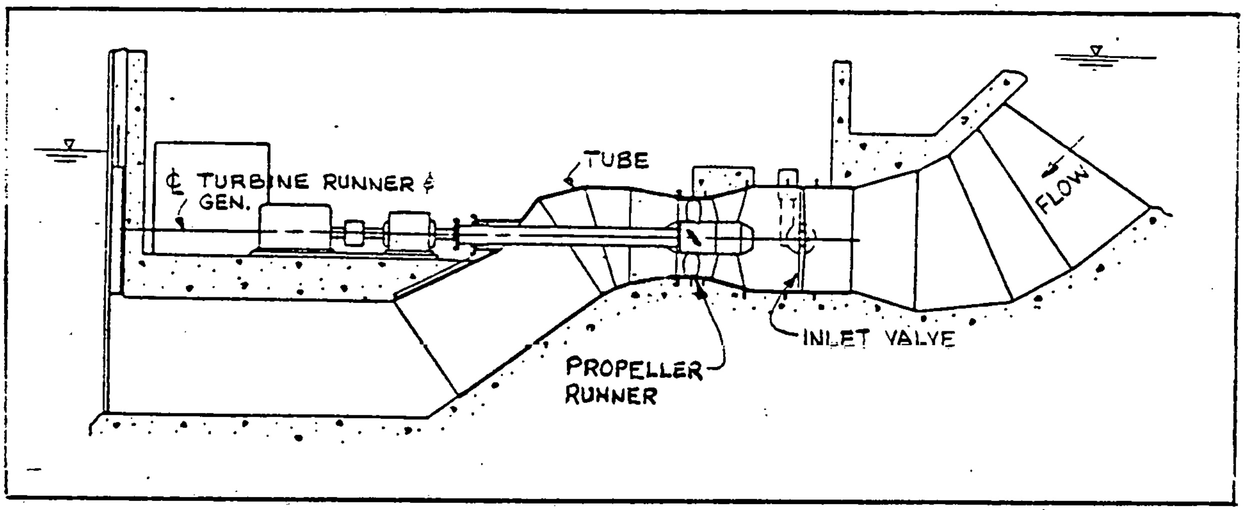


KAPLAN (PROPELLER)

Figure 3

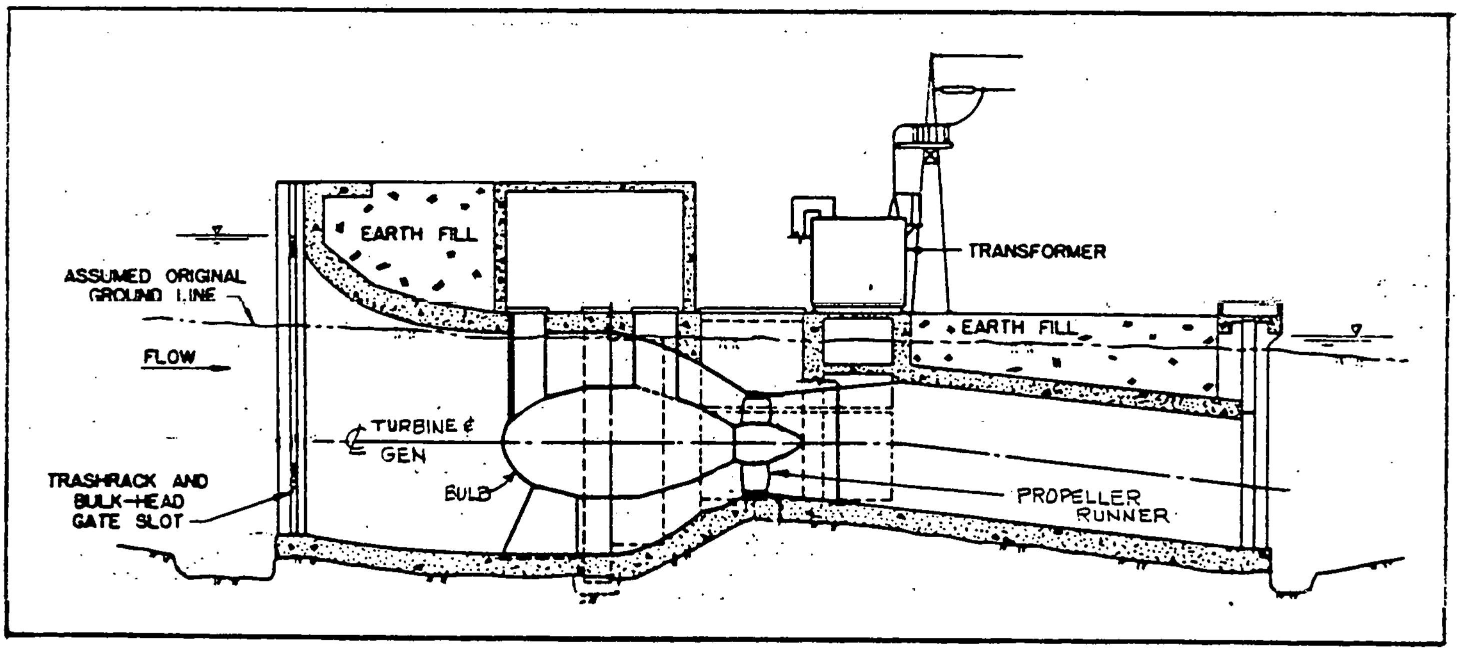
8.3 CONFIGURATIONS (CONT'D)

TURBINE GENERATOR CONFIGURATIONS



AXIAL FLOW (TUBE TYPE)

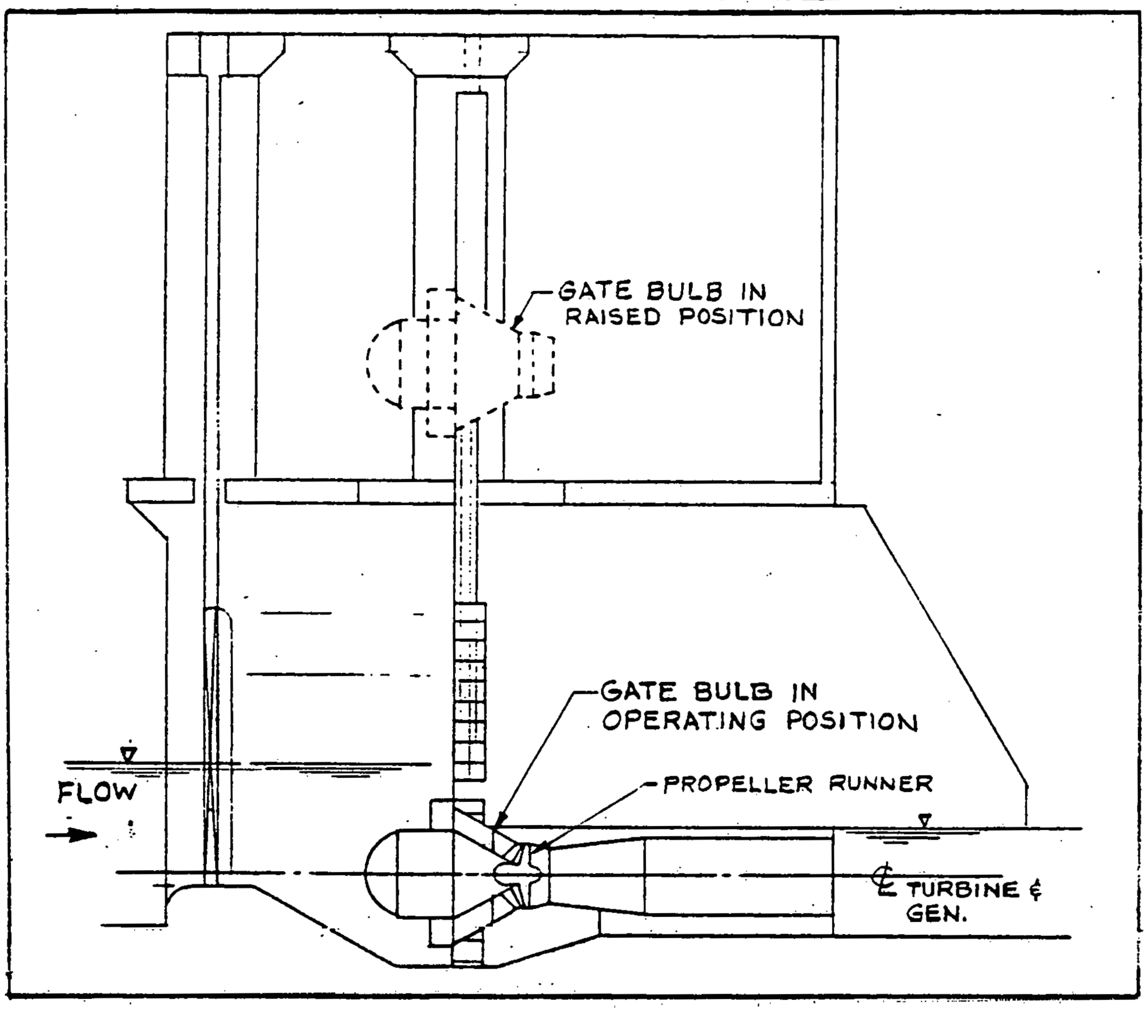
Figure 4



AXIAL FLOW (BULB TYPE)

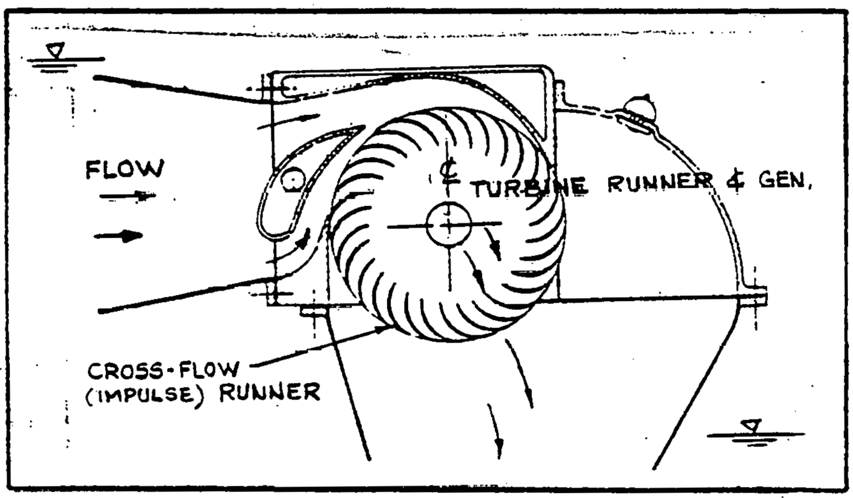
Figure 5

TURBINE GENERATOR CONFIGURATIONS



FUJI (GATE TYPE BULB)

Figure 6



CROSS FLOW TYPE

Figure 7

FES

8.3 CONFIGURATIONS (CONT'D)

The rotating equipment's dimensions, the size of auxiliary equipment, and clearances will establish the power house layouts. The layout, site's planned capacity, flow and head variables, and the characteristics of the connecting electrical system will be integrated to optimize the site's cost versus generation return.

