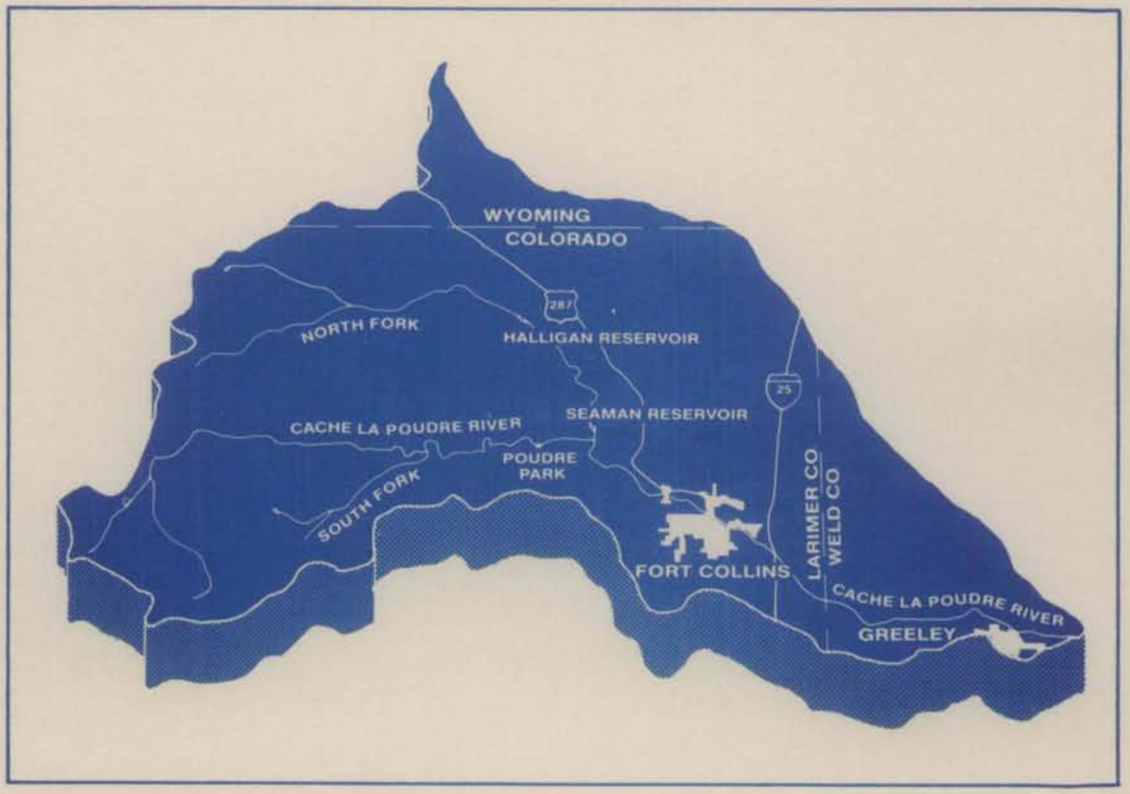
Cache la Poudre Basin Study

Summary Report



COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY

1981

January 1987

January 2, 1987

Mr. Ulrich Kappus, P.E.
Executive Director
Colorado Water Resources and
Power Development Authority
1580 Logan Street, Suite 620
Denver, CO 80203

Subject: Cache la Poudre Basin Study
Submittal of Summary Report for the Prefeasibility Study

Dear Mr. Kappus:

We are pleased to submit this Summary Report on the Cache la Poudre Basin Study consistent with our contract dated June 7, 1985.

The Cache la Poudre Basin has sufficient water supply and storage facilities to satisfy water demand during a 1-in-10 year drought. However, water shortages will be experienced for more severe droughts. A 1-in-25 year drought, such as occurred in 1953 to 1956, will result in serious water shortages.

Municipalities and industry in the Basin are not presently subject to shortages because of policies which require acquisition of agricultural water rights as a prior condition for new urban development. To the extent that agricultural rights remain available for transfer, municipal and industrial water supplies should be adequate in the future.

An extensive effort has been made to identify non-structural elements that could reduce the size and cost of structural measures needed to overcome water shortages. Shortages corresponding to a 1-in-25 year drought can be reduced by almost one-half with application of non-structural plan elements. Given the comparatively low cost of these measures, their importance cannot be over-emphasized.

Two plans combining non-structural and structural elements have been recommended to the Authority as meriting further investigation. The preferred plan provides 274,000 acre-feet (af) of storage which, together with non-structural measures, could greatly reduce the effects of a 25-year drought. The direct cost of this plan, including a large pumped-storage hydropower facility is estimated to be $1.5 billion (January 1986 price level).

The alternative plan would provide about 156,000 af of storage in an initial stage which would provide an average annual yield of 29,000 af from native water and additional Windy Gap and C-BT diversions. This plan could be expanded to 274,000 af of storage in the future. The direct cost of this plan, including hydroelectric power facilities, is estimated to be $1.3 billion.

Both plans include an 1800 megawatt pumped-storage hydroelectric project which could contribute significantly to payment of the water storage facilities if a market for this power develops in Colorado and adjacent states. Smaller pumped-storage facilities could be provided if market conditions dictate or if a staged construction program is pursued.

Both plans achieve an internal rate of return of approximately nine percent excluding inflation. Including inflation, these rates are on the order of 14 percent and are attractive in today's market place.

Federal involvement in water project development has declined substantially. However, there may be future opportunities to subsidize water users with the joint development of pumped-storage hydropower in the Basin. A water project in the Basin may be financable through the sale of revenue bonds. Project implementation could be accomplished without pledging the local tax base.

We wish to express our appreciation for having had the opportunity to prepare the Basin Study. The scope and complexity of the work have made it a very interesting and challenging assignment for the Study Team. We also wish to acknowledge the excellent support and guidance we have received from Blaine Dwyer P.E., your Project Manager, and from the Board. We look forward to any future opportunity to be of service to you.

Very truly yours,

R. J. Hunter, P.E.
Study Manager and
Vice President

SUMMARY REPORT

CACHE LA POUDRE BASIN WATER AND HYDROPOWER RESOURCES MANAGEMENT STUDY

Colorado Water Resources & Power Development Authority
1580 Logan Street, Suite 620
Denver, Colorado 80203

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Tom Pitts & Associates (Loveland)
Morton W. Bittinger, PE & LS

January 1987

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(1) Figures are located at the end of each report chapter.
(2) This figure has two sheets.

1.0 INTRODUCTION

This report summarizes a 16-month-long study of water and hydropower resource development in the Cache la Poudre River Basin. The study was initiated by the Colorado Water Resources and Power Development Authority (Authority) in response to a study application from the Northern Colorado Water Conservancy District (NCWCD). The two-volume final report for the study provides a more detailed presentation of the study results.

This introduction provides general study background, specific project objectives, and an overview of the study procedures. Authorization of the study and the role of the Authority are also described. Finally, the role of the public involvement program is discussed and the contributions of the Advisory Committee and the public are recognized.

Later sections of the Summary Report describe the Cache la Poudre Basin and discuss the forecasted water supplies, demands, and shortages. This is followed by the formulation and evaluation of alternative plans which are comprised of both non-structural and structural measures. The report concludes with a summary of the major findings of the study and the recommendations for future actions for the development of the Basin's water resources.

1.1 BACKGROUND AND PERSPECTIVE

The Cache la Poudre River Basin is located in north central Colorado and is bordered by the Laramie and Medicine Bow Mountain Ranges to the west, and the confluence of the Cache la Poudre River and the South Platte River near the City of Greeley to the east. To the north, a small portion of the Basin is situated in Wyoming, but is excluded from the present study. The study area is shown on Figure 1.1. The Cache la Poudre River drains an area of almost 1,900 square miles consisting of two distinct components. The mountainous upper basin supplies the major surface water runoff from annual snowmelt. The lower basin is a plains area where the water is used by agriculture, municipalities, and industry.

The evolution of the Cache la Poudre Basin points to the importance of water resources and the need for the present Basin Study. Since the area was originally settled, it has focused on agricultural production. As a result, extensive agricultural water supply systems have been developed to utilize the water resources of the Cache la Poudre River. The Cache la Poudre River is among the most carefully managed and controlled river systems in the western U.S. Partially because of these water supplies, northern Colorado is a top producer of corn, livestock and, historically, other agricultural commodities in Colorado and across the nation.

The sophisticated water supply system and the prosperous economy of northern Colorado were not achieved without considerable work and investment toward stabilizing water supplies during times of drought and flood. The facilities of the NCWCD and its role in the development of the Colorado-Big Thompson Project (C-BT) are prime examples of this commitment.

The NCWCD was formed in 1937, largely in response to the extended drought which was experienced in northern Colorado during the 1930's. Shortly after its formation, the NCWCD Board of Directors entered into a contract with the United States of America for the construction of the C-BT Project. The project was to provide an average annual 310,000 acre feet (af) of supplemental water supplies and, secondarily, generate hydroelectric power. As part of this contract, the District is repaying the United States $25 million. Although the NCWCD boundaries only partially overlay those of the Basin, both the NCWCD and Basin interests have exhibited a tradition of vigilance and cooperation in optimizing use of their water resources.

1.2 PREVIOUS STUDIES

Intense interest in optimizing water resources has also been demonstrated by the numerous studies of the Cache la Poudre River Basin. These studies have explored a number of development possibilities and water resource issues.

U.S. Bureau of Reclamation (USBR) investigated the potential for additional water resource development on the Cache la Poudre River in 1928, 1954, 1959, and 1963. The 1963 USBR study focused on major structural facilities on the mainstem consisting of diversion dams, forebay reservoirs, and water conductors to produce conventional hydropower and to provide additional water supplies. The Idylwilde and Grey Mountain storage projects were identified in this USBR study.

In 1980, International Engineering Company performed a study of the Grey Mountain and Idylwilde projects which updated the USBR economic analysis, and identified environmental issues which had become important by 1980. Similar to the USBR study 20 years earlier, this work concluded that development was potentially viable and further feasibility analyses were desirable.

Water and conventional hydropower developments in the Cache la Poudre Basin were examined by Tudor Engineering Company in 1982 and 1983. As specified by the legislation authorizing the study, it was confined to the upper basin above the mouth of the Poudre Canyon. Non-structural measures and environmental issues were not addressed.

It is important to note that none of these previous studies considered the potential benefits of pumped-storage hydroelectric power. The pumped-storage concept is discussed in detail in Section 5 of this report.

Constraints on the previous studies and recent developments in the Basin have limited the applicability of these planning efforts to the current circumstances. Important developments include:

- The National Environmental Policy Act (NEPA). This act requires an in-depth examination of all environmental impacts and issues associated with most major water resource and power development projects prior to construction. NEPA requires public hearings and balanced evaluation of conflicting interests.

- The changing market for water. In recent years, northern Colorado cities have grown considerably while the agricultural community has experienced unfavorable economic conditions. It has become apparent that new municipal and industrial water supplies are obtainable from certain local farmers who must often sell their water rights because of financial difficulties. However, agriculture is still the largest water user in the Basin and remains an important factor in the socio-economic stability of the region. In fact, Weld County for the past decade has been one of the top ten counties in the U.S. in terms of agricultural production.

- The changing market for power. Previous studies included load growth projections which, in retrospect, were unrealistically high. Much more conservative demand assumptions are incorporated in this study.

- The diminished Federal role. The Federal government has recently indicated a declining interest in providing financial support for water resources development. As a result, funding will necessarily come from project beneficiaries and state or local governments.

- Existence of a project proponent. Energy Research Development Associates (ERDA) has publicly announced a plan to develop a major hydroelectric pumped-storage project in the Basin. Although ERDA is conducting their own studies and marketing efforts, the general layout and design parameters of ERDA's project have been considered in the Cache la Poudre Basin Study.

- Wild and Scenic River Designation. In the early 1980's, environmental groups vigorously opposed the idea of any dam in Poudre Canyon. In response to this, area Congressman Hank Brown brought contending factions together and forged an important compromise. This legislation is discussed in more detail in the closing paragraphs of this subsection.

- Recreational needs. Recreational activities in the Cache la Poudre Basin have grown with the population and a desire for increased recreational opportunities including fishing and boating. Given the perceived values of water-based recreation, any opportunities for enhancement as well as potential losses should be carefully considered for prospective Basin water resource development.

The above considerations helped guide the present Cache la Poudre River Basin planning study. Previous studies and analyses have been used as a starting point, incorporating useful data and information where possible.

Given its significance, the Wild and Scenic River Designation deserves further explanation. Under the authority of the Wild and Scenic Rivers Act, the U.S. Forest Service issued a draft environmental impact statement dated April 8, 1980 for the 84 miles of the River from the headwaters to the canyon mouth. Late in 1983, the Forest Service recommended 30 miles of wild river, 32 miles of recreational river, and no designation for the river segment encompassed in the proposed Idylwilde and Grey Mountain Reservoir sites.

Both environmental and and development interests were critical of this recommendation, prompting a period of protracted compromise and negotiation. The key element of the compromise included the elimination of three potentially viable reservoir sites, including Idylwilde. In return, eight miles in the lower canyon area were not designated as Wild and Scenic and may, therefore, be considered for future water development. Congressman Brown and Senator William Armstrong introduced identical bills for the purpose of designating the upper 75 miles of the Cache la Poudre River as a

Wild and Scenic River. The bill was signed by President Reagan on October 30, 1986. These reaches are shown on the Basin Map, Figure 1.1. Both "recreational" and "wild" river segments have been designated. The segments of the river designated as "recreational" will be managed to maintain existing road access, impoundments, and developments along the shore. Segments designated as "wild" will be managed to be free of impoundments, with shorelines remaining primitive, and generally accessible only by trails.

1.3 STUDY AUTHORIZATION AND THE ROLE OF COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

In 1981, the Colorado General Assembly enacted Senate Bill 19 which created the Colorado Water Resources and Power Development Authority. The specific provisions of the Colorado Water Resources and Power Development Authority Act are documented in Title 37, Colorado Revised Statutes 1973, as amended, parts 37-95-101 through 37-95-114. The Authority, by law, is a political subdivision of the state and not an agency of state government. Members of the Authority are appointed by the Governor with confirmation by the Senate. There are nine members of the Authority, eight of which represent the major drainage basins in Colorado, and the ninth represents the City and County of Denver.

The General Assembly created the Authority for the primary purpose of aiding in the planning, design, financing, and construction of water and hydroelectric power projects that will put Colorado's water supplies to beneficial use. To implement this, the Authority has been empowered, under the specific guidelines in the law, to issue revenue bonds for funding of such projects.

The Cache la Poudre Basin Water and Hydropower Resources Management Study (the Study) was authorized on March 18, 1985 by the Authority Board of Directors in response to an application submitted by the NCWCD. On June 7, 1985, the Authority entered into a contract with Harza Engineering Company to provide lead consulting services for the Study. Harza subcontracted with four other firms to provide specialty services: Leonard Rice Consulting Water Engineers (hydrology, water supply, and water rights), Browne, Bortz & Coddington (water and power demands, economics, and finance), Tom Pitts and Associates (environmental evaluations), and Morton W. Bittinger (groundwater).

1.4 STUDY OBJECTIVE

The chief objective of this study is to define that combination of water and hydropower resource management alternatives, both structural and non-structural, which will provide for the efficient and environmentally sound development of the water and hydropower resources of the Cache la Poudre Basin. The study has been performed in such a manner as to become an important component of a potential South Platte Basin management plan.

This is a basinwide study and it has focused on identifying alternatives that will satisfy basinwide needs. There are several potential small projects that may be attractive for specific, smaller scale, purposes. These smaller projects were considered in the plan element identification and evaluation activities. Although they may not be evaluated as alternative plans to meet the basinwide needs, there is considerable technical, economic, and environmental data concerning them in the Task 7 Summary Report and in the Final Report.

The Study was conducted at a prefeasibility level of evaluation. It has been performed in sufficient detail to distinguish the major differences between alternative plans, provide a preliminary indication of viability for each alternative, and determine if feasibility studies are justified.

Following completion of a prefeasibility study, one or more plans could be selected for further, more detailed analysis in feasibility level studies. Feasibility studies would include detailed geologic and geotechnical investigations, application for permits and licenses, environmental studies, and financing arrangements. Final design for a selected project would follow. The prefeasibility study is the first step in a complex process leading to the construction of a water resources project. This process is illustrated in Figure 1.2.

The Study was composed of two phases. The first phase addressed the potential need for water development in the Basin, while the second phase identified and evaluated various structural and non-structural alternatives to enhance water supplies. The prefeasibility study concluded with selection of preferred water development plans and a recommendation that a complete feasibility study be initiated by one or more of the project beneficiaries.

