

ONLY COPY

4565

Executive Summary Report  
For The

# SUNSHINE AND FOUR-MILE HYDROELECTRIC FACILITIES

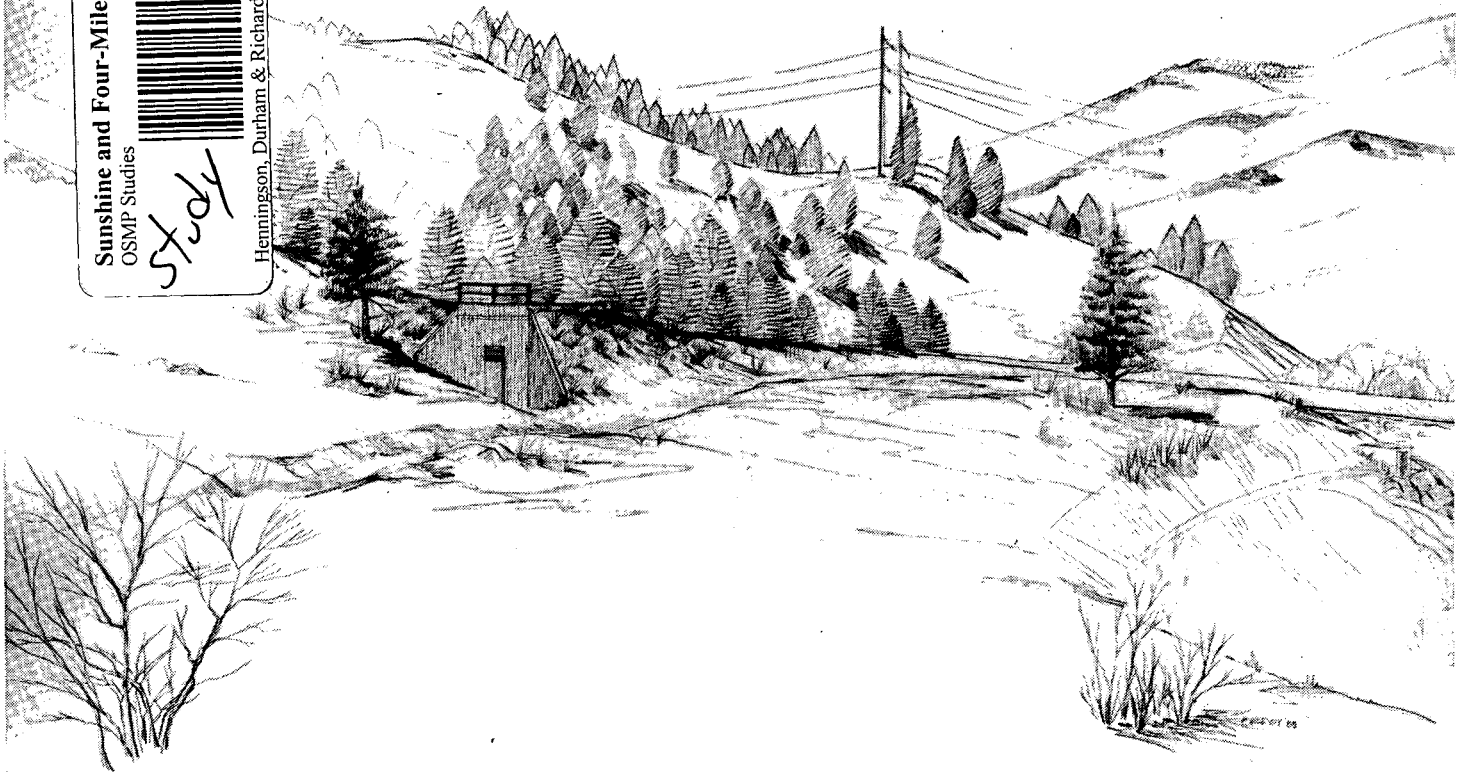
April, 1985

Sunshine and Four-Mile Hydroelectric Fa  
OSMP Studies 4565



Henningson, Durham & Richardson

Study



**CITY OF BOULDER, COLORADO**

Utilities Division

**HDR**

Henningson, Durham & Richardson

20592-2221

EXECUTIVE SUMMARY  
FOR THE  
SUNSHINE AND FOUR-MILE  
HYDROELECTRIC FACILITIES

City of Boulder  
Utilities Department

APRIL, 1985

HENNINGSON, DURHAM & RICHARDSON, INC.  
1100 Capital Life Center  
Denver, Colorado 80203

## ABSTRACT

This Executive Summary is a synopsis containing conclusions and recommendations for the development of the Sunshine and Four-Mile, also referred to as Orodell, Hydroelectric Facilities. The facilities are located west of the City of Boulder, adjacent to existing treated water transmissions system components. The Executive Summary presents key information including site development for both facilities, project costs and project economics that have been previously developed in the Preliminary Design Report. Because this summary acts as a supplement only, the Preliminary Design Report should be referred to concerning alternative development, recommendations for final design and construction. The Executive Summary concludes with the recommendation that the City of Boulder proceed with the ultimate development of the Sunshine and Four-Mile (Orodell) Hydroelectric Facilities.