The plant will have shut-off gates, or valves, probably hydraulically controlled, upstream of the turbine/generators. If possible, the existing shut-off or control gates will be retained to minimize the new structure cost. The gates will be used both for water flow control and for isolation during periods of shutdown for unit repairs. The upstream gates will be protected by trash racks.

If economically feasible, the downstream channel will be modified to pick up additional feet of head, therefore additional generation capability. The structure will have thru-gates allowing water to pass when generation is not desired.

Access ladders and hatches will be built into the structures for easy impellor examination or for equipment repairs. Clear access to the site and roadways will be maintained in order to allow heavy mobile lifting equipment to be properly located for equipment installation or if the runners or generators need to be transported or repaired. The transformer and electrical switching equipment for load connection will be located on a raised pad as close to the power plant as possible without blocking access.

EXPECTED PERFORMANCE

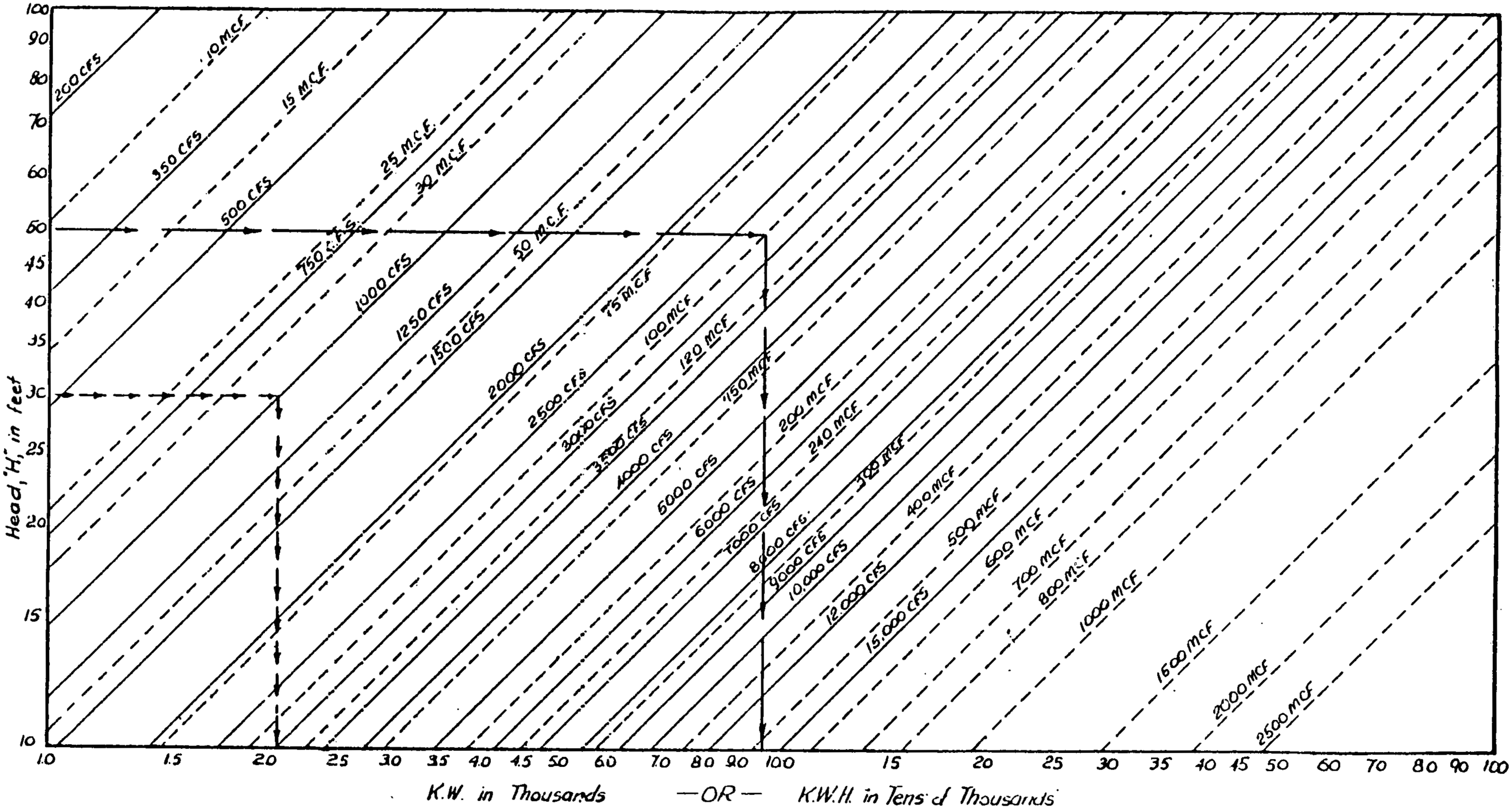
In order for the small hydropower installation to be practical, the efficiency in the turbines should range someplace between 85% and 93%, probably in the 88% to 91% range. The generator should have an efficiency of approximately 95% and the transformer and switch-gear should have approximately a 99% efficiency. Therefore, the total plant efficiency should be in the 80% to 85% range. Water level indicators with remote readouts should be placed both upstream and downstream of the power plant structures and a computer program developed so that the central control system will be able to ascertain when conditions at the site are such as to be within the plant's operational range. Other remote readout equipment should be installed at the developed site so that all required data can be fed back to the centralized control system for total remote control. Localized control that can override the remote control should also be maintained at all stations.

Remotely-sensed data also should be supplied to annunciator boards at the centralized control station so irregular signals or bad data will activate a sound-alarm whenever any part of the generation, electrical, or control systems malfunctions, ceases to function, is damaged or is vandalized. The handling equipment should be standard enough to be available at a relatively low cost. Maintenance of the system's components should be simple, with many of the minor adjustments, repairs, trouble-shooting and component exchanges being within the capability of the owner's existing hydropower maintenance staff. The plant should be visited at least once a week while it is operational so a visual inspection can be conducted.

$$K.W.^{*} = \frac{C.F.S. \times H \times 0.87 \times 0.95 \times 62.5 \times 0.746}{550}$$

$$H.P. = 1.341\ KW$$

$$K.W.H.^{*} = \frac{C.F. \times H \times 0.87 \times 0.95 \times 62.5 \times 0.746}{550 \times 3600}$$



C.F.S. = Cubic feet per second
M.C.F. = Million cubic feet

EXAMPLE-1

Given: Head H-30 ft. ; C.F.S = 1000
Required: K.W. output.
Solution: Enter chart at H-30 ft. and read the answer 2060 K.W., as shown by arrows.

EXAMPLE-2

Given: Head H-50 ft. ; C.F. - 100,000,000 (100 M.C.F.)
Required: K.W.H. output.
Solution: Enter chart at H-50 ft. and read the answer 98,000 K.W.H. as shown by arrows.

*Note: Efficiencies used — for Turbine - 87% for Generator - 95%. Power varies directly with other efficiencies.

JANUARY 1977 COST ESTIMATES BY TUDOR ENGINEERING COMPANY

MERCED IRRIGATION DISTRICT

Reuben E. Schmidt Powerplant

Maximun W. S...................... 300 feet
Normal Tailwater.................. 272 feet
Installed Capacity - 2 units @ 1750 KW each
Energy Production, 520,000 acre-feet: 12.5 M Kw hrs. (Summer Only)
200,000 acre-foot: 4.8 M Kw hrs. (Winter Water)

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CAPITAL COSTS: (Jan. 1977) Add Canal Wall R.B. 10,900' to raise to W.S. to El 300'	48,000	cy	4.00	$192,000
Forebay Excavation (Rock)	1,050	cy	10.00	10,500
Powerhouse excavation (Rock)	570	cy	10.00	5,700
Concrete				
Forebay Lining (Paving)	110	cy	50	5,500
Retaining Dam @ Forebay	1,350	cy	100	135,000
Powerhouse Structure	1,100	cy	150	165,000
Overflow Spillway Gate	1	LS		10,000
Gate Hoists & Motors	4@	LS	2,000	8,000
Gates - Low Head Leaf 8'x8'	4@	LS	3,000	12,000
Stilling Basin @ Outlets	2@	LS	20,000	40,000
Turbine/Generators	2@ 2000Kw	Kw	350	1,400,000
Accessory electrical equipment		LS		160,000
Switchyard structure and equip.		LS		70,000
Tailwater Channel - Excav.	60,000	cy	5.00	300,000
Forebay Dikes	650	cy	8.00	5,200
Total Direct Cost				$2,518,900
Overheads, Engr. & Contingency 35%				881,100
Total Capital Cost *				$3,400,000
ANNUAL COSTS:				
Debt Service 6¼ % 40yrs. bonds (CRF =.0706937)				240,000
Annual O & M				20,000
Total Annual Cost				$260,000
Energy Cost: $260,000 ÷ 12.5 M kw hrs. (Summer Water Only 520,000 A.F.)				20.8 mills kw hr
Energy Cost: 260,000 ÷ 17.3 M̄ Kw hrs. (Summer and Winter -720,000 A.F.)				15,0 mills kw hr

Tudor Engineering Company
January 1977

MAIN CANAL

* for 1977; 1977 thru 1982 escalated at 11%/year = $ 5,729,197

JANUARY 1977 COST ESTIMATES BY TUDOR ENGINEERING COMPANY

SOUTH SAN JOAQUIN IRRIGATION DISTRICT

Woodward Reservoir Power Plant

Maximum W.S. at (at Woodward) . . . . 209 feet
Normal Tailwater (in canal) . . . . 170 feet
Installed Capacity - 2 units @ 900 Kw . . . . 1,800 Kw
Energy Production, 300,000 acre feet . . . . 7.5 $\bar{M}$ Kwh

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CAPITAL COSTS (Feb. 1977):				
Powerhouse and Outlet Structure		L.S.		$ 60,000
Outlet Valves		L.S.		41,000
Penstock - 324' - 8' dia. and backfill concrete	42	Tons	2,000	84,000
Power Plant				
Turbine-Generators, (2 @ 900 Kw)	1,800	Kw	335	603,000
Accessory Elect.		L.S.		165,000
Switchyd. Equipment		L.S.		52,500
Site Work - Roads, Fencing				20,000
Total Direct Cost				$1,025,500
O.H. Engr. & Contingency	@ 35%			359,000
1977 Total Capital Cost *				$1,384,500
ANNUAL COST:				
6% Bonds - 40 yrs. (.06646)				92,000
Annual O & M				30,000
Total Annual Cost				$ 122,000

ENERGY COST:

$122,000 ÷ 7.5 $\bar{M}$ Kwh = 16 Mills/Kwh

Tudor Engineering Comp
February 1977

WOODWARD RESERVOIR

* for 1977; 1977 thru 1982 escalated at 11%/year = $2,332,963

FES

JANUARY 1977 COST ESTIMATES BY TUDOR ENGINEERING COMPANY

SOUTH SAN JOAQUIN IRRIGATION DISTRICT

Frankenheimer Powerplant

Maximum W.S. (at Forebay)	293	feet
Normal Tailwater	215	feet
Installed Capacity - 4 units @ 1500 Hp	4,500	Kw
Energy Production, 300,000 acre feet	19.5 M	Kw