The detailed feasibility study, if conducted, would focus on the preferred plans and the key issues associated with potential development. For example, potential markets for hydropower would be examined along with recreational development possibilities and further utilization of groundwater resources. The level of detail would be suitable to support regulatory processes such as NEPA, to obtain permits and licenses, and to provide the foundation for an investment decision.

1.5 STUDY PROCESS

1.5.1 Structure of the Study

The study procedures were defined in the "The Plan of Study" (POS) prepared by the Authority and the consulting team. The POS identifies the two phases of the Study and the corollary tasks and subtasks to be completed. Table 1.1 identifies the phases and the tasks.

TABLE 1.1

Cache la Poudre Basin Study
Phases and Tasks

Phase	Task No.	Description
Phase I	1	Data Assembly and Review
	2	Description of Existing Water Supply Systems
	3	Regional Hydrologic Assessment for Water Resource Development
	4	Demand Projections
	5	Analysis of Regional and Basinwide Supply and Demand
	6	Baseline Description of the Study Area and Phase I Report
Phase II	7	Identification of Plan Elements
	8	Plan Formulation and Evaluation
	9	Selection of Preferred Plan
	10	Final Report (Including Scope of Work for Phase III Feasibility Study)

Figure 1.3 illustrates the planning process related to the completion of the respective phases and tasks.

The results of this study have been documented in detailed reports for each task, accompanied by abbreviated executive summaries. A report also was prepared to summarize the six tasks comprising Phase I. There is a two-volume Final Report that covers Phases I and II, respectively. This report summarizes the Final Report and encompasses the major findings of the entire Study.

1.5.2 Performance of the Study

At the outset, the Cache la Poudre Basin Study attempted to maximize the use of previous reports and data supplied by others. For example, a considerable amount of hydrologic data was obtained from the Water Commissioner for the Poudre River Basin. Previous studies were reviewed, extracting data and other information applicable to the present effort. Population forecasts, land use studies, and non-structural water resource analyses prepared by local planning agencies were extensively utilized. The

St. Vrain Basin study, recently published by the Authority was also used in a number of instances. The information provided in the Cache la Poudre Basin Study is intended to be the best currently available information suitable for use in a prefeasibility study.

In a prefeasibility level basin planning effort, there will be gaps in available information and some areas of relative uncertainty. In instances where definitive information was lacking, the assumptions for developing estimates were clearly identified and evaluated. In areas of greater uncertainty, such as forecasts of future conditions, a range of possibilities has been provided. The intent has been to bound the range of likely future conditions that can reasonably be expected to occur. The next level of feasibility analysis can explore the critical issues and areas of uncertainty in greater depth.

At critical junctures in this Study, analyses have been performed to assess the validity of interim or final conclusions. These analyses tested key assumptions and explored alternatives where appropriate. For example, a comparatively small-scale water resource and hydropower development has been analyzed to reflect uncertain market prospects for water and hydropower. In response to the various uncertainties associated with a study of this nature, there has been a conscious effort to use conservative estimates.

1.6 PUBLIC INVOLVEMENT

A public involvement program was developed and carried out consistently through the study period. The objectives of the program were:

- To inform the public about the study process, purpose, and need;

- To invite public comment, input, and suggestions during the study process; and

- To involve a broad-based Advisory Committee to provide review and direction throughout the Study.

To accomplish these objectives, the public involvement program included Advisory Committee meetings, small study group meetings, and public meetings.

1.6.1 The Advisory Committee

The Cache la Poudre Basin Study Advisory Committee is comprised of representatives from 30 organizations that, taken together, present a broad range of interests relevant to the water resources of the Cache la Poudre Basin. The intent was to make sure that interested parties were aware of the study progress and interim results in time for the study team to incorporate their advice and concerns. The Advisory Committee members are listed in Table 1.2. The Advisory Committee members were sent a copy of the draft executive summary for each task. They were also notified that a draft copy of the full task report was available at the data repositories (also listed in Table 1.2) and that a meeting to discuss its findings would be held. Advisors were encouraged to offer questions and comments at these meetings. The dates and subjects of the meetings are listed in Table 1.3.

The Advisory Committee provided indispensible direction throughout the course of the effort. Given the wide range of interests represented on the Advisory Committee, it is not reasonable to expect that a unanimous consensus be obtained in an effort of this magnitude. However, the contribution of these individuals has resulted in a comprehensive evaluation of the conflicting interests and their efforts are gratefully acknowledged.

1.6.2 Small Study Groups

Subgroups of the Advisory Committee were formed to explore a number of key issues encountered in performing the ten study tasks. They included water supply, water demand, environmental considerations, and plan

TABLE 1.2

Public Involvement
Advisory Committee Representatives

AUDUBON SOCIETY
Pat Sousa

BUREAU OF RECLAMATION
Roger Weidelman

CITY OF GREELEY
Mark Rybus

CITY OF FORT COLLINS
Gerry Horak/Dennis Bode

COLORADO DIVISION OF PARKS AND OUTDOOR RECREATION
Joe Maurier

COLORADO WATER CONSERVATION BOARD
Bill McDonald

COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY
W.D. Farr

CONSERVE OUR POUDRE
Neeland Siebring

COLORADO FARM BUREAU
Francis Bee/Dale Peterson

COLORADO OPEN SPACE COUNCIL
Norm Mullen

COLORADO RIVER OUTFITTER ASSOC.
Pat Tierney

COLORADO STATE UNIVERSITY
E.V. Richardson

FT. COLLINS CHAMBER OF COMMERCE
Bernie Cain

FORT COLLINS-LOVELAND WATER DISTRICT
SOUTH FORT COLLINS SANITATION DISTRICT
Michael DiTullio

GREELEY CHAMBER OF COMMERCE
Dan Tindall

LAKE RECREATION
John McFarlane

LARIMER COUNTY COMMISSIONER
Court Hotchkiss

NORTHERN COLORADO WATER CONSERVANCY DISTRICT
Larry Simpson

PRESERVE OUR POUDRE CITIZENS GROUP
Chuck Wanner

POUDRE CANYON RESIDENT
Bruce Berends

SIERRA CLUB
Tim Johnson

SOUTH PLATTE WATER COALITION
Jim Park

STATE DIVISION OF HIGHWAYS
Al Chotvacs/Doug Rames

STATE DIVISION OF WILDLIFE
Pete Barrows

STATE ENGINEER'S OFFICE
Jack Neutze

THE CACHE LA POUDRE WATER USERS ASSOCIATION
Bob Stieben

TROUT UNLIMITED
Richard Hamilton/Vance Vorndum

U.S. ARMY CORPS OF ENGINEERS
Col. John Coats/Gregory Moore

U.S. FOREST SERVICE
Milt Robinson

TABLE 1.2 (continued)

Data Repositories

COLORADO STATE UNIVERSITY LIBRARY, FORT COLLINS
Fred Schmidt, Document Librarian

FORT COLLINS PUBLIC LIBRARY, FORT COLLINS
Bob Copeland, Reference

GREELEY PUBLIC LIBRARY, GREELEY
Janet Johnston, Head Librarian

NORTHERN COLORADO WATER CONSERVANCY DISTRICT, LOVELAND
Brian Werner

UNIVERSITY OF NORTHERN COLORADO LIBRARY, GREELEY
Mary Alm

COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY, DENVER
Judy Kriss, Administrative Office Manager

TABLE 1.3

Cache la Poudre Basin Study
Advisory Committee and Public Meetings

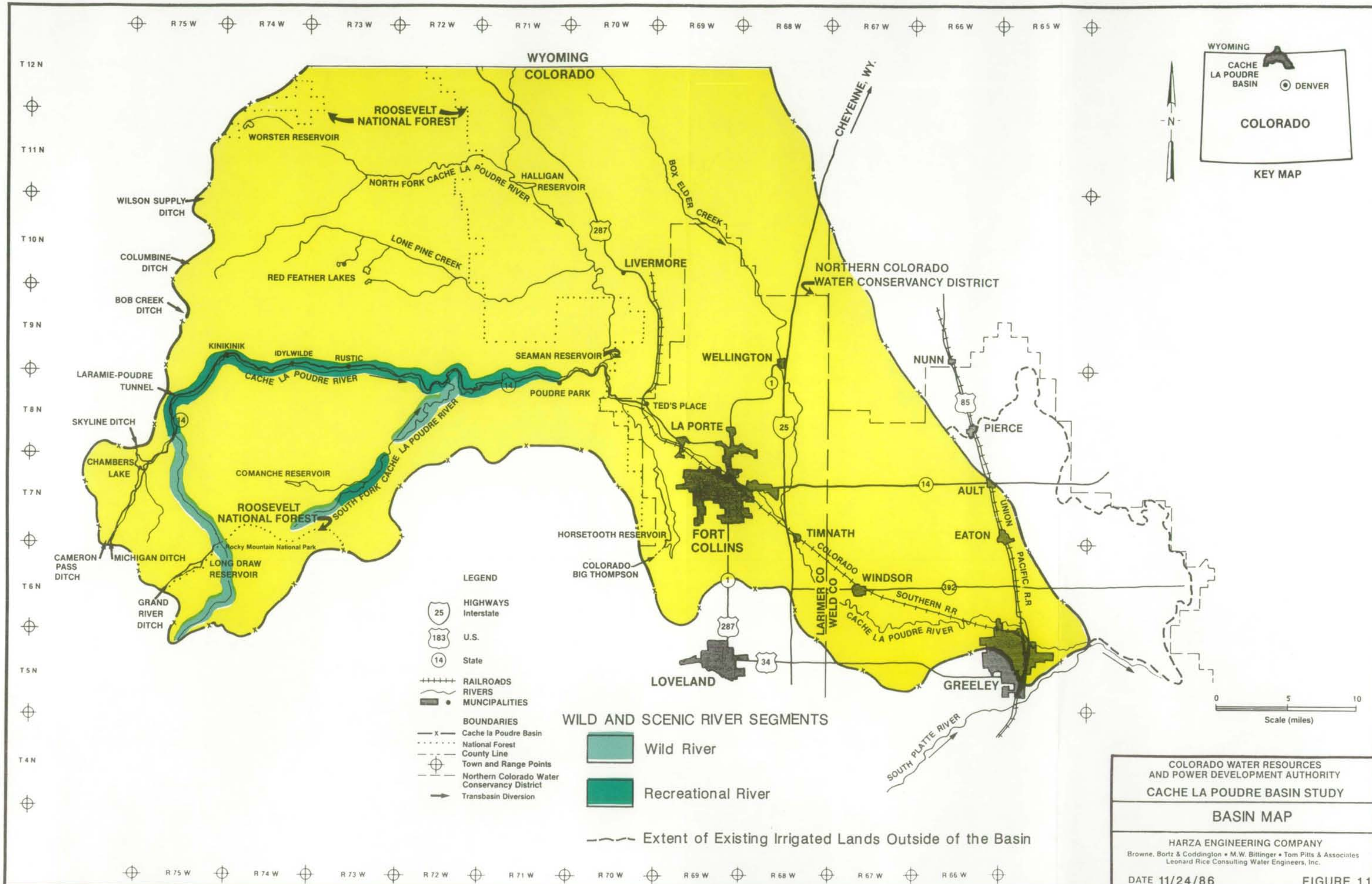
	Date	Meeting
1.	May 28, 1985	Full Advisory Committee on Plan of Study
2.	August 6, 1985	Public Meeting on Introduction to Study
3.	September 12, 1985	Subgroup on Environmental Issues
4.	October 8, 1985	Full Advisory Committee on Tasks 1 and 2
5.	October 17, 1985	Subgroup on Water Demands (Task 4)
6.	October 24, 1985	Subgroup on Water Supply and Hydrology (Task 3)
7.	December 19, 1985	Full Advisory Committee on Task 4
8.	March 4, 1986	Full Advisory Committee on Task 3
9.	April 8, 1986	Subgroup on Supply and Demand (Task 5)
10.	April 22, 1986	Subgroup on Tasks 7a, 8a and 8b
11.	May 8, 1986	Subgroup on Task 8c
12.	May 13, 1986	Full Advisory Committee on Task 5 and Task 6
13.	May 29, 1986	Full Advisory Committee and Public Meeting on Task 6, Phase I
14.	July 28, 1986	Full Advisory Committee Meeting on Tasks 7 and 8c
15.	September 3, 1986	Full Advisory Committee on Task 8
16.	September 10, 1986	Subgroup on Environmental Studies
17.	September 23, 1986	Full Advisory Committee on Task 9
18.	September 30, 1986	Full Advisory Committee on Task 9
19.	November 13, 1986	Full Advisory Committee and Public Meeting on Final Report

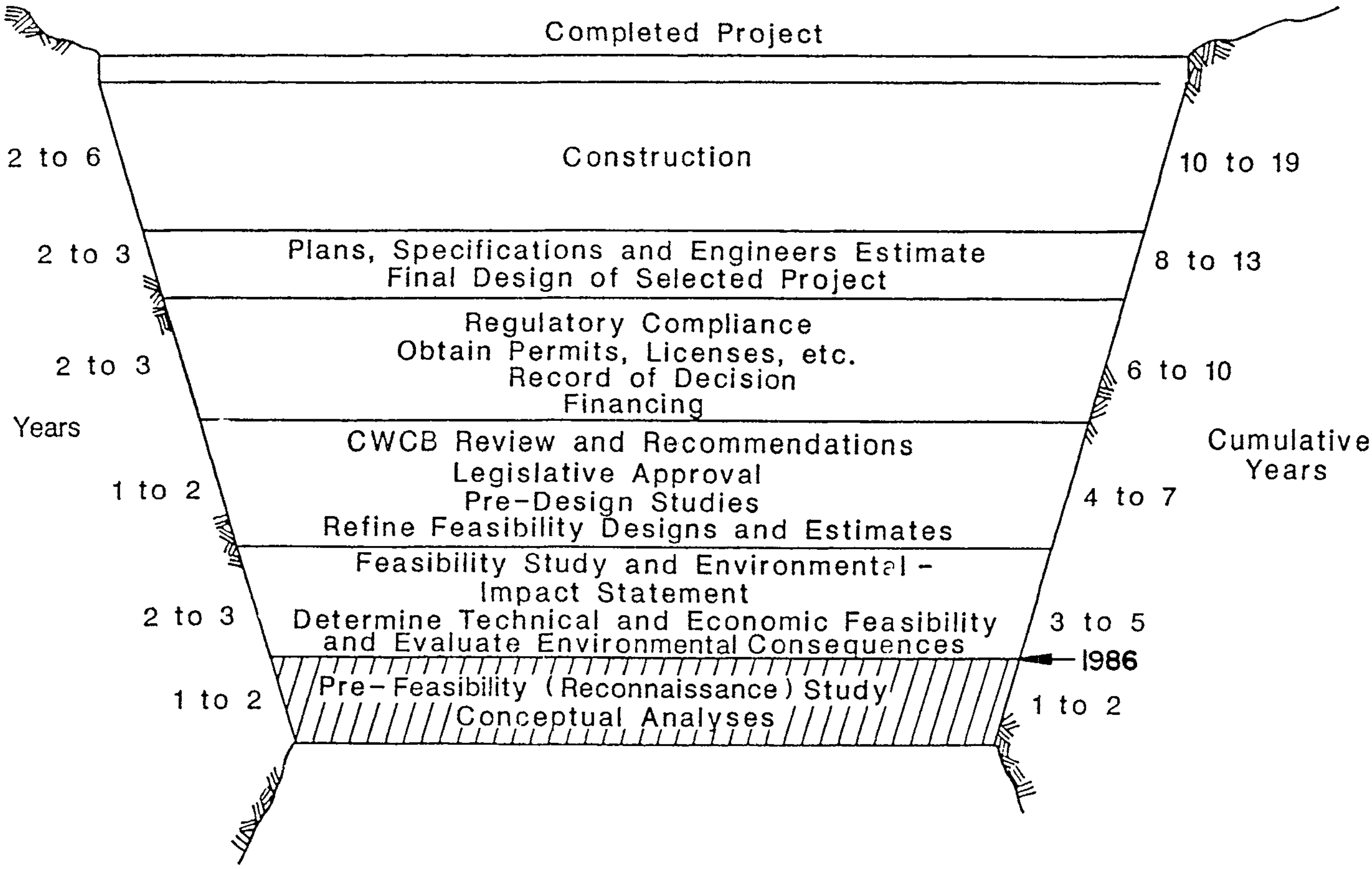
formulation. The selection of participants for the small study groups was based upon their indicated preference and upon their interest and knowledge of the particular topic. The insights provided to the study team from these small groups was significant. Special thanks are extended to these individuals.