## SECTION 1

### EXECUTIVE SUMMARY

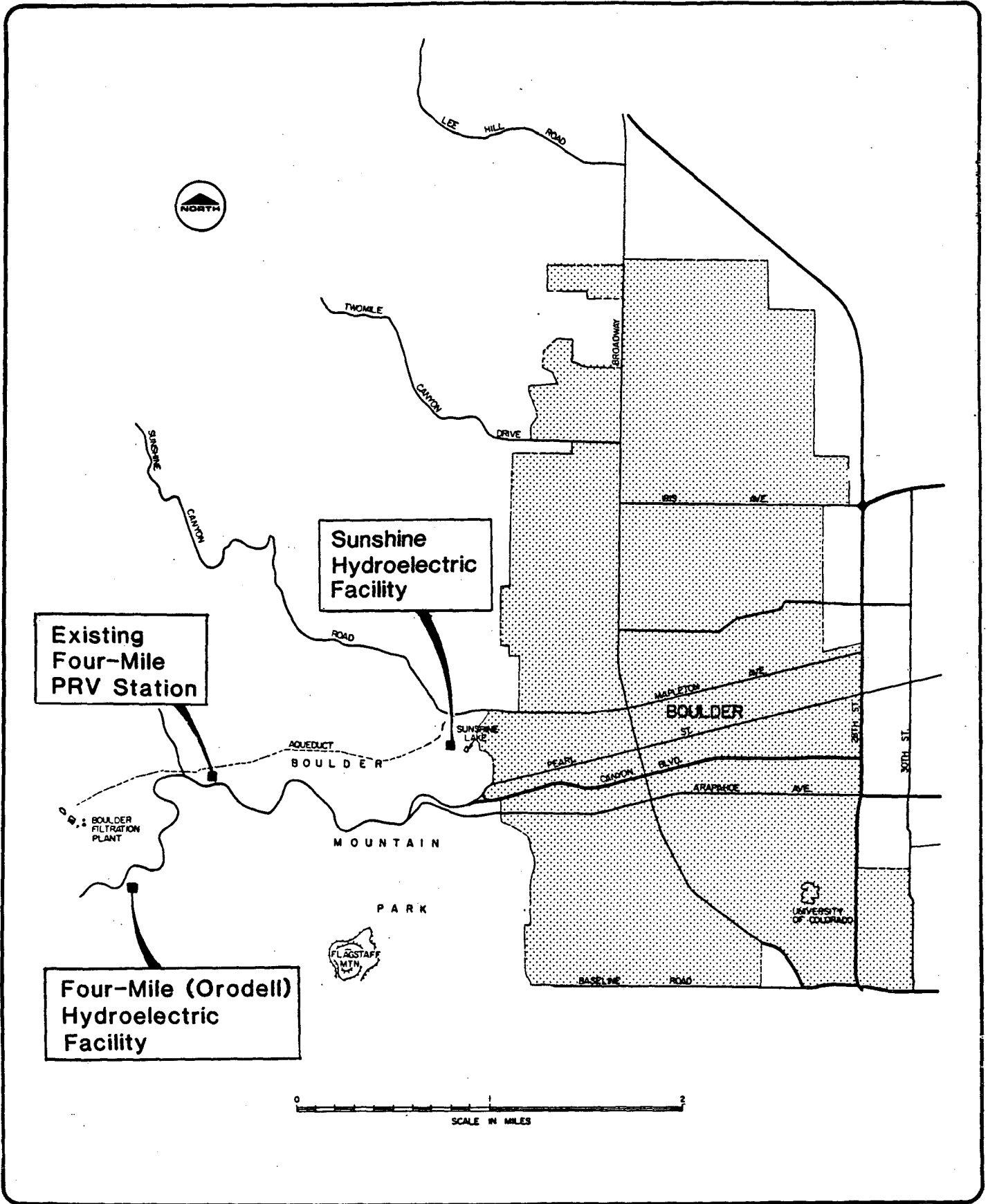
#### Introduction

The purpose of this Preliminary Design Report is to review and analyze the feasibilities and design constraints for the installation of hydroelectric facilities on the potable water transmission system in the City of Boulder system.

Two potential locations, referred to as the Sunshine and Four-Mile project sites as shown in Figures 1-1 and 1-2, are located along existing high pressure water transmission pipelines that transport potable water from Betasso Water Treatment Plant into the City water distribution system. These sites were previously identified in the 1980 Colorado Project TIP study and the 1984 Master Plan For Treated Water Facilities report. Pressure reducing valve stations on both pipelines currently are utilized to dissipate the surplus hydraulic head which develops as a result of a drop in elevation of 800 to 1000 feet between the water plant and the City. Because the pressure loss created in the pipeline could be employed to generate hydroelectric power, these locations have been identified as potential hydroelectric sites. As a result, a positive cash flow for the City could be generated without negatively affecting water system operation. This positive cash flow is reflected by the presentation of key project indicators as shown in Table 1-1.

Although located at two separate sites, the proposed Sunshine and Four-Mile

hydroelectric systems are closely interrelated. Analysis of both systems must consider a variety of concerns that would impact the potential for implementing hydroelectric facilities in varying degrees including: water system operation; hydraulic constraints compatibility with existing systems, and project site conditions. Portions of this Preliminary Design Report identify, in sufficient detail, the necessary improvements needed to implement each potential option including siting, layout requirements, cost estimates and project schedules. The Sunshine and Four-Mile facility project schedules are shown in Figures 1-3 and 1-4. These alternatives relate to project site location, powerhouse positioning on the site, powerhouse structure, exterior architectural treatment, and turbine equipment type. After a review and analysis of the various alternatives for both Sunshine and Four-Mile sites, recommendations for a single alternative at each site are provided. These recommendations should be reviewed for conformance with the original project objectives and goals of the City.