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CAPITAL COSTS (Feb. 1977):				
Diversion from Main Canal		L.S.		$ 3,500
Canal Excav. (16' base, 1.5:1)	50,000	cy	2.90	145,000
Compacted Embankment	58,000	cy	.70	41,200
Canal Lining (4" Unreinf)	4,740	cy	50.00	237,000
Forebay Excavation	15,600	cy	1.50	23,400
Embankments	6,100	cy	2.10	75,800
Tailwater Canal Excav.	93,000	cy	1.30	121,000
Powerplant Structure		L.S.		100,000
Penstock - 9'-6" (Installed)	415	Tons	2,500	1,037,500
Piers & Anchors - Conc.	30	cy	200	6,000
Upper Penstock Valve	1	ea.	135,000	135,000
Turbine/Generators				
4 Ossberger @ 1500 Hp	4	ea.	280,000	1,120,000
Installation		L.S.		100,000
Accessory Elect. Equipment		L.S.		205,000
Switchyard & Equipment		L.S.		140,000
Total Direct Cost				$3,480,400
Overheads, Engr. & Contingencies	35%			1,218,100
Total Capital Cost*				$4,698,500
ANNUAL COSTS:				
Debt Service: 6% @ 40 yr. bonds (CRF = .06646)				312,000
Annual O & M				30,000
Total Annual Cost				$ 342,000

ENERGY COST:

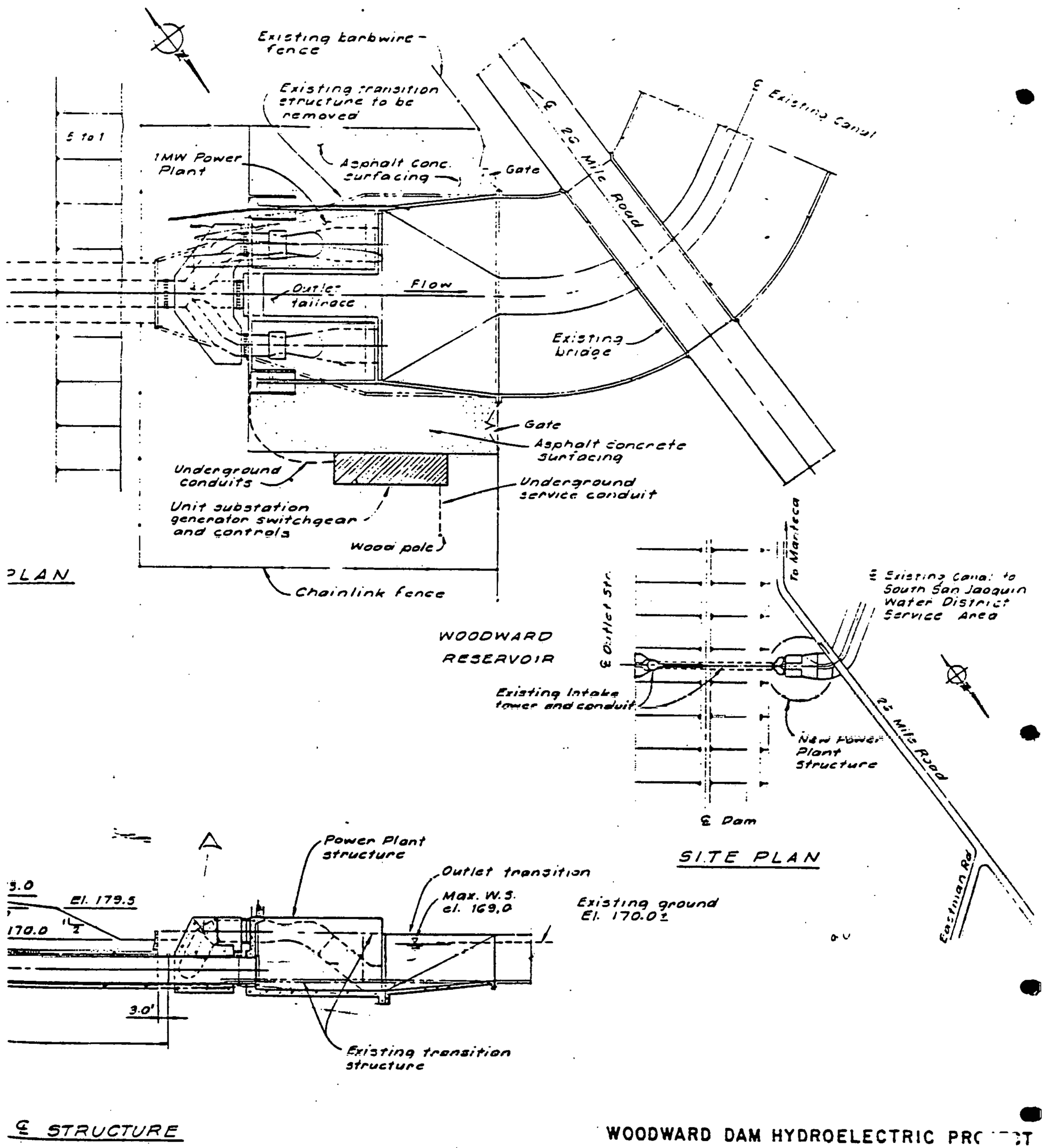
$342,000 ÷ 19.5 M Kw hrs.= 17.5 Mills/Kwh

Tudor Engineering Company

FRANKENHEIMER

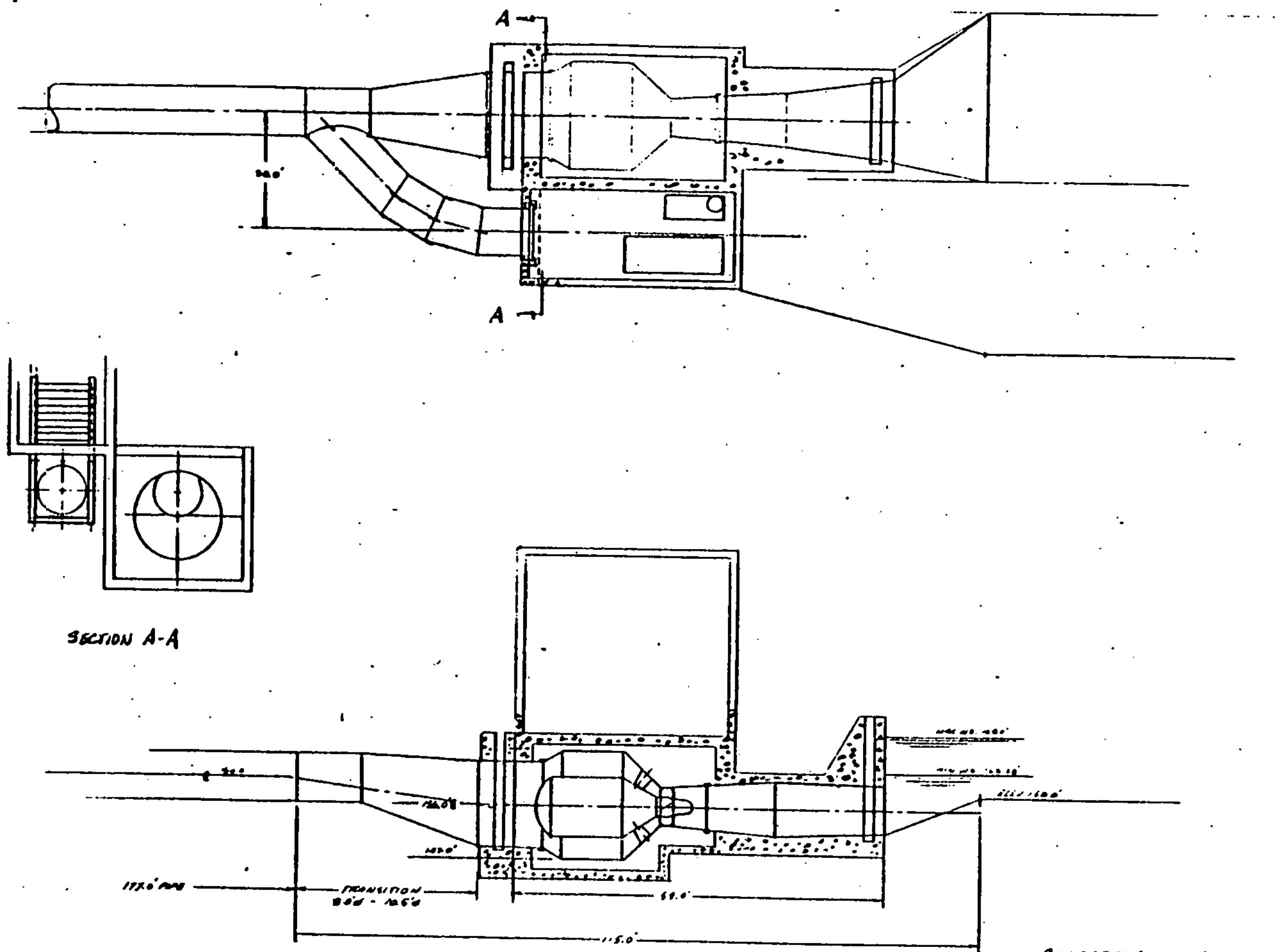
* for 1977; 1977 thru 1982 escalated at 11%/year = $ 7,917,245

FES



WOODWARD DAM HYDROELECTRIC PROJECT

GENENERAL PLAN AND PROFILE



CONCEPTUAL INSTALLATION OF
BULB TYPE TURBINE/GENERATOR V-2
FOR
SO SAN JOAQUIN IRRIGATION DISTRICT
WOODWARD DAM

13 FEB 1979
FLUID ENERGY SYSTEMS, INC.

FES

APPENDIX 8.4

LIST OF REFERENCE MATERIAL

8.4.1 MANUFACTURERS' DATA

ALLIS-CHALMERS

Product Brochures

Hydraulic Turbines
Standardized Hydroelectric Generating Units
Tube Turbines
Tube Turbines to Modernize Hydro Plants

Corporate Information

Annual Report 1976
S. Morgan Smith Memorial Hydraulic Laboratory
Site Manufacture of Grand Coulee 700 mW Francis Turbine Runners
Unique Total Field Service for Hydraulic Turbines
Welcome to Allis-Chalmers, York, PA.

BOFORS-NOHAB

Product Brochures

Bulb Turbines
Small Scale Hydro Turbine Program
Water Turbines Reference List

BROWN-BOVERI

Product Brochures

Marine Alternators Technical Data
Mini Hydro Power Plants from Norway
Tubular Turbines

Corporate Information

The People, Purposes and Capabilities of Brown Boveri Corporation.

ESCHER WYSS

Product Brochures

The Straflo Turbine

GILKES (GILBERT GILKES & GORDON, LTD.)