1.6.3 Public Meetings

In addition to the 19 Advisory Committee meetings, all of which were open to the public, three special public meetings were held during the course of the study. A meeting was held at the beginning of the study effort to explain the study process, introduce the participants, and ascertain particularly sensitive issues. The second public meeting was held at the conclusion of Phase I. Its purpose was to explain the Phase I findings, progress to date, and Phase II activities. The final public meeting was held on November 13, 1986 to present the study conclusions and supporting information. Drafts of this summary report were provided to Advisory Committee members and the data repositories prior to the final public meeting.

Considerable efforts were made to publicize the time and location of the public meetings through the media. In addition, two newsletters were prepared and distributed. As alternative plans for structural facilities were developed and presented to the Advisory Committee, public attention increased dramatically. The last two meetings were each attended by approximately 150 people. The patience, support, and cooperation of all those who participated is thankfully acknowledged.


WYOMING
COLORADO
ROOSEVELT NATIONAL FOREST
WORSTER RESERVOIR
NORTH FORK CACHE LA POUDRE RIVER
HALLIGAN RESERVOIR
BOX ELDER CREEK
CHEYENNE, WY.
WILSON SUPPLY DITCH
COLUMBINE DITCH
LONE PINE CREEK
RED FEATHER LAKES
LIVERMORE
NORTHERN COLORADO WATER CONSERVANCY DISTRICT
BOB CREEK DITCH
KINIKINIK
IDYLWILDE
RUSTIC
SEAMAN RESERVOIR
WELLINGTON
NUNN
LARAMIE-POUDRE TUNNEL
CACHE LA POUDRE RIVER
POUDRE PARK
TED'S PLACE
LA PORTE
PIERCE
SKYLINE DITCH
CHAMBERS LAKE
COMANCHE RESERVOIR
SOUTH FORK CACHE LA POUDRE RIVER
AULT
ROOSEVELT NATIONAL FOREST
Rocky Mountain National Park
HORSETOOTH RESERVOIR
FORT COLLINS
TIMNATH
EATON
CAMERON PASS DITCH
MICHIGAN DITCH
LONG DRAW RESERVOIR
COLORADO-BIG THOMPSON
COLORADO SOUTHERN RR
WINDSOR
UNION PACIFIC R.R.
GRAND RIVER DITCH
LARIMER CO
WELD CO
CACHE LA POUDRE RIVER
LOVELAND
GREELEY
SOUTH PLATTE RIVER
LEGEND
HIGHWAYS
Interstate
U.S.
State
RAILROADS
RIVERS
MUNCIPALITIES
BOUNDARIES
Cache la Poudre Basin
National Forest
County Line
Town and Range Points
Northern Colorado Water Conservancy District
Transbasin Diversion
WILD AND SCENIC RIVER SEGMENTS
Wild River
Recreational River
Extent of Existing Irrigated Lands Outside of the Basin
KEY MAP
WYOMING
CACHE LA POUDRE BASIN
DENVER
COLORADO
N
Scale (miles)
0 5 10
R 75 W R 74 W R 73 W R 72 W R 71 W R 70 W R 69 W R 68 W R 67 W R 66 W R 65 W
T 12 N T 11 N T 10 N T 9 N T 8 N T 7 N T 6 N T 5 N T 4 N
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
CACHE LA POUDRE BASIN STUDY
BASIN MAP
HARZA ENGINEERING COMPANY
Browne, Bortz & Coddington • M.W. Bittinger • Tom Pitts & Associates
Leonard Rice Consulting Water Engineers, Inc.
DATE 11/24/86
FIGURE 1.1



COLORADO WATER RESOURCES
& POWER DEVELOPMENT AUTHORITY

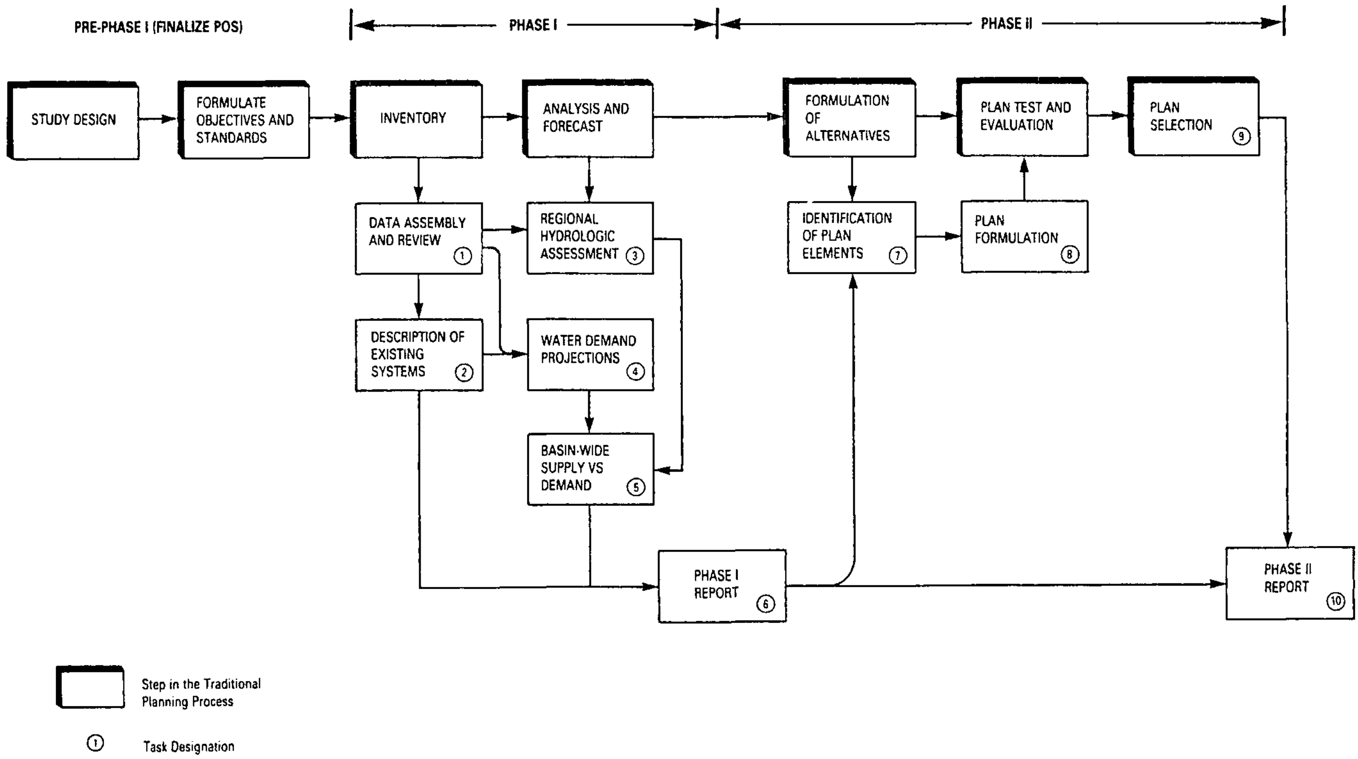
CACHE LA POUDRE BASIN STUDY

TIME REQUIRED TO IMPLEMENT A WATER RESOURCES PROJECT

HARZA ENGINEERING COMPANY
Browne,Bortz & Coddington • M.W.Bittinger • Tom Pitts & Associates
Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986

FIGURE 1.2



COLORADO WATER RESOURCES
& POWER DEVELOPMENT AUTHORITY

CACHE LA POUDRE BASIN STUDY

SCHEMATIC OF
THE PLANNING PROCESS

HARZA ENGINEERING COMPANY
Browne,Bortz & Coddington • M.W.Bittinger • Tom Pitts & Associates
Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986 FIGURE 1.3

2.0 STUDY AREA DESCRIPTION

The initial two tasks in the Study involved inventory of data sources and collection of data needed for a prefeasibility study of water management options for the Basin. Historical water management in the Basin was reviewed. Population, land use, and economic data were obtained for use in preparing water demand forecasts. Environmental data were obtained from secondary sources to enable evaluations to be made of potential adverse impacts of various water management alternatives.

2.1 HISTORICAL OVERVIEW OF THE CACHE LA POUDRE BASIN

The Cache la Poudre River got its name from a famous episode in 1836 when a group of French trappers "cached the powder" and other valuable goods to lighten their load before proceeding on their way.

By the 1860s, the lower part of the basin from Fort Collins to Greeley was well on the path it would follow for the next century; becoming an important part of the breadbasket of Colorado and the Rockies through irrigated agriculture. No significant amounts of precious metals were ever found in the Basin, but the early settlers prospered, supplying the cash crops and livestock needed to provision the Gold Rush and subsequent mining developments in other Front Range watersheds. The key to the success of these early farming settlements was water, which made the fertile but dry plains bloom with successful farms and ranches.

Irrigated agriculture was so successful and developed so quickly that water shortages were apparent in the 1870s. Fort Collins and Greeley were by then thriving communities and there was not enough water to go around. Thus began a tradition that continues today of augmenting the water supply with diversions tapping the headwaters of the Basin and storing water in the spring snowmelt runoff for late summer and winter use.

In the 1890s, northern Colorado agriculture took another step forward by establishing the first transbasin diversions in Colorado. Four major sources were tapped to bring new water into the Poudre from the Western Slope. The Sky Line Ditch brought water from the Medicine Bow Range; Michigan Ditch enlarged the older Cameron Pass Ditch and took water from the Michigan River drainage; another brought in water from the Grand (Colorado) River basin; and finally, a tunnel was bored to bring in water from the Laramie River.

The last major addition to the Basin's water supply was the C-BT Project, which was designed and constructed during the 1930s, 1940s, and 1950s. Concern over water supply has continued, however, because since the C-BT Project went into operation, the population of the region has more than doubled.

2.2 LOCATION AND PHYSIOGRAPHY

The Basin is located in north central Colorado on the eastern slope of the Continental Divide. About 80 percent of the Basin is located in Larimer County, with the remainder in Weld County. Most of the irrigated lands outside the topographic basin are in Weld County.

The topographic basin drains a total area of 1890 square miles (sq. mi.). The mountainous upper basin, above the mouth of Poudre Canyon, has a drainage area of 1050 sq. mi. which consists primarily of national forest lands. There are several small settlements along the river in Poudre Canyon and in the North Fork sub-basin in the Red Feather Lakes area. The highest elevation in the upper basin is Hagues Peak at elevation 13,560 feet. At the canyon mouth, the elevation of the valley is about 5300 feet. More than half the upper basin is drained by the North Fork of the Cache la Poudre River, however this sub-basin produces much less than one-half the mean annual native runoff.

The lower or plains area of the Basin has a drainage area of about 840 sq. mi. (540,000 acres). While most of the water supply is produced in the upper basin, virtually all of the water use occurs in the lower basin, due to urban development and extensive irrigated agricultural development. There are 67,500 acres of irrigated land located outside the topographic basin that are irrigated by diversions from the Poudre River. The major drainage feature of the lower basin is Boxelder Creek, which has a drainage area of 290 sq. mi. Lower basin elevations range from 5300 feet at the mouth of Poudre Canyon to 4600 feet at the South Platte River confluence in Greeley.

2.3 POPULATION, LAND USE, AND ECONOMY

The current (1985) population of the Basin is 204,000 persons. About two-thirds of this population reside in the City of Fort Collins (Larimer County) and the City of Greeley (Weld County), which are major manufacturing and service centers in the northern Colorado region. There are also several small towns scattered throughout the Basin, with populations ranging from 30 to about 5600 persons.

The dominant land use in the upper basin is forest, wildlife, and recreation lands managed by the U.S. Department of Agriculture/Forest Service (Roosevelt National Forest). A small part of Rocky Mountain National Park is located in the southwest corner of the upper basin. There are several small population centers and limited irrigated haymaking areas in the upland meadows along the Cache la Poudre River. Other privately owned land in the upper basin is located primarily in the eastern part of the North Fork sub-basin. Some of this land is used for cattle grazing; most of it is not irrigated.

The dominant land use in the plains of the lower basin area is cropland. There are today about 219,000 acres of irrigated land in the Study Area which includes the topographic basin and lands outside the topographic basin that receive water from the Basin. Ninety percent of these lands are supplied by diversions from the Cache la Poudre River and by transbasin diversions into the Basin. About 70,000 acres of land are developed to urbanized or rural subdivision use.

The economic base of the Larimer and Weld County region is strong, as demonstrated by the relative diversity of employers and low unemployment rates. Two major universities, light manufacturing and high-tech industries, and local government are major employers. Agriculture, although under duress, continues to be an important part of the regional economy. The total value of agricultural production in the two-county region was over $900 million in 1982. However, the region and the Basin itself have not been immune to the nationwide decline in agriculture that has resulted from overproduction, weak international markets, and pricing policies.

2.4 VEGETATION AND TERRESTRIAL WILDLIFE

The Basin covers portions of four vegetative regions (grasslands, montane, subalpine, and alpine tundra) and supports native vegetation common to such regions. There are several plant species of concern in the Basin, including Larimer aletes, Colorado butterfly plant, and Bell's twinpod (under review for federal protective status) and white upland aster, purple cliffbrake, and feverfew (plants of state concern). There are also 10 plant associations considered to be of special concern because they are rare or extremely rare in Colorado. The locations of these associations and those plants of concern at Federal and State levels have been mapped and presented in earlier volumes of this Study.

Certain species of mammals in the Basin are important because of their recreational and economic value, sensitivity to disturbance, large home ranges, and low reproductive rates. These species include bighorn sheep, American elk, mule deer, pronghorn antelope, and white-tailed deer. Bighorn sheep are perhaps of greatest importance. In the Basin, bighorn sheep reportedly occur along much of the main Poudre Canyon west of Greyrock Mountain. American elk is considered by many to be the most important game animal in Colorado. Elk are distributed widely throughout the Poudre Basin. Both bighorn sheep and elk are sensitive to human activity, particularly in terms of barriers to movement and loss of winter ranges. Mule deer are widespread in the Basin but whitetail deer are present in the Basin only in small numbers.

The birds of the Basin include raptors, game birds, water birds, and small birds. The study area supports two raptorial species that are endangered: the American peregrine falcon and the bald eagle. Golden eagles and other raptors are widespread and fairly common in the Basin and generally are more tolerant of man's activities. Osprey are considered to be rare in Colorado and this species is also present in the Study Area.

Upland game birds (blue grouse, pheasant, and turkey) and water birds (ducks, geese, grebes, loons, wading birds, and shore birds) are common in the area. Ducks, geese, and game birds are important because of their recreational value. White pelicans, a species considered threatened by the State, use several plains reservoirs as feeding habitat. The Cache la Poudre River and many reservoirs in the Basin are habitat for the great blue heron. The great blue heron has communal nesting areas on the plains of eastern Larimer County.

Other fauna of interest are the Rocky Mountain wood frog, which in Colorado is limited to the North Platte and Laramie River drainages, including the Chambers Lake area; the sandhill fritillary butterfly which occurs along the river near Timnath; and the smokey-eyed brown butterfly reportedly sighted near LaPorte. The wood frog generally is considered a threatened species, and the two butterfly species are limited in their abundance.

2.5. AQUATIC LIFE AND WATER QUALITY

The Cache la Poudre River upstream of Fort Collins includes an extensive cold water fishery of dramatically varying quality from one section to another, due to wide variations in available habitat, regulations, and sportsfishing uses. In general, cold water habitat for salmonid species (trout) is fair to good when streamflows are sufficient.

Natural winter streamflows are minimal, however, and overwintering habitat in the canyon is severely reduced. Many fish do not survive the winter period. Fishing pressure is extreme throughout the mainstem canyon. The primary salmonid species in the canyon is rainbow trout, with lesser populations of native Greenback cutthroats in the upper tributaries and German brown trout in the lower canyon areas and downstream of the canyon mouth.

In the upper basin, Greenback cutthroat trout exist at several locations. A population of pure stock occurs in the South Fork near Pingree Park, and this segment of the river is rated by federal and state standards as Class I, "unique" and "irreplaceable." This species is listed as "threatened" under the Federal Endangered Species Act and sportsfishing is presently prohibited. There are no species of fishes on the federal listings of endangered and threatened species that occur, or might be expected to occur, in the waters of the lower Cache la Poudre River. The State of Colorado has listed three warmwater species which do occur in the Poudre and its tributaries as species of special concern. These include the Iowa darter, common shiner, and river carpsucker. These three species are peripheral in Colorado but are widespread elsewhere.

On the mainstem above Poudre Park, the Colorado Division of Wildlife (CDOW) conducts an extensive game management program and stocks the river heavily with rainbow trout except for limited "Wild Trout" areas. The CDOW operates two hatchery and rearing facilities in support of this program at Watson Lake and Rustic. Wild Trout areas are not stocked, and fishing with artificial lures only is allowed.