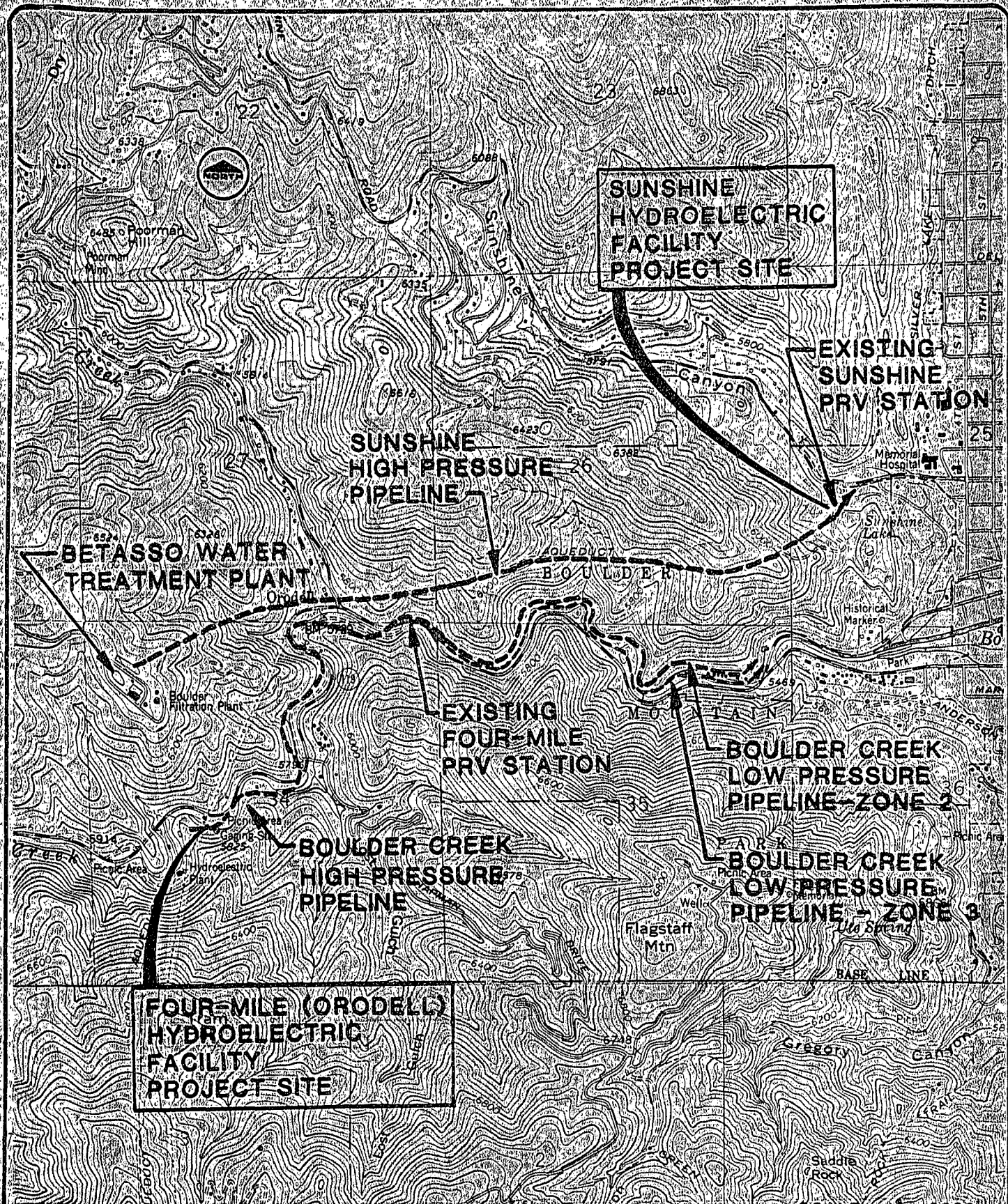


**BOUR**

**BOULDER  
HYDROELECTRIC  
FACILITIES**

**SUNSHINE AND FOUR MILE  
HYDROELECTRIC FACILITIES  
VICINITY MAP**

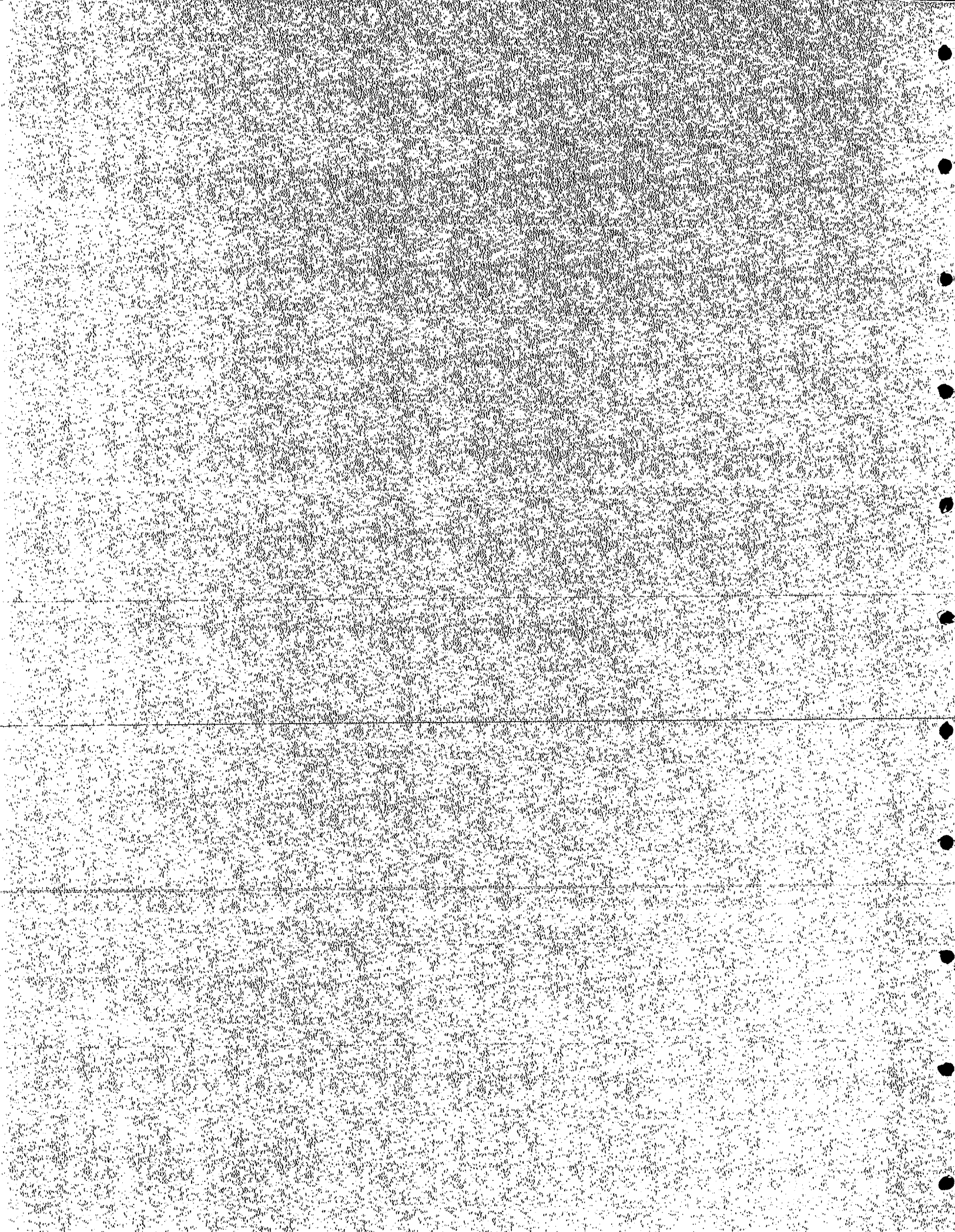
**FIG  
1-1**



**BOULDER  
HYDROELECTRIC  
FACILITIES**

**SUNSHINE & FOUR-MILE  
PROJECT SITE LOCATIONS**

**FIG  
1-2**



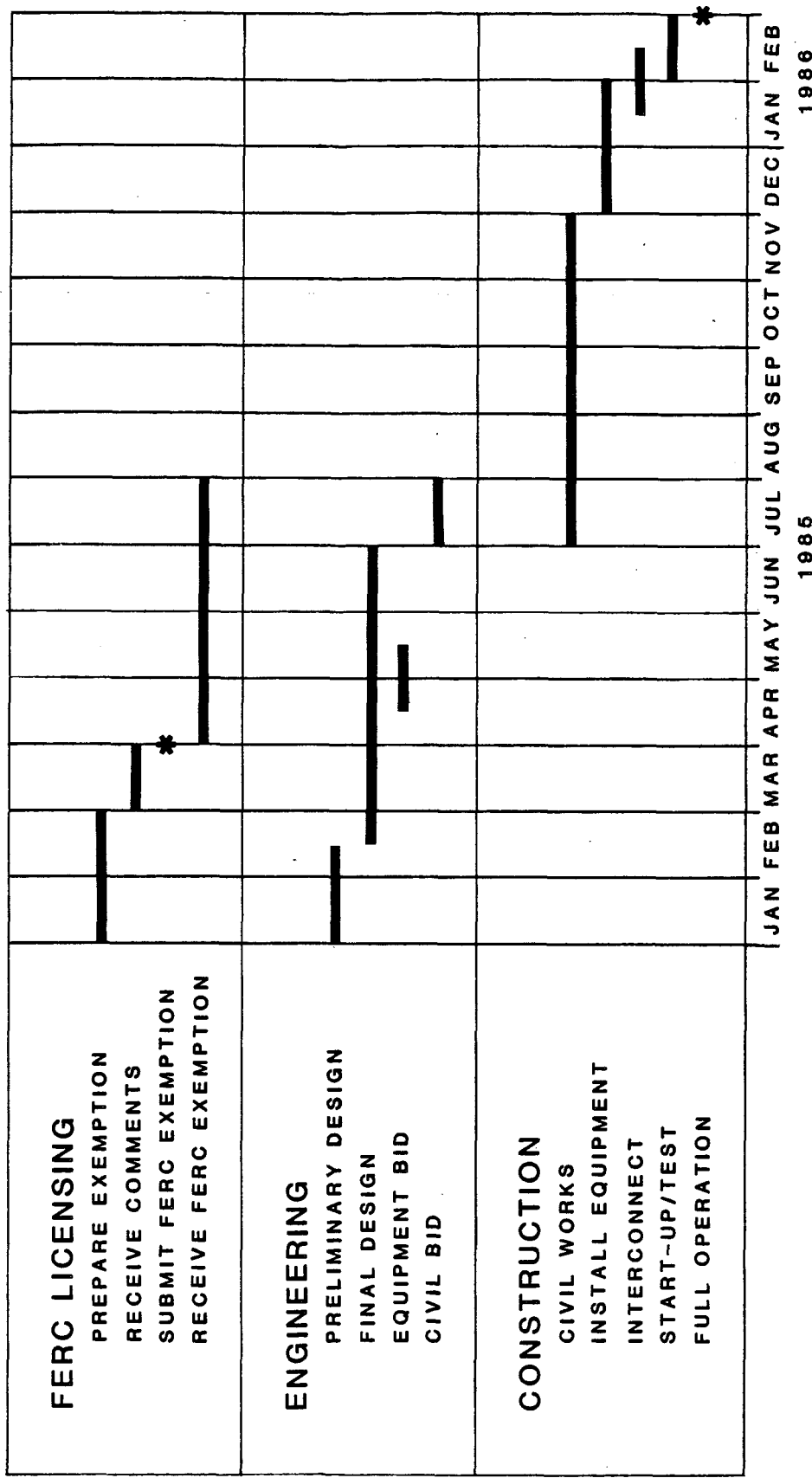


### SUNSHINE HYDROELECTRIC FACILITY

PROJECT INDICATORS	SINGLE HORIZONTAL TURBINE	TWIN VERTICAL TURBINE
Project Cost (1985 dollars)	\$844,000	\$974,000
Installed Capacity	700 KW	700 KW
Annual Power Generation - 1986	2,954,000 KWh	3,160,000 KWh
Annual Power Generation - 2011	3,150,000 KWh	3,300,000 KWh
Payback Period	10 years	11 years
Rate of Return	13.4%	12.3%