Product Brochures

Water Turbines for Hydro-Electric Power

HOME WATER POWER

Articles

Farm Water Power, U.S. Department of Agriculture, Farmers' Bulletin No. 1658, 1931
Hydropower (copy in FES file, no bibliographical information included)
Water Power for Your Home by E. F. Lindsley, Popular Science, May, 1977.

Brochures

Independent Power Developers Hydroelectric Power

8.4.1 MANUFACTURERS' DATA (CONT'D)

KOSSLER

Product Brochures

- 50 Jahre Turbinen (50 Years of Turbines)
- Modern Equipment for Small and Medium Sized Hydroelectric Power Stations.

LEFFEL

Product Brochures

- Vertical Shaft Hydraulic Turbines (Bulletin A-45)
- Hydraulic Laboratory
- Hydraulic Turbine Increases Power Production at Wilbur Dam
- Anderson Ranch Power Project
- Nevada Irrigation District
- Water Power
- Central Maine Power Company's Bar Mills Station
- Horizontal Turbine for Pleasant Valley
- 2 Leffel Turbines for Deer Creek
- Niagara-Mohawk
- Sacramento Municipal Utility District
- Flaming Gorge
- Cougar Reservoir
- Heredia, Costa Rica
- Duke Power Company
- Chelan County Public Utility District
- Laboratory Turbine with Francis and Propeller Runners (Bulletin No. HL-1976)
- Pamphlet "A"
- Turbine Water Wheels (Bulletin No. 36)
- Improved Vertical Samson Turbine (Bulletin No. 38)
- Hydro-Electric Power from a Hoppes Hydro-Electric Unit (Bulletin H-49)

NISSHO-IWAI (FUJI ELECTRIC)

Product Brochures

- In Step with Tomorrow
- Hydraulic Turbines and Generators
- Fuji Hydraulic Turbines
- Record of Fuji Hydraulic Turbine
- Application of Finite Element Method to the Stress Analysis of Hydro-Turbine Components
- Hydraulic Research Laboratory
- Fuji Francis Turbine
  - 306 mW Francis Turbine for Peace River Hydro-Electric Project Canada
  - Jordan River
  - Cethana
  - Hendrik Verwoerd
- Vertical Shaft Kaplan Turbine UIAM
  - UIAM
  - Ohyodogawa 1
  - 58,500 kW Kaplan Turbine for Kamose No. 2 Power Station Tahoku Electric Power, Inc.
  - Toyomi II

NISSHO-IWAI (FUJI ELECTRIC) (Continued)

Product Brochures (Continued)

- Fuji Gate Type Bulb Turbine and Generator
  - Bulb Turbine and Generator for AKAO Power Station, Kansai Electric Power Co., Jyoganjigawa II, II, IV
  - Poatina No. 6
  - Bambajima
  - Aricota II
- Outline of Major Equipment for Chong pyong Pump Storage of Messrs. Korea Electric Co. LTD.
- Fuji Electro-Hydraulic Governor
  - Transidyn Type
  - Signal Converter and Hydraulic Operating Mechanism
- Fuji Valves
- Fuji Hydraulic Turbine Generator
  - Peace River
  - Soyang Gang
  - Toyomi II
- Fuji Thrust Bearing for Water Turbine Generator
- F-Resin Insulation (New Insulation System for Stator Coils of Large Alternator
- Automatic Voltage Regulator for Synchronous Generator
- Hydraulic Turbines and Generators (Supply List)

Corporate Information

- Annual Report 1976

OSSBERGER

Product Brochures

- Water Power from Weissenburg
- Ossberger Turbine Generating Sets(Stapenhorst, Inc.)
- Water Power - Ossberger (F.W.E. Stapenhorst)

VOEST-ALPINE

Product Brochures

- Structural Steelwork
- Infomation
- Impulse Turbines
- Construction of Hydro Electric Power Plants

8.4.2 BIBLIOGRAPHY (CONT'D)

Multiple Access, Inc. Beginning WYLBUR I. Los Angeles.

______. User Reference Manual. Los Angeles.

______. WYLBUR Reference Manual. Los Angeles, 1976.

National Academy of Sciences. Energy for Rural Development, Renewable Resources and Alternative Technologies for Developing Countries. Washington, D.C., 1976.

Placer County Water Agency. Middle Fork American River Development, A Water Conservation and Hydro-Electric Project.

Proceedings from the Midwest Regional Conference on Small Low-Head Hydroelectric Power. East Lansing, 1978.

Scott, Ramon C. and Norman E. Sondak. PL/1 for Programmers. San Francisco, 1970.

Streeter, Victor L. Fluid Mechanics. New York, 1962.

TID - Drops 1 and 9 Machinery Evaluation. FILE.

del Toro, Vincent. Electromechanical Devices for Energy Conversion and Control Systems. New Jersey, 1968.

Turlock Irrigation District. Application for License to Authorize the Construction of Drop No. 1 Power Plant. Turlock, September, 1978.

______. Application for Short Form License. Turlock, October, 1978.

______. Joint Irrigation Districts Hydropower Assessment Study: Proposal No. TID-78-1 in Response to DOE's PRDA ET-78-D-07-1706. Turlock, 1978.

______. Schneider Hydrodynamic Power Generator Prototype Installation, Test and Evaluation. Turlock, 1978.

______. Turlock Irrigation District.

______. Turlock Irrigation District 1975 Annual Report (87). Turlock, 1975.

______. Turlock Irrigation District Eighty-Eighth Annual Report. Turlock, 1976.

______. Turlock Irrigation District Main Canal Drop Number One Low-Head Hydroelectric Power Demonstration Project; Proposal Number TID-2. Turlock, 1978.

______. Turlock Irrigation District Main Canal Drop Number One Low-Head Hydroelectric Power Feasibility Assessment. Turlock, 1977.

8.4.2 BIBLIOGRAPHY

Arthur D. Little, Inc. An Analysis of Future Electric Power Needs and Sources for the Turlock and Modesto Irrigation Districts, A Report to Turlock and Modesto Irrigation Districts, Volume I - Introduction and Summary. San Francisco, April 1975.

______. An Analysis of Future Electric Power Needs and Sources for the Turlock and Modesto Irrigation Districts, A Report to Turlock and Modesto Irrigation Districts, Volume II - Analysis. San Francisco, April, 1975.

California State Water Resources Control Board. Policy and Action Plan for Water Reclamation in California. Sacramento, 1978.

Chow, Ven Te. Open Channel Hydraulics. New York, 1959.

Considine, Douglas M. Energy Technology Handbook. Los Angeles, 1977.

Daugherty, R. L. Hydraulic Turbines. New York, 1920.

Davis, C. V. and K. E. Sorenson. Handbook of Applied Hydraulics. New York, 1969.

Department of Energy, Division of Geothermal Energy. Low-Head/Small Hydro-Electric Workshop. Washington, D.C., 1977.

Energy Sources and Uses in Stanislaus County Summary. September, 1977.

Fluid Energy Systems, Inc. A Preliminary Evaluation Report on the Schneider Hydrodynamic Power Generator. Los Angeles, 1978.

Gladwell, John S. and Calvin C. Warnick. Low-Head Hydro, An Examination of an Alternative Energy Source. Moscow, 1978.

Hand, A. J. Home Energy How-To. New York, 1977.

IBM System/360 Operating System Fortran IV (G and H) Programmers Guide. September, 1973.

IBM System/360 Principles of Operation. November, 1970.

Kennedy, Michael and Martin B. Soloman. Eight Statement pl/c (pl/zero) plus pl/one. New Jersey, 1972.

Knowlton, Archer E. Standard Handbook for Electrical Engineers. New York, 1949.

Loftness, Robert L. Energy Handbook. New York, 1978.

Merced (Ken McSwain). Flow Data and Other Data. FILE.

FES

8.4.2 BIBLIOGRAPHY (CONT'D)

______. Turlock Irrigation District Main Canal Drop Number Nine Low-Head Hydroelectric Power Feasibility Assessment. Turlock, 1977.

U. S. Department of the Interior, Bureau of Reclamation. Design of Small Canal Structures. Denver, 1974.

URS Company. Environmental Data Statement on the Water Supply System for the Stanislaus Nuclear Project. July, 1977.

______. Project Report on the Water Supply System for the Stanislaus Nuclear Project. July, 1977.

FES

APPENDIX 8.5

SUPPORTING DATA

8.5 SUPPORTING DATA

8.5.1 State of California Energy Commission Letter, March 24, 1978
- Economic value of new hydroelectric power

8.5.2 Turlock Irrigation District (TID) Letter, October 26, 1978
- TID system flows, transmission line locations, right-of-way maps.

8.5.3 A. L. Linhardt Memorandum, October 27, 1978
- Transmission line and grid evaluation requirements.

8.5.4 Review Meeting Agenda, November 15, 1978.

8.5.5 Turlock Irrigation District (TID) Letter, November 17, 1978
- Geological and Soil Conditions

FES

ENERGY RESOURCES CONSERVATION
AND DEVELOPMENT COMMISSION
1111 HOWE AVENUE
SACRAMENTO, CALIFORNIA 95825

March 24, 1978

The economic value of new hydroelectric generation in California in 1981 is determined by the opportunity cost of thermal generation in that time frame. Opportunity cost is the cost that California utilities will have to pay to provide the equivalent electricity for their customers if they do not purchase the hydroelectricity.

For firm power and energy the value is equal to the total cost of new thermal generation. The attached memorandum by Commissioner Reed supporting electric cogeneration in California provides capital cost estimates for new oil-fired baseload stations in 1978 dollars equal to $500 to $700 per kilowatt and operating costs of 2.8 to 3.0 cents per kWh. The capital costs add 1.1 to 1.4 cents to the operating costs with a conservative capital charge of 15% and a 75% plant factor. Thus at todays prices we have 3.9 to 4.4 cents per kWh as the "opportunity value" of firm thermal generation, and can assume these costs will escalate at a minimum of 6% per annum. Coal-fired, or nuclear generation costs are not likely to be lower.

Thus the economic value of firm hydroelectric energy is equal to 3.9 to 4.4 cents per KWH in 1978 dollars, escalating at 6% per annum.

For nonfirm hydroelectric energy the opportunity value is equal at a minimum to the cost of oil utilized to generate the equivalent electricity in California' oil-fired generating station. This is the generation which will be displaced by the utilities if they purchase additional non-firm hydroelectricity.

These costs are equal to approximately 25 mills per kWh in 1978 dollars. This value will also escalate at a minimum of 6% per annum into the early 1980's. This is the economic value placed on the acquisition of additional non-firm secondary energy from the new Pacific Northwest hydroelectric generation stations in the attached study of Pacific Northwest transmission interties.

Thus the economic value of non-firm hydroelectric energy generated in California can be placed at a minimum of 25 mills per kWh in 1978 dollars, escalating at 6% per annum.