The eight-mile stretch of the mainstem river from Poudre Park downstream to the canyon mouth includes 4.7 miles of stream designated as "Wild Trout" water. This is not, however, a high-quality cold water fishery by either federal or state standards. Under federal mitigation classifications and state classifications used to determine economic value (the latter measure is based on stream width, biological productivity, and fishing pressure), this section of the Poudre rates as a "fair" fishery (between a lower Class II and a higher Class III). CDOW electroshocking surveys of fish populations in this stretch show about 83 pounds of fish per surface acre of water (lbs per acre). When compared to a Class I fishery, such as the South Platte near Deckers, which yields from 600-700 lbs per acre, the productivity of this fishery is relatively poor.

Another measure of quality in the lower canyon section of the river is biological density, i.e., number of fish per surface acre. The density in this section of the Poudre is about 800 fish per acre. Serious flyfishermen claim these Wild Trout sections are dominated by little rainbows in the 5 to 7-inch class, possibly "stockers" who have moved down from the stocked areas upstream. Larger fish in this stretch are often taken by fishermen, since there are presently no fish release requirements. There are several factors which account for this low productivity, including low winter flows and consequent poor overwintering habitat, low sunlight and insect activity, lack of nutrients, and the lack of fish kill restrictions. The North Fork of the Poudre, in the vicinity of potential water developments, is closed to public fishing access by private owners and local water department regulations.

Below the mouth of the canyon, CDOW surveys show that productivity is slightly higher, particularly through privately-owned sections. Trout species, notably German browns, have been noted as far downstream as Fort Collins, but in small numbers. In general, however, most of this stretch is rated Class IV, the poorest quality trout habitat, and like stretches of the river farther downstream, the fish community is dominated by suckers and minnows. According to CDOW biologists, however, this section of the stream could be greatly improved as a cold water fishery if adequate streamflows were available and habitat improvement activities were undertaken. The lower mainstem of the Cache la Poudre below the mouth of the canyon is not stocked by CDOW, and no attempts are presently being made to manage this segment of the river as a game fishery.

In the lower basin, numerous irrigation reservoirs support warm water fisheries dominated by yellow perch, black and white crappie, green sunfish, largemouth bass, and catfish. Many of these reservoirs are managed as fishery habitats through agreements between reservoir owners and the CDOW or private groups.

Horsetooth Reservoir, to the west of Fort Collins, is an important recreational fishery resource with public access. The reservoir is stocked with rainbow trout, walleyes, kokonee salmon, and some lake trout and brown trout.

Based on available data, surface water quality in the upper portion of the Basin is considered excellent. Throughout the Basin, current chemical water quality is within the limits established by the use classifications assigned by the Colorado Water Quality Control Commission for the various stream segments. Biological data on benthic organisms and fish are available for several stations in the lower basin but these show extreme variations. These variations do not correlate with specific seasons or locations along the river.

2.6 RECREATION OPPORTUNITIES

The Basin possesses diversified recreational opportunities that attract thousands of visitors annually. The key attractions of the upper basin include the Cache la Poudre River itself and the scenic views, camping, and fishing opportunities along the river and associated with the Roosevelt National Forest. Fishing also is popular at the numerous upper mountain lakes and reservoirs and along many of the tributaries of the Cache la Poudre River. Many hiking trails are available throughout the upper basin. During certain times of the year the river provides excellent conditions for whitewater boating, including rafting and kayaking. Most of the upper basin is within the Roosevelt National Forest, and parts of this area are designated as Wilderness Areas. As noted previously, the mainstem Cache la Poudre from Poudre Park upstream, and the South Fork, excluding the potential Rockwell dam and reservoir area, have been designated as Wild and Scenic River segments. Both "wild" and "recreational" river segments are included in the designation. Hunting for big game and upland game birds are important seasonal activities in the upper basin and certain areas of the lower basin.

Primary recreational opportunities in the lower basin include flat-water recreation on numerous plains reservoirs, particularly Horsetooth Reservoir. The plains reservoirs offer warm-water fishing opportunities and waterfowl hunting opportunities as well. Developed parks and recreational facilities exist in most of the cities and towns of the lower basin. Lory State Park and Boyd Lake State Recreation Area are important state-operated recreational facilities in the lower basin.

3.0 WATER SUPPLY

3.1 SOURCES OF SUPPLY

Both surface and ground water sources of supply are used in the Study Area to meet agricultural and municipal and industrial (M&I) demands for water. These two sources are interrelated because most of the recharge of ground water aquifers results directly from irrigation operations using water supplied from surface sources.

3.1.1 Surface Water

Average annual surface water supply of the Basin for the 1951-1980 period is estimated to be 540,000 acre-feet (af), as shown in Table 3.1. An af of water is equivalent to about 326,000 gallons, the water use by a typical family of four during one year.

TABLE 3.1

Surface Water Sources
(1951-1980 Average)

Source	Average Annual Flow (af)	Percent of Total
Native runoff	274,000	51
Transmountain Imports	38,000	7
C-BT Imports	89,000	16
Big Thompson Return Flows	14,000	3
Additional Precipitation	125,000	23
Total	540,000	100

About one-half of the water comes from native runoff originating in the Basin. Most of this runoff occurs from snowmelt in the May-July period. There are six operational transmountain diversions that bring water (38,000 af/yr) into the upper basin from the North Platte, Laramie, and Colorado River Basins. The Colorado-Big Thompson (C-BT) Project was completed in the early 1950s. Imports to the Basin from C-BT facilities have averaged 89,000 af/yr for the 1953-1980 period. During periods of low native runoff, C-BT imports may be as high as 128,000 af/yr. Several ditch systems in the southern portion of the Basin are supplied from the Big Thompson River. Return flows from these systems (about 14,000 af/yr) reach the Poudre River and become part of the Basin's water supply. A portion of the precipitation falling on irrigated lands in the Study Area is not required immediately for crop consumptive use. This "additional" precipitation (about 125,000 af/yr) becomes available as a source of supply at a different time and place because it percolates into the ground water aquifers, which underlie irrigated lands in the Study Area, or is intercepted as surface runoff by downstream ditches.

The Study was based on hydrologic conditions, as they affect water supply and water demand, for the 1951-1980 period. During 1981-1985, streamflows have been above normal. In 1983, for example, the annual native flow at the canyon mouth reached its highest level in the 100 years for which records are available. Recent wet years were not accounted for in reservoir sizing because it was determined that they would reduce the representative nature of the selected study period (1951-1980) which closely approximates longer-term average flow conditions.

Of the total water supply, about 70 percent (390,000 af/yr) has historically been used to meet consumptive use needs in the Basin. About 150,000 af/yr leaves the Basin as outflow in the river and beneath the river in the alluvial aquifer or as return flows from ditches located in the Study Area but outside the topographic basin. A portion of this outflow meets diversion needs of downstream users; however, some of this flow could be stored for later use in the Basin. During a dry year such as 1954, the water available for consumptive use is about 260,000 af, two-thirds of the amount available in an average year. Some of the flow passing Greeley could be used in the Basin during dry years if storage facilities were provided and/or if the water was pumped back for Basin use or exchange agreements were negotiated with downstream senior water rights holders.

3.1.2 Ground Water

Ground water is an important source of water supply in the Study Area. Historically, ground water has been used to supplement surface water supplies. There are six alluvial aquifers with a combined storage volume of 420,000 af. Because virtually all of the ground water recharge results from irrigation operations, the use of ground water represents a reuse of surface water.

There are about 1600 wells in the Study Area. Pumpage in 1985 from these wells was estimated to be 126,000 af. Since the C-BT Project became operational in the 1950's, water levels in wells of the Study Area have been essentially stable, indicating that pumping about equals recharge. The safe yield of aquifers in the Study Area is estimated to be 110,000 af per year based on estimated long-term (1951-1980) average annual pumpage.

3.2 EXISTING WATER SYSTEM

The existing water supply facilities in the Study Area form a very complex physical system. There are three major M&I users, 30 large agricultural users, and several industrial users that obtain water from the Cache la Poudre River.

3.2.1 Major Systems

Major water systems in the M&I sector are the City of Fort Collins, the City of Greeley, and the Platte River Power Authority (PRPA). Fort Collins and Greeley own and operate water diversion, conveyance, and treatment systems together with wastewater facilities that serve about three-fourths of the Basin's population, including smaller communities such as Rosedale, Garden City, and Evans. Larger industries such as Kodak, Anheuser Busch Brewery, and Monfort Packing obtain most of their water from Fort Collins or Greeley. PRPA obtains water from the river and Horsetooth Reservoir under a reuse plan. There are six rural domestic water districts that currently serve about 23 percent of the Basin's population in smaller towns (Windsor, Timnath, Severance, Eaton, and Ault) and rural areas. Wellington has its own water system.

There are over 200 ditches in the Study Area; however, the 30 major agricultural water systems account for over 90 percent of the water diverted. The four largest mutual ditch companies (North Poudre, Water Supply and Storage, Larimer and Weld, and New Cache la Poudre) control over 60 percent of the diversions. The ditch systems typically are supplied from direct flow rights of varying seniority, transmountain imports, and C-BT units. Existing storage facilities provide some capability to retain Spring runoff for later use. Currently, about 219,000 acres of land are irrigated within the Study Area; of these, about 198,000 acres are irrigated by diversions from the Cache la Poudre River. The irrigation systems are located in tiers across the Study Area. Return flows from one system are available to downstream systems by the processes of overland runoff and seepage into aquifers that provide supplemental irrigation water.

3.2.2 Management

The Water Commissioner for the Basin is responsible for day-to-day administration of the water resources of the Basin. Key management options to achieve the legislatively mandated goal of "maximum water utilization" are out-of-priority storage and exchanges among water rights holders. Storing water out of priority maximizes use of the most efficient reservoirs by minimizing evaporation and seepage losses. Exchanges normally involve a downstream senior right holder using water stored in an upstream junior right holder's reservoir while the junior right holder diverts water from the river under the senior right holder's direct flow water right.

Successful application of these management measures requires cooperation among water users in the basin. The high levels of management achieved through cooperation have contributed to the high overall efficiency of water use in the Basin.

3.2.3 Overall Water Use Efficiency

Occasionally, Cache la Poudre River flows are required to meet the needs of senior water right holders on the South Platte River. About 90 percent of the total surface water flows to which the Basin is entitled currently are diverted. The remaining 10 percent occurs as flood flows that exceed present diversion and storage capabilities or could not be used at the time they occurred. Putting this water to beneficial use would require construction of additional storage facilities. About 78 percent of the water diverted is consumed by man's activities and by crops grown in the Study Area. The remaining 22 percent is returned to the river. Overall water use efficiency (90% x 78%) is estimated to be 70 percent; that is, for each 10 af now available for use, 7 af are consumed. This high level of efficiency, in comparison to other basins, is attributable to the high level of water resource management and the high level of water reuse that exist in the Basin. The level of water reuse in the Basin is high because of the capture of return flows by downstream ditch systems, and because of irrigation water seepage into aquifers that are pumped to provide supplemental irrigation water.

3.3 DEVELOPABLE WATER RESOURCES

There are four sources of additional water supply that could be developed: storable native flows; additional West Slope imports (Windy Gap and C-BT water); ground water; and return flows at Greeley that are not needed to meet requirements of senior diverters on the South Platte below Greeley. There also are several possibilities to reduce water demands, thereby stretching the currently developed supplies. These possibilities are discussed later under non-structural water management measures.

3.3.1 Storable Native Flows

On an average annual basis, about 37,000 af of water produced by runoff in the Basin is lost because existing water diversion and storage capacities are not adequate. These storable native flows occurred in 17 years of the 30-year historical study period (1951-1980) and range from a few hundred to over 200,000 af/yr. In order to convert the intermittently occurring storable flows into a constant or firm annual supply, it would be necessary to provide additional storage capacity in the Basin. This storage would conserve water available during a wet year with large storable flow volume for use in a subsequent drier year. A yield of 25,000 af/yr can be developed with additional storage of 150,000 af (Figure 3.1).

3.3.2 Additional West Slope Imports

Just as there are many years when storable flows occur within the Cache la Poudre Basin itself, there are also many years when additional water is available from the C-BT and Windy Gap Projects beyond the water presently being diverted. The constraints which now prevent the use of this additional water are storage and conveyance capacities. Over the same time period for which the Cache la Poudre Basin hydrology was evaluated, the amount of additional Windy Gap water that could be conveyed through existing facilities to storage, if 124,000 af of new storage was available, was calculated to be an average of 24,000 af/yr. A similar calculation was made to determine the amount of additional water available from the C-BT Project. However, without performing operations studies, it was not clear whether there was sufficient conveyance capacity to convey all of the additional C-BT water and all of the additional Windy Gap water. Consequently, for the prefeasibility studies described in this report, it was decided to conservatively assume that only a total of 24,000 af/yr could be considered additional firm yield from both. During the next level of feasibility study, the possibility of increasing the firm yield to more than 24,000 af/yr should be evaluated further.

3.3.3 Ground Water

The aquifers of the Study Area currently provide supplemental water for irrigation. An average of about 110,000 af of ground water is pumped each year (1951-1980). This represents a reuse of surface water. If new wells were constructed to replace those that are poorly located and have reduced hydraulic capacity, pumpage could be increased by about 12,000 af/yr. With proper well location and management, as well as planned recharge operations, the aquifers could be effectively managed to provide drought protection. During a single dry year, pumpage could be increased by about 85,000 af over the present average. Recharge facilities would be used in subsequent wet periods to refill the aquifer storage, returning water levels to their original levels. This operation is referred to later in this report as planned conjunctive use of surface water and ground water.

3.3.4 Return Flows

There are some flows in the river, in addition to the native storable flows, that could be developed. These are return flows in the river at Greeley that are not legally entitled to downstream diverters on the South Platte River below Greeley. Unlike native storable flows, this potential resource occurs fairly uniformly over time and averages about 40,000 af/yr. This water could be pumped back to a higher location in the Basin and made available to users or stored for later use. If there were a downstream storage facility on the South Platte River, this water could be stored there and exchanged to increase the native storable flow at a new facility in the Basin. Because of irrigation applications, the quality of this return flow water is much lower than the native storable flows originating in the upper basin.

3.4 SUMMARY

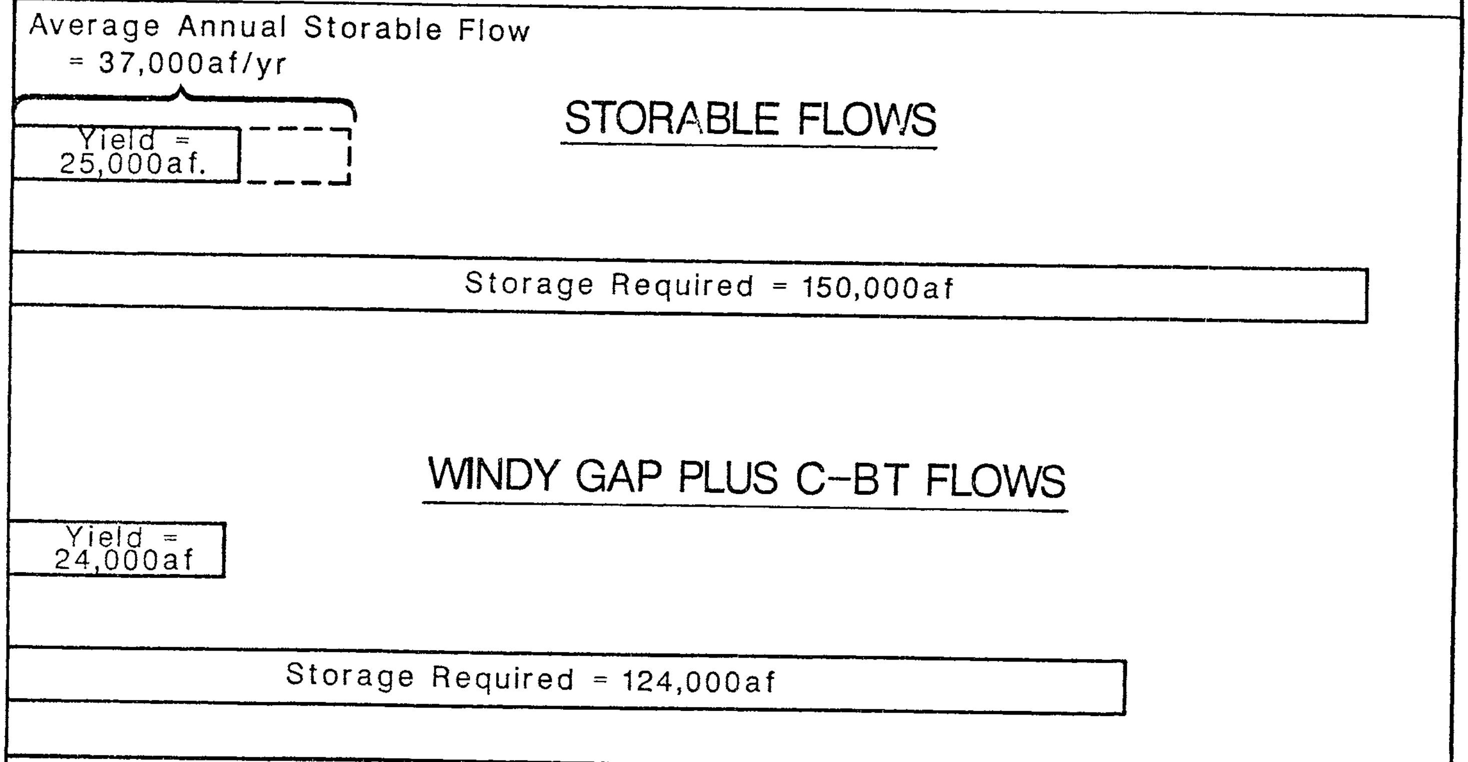
If all of the potential new surface water supplies could be developed, the amount of surface water available to meet consumptive use needs in the Basin could be increased to about 490,000 af/yr, on average (Table 3.2). Increases in ground water pumpage possible with a planned conjunctive use operation would represent increases in the reuse of surface water because ground water recharge is due almost entirely to irrigation using surface sources of supply.