### FOUR-MILE HYDROELECTRIC FACILITY

PROJECT INDICATORS	SINGLE HORIZONTAL TURBINE	TWIN VERTICAL TURBINE
Project Cost - Hydroelectric Facility Only (1985 dollars)	\$427,000	\$509,000
Installed Capacity	210 KW	210 KW
Annual Power Generation - 1986	1,360,000 KWh	1,428,000 KWh
Annual Power Generation - 2011	1,540,000 KWh	1,617,000 KWh
Payback Period	10.5 years	13 years
Rate of Return	12.2%	10.5%
PRV Station Improvement Cost	\$25,000	\$25,000



\* KEY TARGET DATES

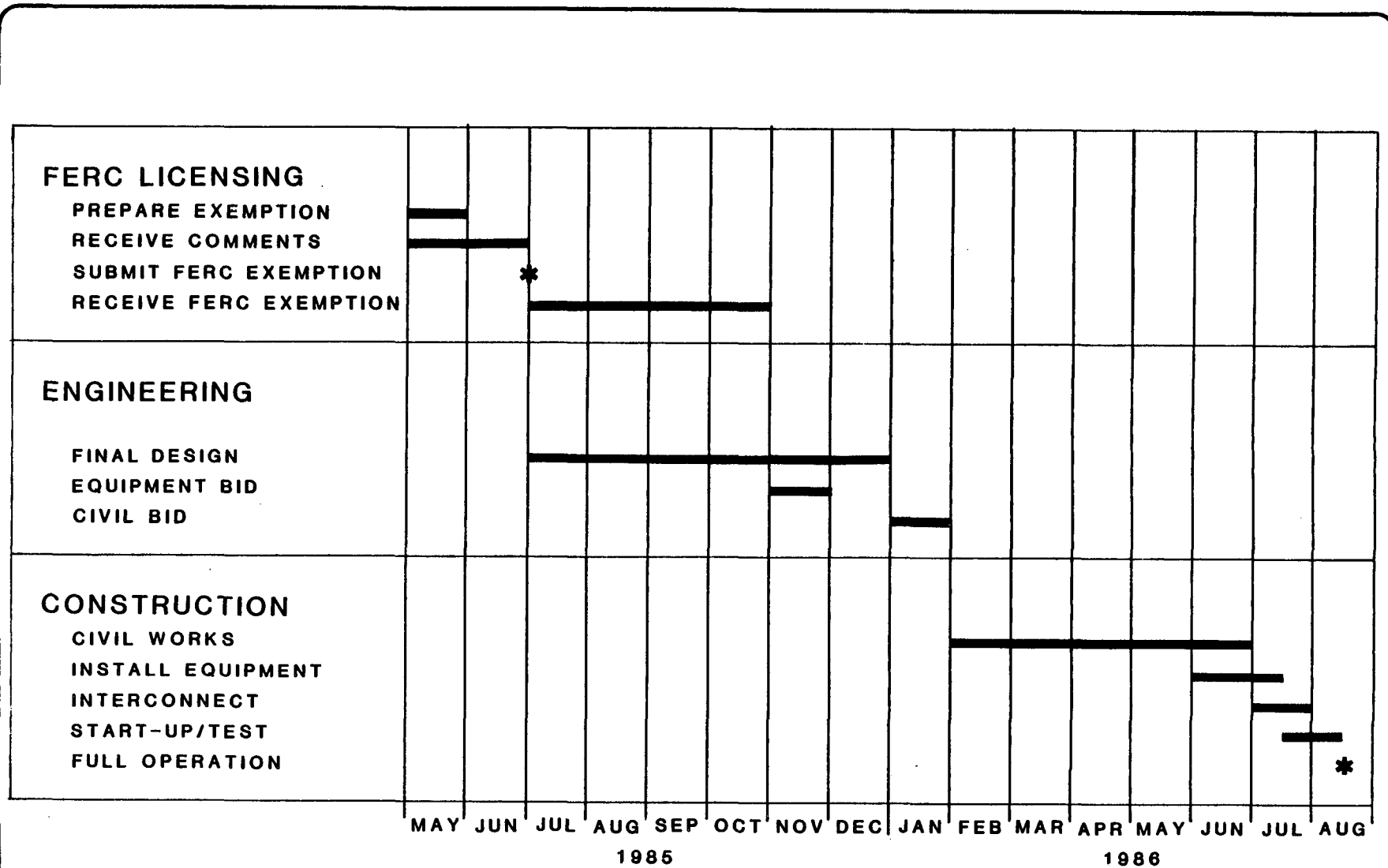
**SUNSHINE PROJECT SCHEDULE**

**HDR**

**FOUR-MILE  
HYDROELECTRIC  
FACILITY**

**PROJECT SCHEDULE**

**FIG  
1-4**



\* KEY TARGET DATES

**FOUR-MILE PROJECT SCHEDULE**

## Scope of Service

The Scope of Service for the Sunshine and Four-Mile Preliminary Design Report, authorized in the Engineering Agreement dated December 18, 1984, can be summarized as follows:

- Analyze flow and pressure records and prepare statistical analysis to select the optimum turbine designs.
- Complete system tests necessary to provide hydraulic head and flow data needed for preliminary and final design.
- Determine site location.
- Evaluate alternate locations and alternate types of structures.
- Prepare detailed cost estimates for all alternatives.
- Prepare station layout, operational scheme and required control and telemetry needs.
- Prepare renderings of alternative site plans.
- Prepare an environmental impact report to address local environmental concerns for the Sunshine facility.
- Provide an economic analysis, including projected revenue and capital recovery.

## Existing Reports and Data

A significant amount of time and effort was expended collecting pertinent information from existing reports and data from the Betasso WTP plant recorders. The following is a summary of the information that was utilized:

- . "Wasted Water Pressure and Potential Energy Generation" Colorado Project/TIP, Inc., December 1980
- . "Master Plan of Treated Water Facilities for Boulder, CO" Black & Veatch, January 1984
- . "Contract No. 4 - Water Transmission Lines" Specification for 20" raw water and 30" treated water transmission lines, Black & Veatch, 1962
- . Flow Records for 1983/1984 for the Sunshine and Four-Mile Pipelines. records were reduced from strip charts obtained from the Betasso WTP.
- . Pressure Records for 1983/1984 which were monitored at the following points:
  - Downstream of the Sunshine PRV Station
  - Downstream of Zone 2 at the Four-Mile PRV Station
  - Downstream of Zone 3 at the Four-Mile PRV Station

## Summary and Conclusions

During the course of the preparation of the Preliminary Design Report, several key considerations and constraints were identified that impacted the evaluation of the potential for addition of hydroelectric facilities at both the Sunshine

and Four-Mile project sites. Following is a brief summary of the significant concerns developed during the investigation.

1. Only one site appears feasible for development of a Sunshine hydroelectric facility, while two sites are viable for the Four-Mile hydroelectric system. All sites are located near existing City of Boulder water system installations as shown in Figure 1-2.
2. Pipeline hydraulic data developed during field testing of the existing Sunshine and Four-Mile systems exhibit differing characteristics, but provide an adequate basis from which to determine available net head for hydroelectric development as shown in Appendices D and E.
3. Water distribution system flow and gradient requirements dictate that the Sunshine system be utilized to handle variable flows, with the Four-Mile system serving as more of a base load, constant flow supply source.
4. Upgrading of the existing site and facilities at each hydroelectric facility location is recommended to integrate the new facilities with those currently in use.
5. Development of facility options at the Sunshine site addressed both aesthetic and environmental concerns, as the site is located within the confines of Boulder Mountain Park. Selection of a preferred structure location and exterior architecture were coordinated through the City Parks Board.
6. Pipeline pressure surge testing and evaluation was conducted to establish

constraints that any new turbine-generator must operate within at both the Sunshine and Four-Mile sites. Pressure surges upstream and downstream at Sunshine will be controlled through proper turbine selection and use of pressure relief valves. Four-Mile pressure surges will be minimal because of the constant flow turbine characteristics to be employed there.