October 27, 1978

MEMORANDUM

TO: K. THOMAS MILLER

FROM: ANTHONY LINHARDT

RE: PHASE D: TECHNICAL ASSESSMENT
TID - 78-1

The available power to be generated at the individual drops may be relatively small, but the combined power input of all sites will constitute a considerable percentage of the total energy used in the District. When this additional power is fed into the existing distribution network, it will affect it two basic ways:

1. Some sections of the network have to be increased to be able to carry the additional load.

2. The short circuit duty of the various nodes of the network will be strongly affected; that may necessitate the replacement or recalibration of the existing disconnecting and protective devices.

These is a need to evaluate the feasibility of building transmission lines from the far sites, such as the Merced and San Joaquin sites. The cost of these transmission lines may be prohibitive; selling the power from these sites directly to PG&E may be more economical, subject to a feasibility study.

If these transmission lines are decided to be built, they also have to be connected to the power grid. The point of connection has to be carefully chosen. The geometrically most advantageous point may not be economically suitable due to major alterations for accepting the increased load.

As a conclusion, the following recommendations may be considered:

1. The overall network has to be subjected to an evaluation to establish the points where the newly generated power can be fed in.

2. Based upon the result of Drop One, the network has to be redesigned. The current-carrying capacities have to be increased at some places to accommodate the increased load.

3. The redesigned network has to undergo a short circuit analysis to establish the fault duty at various nodes and to coordinate and/or recalibrate the protective relays, fuses, etc.

4. A feasibility study has to be conducted to see if the building of the transmission lines from far sites would be economical versus direct selling to PG&E.

AL:bjb

FES

I trust the above information will assist you in appraising the economic value of your new hydroelectric generation plants in California.

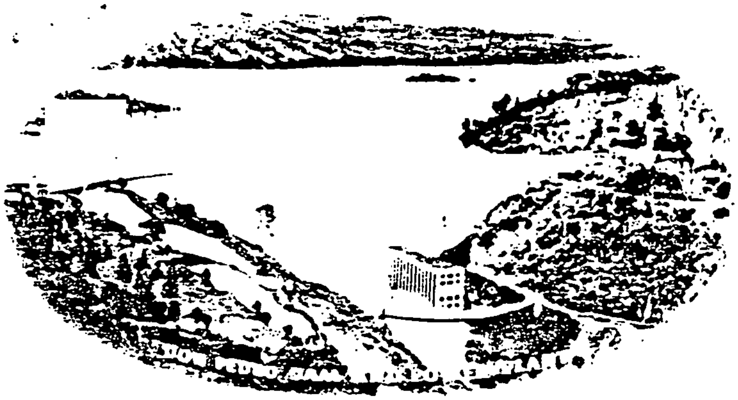
Yours Sincerely,

Stanton R. Smith
Senior Energy Economist

Attachments: (2)

1) Co-generation Memorandum by Commissioner Suzanne Reed; California Energy Commission, February 23, 1978

2) Opportunity to Benefit from Expanded Pacific Northwest-California Power System Integration by the Construction of Additional Transmission Interties by Stanton R. Smith; California Energy Commission, January 1978.



TURLOCK IRRIGATION DISTRICT

STANISLAUS AND MERCED COUNTIES, CALIFORNIA
P. O. BOX 949
333 EAST CANAL DRIVE
TURLOCK, CALIFORNIA 95380
(209) 632-3861

October 26, 1978

Lee Royalty
Fluid Energy Systems
4241 Redwood Avenue
Los Angeles, CA 90066

Dear Lee:

On your last trip to Turlock (10-20-78) you asked for additional site data from the Turlock system. The following data is enclosed per your request.

1. FPC opinion No. 420 which describes fish water requirements at La Grange.

2. Turlock Lake elevation and outflow charts 1966 thru 1978 (3 sheets).

3. Daily flow records at La Grange Dam powerhouse and T.I.D. Main Canal (1967 thru 1976).

4. Sketches showing T.I.D. 12 KV distribution lines near Drop #2, Drop #7 and Ceres Spill and description of lines. (3 sheets plus map)

5. Canal right of way maps at Drop #2, Drop #7 and Ceres Spill.

In additon, to confirm our discussions on 10-20-78, the following is offered.

1. Winter flows through Ceres and Hickman drops prior to 1973 is nonexistent since there were no fish water regulations prior to New Don Pedro power plant.

2. Estimates made by our Water Superintendent of the flow capacity at the spill structures are as follows:

Ceres Spill

thru gates	400 cfs
thru channel	500 cfs
thru spill	300 cfs

Hickman Spill

thru gates	400 cfs
thru channel	600 cfs
thru spill	350 cfs

3. Water surface elevation in our main canal is normally kept high to enable making gravity side deliveries and also to reduce delivery times.

Yours very truly,

TURLOCK IRRIGATION DISTRICT

Alvin K. Hagiwara
Asst. Electrical Department Manager

AKH:im
Enclosures
cc: Ben Lusk
Leroy Kennedy
Bob Ruether

"JOINT DISTRICTS" HYDROPOWER ASSESSMENT STUDY

REVIEW MEETING

DATE: NOVEMBER 15, 1978

TIME: 9:00 A.M. to 3:00 P.M.

PLACE: FLUID ENERGY SYSTEMS, INC.
4241 Redwood Avenue
Los Angeles, CA 90066

SUBJECT: ACTIVITIES PROGRESS, REVIEW AND PROBLEMS

A G E N D A

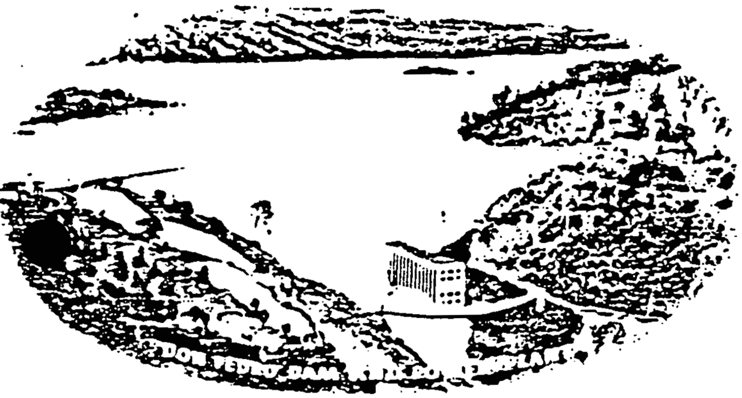
9:00 A.M. - 9:15 A.M.	INTRODUCTIONS AND SIGN-IN
9:15 A.M. - 9:45 A.M.	STATUS AND OVERVIEW - K. T. Miller
9:45 A.M. - 10:20 A.M.	SITE DATA AND PHASE REPORT STATUS - Lee Royalty
10:20 A.M. - 10:40 A.M.	BREAK
10:40 A.M. - 11:30 A.M.	PHASE D ASSESSMENT: *Power Marketing - A. L. (Tony) Linhardt *Environmental Problems - Wallace Stokes
11:30 A.M. - 1:15 P.M.	LUNCH HOSTED BY FES
1:15 P.M. - 1:45 P.M.	PHASE D ASSESSMENT (Continued): *Technical Problems - Ben Lusk *Schedule Problems - K. T. Miller
1:45 P.M. - 2:15 P.M.	PROPOSED STATEMENT OF WORK - All SCHEDULE CHANGES - K. T. Miller
2:15 P.M. - 3:00 P.M.	DISCUSSIONS - All PROBLEM RESOLUTIONS

ATTENDEES:

TID
* Ernest Geddes
* Al Hagiwara

FES
* K. Thomas Miller
* A. L. Linhardt
* Ben Lusk
* Lee Royalty
* Wally Stokes, III

FES



TURLOCK
IRRIGATION DISTRICT
STANISLAUS AND MERCED COUNTIES, CALIFORNIA
P. O. BOX 949
333 EAST CANAL DRIVE
TURLOCK, CALIFORNIA 95380
(209) 632-3861

November 17, 1978

Mr. Tom Miller
Fluid Energy Systems
4241 Redwood Avenue
Los Angeles, California 90066

Dear Tom:

This will confirm our telephone conversation of November 17, 1978 with regard to geologic conditions within the four participating Districts.

Noel Negley has informed me that the Frankenheimer site is similar to their Woodward Reservoir location. Soil conditions at this location is expected to be alluvial, silty with cobbles up to about 2 inches in diameter. He feels that civil cost estimates should be based on the above soil conditions.

Noel also informed me that he forwarded xerox copies of flow information at Goodwin Dam for both the SSJID and Oakdale diversions. You and I agreed that this information would be sufficient for the Goodwin Dam location.

I also talked with Ken McSwain of the Merced Irrigation District and he feels that similar soil conditions could be expected in the Merced District area, except where he specifically calls out hardpan areas in excavation data that was sent to you with other water operating data. He also feels that civil cost estimates should be based on these soil conditions. He estimates cost of excavation for the hard materials to be around $10 per yard and for soft earth at $1.50 per yard.

Ken feels that the structure at the Escaladian Drop should be replaced if a power facility is installed. All other structures are good.

If there are no other complications, Ken and I feel that the Canal Creek site should replace the Fisher site for DOE reporting. Canal Creek appears to be a more worthwhile site to consider.

As far as the Turlock Irrigation District sites are concerned, soil conditions should be considered to be alluvial and existing structures stable.

Very truly yours,

TURLOCK IRRIGATION DISTRICT

Alvin K. Hagiwara,
Assistant Electric Department Manager

AKH:bh

cc: Noel Negley
Ken McSwain
Ernest Geddes
Roger Masuda
Norman Boberg
Leroy Kennedy

APPENDIX 8.6

THE

CALIFORNIA ENVIRONMENTAL

ASSESSMENT PROCESS

THE CALIFORNIA ENVIRONMENTAL ASSESSMENT PROCESS

An environmental assessment of the project will be required in accordance with the California Environmental Quality Act of 1970 (CEQA), as currently amended, and the current guidelines for implementation of the Act as issued by the Resources Agency of the State of California.

In accordance with the provisions of CEQA, the Lead Agency responsible for the environmental assessment shall be the public agency which has the principal responsibility for carrying out or approving the project. The Lead Agency for this project may be an irrigation district or another agency that may be responsible for project development. In addition the environmental assessment process must include the participation of all "Responsible Agencies." A responsible agency is any public agency that will either be carrying out the project, or will have discretionary approval authority over the project. All environmental determinations require the approval of all the responsible agencies as well as the Lead Agency. As an example, the responsible agencies will include the State of California Division of Safety of Dams since they will exercise approval over the design and construction of the project.

The responsible public agencies must first make a determination if the project is subject to requirements of CEQA and is not exempt in accordance with the CEQA guidelines. The project does not appear to meet the requirements for exempt status as ministerial, emergency or discretionary, or categorically exempt projects.

Following the findings of CEQA applicability the Lead Agency is responsible for the preparation of an Initial Study. The purposes of an Initial Study are to:

- Identify environmental impacts;
- Enable an applicant of Lead Agency to modify a project, mitigating adverse impacts before an EIR is written:
- Focus an EIR, if one is required, on potentially significant environmental effects;

- Facilitate environmental assessment early in the design of a project;
- Provide documentation of the factual basis for the finding in a Negative Declaration that a project will not have a significant effect on the environment;
- Eliminate unnecessary EIR's.