TABLE 3.2

Existing and Potential New Surface Water Supply

	Average Flow (af/yr)
Existing Surface Water Supply[(1)]	390,000
Potential New Supplies	
Storable native flow	37,000
Additional Windy Gap/C-BT	24,000
Return flows	40,000
Total	491,000

[(1)] Total water available (540,000 af/yr, as shown in Table 3.1) less flows now leaving the Basin at Greeley (150,000 af/yr).



Yield

STORABLE	= 25,000af
WG+CBT	= 24,000af
Total Yield	= 49,000af/yr.

Storage

STORABLE	= 150,000af
WG+CBT	= 124,000af
Total Storage	= 274,000af

COLORADO WATER RESOURCES
& POWER DEVELOPMENT AUTHORITY
CACHE LA POUDRE BASIN STUDY

STORAGE -YIELD RELATIONSHIPS

HARZA ENGINEERING COMPANY
Browne,Bortz & Coddington • M.W.Bittinger • Tom Pitts & Associates
Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986 **FIGURE 3.1**

4.0 DEMANDS AND SHORTAGES

4.1 PRESENT WATER DEMANDS

The present (1985) water demand for consumptive use in the Study Area is about 340,000 af. As shown in Table 4.1, irrigated agriculture currently accounts for 94 percent of the consumptive demand in the Basin.

TABLE 4.1
Basin Water Demands, 1985[1]

	Consumptive Use (af/yr)	Percent
Municipal and industrial	21,000	6
Agriculture	320,000	94
Total	341,000	100

---

[1]Theoretical demand based upon average weather conditions.

4.1.1 M&I Demand

M&I demand is concentrated in the Fort Collins and Greeley Areas. The analysis of current and future water use patterns distinguished indoor and outdoor demand for different types of residential, commercial, and public users. Metered and unmetered users were examined separately. Major industrial users including Platte River Power Authority, Kodak, Anheuser Busch and Monfort Packing were analyzed individually. Population and consumptive use in the M&I sector in 1985 is summarized in Table 4.2.

TABLE 4.2

Population and Water Demand
in the M&I Sector, 1985

	Population	Consumptive Use (1) (af/yr)
Fort Collins Area	92,000	10,000 (2)
Greeley Area	66,000	7,000
Other Basin	46,000	4,000
Total	204,000	21,000

(1) Based upon average weather conditions.

(2) About 2,000 af/yr consumptive use is met by diversions from the Big Thompson River.

4.1.2 Agricultural Demand

Total consumptive use for irrigated agriculture is based upon acreage of irrigated crops, crop mix, consumptive use by type of crop, and precipitation that is effective in meeting consumptive use requirements. There are about 219,000 acres of land under irrigation in the Study Area. About 198,000 acres are irrigated by water from the Basin including native flows and imports. Of the other 21,000 acres, a major portion is irrigated by other sources, primarily the Big Thompson River. Other lands are located in the upper basin and accounted for in the available supply estimates.

The rapid growth of Fort Collins and Greeley since 1970 has largely taken place on formerly irrigated cropland. As a result, acreage in irrigated crops has steadily decreased. The future rate of decline is related to growth prospects for these urban areas.

Corn grain, corn for silage, and alfalfa hay account for about two-thirds of irrigated acreage in the Basin. Demand for these crops comes from major feedlots in the area including Monfort, the Miller Feedlot, and Farr

Farms. Feedlot capacity in the Basin exceeds 400,000 head of livestock. In some years, feed requirements of these feedlots exceed available crops harvested in the Basin. Historic cropping patterns are reviewed in Table 4.3.

TABLE 4.3

Cropping Patterns, 1970-1985

	1970 (%)	1985 (%)
Corn	30	51
Alfalfa	21	14
Other Hay	5	5
Pasture	8	11
Barley	6	4
Other	30	15
Total	100	100

Irrigation water comprises a high proportion of the total consumptive use requirements of an acre of cropland because of limited rainfall available to meet crop needs. For example, consumptive use of corn grain averages about 22 inches of water per year, but effective precipitation will typically provide only 7 inches with the balance made up by irrigation. In hot, dry years irrigation demands are greater because of higher consumptive use requirements and lower precipitation.

Based upon analysis of irrigated acreage, crop mix, and net consumptive use requirements, current average consumptive use demand for irrigation water is estimated to be 320,000 af. Dry year demand can reach as much as 390,000 af.

Because of losses attributable to the conveyance and application of irrigation water, more water must be diverted than the consumptive use need. The overall irrigation system efficiency in the Basin is about 55 percent. This measures the proportion of water diverted which is consumed by crops within a single irrigation system. Because of the interrelationship between irrigation systems, as well as groundwater development, 78 percent of the water diverted is consumed at some point in the Basin. This relatively high rate of efficiency is maintained because of the magnitude of the water reuse which occurs in the Basin.

4.1.3 Recreational Water Demands

Several major recreation activities in the Basin depend on water. The streams of the upper basin, particularly the mainstem of the Cache la Poudre River, are popular for fishing. Whitewater boating also is a popular recreation activity on the mainstem above the mouth of the canyon. Hiking along the streams and scenic viewing along Highway 14 are activities at least partially related to the existence of flowing streams. In the lower basin, water oriented recreation includes swimming, boating, and fishing in the larger reservoirs, most notably Horsetooth Reservoir.

The Colorado Division of Parks and Outdoor Recreation Plan presents recreation demand for Larimer and Weld Counties. The plan identifies a need for expansion for three types of water-oriented recreational activities: swimming, water skiing, and fishing.

4.2 FUTURE WATER DEMANDS

4.2.1 Projected Population and Irrigated Lands

A wide range of potential economic scenarios were identified to examine possible future M&I and agricultural demands in the Basin:

- Series 1 - slow growth of major basic industries, decline of agricultural prospects.

- Series 2 - gradual growth of key local economic sectors such as high tech and universities, stable agricultural industry.

- Series 3 - continuation of rapid economic expansion experienced in the 1970s, significant growth of the local feedlot industry, growing market for specialty, cash-oriented crops such as fruits and vegetables.

The three sets of population and economic projections were developed through analysis of U.S. Bureau of Economic Analysis, Colorado Division of Local Government, and Larimer-Weld Regional Council of Government forecasts. These projections were confirmed by the study team through independent development of a long-range forecasting model.

Under Series 1, Basin population would increase from 204,000 in 1985 to 278,000 by 2020. This reflects growth of less than one percent per year compared with four percent annual growth experienced from 1970 to 1985. Population in 2020 would reach 404,000 to 486,000 under Series 2 and Series 3, respectively. An annual growth rate of 2.5 percent is evident for Series 3. Figure 4.1 depicts these population forecasts. Household and employment projections were also developed. Basin-wide projections were disaggregated to the Fort Collins Area, Greeley Area, and an "Other Basin" category based on local planning assumptions.

Since 1970, 90 percent of land urbanized in the Basin was previously irrigated cropland, and this trend is expected to continue. Future growth of the Fort Collins and Greeley Areas would likely occur at a residential density of six households per acre. Based upon these factors, irrigated land expected to be lost to urbanization was calculated. Future irrigated land (year 2020) is projected to range from 163,000 acres (Series 3) to 188,000 acres in 2020 (Series 1).

These projections assume no previously unirrigated lands are brought into production in the future. In fact, over 100,000 acres of land north and east of the existing irrigated area could become prime irrigated land if water could be made available. Since much higher returns from irrigated agriculture would be required to justify expanded irrigation and since additional water supplies are not adequate to irrigate significant amounts of new lands, no new lands were included in the water demand projections.

Crop mix is expected to vary depending upon underlying economic forecasts. Feed crops would decline under Series 1 due to a downturn in feedlot marketings. Under Series 3, corn and alfalfa acreage would comprise a larger share of Basin crops in response to expanded feedlot activity.

Table 4.4 summarizes the population and irrigated lands projections for the Basin under the three series.

TABLE 4.4

Future Population and Irrigated Lands for the Cache la Poudre Basin

Year	Projection Series	Population	Change From 1985	Irrigated Acres[1]	Change From 1985
1985	--	204,000	--	198,000	--
2020	1	278,000	74,000	188,000	(10,000)
2020	2	404,000	200,000	173,000	(25,000)
2020	3	486,000	282,000	163,000	(35,000)

(1) Excludes area irrigated by non-basin waters.

4.2.2 Projected Demands

M&I water demand projections were developed based on a disaggregated sector by sector approach. Current water use patterns by sector are projected to change in response to declining household sizes, installation of lower water using plumbing fixtures, increasing household income, and other influences such as the metering program being implemented in Greeley. Possible metering plans in the older sections of Fort Collins are treated as a potential non-structural water supply measure in the plan formulation, as discussed in later chapters of this report.

Agricultural consumptive use requirements are projected from estimates of future irrigated acreage and crop mix. Table 4.5 presents consumptive use projections under Series 1, 2, and 3. Under each series, growth in M&I demand is offset by declining agricultural demand. Thus, even under very different underlying economic assumptions, future consumptive use is expected to be about the same as the current level in the Basin.

TABLE 4.5

Cache la Poudre Basin Water Demand
1985 and 2020, in af per year,
Assuming Average Weather

Year	Projection Series	M&I	Agriculture	Total
1985	--	21,000	320,000	341,000
2020	1	27,000	300,000	327,000
2020	2	40,000	280,000	320,000
2020	3	53,000	260,000	313,000

4.2.3 Possible External Demands for Water

While the scope of this Study was limited to the Cache la Poudre Basin and irrigation systems served from the Basin, demands for water from the Cache la Poudre are expected to occur outside of the Study Area. The City of Thornton, located about 50 miles south of Fort Collins, has acquired options to purchase agricultural water rights from owners of shares in the Water Supply and Storage Company, one of the older ditch companies that depends on water from the Basin. Thornton is developing plans to convey water for M&I use outside the Basin. There are indications that Thornton is considering returning treated wastewater to the Basin for reuse by agricultural users. Other water users in the Denver Metropolitan Area might also look north for future water supplies during the forecast horizon of this Study.

The Northern Colorado Water Conservancy District and its Municipal Subdistrict operate and maintain the C-BT Project and Windy Gap Project. Water from these projects is used throughout Northern Colorado extending from Boulder to 17 miles north of Fort Collins and as far east as the

Nebraska State Line. C-BT water is used primarily for agriculture but also is an important source of M&I water supply. Windy Gap water is used in the M&I sector, but it is available for reuse in the agricultural sector after treatment. There could be external demands for additional Windy Gap and C-BT imports stored in the Basin.

4.3 FORECAST WATER SHORTAGES

Basin water shortages were simulated for each year of a 30-year time period through a river simulation model, RIBSIM. The supply side of the model incorporated monthly water supply conditions for 1951 to 1980. The demand side of the model was initially based on 1985 water demands by point of diversion for each month of the year adjusted by weather conditions. Monthly surpluses or shortages were examined for each year of the study period. Shortages in the year 2020 were then examined using year 2020 demand and the same 30-year history of available supplies. The historic period includes a 1-in-10 year drought and a 1-in-25 year drought, as well as years with average and above average streamflows.

4.3.1 Drought Definition

The concept of drought is important in planning for water resources development and is one that often is misunderstood. A drought can be defined as one year or a series of consecutive years of below average water supply. During the historical study period (1951-1980) selected for Cache la Poudre Basin Study there are 15 years in which water supply was above average and 15 years of below average supply.

Droughts occur randomly over time; it is not possible to predict when a drought will occur. On a long-term statistical basis, a 25-year drought can be expected to occur an average of four times in a 100-year period. A 50-year drought would occur twice. The drought that occurred in the 1930s had the characteristics of a 50-year drought event.

Within the study time frame, there is a four-year period of 1953 through 1956 with consecutive years of below average water supply, based on native runoff from the upper basin. This is estimated to represent a 25-year drought based on the analyses performed for the City of Fort Collins as part of their recent drought study. These analyses considered much longer flow records and synthetic flow data in assigning probabilities to various drought events.

An estimated 10-year drought occurred in 1976-77 based on native flows occurring in the Basin. Because of C-BT availability, water shortages did not occur. If below average runoff had occurred in 1978, a potentially severe shortage may have resulted.

Very high streamflows have been experienced in the Basin from 1981 through 1985. In fact, this period is estimated to represent a wet cycle of 100- to 200-year frequency. It in no way represents typical future supplies that can be anticipated in the Basin.

4.3.2 Shortage Estimates

The hydrologic simulation model was operated comparing water supplies available annually during the 1951-1980 historical study period with present demand conditions (1985) and future demand conditions in the year 2020 under Series 2 and 3. Future water demands for Series 1 are in between those for Series 2 and 3. Therefore, Series 1 demands were not considered in the water supply and demand comparisons. No significant shortages were evident with the 1-in-10 year drought. For the 1-in-25 year drought event, M&I users might face small shortages under Series 3, whereas irrigators would face shortages of about 250,000 af in terms of net consumptive use. Table 4.6 summarizes these findings.

TABLE 4.6

Potential Basin Water Shortages Under Defined Drought Conditions[1]

Drought Event	M&I Sector	Agricultural Sector
1-in-10 year drought	No shortage.	No significant shortage.
1-in-25 year drought	Possible small shortages only under Series 3.	Consumptive use shortage of about 250,000 af over a four year period. This corresponds to a shortage of 450,000 af in terms of total diversions.
1-in-50 year drought	Similar to 1-in-25 year drought event.	Similar to 1-in-25 year drought event.

(1) Modeled under 1985 and Year 2020 Series 2 and Series 3 conditions. The agricultural sector shortages are similar under each.

The lack of significant M&I sector water shortages is attributable to the cities' policies of requiring agricultural water rights prior to annexation and land development. This is facilitated since most future urbanization occurs on irrigated lands. Even during a 50-year drought, shortages in the M&I sector can be expected to be small.

The conclusions above are based on the assumption that no new lands are brought under irrigation to replace cropland lost to urbanization. Shortages would be much more severe if new lands were brought under irrigation. On average, 150,000 af of new water supply at the river diversion point would be needed each year to irrigate 66,500 acres of the most promising, potentially irrigable new lands. The available water supplies of the Basin are not adequate to support this level of additional irrigated agricultural development.

4.3.3 Economic Effects of Drought Period Shortage

Economic losses resulting from water shortages were calculated based upon analysis of historic drought periods, rental prices of water under periods of shortage, and financial models of Basin farm operations. Direct economic losses to Basin farmers under a 25-year drought might range from $20 to $70 million, depending on how effectively shortages can be anticipated and managed. Because many other local industries depend directly or indirectly on irrigated agriculture for business, the total economic losses to the Basin would translate into a $40 to $155 million regional economic loss.

4.4 POWER DEMAND

4.4.1 Overview of the Regional Market

The power demand analysis was based on available data. A number of recent studies have been completed, which are particularly applicable to this hydropower market analysis, including:

- "1985 Annual Data Summary Report," North American Electric Reliability Council, 1985.

- "Colorado Electric Supply Survey 1983-1993," Colorado Public Utilities Commission, April 2, 1984.

- "Task 1-5, Power Demand Forecast and Preliminary Market Assessment," St. Vrain Basin Reconnaissance Study, R.W. Beck and Associates/Dames & Moore, January 1984.