7. Several system interrelationships were identified as part of the study that impacted development of the various hydroelectric alternatives:

- Flow through Sunshine system must normally exceed approximately 6 mgd to maintain adequate pressure in the northwest area of the City.
- Four-Mile system is secondary in importance to the Sunshine system from an overall water system standpoint, required primarily during high summer demand and to serve as back-up supply.
- Air entrapped in the Sunshine pipeline may be reducing pipeline capacity.
- Downstream pressure at the Four-Mile pressure reducing station is the same for Zone 2 or 3 at 5 mgd flow.

8. A variable flow turbine-generator unit(s) with an installed capacity of 700 KW is recommended at the Sunshine site. Overall annual power generation would range from 3,160,000 KWh in 1986 to 3,300,000 KWh in 2011 for a twin unit configuration.

9. At Four-Mile a constant speed turbine-generator unit with a capacity of

210 KW is recommended. Average annual energy generation would be 1,360,000 KWh in 1986 and 1,540,000 KWh in 2011.

10. Total project cost estimates for the Sunshine turbine-generator alternatives ranged from \$844,000 for the single turbine unit to \$974,000 for the twin turbine units. Rate of return on investment also varied between the options from 13.4% for the single unit to 12.3% for the twin units.
11. Rate of return data and cost estimates developed for Four-Mile turbine-generator alternatives established a range of costs from \$427,000 for a single turbine unit to \$509,000, for the twin turbine units. Rate of return on investment varied from 12.2% for the single unit to 10.5% for the twin units.

The considerations and constraints summarized in the previous paragraph resulted in the selection of recommended alternatives for both the Sunshine and Four-Mile hydroelectric facilities. Of principal concern in selecting each alternative was implementability and cost effectiveness. Following is a summary of the feature components for the Sunshine and Four-Mile hydroelectric facilities:

#### Sunshine Hydroelectric Facility

1. Construction of a partially buried powerhouse structure near the existing Sunshine pressure reducing station, to house a new turbine-generator and associated controls and electric components as shown in Figures 1-5 and 1-6.



2. Installation of variable flow, adjustable wicket gate turbine-generator with a 700 KW capacity, suitable for a flow range of 10-44 cfs.
3. Interconnection to the existing 13,000 KVA underground PSC power line west of the powerhouse.
4. Modification of existing Sunshine pressure reducing station to serve as bypass facility for the turbine-generator. Modifications include upgrading the station including replacing the two manual valves with motorized valves in order to improve reliability and reduce maintenance.
5. Upgrading of access road for construction and future maintenance, including regrading and surface improvements.
6. Installation of interconnecting piping between the existing Sunshine pipeline and the new powerhouse, including surge protection devices and isolation valves.
7. Integration of the Sunshine hydroelectric facility control system with the Betasso WTP control panel to permit remote monitoring and control.

#### Four-Mile Hydroelectric Facility

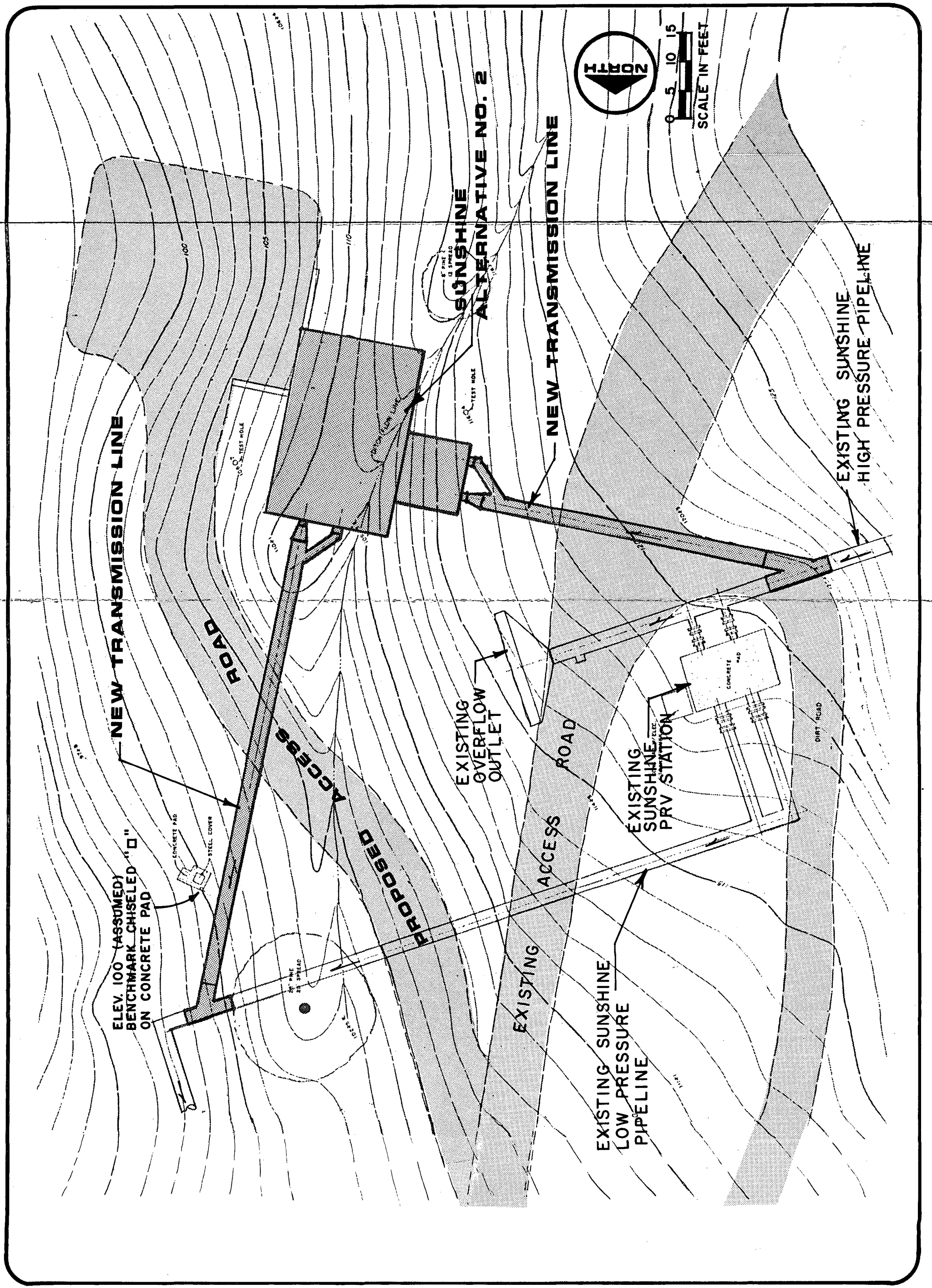
1. Construction of a new powerhouse structure at the upper site along the existing Boulder Creek transmission pipeline as shown in Figures 1-7 and 1-8.