An Initial Study shall contain in brief form:

- A description of the project;
- An identification of the environmental setting;
- An identification of environmental effects by use of a checklist, matrix, or other method;
- A discussion of ways to mitigate the significant effects identified, if any;
- An examination of whether the project is compatible with existing zoning and plans;
- The name of the person or persons who prepared or participated in the Initial Study.

Following the completion of the Initial Study the Lead Agency shall make a determination of whether the project may have a significant effect on the environment in accordance with the CEQA guidelines and requirements. It is presently anticipated that there will be a finding of non-significance and that a complete Environmental Impact Report will not be required.

Following a determination of non-significance a Negative Declaration could be prepared by the Lead Agency in consultation with all of the responsible agencies. A Negative Declaration would include:

- A brief description of the project, including a commonly used name for the project, if any;
- The location of the project and the name of the project proponent;
- A finding that the project will not have a significant effect on the environment;
- An attached copy of the Initial Study documenting reasons to support the finding;
- Mitigation measures, if any, included in the project to avoid potentially significant effects.

The preparation of the Initial Study and Negative Declaration would require a minimum of about four (4) to eight (8) weeks.

A public notice and review of a "reasonable" period is required following the preparation of a Negative Declaration. Generally, a minimum of 30 days is considered a reasonable period. However, if a state agency, such as the Division of Safety of Dams, is designated as a responsible agency the minimum public notice and review period will be 45 days.

Following the review period and a decision or decisions to carry out or approve the project by the Lead Agency and responsible agencies the Lead Agency shall prepare and file a Notice of Determination with a copy of the Negative Declaration. The Notice shall include:

- The decision of the agency to approve the project;
- The determination of the agency whether the project will have a significant effect on the environment; and
- A statement that no EIR has been prepared pursuant to the provisions of CEQA.

Following the filing of the Notice with the County Clerk the project may proceed subject to legal challenge with a 30-day statute of limitations.

If after completion of the Initial Study, the Lead Agency finds that the project may have significant effect on the environment, or if there is serious public controversy concerning the environmental effect of the project, an environmental impact report must be prepared by the Lead Agency. The EIR process is similar to but significantly more lengthy than that for the Negative Declaration. The EIR process requires:

- Early consultation with all responsible agencies and concerned organizations or individuals;
- Preparation of the draft EIR;
- Public notice and reveiw of the draft EIR;
- Lead Agency evaluation of the draft EIR;
- Preparation of the final EIR;
- Certification that the final EIR has been completed in accordance with CEQA and the state guidelines;
- Notice of determination following project approval; and

- Filing of the final EIR.

In accordance with CEQA, the EIR must include:

- Description of Project;
- Description of Environmental Setting;
- Environmental Impact:
  - The significant environmental effects of the proposed project;
  - Any significant environmental effects which cannot be avoided in the proposal if implemented;
  - Mitigation measures proposed to minimize the significant effects;
  - Alternatives to the proposed action;
  - The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity;
  - Any significant irreversible environmental changes which would be involved in the proposed action should it be implemented;
  - The growth-inducing impact of the proposed action.

All responsible agencies shall consider the Lead Agency's final EIR before acting upon or approving the project.

The complete EIR process would normally require three (3) to six (6) months, or more.

APPENDIX 8.7

ELECTRICAL AND CONTROL EQUIPMENT FOR SMALL HYDROELECTRIC POWER PLANTS

BY MARTTI T. MAATTANEN, M.SC. (ELEC.ENG.)

FROM FINN ENERGY, 1979

FES

ELECTRICAL AND CONTROL EQUIPMENT FOR SMALL HYDROELECTRIC POWER PLANTS

by Martti T. Maattanen, M.Sc. (Elec. Eng.)
Oy Stromberg Ab
P.O. Box 69
65101 Vaasa 10, Finland

SUMMARY

Electrical and control equipment is the primary interface for the user in the operation of a hydroelectric plant. This report introduces Oy Stromberg Ab as a company with long experience in this field, one in which the company is a recognized specialist in small induction and synchronous generators. The selection of main circuit diagram, voltage levels and component types involves both technical and economic analysis. A modern control board is an integrated factory-tested unit capable of remote control applications and rapid installation.

1. General

Electricity generation has long been the primary way to utilize hydro power. In modern unmanned and automated plants, which are often operated by remote control, the role of the control systems has become extremely important.

Oy Stromberg Ab has long experience in hydroelectric engineering. As early as 1889, the young Finnish engineer Gottfrid Stromberg founded an electrical workshop in Helsinki and manufactured his first d.c. dynamo. This was the start of Oy Stromberg Ab, which today is the leading electrical manufacturing enterprise in Finland.

Stromberg electrical equipment can be found in most Finnish hydroelectric plants and in projects overseas. The company today specializes in small size units which, if required, can include custom electrical and control systems. Stromberg products - generators, switchgears, transformers and other electrical equipment - are characterized by high quality and performance data. With special surface treatment, they are suitable for use in corrosive conditions and in the tropics.

2. Generator

Power stations are generally equipped with synchronous generators, especially when:

- the unit power is large, 2 MVA or more
- the station is to be used in isolated operation
- power factor improvement is needed

When planning small hydro power stations, there are situations when the use of an induction generator is the most economic solution:

- small unit, less than 2 MVA
- no need for or possibility of remote operation
- the rotational speed of the turbine is high

Generally, an induction generator is advantageous only for the generation of additional energy in conjunction with a larger, reliable system.

The generator type is selected according to the turbine data. The voltages of 400 V, 450 V or 660 V are generally used in small generators; in larger generators, the high voltage can be selected from the range of e.g. 3 kV to 10.5 kV. According to the rotation speed of the turbine and taking into account a possible gear, the rotation speed of small generators is usually 500 rpm to 1800 rpm at the frequencies 50 Hz or 60 Hz. The small generators are usually of brushless design. In this case, the excitation power is taken from the exciter installed in the generator shaft through a rotating rectifier bridge (Fig. 1). Bigger units, especially when the speed is slower than 300 rpm, are often delivered with static exciters (Fig. 2). The generator frame is often of welded design and the rotating parts are dimensioned according to the runaway speed determined by the water turbine.

Stromberg manufactures generators mainly with a horizontal shaft (Fig. 3), but all induction and HV synchronous generators can also be delivered with a vertical shaft.

a. Synchronous LV (up to 660 V) generators
   190 kVA - 3000 kVA

b. Synchronous HV (3.3 - 13.8 kV) generators
   1.5 MVA - 20 MVA (the upper limit depending of the rotational speed)

c. Asynchronous LV generators up to 1000 kW

d. Asynchronous HV generators up to 6000 kW

These modern and reliable machines are remarkably efficient. The use of new technology in magnetic circuits and insulating materials has resulted in comparatively small, compact, high performance equipment. Thus when modernizing:

- today a new generator that is the same size as an older machine operates at higher capacity or better efficiency
- a machine with the same capacity as its predecessor needs less space

For small units up to about 2000 kVA, it is, in general, recommended to choose an LV generator. In these cases, the use of a gear between the turbine and the generator is economical and often, in fact, the only rational choice.

3. Switchgears

The choice of main circuit diagram is based on an analysis of the alternatives:

- purchase prices
- the efficiency and/or loss of efficiency when taking into account the duration of different situations
- availability and operating costs
- possibility or need for later expansions of the plant
- the actual situation (construction of a new plant, enlargement, modernization, changes)

In general, it is recommended:

- not to ground the generator neutral point directly
- to use a transformer between the generator and network
- to connect the station supply directly to the network (Fig. 4). In some cases, however, the connection to generator terminals or a switchover possibility to either of the alternatives is advantageous.

A plant with an induction generator (Fig. 5) has some special features:

- the economic savings due to an induction generator are largely lost if the plant is equipped with control systems facilitating isolated operation;

- the synchronization is in general performed by connecting to network the unexcited generator running at about rated speed. Thus, the phase-angle control is not necessary;

- the excitation current can be taken from network, but this causes considerable extra losses. It is more economical to connect a capacitor bank to the generator terminals after synchronization. When the network connections are tripped off, causing in general a runaway situation, these capacitors should be rapidly disconnected to avoid overvoltages.

A plant with small units often has an LV main switchgear. Indoor-type LV switchgears for installation in dry electrical rooms can be equipped with fixed or withdrawable type circuit breakers. The connections between the main transformer and the LV switchgear can at small units be arranged by heavy current cable systems. However, either an open or an enclosed busbar is frequently selected.

The LV switchgear is of multicubicle type and often forms a compact unit containing also the control board, the station supply board and the auxiliary d.c. board. The structures are of hot-galvanized steel sheet painted with epoxy and are suitable for difficult environmental conditions.

Indoor-type HV switchgears for installation in dry electrical rooms are available at voltages of 3.6 to 24 kV as factory-made, metal-enclosed switchgears. The switchgears can be equipped either with fixed or withdrawable type circuit breakers. The standard type switchgear structures are arc-pressure tested, taking into consideration the safety of the personnel. Switchyards for voltages over 24 kV are usually of outdoor open-terminal type.

4. Transformers

The power of the main transformer of the station is chosen in accordance with the power of the generator. The transformers are of standard type and fulfill the requirements of IEC Recommendations 76/1976. They are self-cooled, oil-insulated three-phase transformers equipped with an oil conservator, and are suitable both for indoor and outdoor installation.

The power of the station service transformer is determined in accordance with the demands of the station. For example, standard type transformers of 16, 30, 50, 100 and 200 kVA are available.

5. Control and Protection Equipment

The control panel consists of the following main parts:

- station supply a.c.
- auxiliary d.c. system
- manual controls, instruments and displays
- automation equipment
- protection and alarm system

The excitation equipment and the protective relays of larger generators are in separate cubicles located in dry electrical rooms. The voltage regulators of small generators are usually placed on top of the generator and the protective relays can be mounted, e.g. into the control panel.

The control panel also includes the d.c. board which comprises displays, battery monitor and auxiliary voltage supplies. The rectifier and battery are normally delivered separately. A lead acid battery is suitable for ordinary cases, and an alkalic battery is delivered for special conditions.

One of the main parts of the control system is the water level control, where today direct pressure measurement is mainly used (Fig. 6).