Because of its proximity and the current and future magnitude of the Public Service Company of Colorado (PSC) load relative to its supplies, PSC would be the most likely local market for hydropower generation in the Cache la Poudre Basin. PSC serves most major load centers along the Front Range accounting for over one-half of the power demand within the Rocky Mountain

Power Area (RMPA). The rapid load growth experienced during the 1970s (7 percent per year) has moderated in the 1980s (2 percent per year). Peak demand in 1985 was 3050 MW. Company owned capacity in 1985 was 3045 MW. Purchases from other producers of electricity comprise the company's only reserve.

R.W. Beck extrapolated PSC load forecasts (based upon a 2.1 percent annual growth rate) to project demand of 6830 MW in the year 2020. The 1985 PSC Loads and Resources Study identifies two planned capacity additions--a 485 MW coal-fired unit at their Pawnee Station in 1991 and another 250 MW coal-fired unit in 1994.

The additional resources required by PSC could come from new PSC capacity or purchases of excess capacity from other utilities. For example, Platte River Power Authority (PRPA), Tri-State Generation and Transmission, and Colorado-Ute Electric Association currently have excess generating capacity.

Supply and demand projections developed by the RMPA of the Western Systems Coordinating Council are valuable in analyzing the overall regional power market. PSC, PRPA, Tri-State and Colorado-Ute comprise over 80 percent of RMPA loads. RMPA summer capacity for 1984 was 8807 MW while the peak demand was only 5608 MW. By 1994, resources and demands are expected to be more in balance: demand of 8335 MW and capacity of 10,338 MW are projected, implying a reserve margin of 24 percent.

Given current forecasts of power demand in the region, there will be little local need for additional power production facilities, either for base load or peaking generation, between now and the year 2000. As power demand increases, however, the current surplus of generation capacity will diminish. New power production facilities will be needed beyond the year 2000. Hydropower developed in the Basin could meet this post-2000 demand in the region. Whether this local demand is met by hydropower or thermal generation will depend upon the economics of the alternative facilities.

4.4.2 National Market for Power

Energy Resources Development Associates, Inc. (ERDA), a Fort Collins-based energy development company, has developed an operational and marketing concept for an Energy Storage and Transmission System (ESTS). ESTS incorporates a series of hydroelectric pumped-storage plants including a 2100 MW pumped-storage hydroelectric facility in the Cache la Poudre Basin. Under the ESTS concept, pumped-storage peaking facilities would be linked with base load thermal facilities to meet loads in different regions of the nation.

ERDA has conducted preliminary market studies to assess demand and market prices. Based on these studies, ERDA believes that there will be a substantial shortfall of peaking power generating capacity in the U.S. beyond the year 2000. ERDA has initially focused on the Upper Midwest, Texas/Oklahoma, Colorado/New Mexico, and Pacific Southwest markets. Studies by the Department of Energy and data from the North American Electric Reliability Council (NERC) indicate that by 1990 certain utilities in these regions might lack sufficient generating capacity and imports to meet forecast loads with adequate reserves.

An in-depth, long-range study of power demand and supply throughout the country was well beyond the scope of the Cache la Poudre Basin Study. It is clear that the power from a potential pumped-storage facility of 1800 to 2100 MW in the Basin could not be absorbed within the local power market and the excess would have to be sold outside the region.

4.4.3 Market Prices for Power

A combined price of $.081 per kWh was used to determine the value of on-peak energy sales from a pumped-stroage project in the Basin. This includes a demand charge and an energy charge. The cost of off-peak energy for pumping was assumed to be $0.018 per kWh.

Table 4.7 identifies actual firm demand and energy purchases in 1985 (i.e., prices paid to qualifying facilities) and several estimates of avoided cost rates (i.e., the cost a utility avoids by not having to build and operate an increment of generating capacity). Avoided cost for a combined cycle plant in the Midwest was applied in the analysis of a large pumped-storage facility in this Study to provide a conservative estimate of potential benefits.

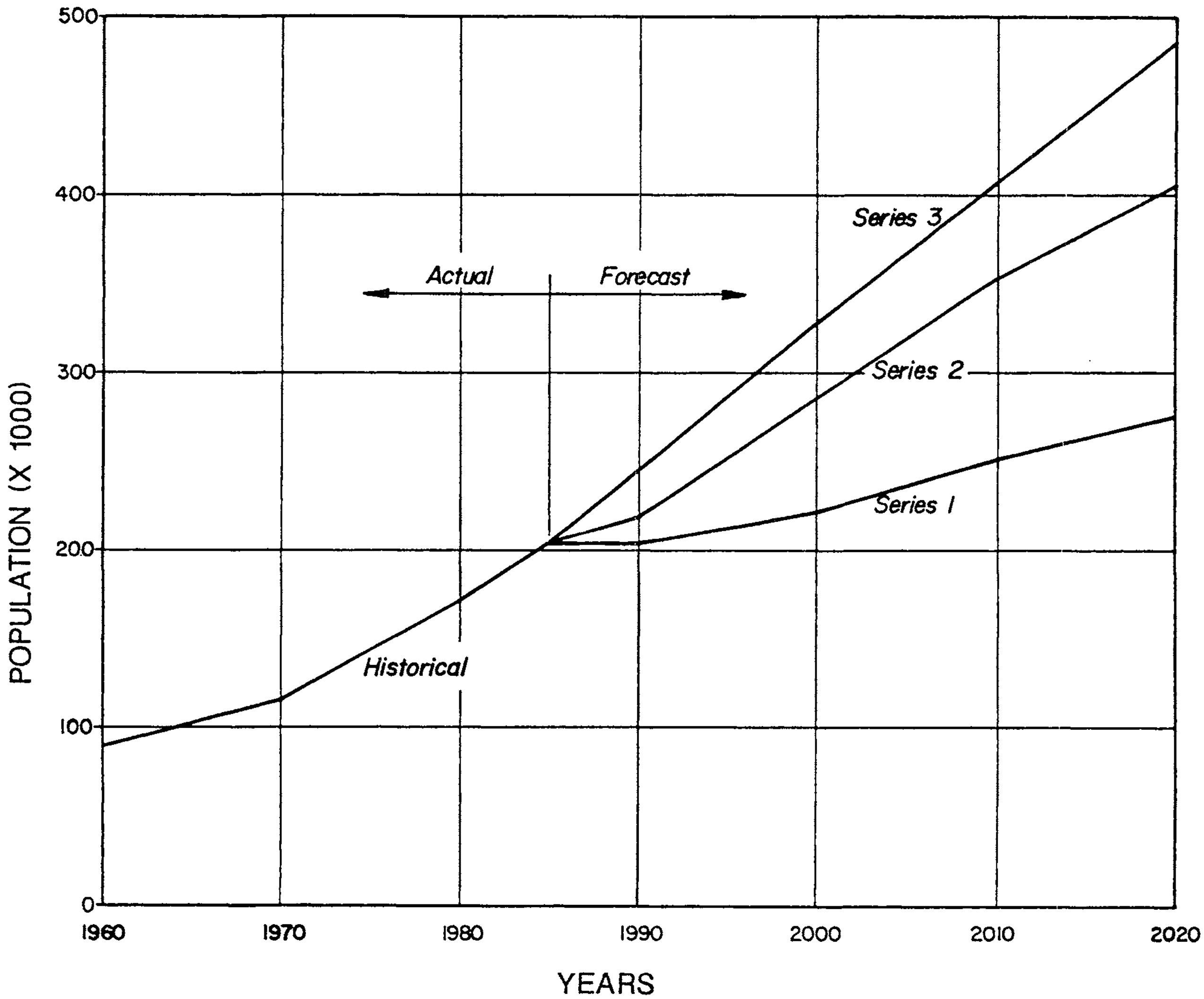
Utilities are obligated to purchase power from conventional hydro facilities under 80 MW in accordance with the Federal Public Utilities Regulatory Policies Act guidelines. The rationale for this obligation is that it results in avoided costs for the utilities because they do not need to expand generating capacities using their own resources. PSC's avoided cost rate in 1986 was $19.38 per kW-month for demand charges and $0.01603 per kWh for energy charges. Power from larger pumped-storage facilities would have to be competitive with rates from new thermal plants. Based upon a 20 percent load factor, recent PSC and Tri-State purchases range from about $.06 to $.13 combined price per kWh. (These combined prices are relatively high because a relatively low load factor is applied, i.e., the plant does not operate at full capacity for a high percentage of time each year.) At an assumed 20 percent load factor, power from a new coal-fired cycling plant would cost about $.18 per kWh, based on studies by Tudor Engineering in the Basin in 1982. Analysis of a new thermal plant in the Midwest indicates a combined price of about $.08 per kWh at 20 percent load factor. The thermal plant would be a liquid fueled combined cycle unit using distillate fuel and an advanced combustion turbine/electric generator.

Off-peak power sells for about $.01 per kWh in the local market. Analysis of nuclear and coal-fired generating facility data in the Midwest suggests a cost of $.0184 per kWh for the future real cost of off-peak energy.

TABLE 4.7

Selected Electricity Prices for Demand and Energy

	Demand Charge ($/kW-mo)	Energy Charge ($/kWh)	Combined Price ($/kWh @ 20% Load (Factor)
Firm Power Purchases, 1985			
Public Service Company of Colorado (PSC)	7.02	0.013	0.061
Tri-State Members	13.71	0.0198	0.114
Tri-State Generation and Transmission	15.34	0.0226	0.128
Avoided Cost			
PSC (Purchase from Cogenerators, 1986)	19.38	0.01603	0.149
Tudor Study (Avoided Cost of Coal-fired Cycling Plant, 1982)	24.17	0.015	0.181
Combined Cycle Plant Costs in Midwest	5.79	0.0411	0.081



COLORADO WATER RESOURCES
& POWER DEVELOPMENT AUTHORITY
CACHE LA POUDRE BASIN STUDY

POPULATION FORECASTS

HARZA ENGINEERING COMPANY
Browne,Bortz & Coddington • M.W.Bittinger • Tom Bitts & Associates
Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986 FIGURE 4.1

5.0 FORMULATION OF ALTERNATIVE PLANS

5.1 APPROACH

Alternative plans were formulated to meet the objective of providing additional water supply for users in the Basin. This additional supply of water would be used to alleviate the drought shortages identified in Section 4.3.2. Alternative plans to satisfy basinwide needs were identified. There are other smaller potential projects that may be attractive for specific, smaller scale purposes. Both non-structural and structural plan elements were considered in the plan formulation process. Each plan includes a selected set of non-structural plan elements that, if implemented, would reduce the 25-year drought shortage by nearly one-half.

Structural plan elements include various dam and reservoir options. The existing water diversion and storage facilities in the Basin do not have adequate capacity to capture the runoff that occurs. In about one-half of the years in the study period, there are flows to which the Basin legally is entitled that pass Greeley without having been put to beneficial use. These storable native flows could be put to beneficial use provided they are stored until needed. Additional Windy Gap and C-BT water would be delivered to the Basin. Storage space to regulate native storable flows, additional Windy Gap water, and additional C-BT water can be provided by constructing a dam.

A new dependable water supply of 25,000 af/yr could be developed from native storable flows if 150,000 af of storage space is provided. Regulation of additional Windy Gap and C-BT water brought into the Basin would require an additional 124,000 af of storage to produce a firm supply of at least 24,000 af/yr.

5.2 NON-STRUCTURAL PLAN ELEMENTS

An extensive inventory of potential non-structural elements was conducted. Non-structural elements are those that do not involve major physical structures or facilities for water management. Thirty-two candidate non-structural elements were identified and screened to determine those that should be considered in the plan formulation.

5.2.1 Identification of Elements

Potential non-structural elements were identified from several recent sources:

- St. Vrain Basin Reconnaissance Study prepared for the Authority in 1986.

- Informational Report on Conservation and Metering in Fort Collins prepared by the Water Utilities Department in 1980 and later updated.

- U.S. Army Corps of Engineers' Denver Metro EIS currently under preparation.

- Environmental Defense Fund's Water for Denver, An Analysis of the Alternatives.

- U.S. Army Corps of Engineers studies including Evaluation of Drought Management Measures for Municipal and Industrial Water Supply, 1983; and The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Illustrative Examples, 1981.

Members of the Study Advisory Committee provided inputs and directions that led the Study Team toward the comprehensive inventory approach that was taken. Their ideas and suggestions regarding identification, screening, and evaluation of non-structural plan elements were incorporated in the planning process.

5.2.2 Screening

Non-structural plan elements were eliminated from further consideration in plan formulation if:

- The element already had been implemented and/or was accounted for in making water demand forecasts;

- Adverse environmental effects, expected to be serious in nature, could occur with implementation of the element;

- Reductions in water consumption or increases in water supply would be small in relation to expected costs and implementation requirements;

- There appeared to be no clear advantage for the element in comparison to present methods of water system operation and management in the Basin; and

- Only minimal reductions in consumptive use would be achieved.

The inventory and screening results of non-structural plan elements is provided in Table 5.1. This table also indicates other studies in which the various elements were considered. Certain of the non-structural measures are not effective or acceptable as long-term supply or demand management strategies; however, they might be beneficial during emergency conditions such as could be expected to occur in the later years of a severe drought or because of a failure within the water supply system.

TABLE 5.1

Inventory and Screening of Non-structural Options

Potential Non-Structural Element	CWPRDA St. Vrain Study	EDF Water for Denver	Fort Collins Conservation Study	Corps of Engineers Denver Metro EIS	Selected Corps of Engineers Studies	Comments	Consider In Plan Formulation (Task 8)	Consider for Emergencies
Water Supply Management								
Phreatophyte Control/Vegetation Management	•			•		Adverse environmental effects; limited effectiveness.		
Ditch Lining	•				•	Relatively small benefits in comparison to expected costs; additional data is needed to quantify results.	•	
Conjunctive Use of Groundwater and Surface Water	•			•	•	High potential for alleviating shortages; possible water quality concerns.	•	
Dredge Existing Reservoirs	•			•		Small benefits in comparison to expected costs.		
Hydrologic Instrumentation	•					Required for more-effective and real-time water management.	•	
Reuse of Municipal Waste Water	•		•	•	•	Already implemented through current practices and accounted for in water supply and demand analyses.		
Transfer of Storage Decrees	•					Would be part of reservoir consolidation to reduce evaporation loss and replace storage lost due to restrctions.	•	
Transfer of Points of Diversion	•					Already implemented but additional opportunities may exist.	•	
Modification of Reservoir Filling Sequences	•					Already implemented.		

TABLE 5.1 (Continued)

Inventory and Screening of Non-structural Options

Potential Non-Structural Element	CWPRDA St. Vrain Study	EDF Water for Denver	Fort Collins Conservation Study	Corps of Engineers Denver Metro EIS	Selected Corps of Engineers Studies	Comments	Consider In Plan Formulation (Task 8)	Consider for Emergencies
Reduce Municipal Distribution System Leakage			•	•	•	Relatively small benefits; system leakage is not excessive.		
Evaporation Suppression					•	Adverse environmental effects.		
Weather Modification	•			•		Sufficient information not expected for several years; possible adverse environmental effects; present information indicates that it is not viable with existing methods.		
Deficit Irrigation Practices	•					Reduce storage requirements; needs to be considered in reservoir sizing.	•	•
Water Demand Management								
Water Conservation Kits/Public Information	•	•	•	•	•	Public information is part of conservation strategy; kits are of limited effectiveness.	•	
Increasing Block Rates/Summer Surcharge	•	•	•	•	•	Requires metering/education; strong public opposition possible.		
Low Demand Plumbing Fixtures	•	•		•	•	Already implemented; built into demand forecasts.		
Universal Metering	•	•	•	•	•	Incorporated in demand forecasts; except part of Fort Collins which could become metered.	•	

TABLE 5.1 (Continued)

Inventory and Screening of Non-structural Options

Potential Non-Structural Element	CWPRDA St. Vrain Study	EDF Water for Denver	Fort Collins Conservation Study	Corps of Engineers Denver Metro EIS	Selected Corps of Engineers Studies	Comments	Consider In Plan Formulation (Task 8)	Consider for Emergencies
Outdoor Watering Restrictions	•	•	•	•	•	Accepted practice during water-short periods.	•	•
Water Use Rationing	•	•			•	Mild rationing is ineffective. Severe rationing could result in major land-scape damage.		•
Landscaping Restrictions for New Homes	•	•		•	•	Demand reduction might be significant.	•	
Prohibitions on New Connections						Major implications for local economy.		•
Ban on Outdoor Use					•	Adverse effects on urban vegetation.		•
Commercial/Industrial Conservation				•	•	Accounted for in other non-structural measures and/or considered in demand forecasts.		
Pressure Reduction			•		•	Limited savings; public opposition		•
Landscape Irrigation System Improvements			•			High cost measure; not considered further in Denver EIS.		
Irrigation Efficiency Improvements	•				•	High cost to improve on-farm efficiency.		
Institutional Measures								
Drought Insurance	•					"Defacto" programs now in place with existing leasing, but formalization may be beneficial.	•	

TABLE 5.1 (Continued)

Inventory and Screening of Non-structural Options

Potential Non-Structural Element	CWPRDA St. Vrain Study	EDF Water for Denver	Fort Collins Conservation Study	Corps of Engineers Denver Metro EIS	Selected Corps of Engineers Studies	Comments	Consider In Plan Formulation (Task 8)	Consider for Emergencies
Basinwide Cooperative Management Organization	•					Could be required to implement various non-structural measures, particularly planned conjunctive use.	•	
River Basin Authority with Regulatory Power	•					No clear advantage over present operations.		
Restructured Water Rights	•					Requires changing State laws.		
Improved Water Management Through Market Process	•					No clear advantage over present operations.		
Water Court Enforcement of Water Use Efficiency Goals	•					Requires changing State laws.		