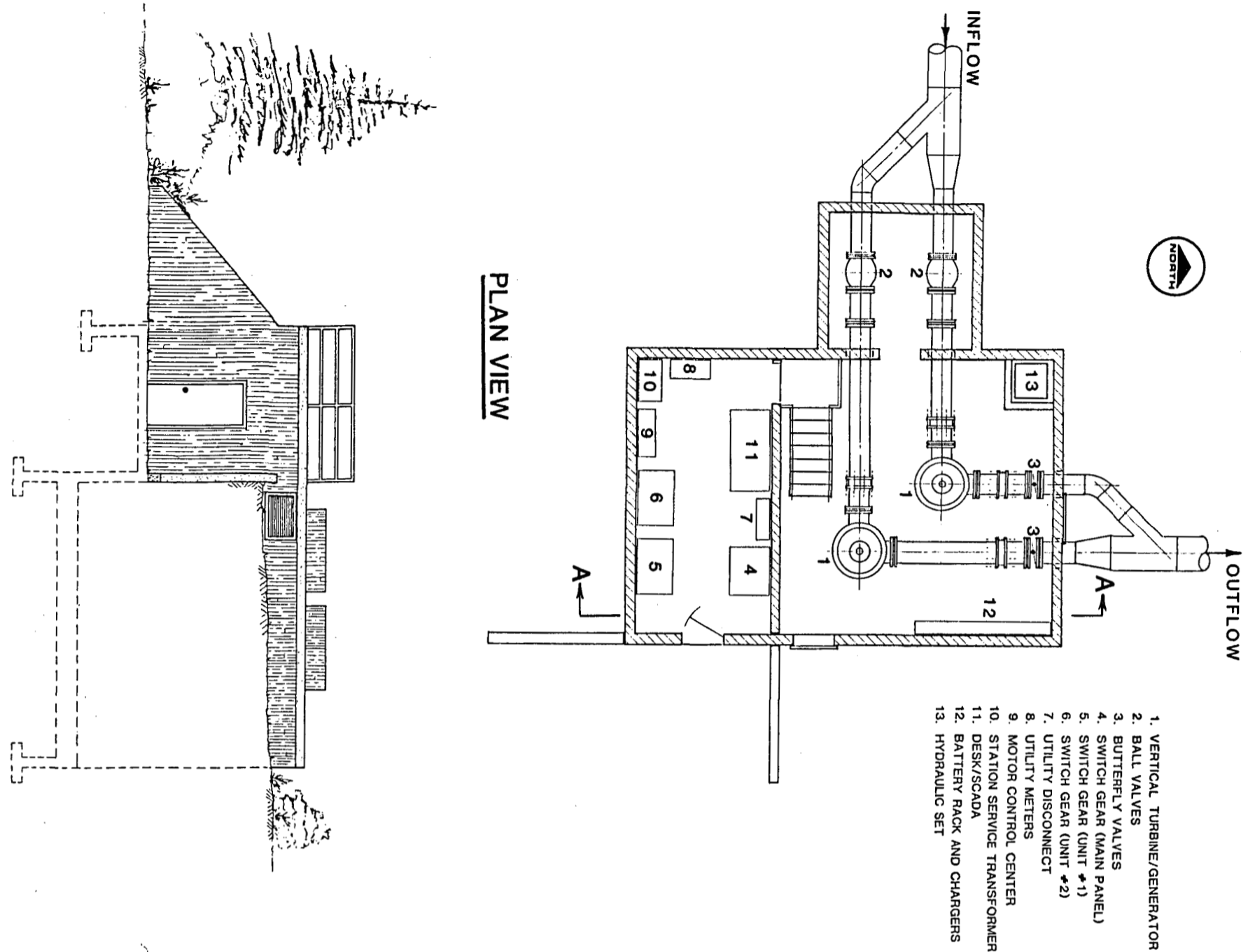
Throughout the writing of the Preliminary Design Report, the facility to be built along Boulder Creek was referred to as the Four-Mile

Hydroelectric Facility. The Four-Mile reference resulted from the proposed facility being built in close proximity to the existing Four-Mile Pressure Reducing Valve vault. Upon final selection and approval the upstream site will be called the Orodell Hydroelectric facility so as to avoid confusion with the existing Four-Mile PRV. The name Orodell is in reference to the Orodell Stream Gaging Station located nearby at the upper site. Verbal references will still be made to the Four-Mile PRV vault and the Boulder Creek transmission pipeline; however, all figures and tables associated with the new Orodell Facility will continue to be referred to as the Four-Mile Hydroelectric Facility.

2. Installation of a single 210 KW fixed flow turbine-generator inside the powerhouse, including associated controls and electrical equipment.
3. Improvements to site access road to upgrade road for construction and future maintenance trips.
4. Elevate powerhouse facilities above Boulder Creek 100-year floodplain.
5. Interconnect to existing Boulder Creek 24-inch transmission pipeline with inlet and outlet pipe from the turbine-generator. Included are bypass valves and pipe to permit removal of turbine-generator from service without pipeline shutdown.
6. Interconnection to the existing 13,000 KVA overhead PSC power line that feeds the Boulder power plant.
7. Upgrade Four-Mile PRV station including possible installation of a new

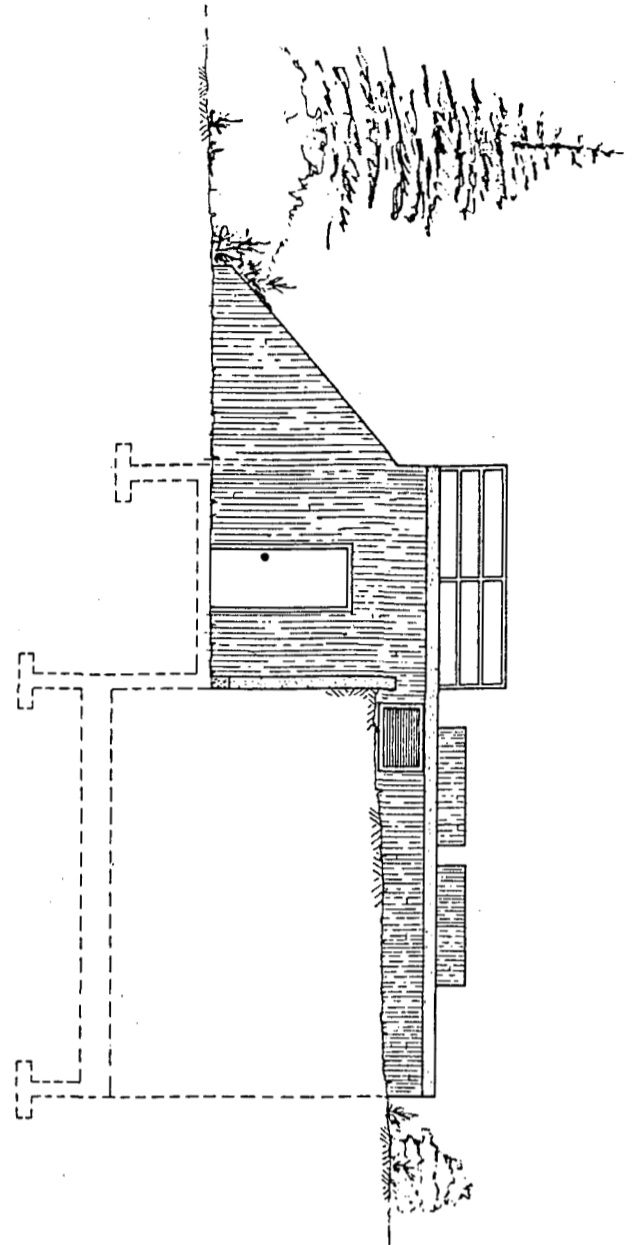
7. Upgrade Four-Mile PRV station including possible installation of a new pressure reducing valve to Zone 3 and building improvements. It is recommended that this portion of the project be considered separate from the construction of the hydroelectric facility. Separate construction documents are recommended for these improvements as well as a separate bidding process. The project cost associated with upgrading the Four-Mile PRV station is \$25,000.
  
8. Interface of the Four-Mile and Sunshine control system with Betasso WTP control panel to facilitate remote monitoring and control of the turbine-generator systems.