6. Remote Control

In industrialized countries, small hydroelectric plants have as operational features:

- unmanned operation
- automatic operation with the possibility of complete manual control in exceptional conditions
- remote control in normal times

Even in cases when the plant is initially operated locally, provision should be made for easy hook-up to remote control equipment of:

- operational commands
- state indications
- alarms
- measurements

In ordinary cases, the primary delivery includes:

- the operational changeover switches in the control board
- the wiring of control signals to terminal blocks in switchgears and the control board
- space reservations for measuring transducers and auxiliary relays

7. Other Electrification

The complete electrification also includes such other activities and components, partly delivered by local companies, as:

- civil works for outdoor switchyard and electrical rooms in the station building
- supporting structures
- earthing systems
- internal, external and emergency lighting
- cables and cable shelves
- installation
- commissioning

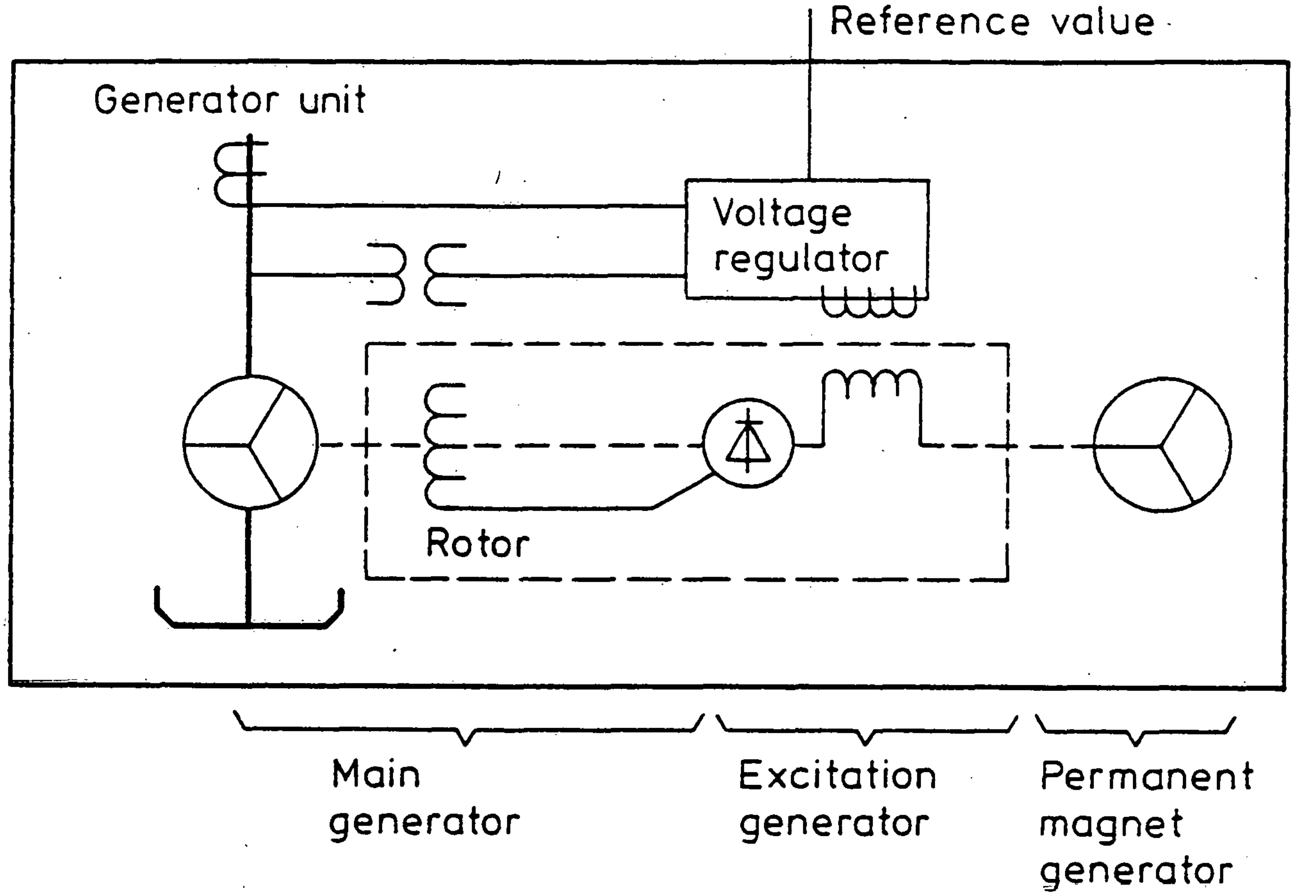


Fig. 1 Brushless excitation

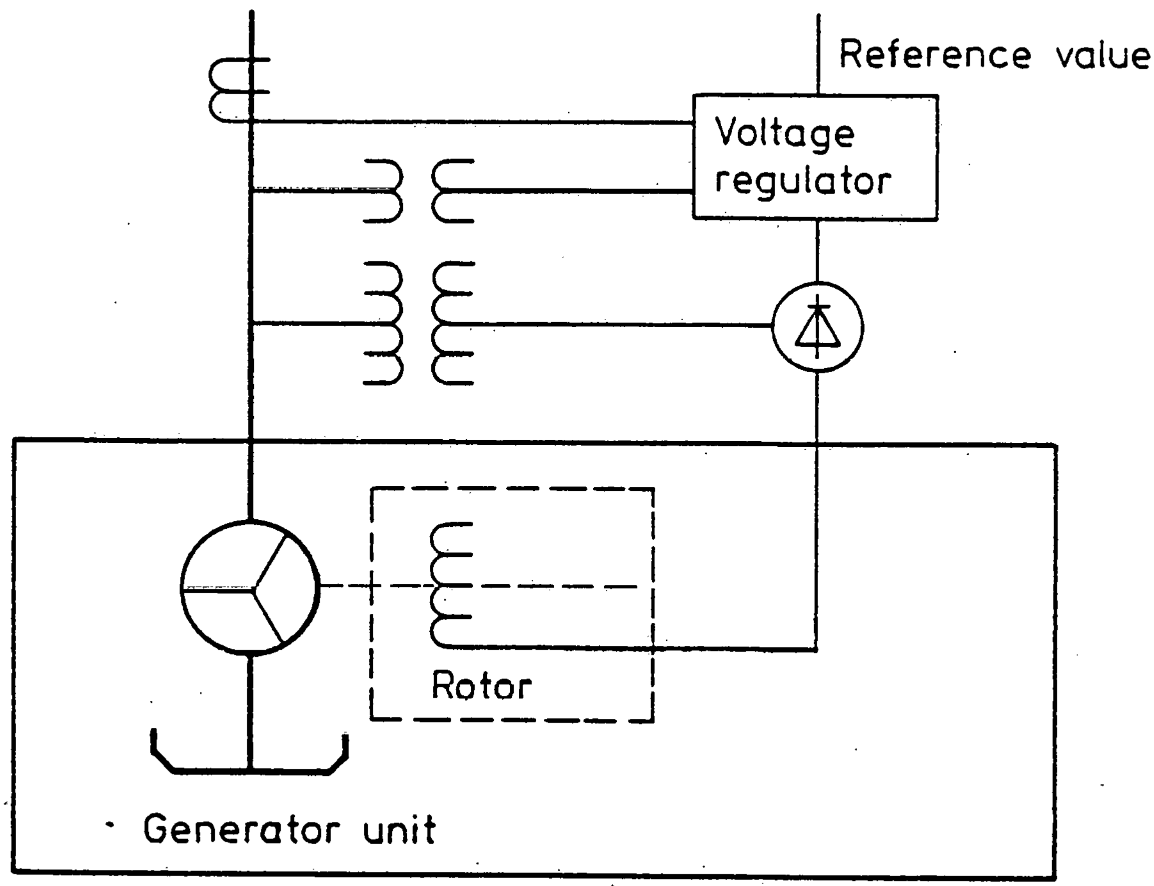


Fig. 2 Static excitation

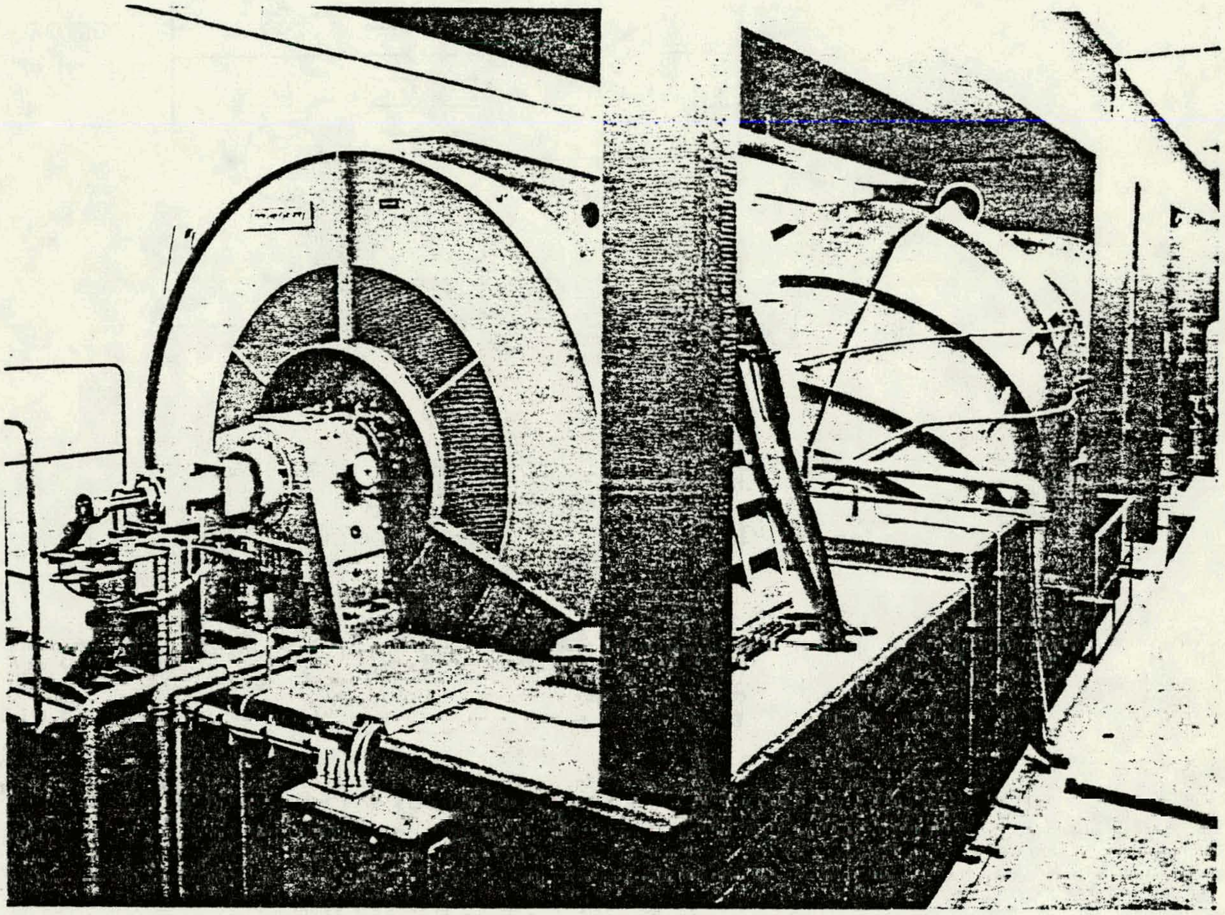


Fig. 3 A miniplant of 3.0 MW

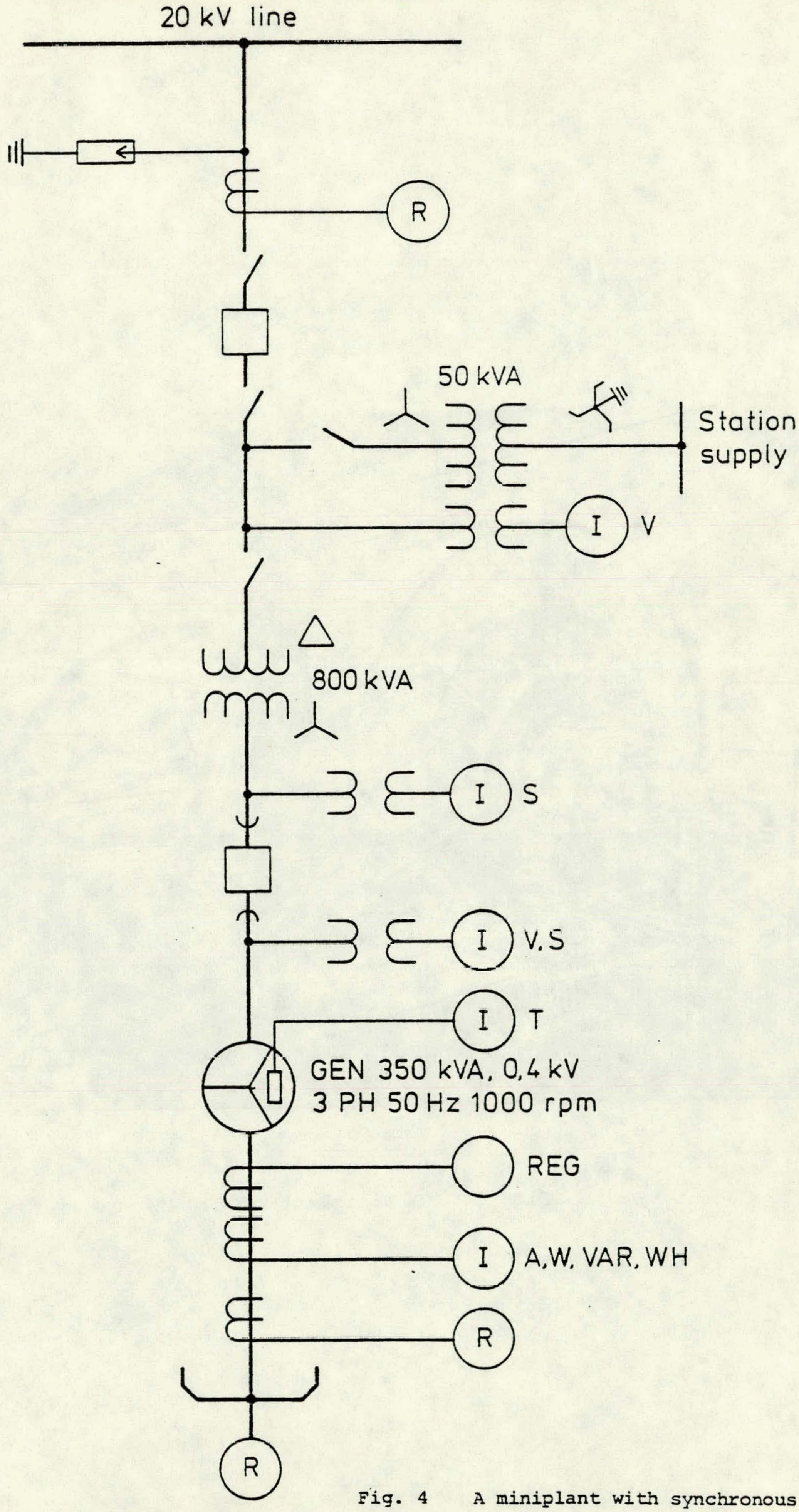


Fig. 4 A miniplant with synchronous generator

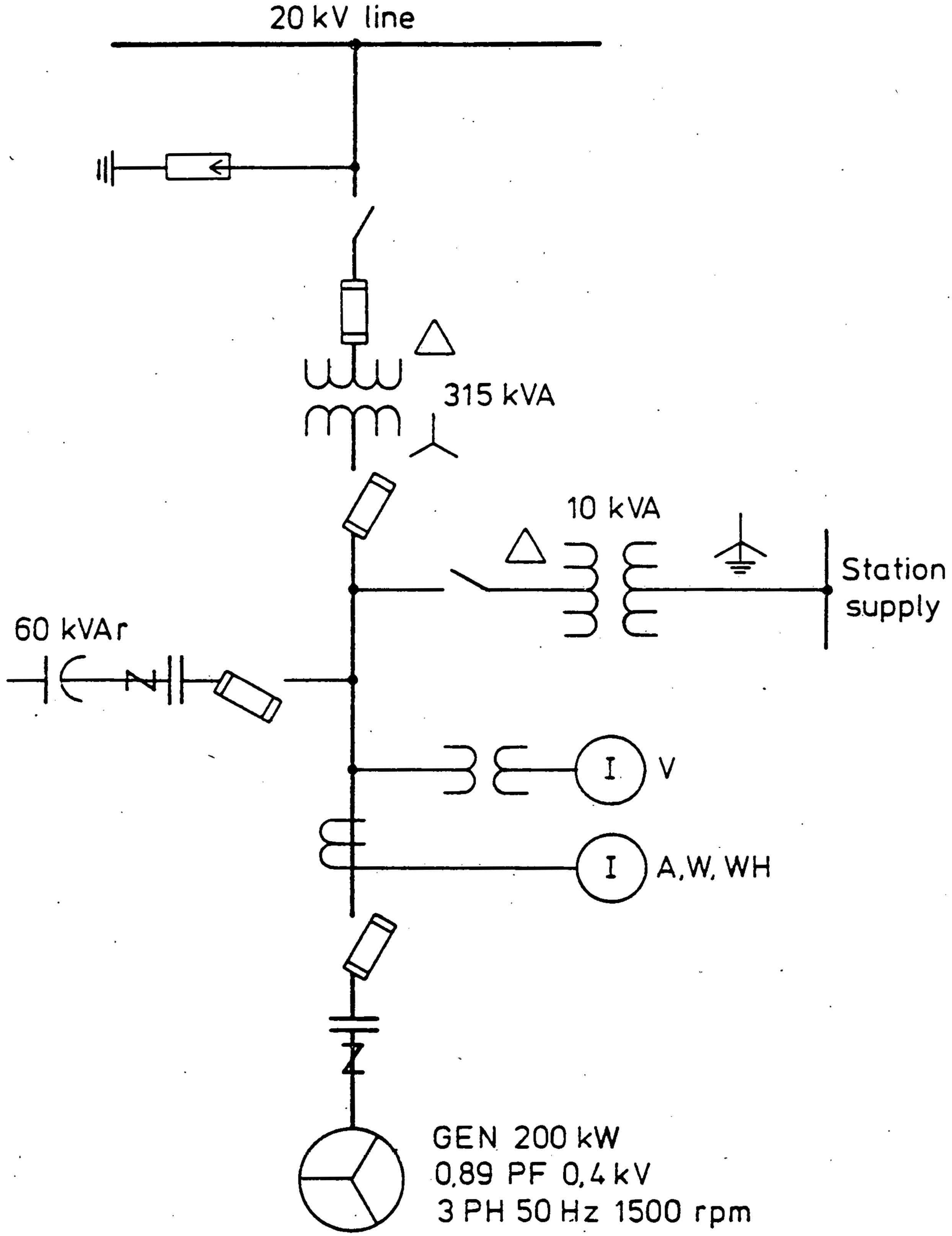


Fig. 5 A miniplant with induction generator

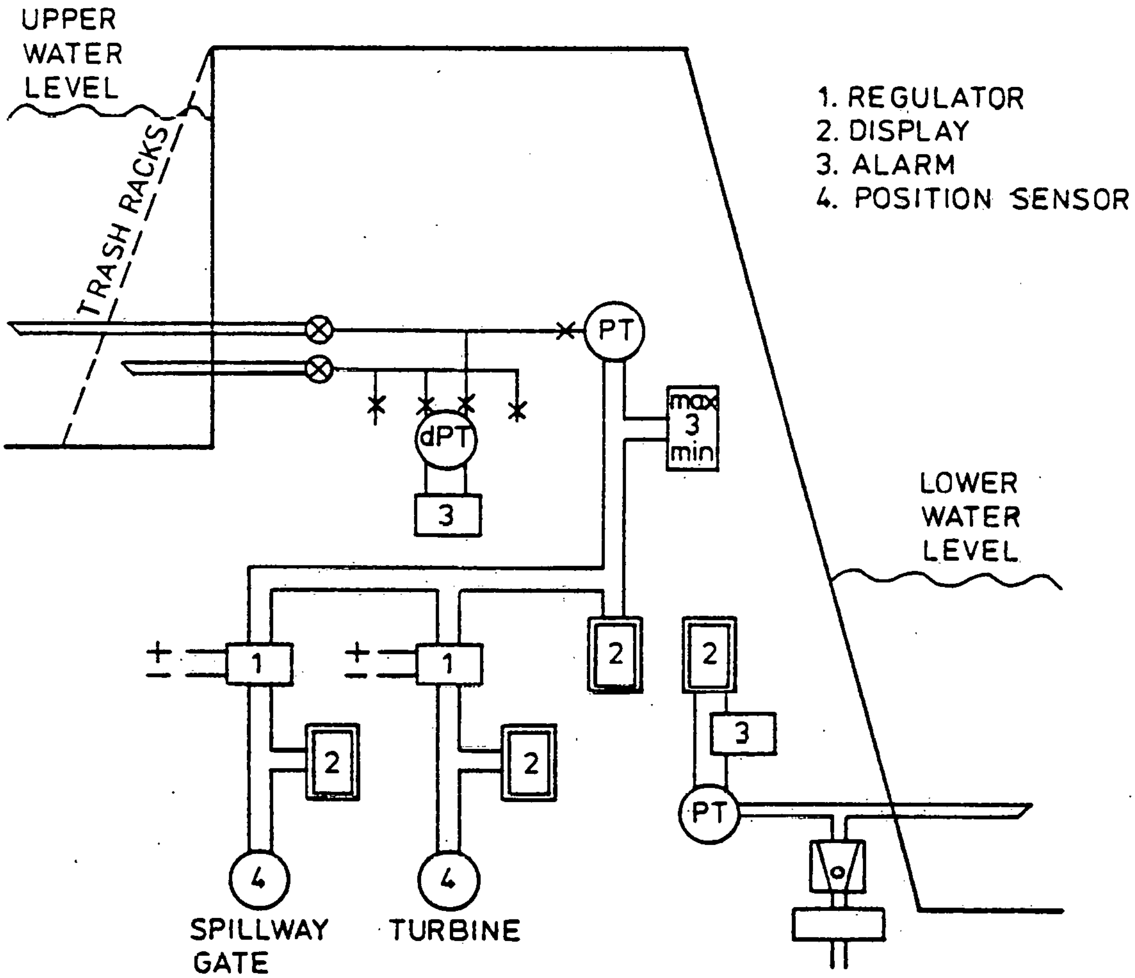


Fig. 6 Water level control