5.2.3 Application to Shortage Reduction

Non-structural plan elements included with each plan are identified in the following table.

TABLE 5.2
Non-Structural Plan Elements

Element	Purpose	Yield
Conjunctive Use	Further develop the ground water resources of the Basin to increase firm supplies and provide drought protection	12,000 af/yr new supply; up to 85,000 af during a drought
Additional Metering	Reduce M&I water diversions	4,300 af/yr (each year)
Water Use Restrictions	Reduce M&I water diversions	12,000 af/yr during water short periods
Landscape Restrictions	Reduce M&I water diversions	5,600 af/yr (each year)
Ditch Lining	Reduce non-beneficial consumptive use of irrigation water	Not quantified(1)
Hydrologic Instrumentation	Provide additional data to support water management and cropping decisions	Not quantified
Transfer of Storage Decrees	Provide the opportunity for ditch companies and municipalities to place existing storage rights in a new reservoir	Not quantified
Transfer of Diversion Points	Provide the opportunity for ditch companies and municipalities to obtain water under existing rights from new diversion points in the Basin	Not quantified

(1)Yields from certain non-structural elements were not quantified because of inadequate data to characterize water savings or uncertainties with regard to the amount of water savings that might be attained.

Deficit Irrigation Practices	Provide less than optimum water supplies to crops during a drought	Not quantified; would affect reservoir sizing
Public Information	Educate the public with respect to water issues and encourage good water use practices	Not quantified
Drought Insurance	Formalize existing "defacto" program to provide drought protection through leasing arrangements	Not quantified; would affect reservoir sizing
Basinwide Organization	Establish an organization to operate and administer the conjunctive use operation and possibly the drought insurance program	Not quantified

Total investment cost for implementing the twelve non-structural elements is estimated to be about $34 million and total annual cost is estimated to be approximately $3.7 million. Water savings from several of the non-structural elements are very difficult to quantify. However, if only those elements that produce a quantifiable annual water savings are considered, their annual cost per af is estimated to be in the range of $5 per af up to over $200 per af. By comparison, structural elements result in unit costs for water yield in the range of $500 to $1500/per af, thus emphasizing the cost effectiveness and, therefore, the importance of non-structural measures.

The effect of implementing non-structural measures having quantified yields is demonstrated in Table 5.3. Total shortage during a 1-in-25 drought can be reduced from 450,000 af to 250,000 af. The total water shortage given in Table 5.3 is the consumptive use shortage adjusted for conveyance and application losses. Non-structural savings are the result of additional metering, water use restrictions, and landscape restrictions that together would reduce consumptive use by about 22,000 af/yr during a water short period. Planned conjunctive use of ground water and suface water would provide a higher level of reuse of the existing water supply achieved through constructing new wells and recharge facilities and intensive management.

TABLE 5.3
Effect of Non-Structural Measures on Reducing
25-Year Drought Shortage (Series 3, Year 2020)
(acre-feet)

Drought Year	Consumptive Use Shortage	Total Water Shortage	Non-Structural Savings	Conjunctive Use Water Pumpage	Remaining Total Water Shortage[4]
1	6,000	11,000	11,000[1]	[2]	0
2	123,000	224,000	22,000	97,000[3]	105,000
3	67,000	121,000	22,000	12,000	87,000
4	51,000	93,000	22,000	12,000	59,000
Total	247,000	449,000	77,000	121,000	251,000

(1) Savings of 11,000 af can be effected by ditch lining, metering, and minor restrictions.
(2) Not needed in first year of drought.
(3) Includes yield of 85,000 af to reduce worst-year shortage.
(4) Structural measures would be needed to overcome these shortages.

Note: Shortages do not include those associated with bringing new agricultural lands into production.

Extensive cooperation among water users in the Basin would be needed to implement the non-structural measures, particularly a planned conjunctive use operation. Various legal and institutional issues would need to be resolved before some of the measures can be effective. Changes in existing laws also may be required. A basinwide cooperative water management organization, comprised of water users, administrators, and other interests, would be useful in securing the necessary cooperation and in avoiding excessive litigation.

Metering and landscape restrictions would provide a water savings each year. A new storage reservoir may be needed to conserve this water for later use in a drought. This has not been considered in reservoir sizing for each alternative plan because of uncertainties as to whether these measures would be implemented.

5.3 STRUCTURAL PLAN ELEMENTS

5.3.1 Identification of Elements

Many structural plan elements comprising dams, conveyance facilities, hydroelectric plants, and appurtenant structures were identified from prior engineering reports and original conceptualizations made for this Basin Study. Over 30 individual structural elements were considered. These elements were used as building blocks to develop alternative plans to meet projected water supply deficits.

5.3.2 Screening

Storage sites identified in early studies but located in proposed Wild and Scenic river segments were not considered in the plan formulation process. Map studies to identify new sites were limited to areas outside of the Wild and Scenic river segments and Wilderness Areas. Additional storage in the plains area of the Basin is limited. The best storage sites in the plains have been developed and based on preliminary analysis for this Study, raising existing dams would not be practical for meeting storage capacity needs due to the associated costs, the high evaporation potential, and the adverse impacts on surrounding vegetation and wildlife habitat.

Ten potential storage sites were selected for consideration in plan formulation. These sites are shown on Figure 5.1. Based on high cost in relation to water yield estimates, two sites, Calloway Hill on the North Fork and Rockwell on the South Fork, were eliminated prior to formulating alternative plans. The City of Fort Collins has a conditional storage right for the Rockwell site with a decreed volume of 4900 af. A reservoir of this capacity was not considered in the Study. This amount of storage could be provided less expensively in a large reservoir that serves basinwide needs. Future studies by the City may indicate that a small reservoir at the Rockwell site may be a desirable addition to the City's water system, particularly if larger storage facilities are not implemented. Of the remaining eight sites, five are on the mainstem, two are on the North Fork, and one is located off-channel just north of Ted's Place.

5.3.3 Application to Shortage Reduction

As indicated in Section 5.1, total storage of 274,000 af would provide a firm additional yield of water of 49,000 af/yr from native storable flows (25,000 af/yr) and additional Windy Gap plus C-BT imports (at least 24,000 af/yr). This additional water would further reduce the drought shortage, as shown in Table 5.4 and on Figure 5.2.

The City of Thornton has acquired options to buy ditch company shares in the Basin and plans to divert water from the Basin for M&I use. This issue has not been addressed specifically in the Study; however, in subsequent studies this issue will need to be addressed as to how it affects future water planning in the Basin.

TABLE 5.4
Application of Structural Measures

Year	Remaining Shortage After N-S[1] (af)	Upper Basin Storable Flow (af)	Additional Windy Gap and C-BT (af)	Remaining Shortage (af)
1	0	0	0	0
2	105,000	50,000	24,000	31,000
3	87,000	25,000	24,000	38,000
4	59,000	25,000	24,000	10,000
	251,000	100,000	72,000	79,000

(1) Shortage remaining after application of non-structural (N-S) measures (see Table 5.2).

Return flows passing the Greeley Gage and legally usable in the Basin could be developed in several ways. A pump-back arrangement might be considered whereby the return flows would be pumped upstream and made available for diversion by water users. Alternatively, a storage reservoir on the South Platte River (such as Narrows or Hardin) or possibly a ground-water storage development (such as Beebe Draw) could provide the ability to meet downstream calls on the Poudre Basin from stored return flows. With this capability, additional native runoff could be stored within the Basin. Whether by pump-back or exchange, the flows at Greeley that could be used in the Basin without injuring downstream water users would nearly overcome the remaining shortage given in Table 5.4.

5.3.4 Pumped-Storage Potential

The electric utility industry of the United States is not constructing enough peaking power plants to meet projected national and local demands beyond about 1995 to 2000. The large differences in elevation of the Colorado Rocky Mountains offer a significant opportunity for conventional and pumped-storage hydroelectric generation to meet these demands and thus become important income producing elements in Colorado's future water resource development projects. In the Cache la Poudre Basin, for example, an opportunity exists to develop a major water supply system together with a large pumped-storage facility. The amount of peaking power that could be produced could serve the needs of major load centers in and outside Colorado. The sale of this power could provide a large percentage of funds for development of water needs in the Basin and region.

A pumped-storage project is like the storage battery of an automobile. Energy is put into the project or the battery when it is not otherwise needed and taken from the project or the battery when it is needed. In the case of the pumped-storage project, low cost off-peak energy from thermal electric systems, which cannot be shut down at night[2] when electrical demands are low, is used to pump water to an upper reservoir. That water,

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[2] Certain thermal units cannot be shut down at night because they need to be maintained at the proper temperature to facilitate generation during the next day.

when stored in an upper reservoir represents energy that can be used to generate power to meet the peak demands of thermal electric systems. The same water conductors are used for both the pumping and generating modes of the project. Similarly, the pumps and their motors become turbines and generators when operated in the opposite direction, as shown on Figure 5.3. The economic viability of a pumped-storage project is based on the difference in the cost of energy purchased to pump water and the price charged for generated peaking energy.

The best pumped-storage sites have a large elevation difference between the higher (upper) reservoir and the lower reservoir and a short horizontal distance between the two reservoirs. A common rule of thumb for screening potential projects is that the horizontal distance between upper and lower reservoirs not exceed ten times the hydraulic head. In the Cache la Poudre Basin, an upper reservoir at Greyrock Mountain, just northeast of Poudre Park, connected to a lower mainstem reservoir would provide about 1400 ft of elevation difference over a 6500 ft horizontal distance for a ratio of approximately 4.6 to 1. This ratio indicates a very attractive site.

Prior studies of water storage in the Basin from the Bureau of Reclamation studies in the 1960s to the Colorado Water Conservation Board study completed in 1983 have considered the opportunities for hydroelectric power development to provide revenues for a multi-purpose water storage facility. These studies only considered conventional hydroelectric peaking facilities and not the pumped-storage concept.

A major pumped-storage installation, on the order of 1800 megawatts[3] (MW), in the Basin will serve a power market outside the State perhaps in the Midwest, Southwest, or Pacific coastal states. Major transmission interties from a large pumped-storage installation in the Basin to other

[3] One megawatt is equal to 1000 kilowatts (kW) or 1,000,000 watts.

target load centers would be required. The benefits derived from having the interties has been assumed to offset the costs of constructing the transmission lines. Therefore, transmission costs for a major pumped-storage installation have not been included in the cost estimates.

By the year 2000, the local demand for peaking power only is expected to be 400 to 500 MW. This demand could be met from a portion of a large pumped-storage facility or from a smaller facility sized for the local market.

The marketability of any conventional hydroelectric or pumped-storage project will, however, depend mainly on comparative costs with other pumped-storage projects or peaking power alternatives being developed and marketed during the same time period. Difficulties exist in marketing pumped-storage capacity if the loads to be served and the sources of pumping power are located at substantial transmission distances from the project. Getting large amounts of power to market may require substantial new transmission systems.

It is very important to clearly recognize that at the present time in Colorado, in the absence of federal funding, a major project must essentially be able to carry itself financially. Hydropower offers the best hope for reducing water-user costs.

5.4 THE ALTERNATIVE PLANS

Seven alternative plans were formulated during the Study, including five initial plans (A-E) and two additional plans (B1 and C1) formulated after study advisor inputs. Each plan includes the non-structural elements identified in Section 5.2.3.

The seven plans cover a range of storage options in terms of reservoir capacity and yield. Five plans incorporate a major (1800 MW) pumped-storage installation, one incorporates a (400-500 MW) installation, and the remaining plan does not include a pumped-storage component.

The water storage objective for the structural portion of the alternative plans has been to provide either 274,000 af of storage which would regulate storable flows plus additional Windy Gap and C-BT diversions or approximately 150,000 af which would suffice to regulate one or the other of these flows. Table 5.5 summarizes the basic characteristics of each plan.

TABLE 5.5

Summary of Structural Components of Alternative Plans

Plan	Live Storage (af)	Heights of Dams (ft) Mainstem	North Fork	Off-Channel[1]	Yield (af/yr)	Power Capacity (MW)
A	259,000	440[2]	-	-	46,000	1,800
B	156,000	390[2]	-	-	29,000	1,800
C	274,000	280	-	315	49,000	1,800
D	274,000	130	260	315	49,000	1,800
E	119,000	145	230	180	17,000	0
B1	274,000	375	-	310	49,000	1,800
C1	144,000	230	-	250	24,000	450

[1] Excludes dams to form an upper reservoir for pumped-storage.

[2] Highest of two mainstem dams. The second dam is needed for pumped-storage operations.

A new storage facility in the Basin will be of significance to the northern Colorado region. The NCWCD and its Municipal Subdistrict serve water users from Boulder to 17 miles north of Fort Collins and along the South Platte River to the Nebraska state line. Storage in the Basin will enable the NCWCD to better manage its trans-basin imports and to deliver additional water to the region. It would afford more operational flexibility as well, primarily in the area of water exchanges.

Descriptions of the alternative plans provided below include mention of specific dam types at potential damsites. This was done to indicate how cost estimates were developed. Dam type selection was based on preliminary information about geological conditions at each site. In the feasibility phase, more detailed information may lead to selection of different dam types.

Each of the figures depicting the alternative plans show the relocation of Highways 14 and/or 287. The alignments shown on the drawings are preliminary and were used only in preparing cost estimates for the plans. Routing studies would be performed in the full feasibility study, if it is conducted.

Construction cost estimates presented herein are in January 1986 dollars and include allowances for contingencies (25% for water supply and 30% for pumped-storage elements) and engineering and administration costs (15%). Costs for mitigating adverse environmental impacts and for various environmental enhancements that might be implemented have not been included in the construction cost estimates at this level of study. In aggregate, the mitigation and enhancement costs are expected to be a small percentage of the construction cost for each plan. Inclusion of these costs would not materially affect the financial viability of a particular plan. Mitigation and enhancement costs would be about the same for each plan.

5.4.1 Plan A (Figure 5.4)

This plan provides 259,000 af of active reservoir storage behind Portal Dam located at the mouth of Poudre Canyon. This storage would provide a new firm water supply of 46,000 af/yr. Together with non-structural measures this yield would reduce the 25-year drought shortage from 450,000 af to about 90,000 af. Portal Reservoir could provide significant downstream flood protection because it would control runoff on both the mainstem and North Fork. Portal Dam would be a 440 ft high concrete gravity dam with an ungated spillway designed to pass the probable maximum flood (PMF) without overtopping the dam.

Plan A includes an 1800 MW pumped-storage project which would generate 3150 gigawatt[4]hours (GWh) per year of on-peak electrical energy. The pumped-storage features of the plan include the Greyrock Mountain upper reservoir, Trailhead Dam (265 ft high) to isolate a lower reservoir for power operations, water conveyance facilities between the upper and lower reservoirs, and an underground powerplant.

Plan A has an estimated construction cost of $1.6 billion of which about 70 percent is for pumped-storage facilities.

5.4.2 Plan B (Figure 5.5)

Plan B provides 156,000 af of active storage and involves construction of Grey Mountain Dam at a location about 2 miles downstream from the mainstem-North Fork confluence. Firm yield of new water in the Basin would be 29,000 af/yr and significant flood protection benefits are possible. This plan includes the power features of Plan A, including Trailhead Dam, providing 1800 MW of installed capacity and 3150 GWh/yr of on-peak energy production. Grey Mountain dam would be a 390 ft high concrete gravity dam. Plan B has an estimated construction cost of $1.3 billion. About 80 percent of this cost is attributable to pumped-storage.

5.4.3 Plan C (Figure 5.6)

This plan provides a total active storage of 274,000 af and a firm yield of new water of 49,000 af/yr. Poudre Dam located just below the mainstem-North Fork confluence would be the lower reservoir for pumped-storage operations and would provide about 46,000 af of flow-regulating storage as well. It could provide significant downstream flood protection by temporarily storing peak flows before they are delivered to Glade Reservoir. Glade Dam, located off channel just north of Ted's Place, would provide the main storage facility (228,000 af of active storage). Glade

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[4] One gigawatt is equal to 1,000,000 kilowatts or 1,000,000,000 watts.