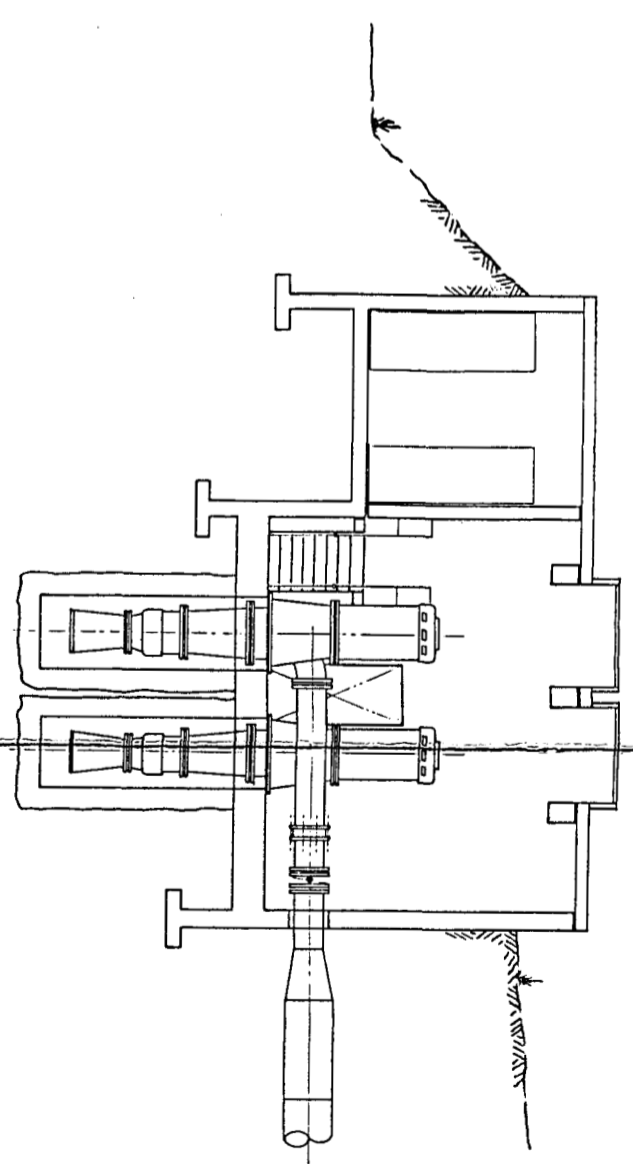


- 1. VERTICAL TURBINE/GENERATOR
- 2. BALL VALVES
- 3. BUTTERFLY VALVES
- 4. SWITCH GEAR (MAIN PANEL)
- 5. SWITCH GEAR (UNIT #1)
- 6. SWITCH GEAR (UNIT #2)
- 7. UTILITY DISCONNECT
- 8. UTILITY METERS
- 9. MOTOR CONTROL CENTER
- 10. STATION SERVICE TRANSFORMER
- 11. DESK/SCADA
- 12. BATTERY RACK AND CHARGERS
- 13. HYDRAULIC SET

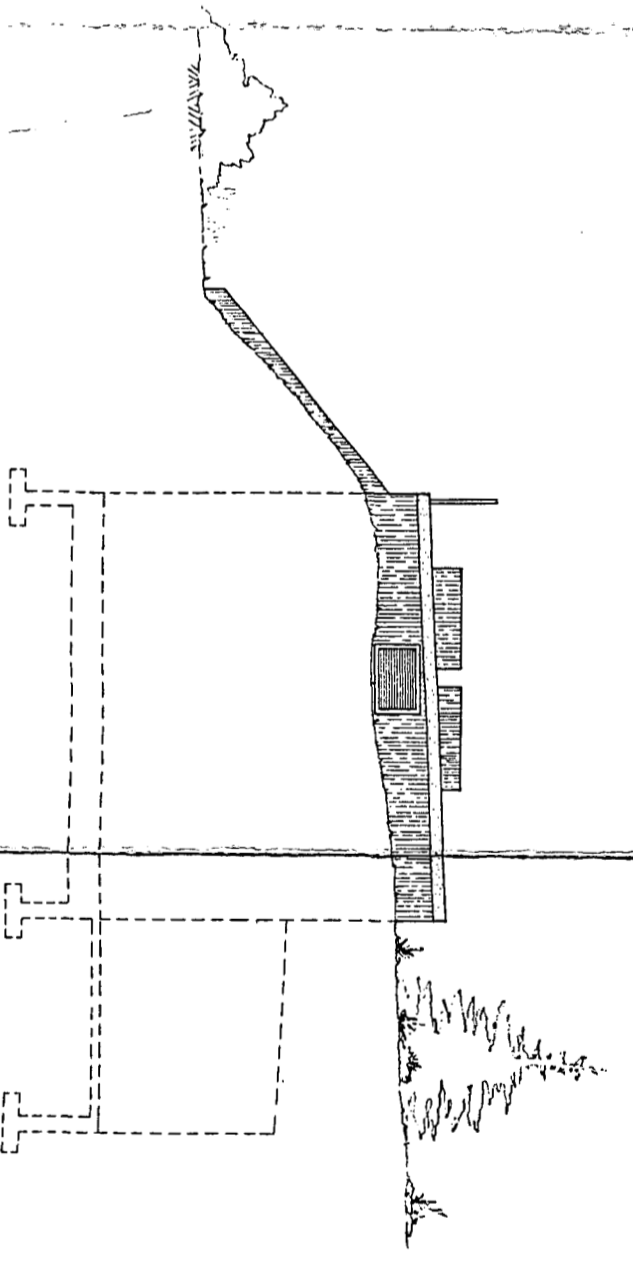
**PLAN VIEW**



**EAST VIEW**

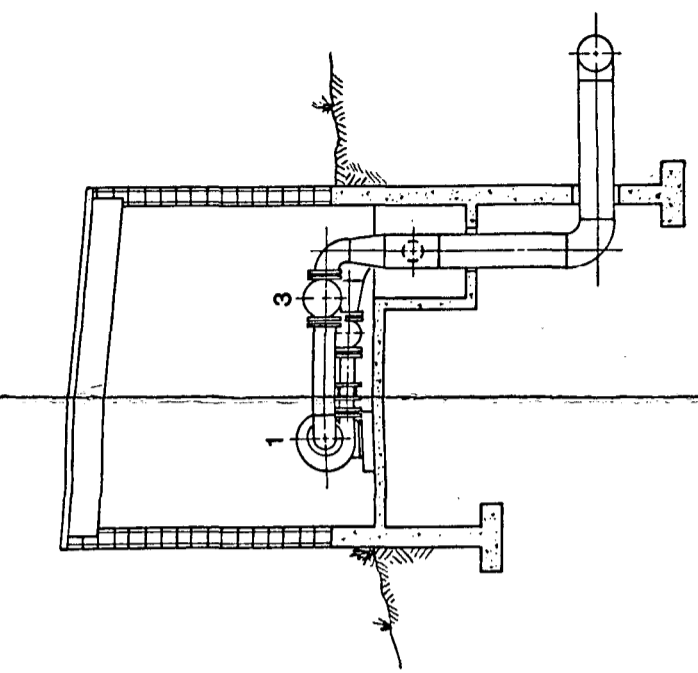


**SECTION  
A-A**

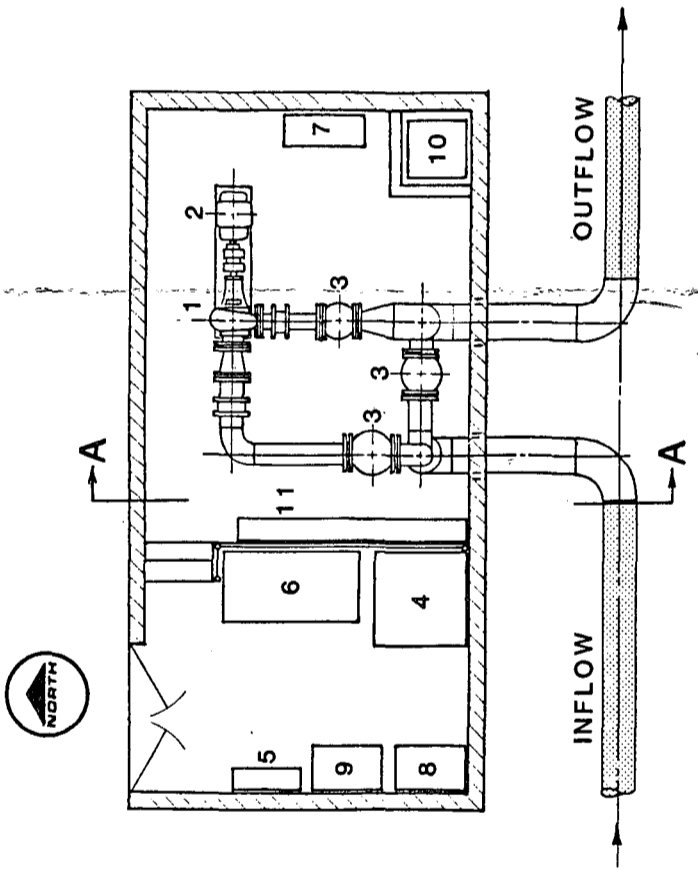


**NORTH VIEW**



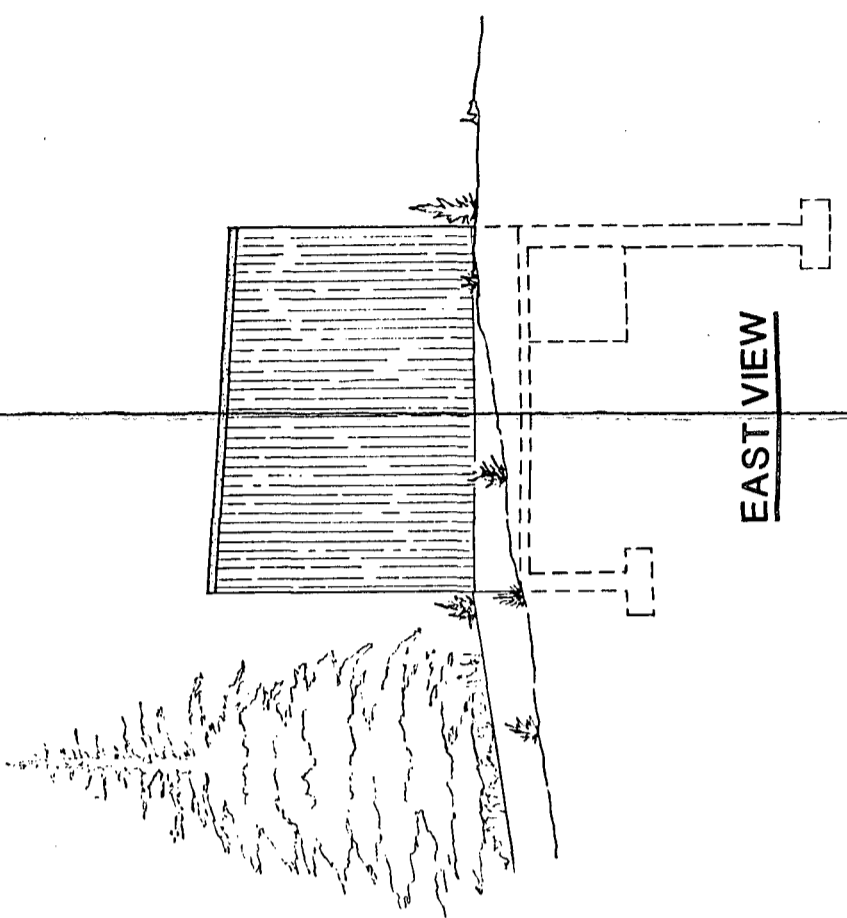


SECTION A-A

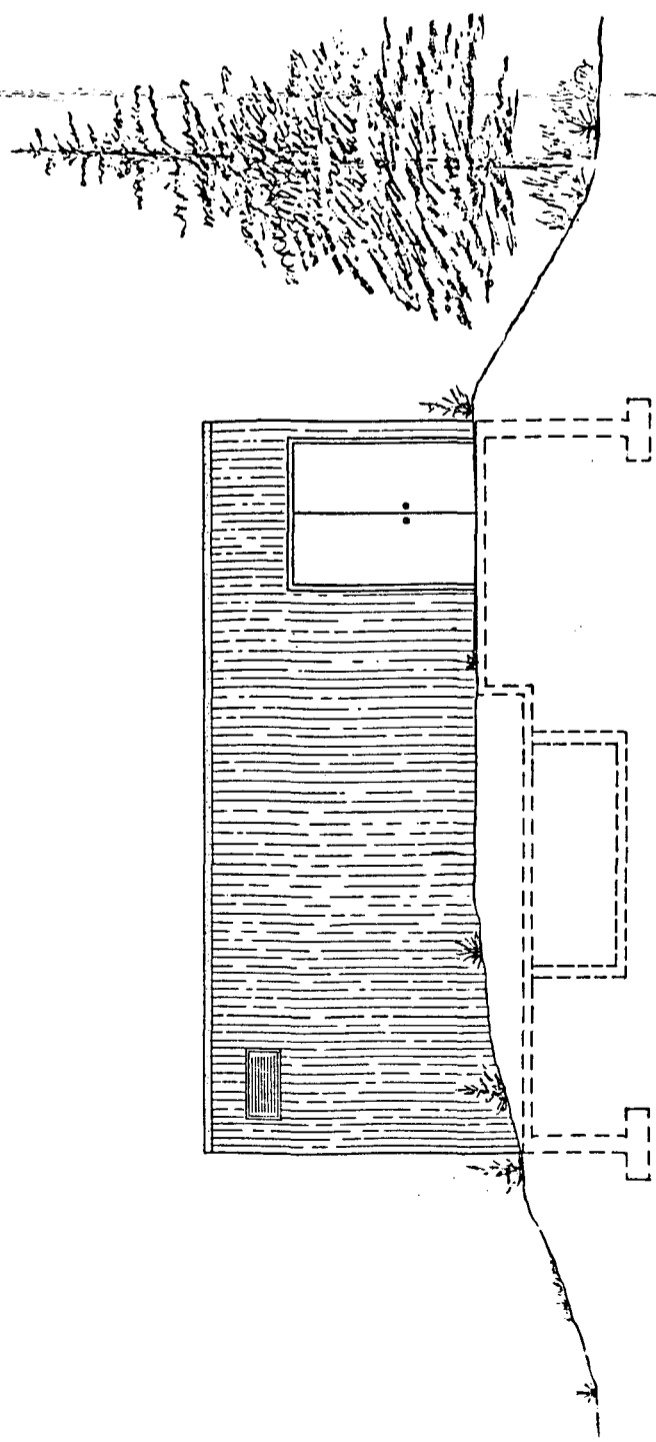


PLAN VIEW

- 1 TURBINE
- 2 GENERATOR
- 3 BALL VALVES
- 4 SWITCH GEAR (MAIN PANEL)
- 5 SWITCH GEAR (UNIT #1)
- 6 DESK/SCADA
- 7 MOTOR CONTROL CENTER
- 8 UTILITY METERS
- 9 STATION SERVICE TRANSFORMERS
- 10 HYDRAULIC SET
- 11 BATTERY RACK AND CHARGER



EAST VIEW



NORTH VIEW