Reservoir would be filled by diversion from Poudre Reservoir through the Glade Tunnel. Poudre Dam would be a 280 ft high roller compacted concrete (RCC) dam and Glade Dam would be a 315 ft high rockfill embankment dam. Because of slightly higher head, the pumped-storage facility would be about 1860 MW in capacity with on-peak energy production of 3260 GWh.

Plan C was formulated primarily because the location of Poudre Dam would cause less inundation of the canyon than either Plan A or B. Construction cost for Plan C is estimated to be $1.5 billion. About 70 percent of this cost would be attributable to pumped-storage.

5.4.4 Plan D (Figure 5.7)

Plan D provides 274,000 af of active storage and a new firm yield of 49,000 af/yr. It is similar to Plan C except that all of the major storage is located off the mainstem at New Seaman Reservoir on the North Fork and off-channel at the Glade site. A diversion dam on the mainstem called Footbridge Dam would divert mainstem flows into a by-pass tunnel to New Seaman Reservoir.

New Seaman Dam would be a 260 ft high RCC gravity dam and Footbridge would be a 130 ft high RCC structure. Glade Dam would be a 315 ft high rockfill embankment dam.

Water diverted from the mainstem at Footbridge would be conveyed to New Seaman Reservoir through the Bypass Tunnel. There would be no significant storage in Footbridge Reservoir. The "skimming" of mainstem flood flows into the Bypass Tunnel would involve sophisticated operational procedures that could be subject to interruption. Providing additional storage at Footbridge for absorbing flood peaks would not be possible because a higher dam would cause inundation of Poudre Park during high flow events.

In Plan D, the pumped-storage potential (1860 MW and 3260 GWh of on-peak energy) is developed between Greyrock Mountain and New Seaman Reservoir. The distance between these two reservoirs is more than double that for Plans A through C. Therefore, pumped-storage costs are much higher and operational problems are of concern.

Plan D has an estimated construction cost of $1.65 billion, higher than Plan C due mostly to increased pumped-storage cost. About 70 percent of the construction cost is attributable to pumped-storage facilities.

5.4.5 Plan E (Figure 5.8)

Plan E was formulated as a type of "minimum" development that could be expanded at a later date to provide pumped-storage generating capacity and more water storage capacity. It involves construction of Trailhead Dam (145 ft high RCC gravity dam) on the mainstem, modification of existing Munroe Canal conveyance facilities for pressure flow, off-channel storage at Glade, and North Fork storage at New Halligan Dam (230 ft high RCC gravity dam). Glade Dam would be a 180 ft high rockfill embankment dam. This plan provides a total active storage of 119,000 af and a firm yield of new water of about 17,000 af/yr from storable native flows. In its initial stage, pumped-storage would not be provided; however, Trailhead Dam would be designed for later raising by about 125 ft.

Plan E has an estimated construction cost of $280 million and does not include a pumped-storage component.

5.4.6 Plan B1 (Figure 5.9)

This plan is similar to Plan C except that Grey Mountain Dam is provided in place of Poudre Dam. Although more of the Poudre Canyon would be inundated, the additional storage provided by Grey Mountain Reservoir would reduce somewhat the needed storage volume in Glade Reservoir and, therefore, the height of Glade Dam. Grey Mountain Dam would be a 375 ft high concrete gravity dam and Glade Dam would be a 310 ft high rockfill dam.

Combined active storage capacity in both reservoirs would be 274,000 af providing a new firm supply of 49,000 af/yr. Glade Tunnel and the pumped-storage hydroelectric facilities would be as described for Plan C.

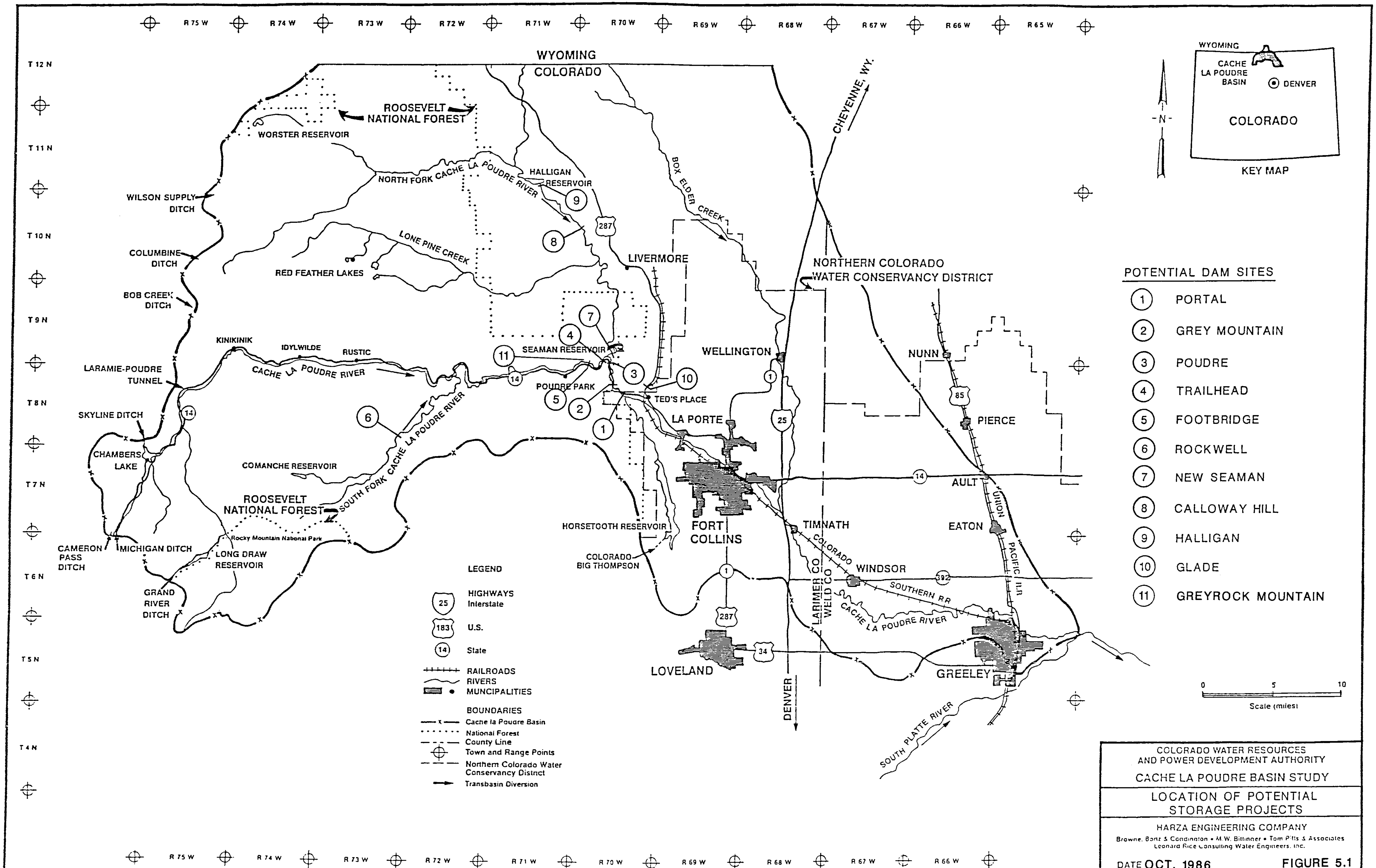
Plan B1 has an estimated construction cost of $1.6 billion of which 70 percent is attributable to the pumped-storage component.

5.4.7 Plan C1 (Figure 5.10)

Plan C1 is a reduced version of Plan C that involves about one-half of the storage volume and one-quarter of the installed pumped-storage capacity. It could be a first stage of an ultimate development. Poudre Dam would be a 230 ft high RCC dam and Glade Dam would be a 250 ft rockfill embankment dam. Combined storage capacity would be 144,000 af. A new firm yield of about 24,000 af/yr would be developed. The two reservoirs would be interconnected by Glade Tunnel as in Plan C.

The 460 MW pumped-storage project would produce 806 GWh/yr of on-peak energy. For this installation, the upper reservoir dam would be considerably lower. They would be designed to accommodate raising in the future if additional generating capacity is needed.

Plan C1 has an estimated construction cost of $620 million. About 70 percent of this cost is attributable to pumped-storage facilities.



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

CACHE LA POUDRE BASIN STUDY

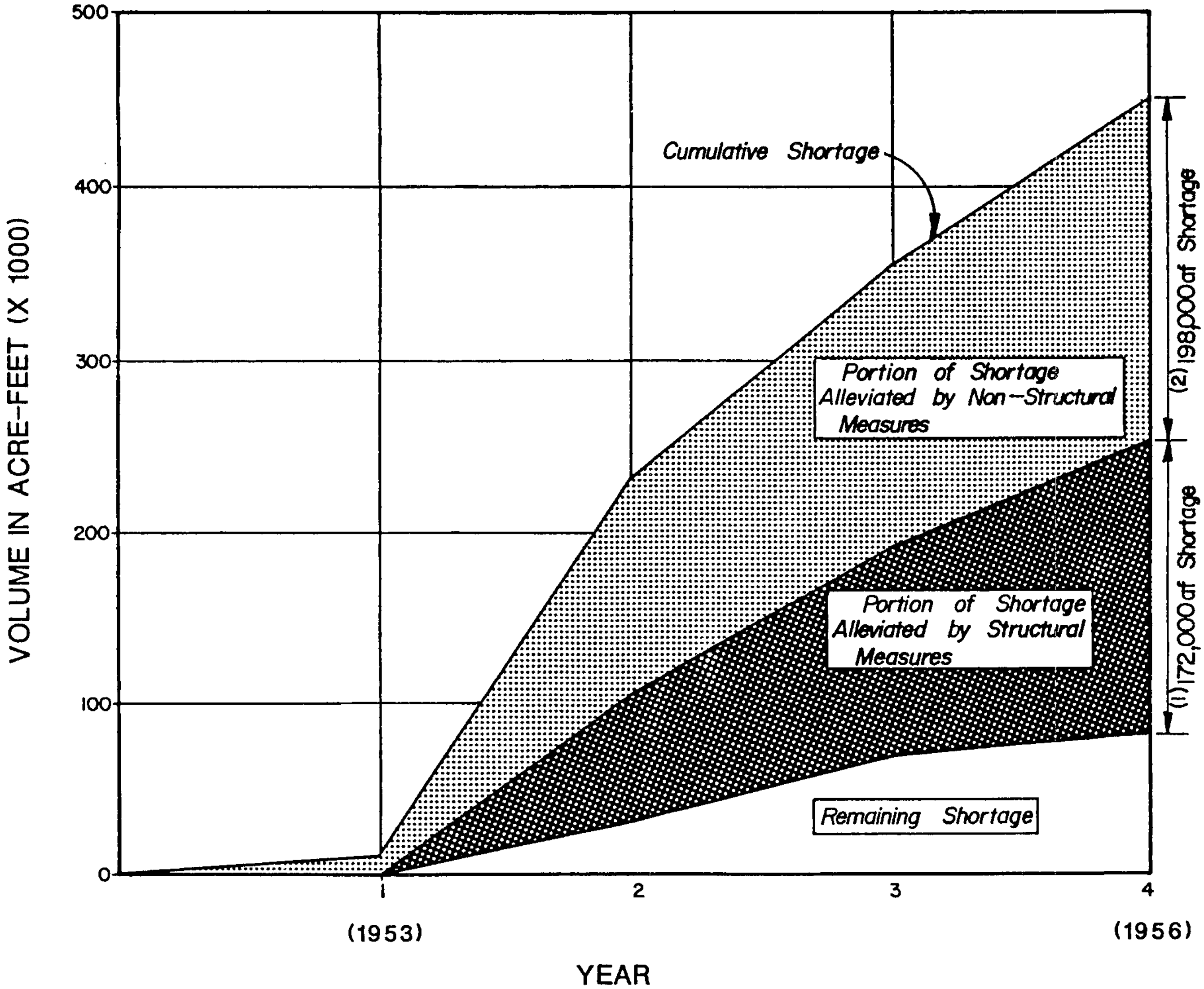
LOCATION OF POTENTIAL STORAGE PROJECTS

HARZA ENGINEERING COMPANY

Browne, Bortz & Coddington • M.W. Bittinger • Tom Pitts & Associates
Leonard Rice Consulting Water Engineers, Inc.

DATE OCT. 1986

FIGURE 5.1



(1) *Alleviated by Structural Measures*

(2) *Alleviated by Non-Structural Measures*

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CACHE LA POUDRE BASIN STUDY

SHORTAGE REDUCTION BY NON-STRUCTURAL AND STRUCTURAL MEASURES

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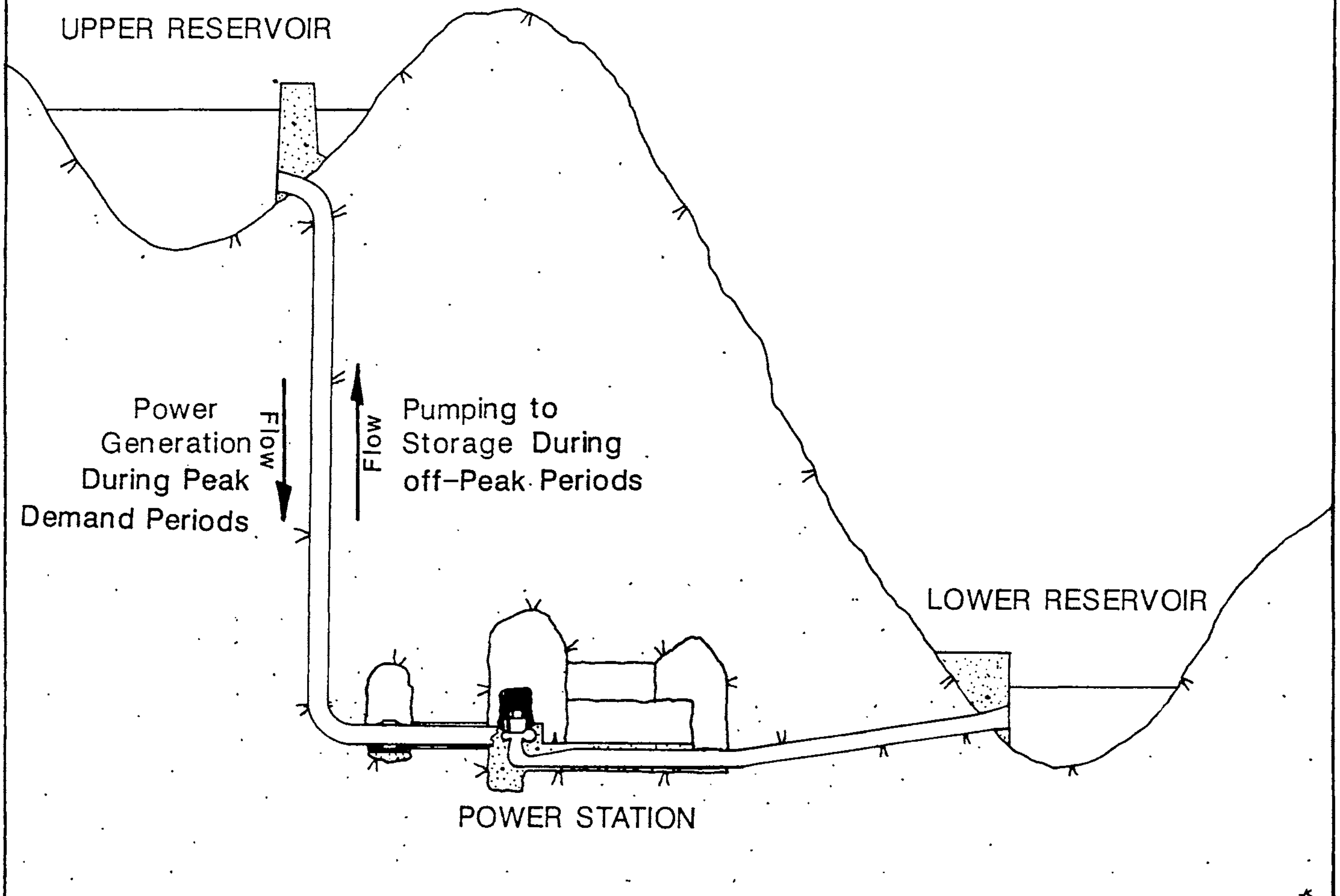
DATE NOV. 1986 FIGURE 5.2



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CACHE LA POUDRE BASIN STUDY

PRINCIPLES OF PUMPED STORAGE OPERATION

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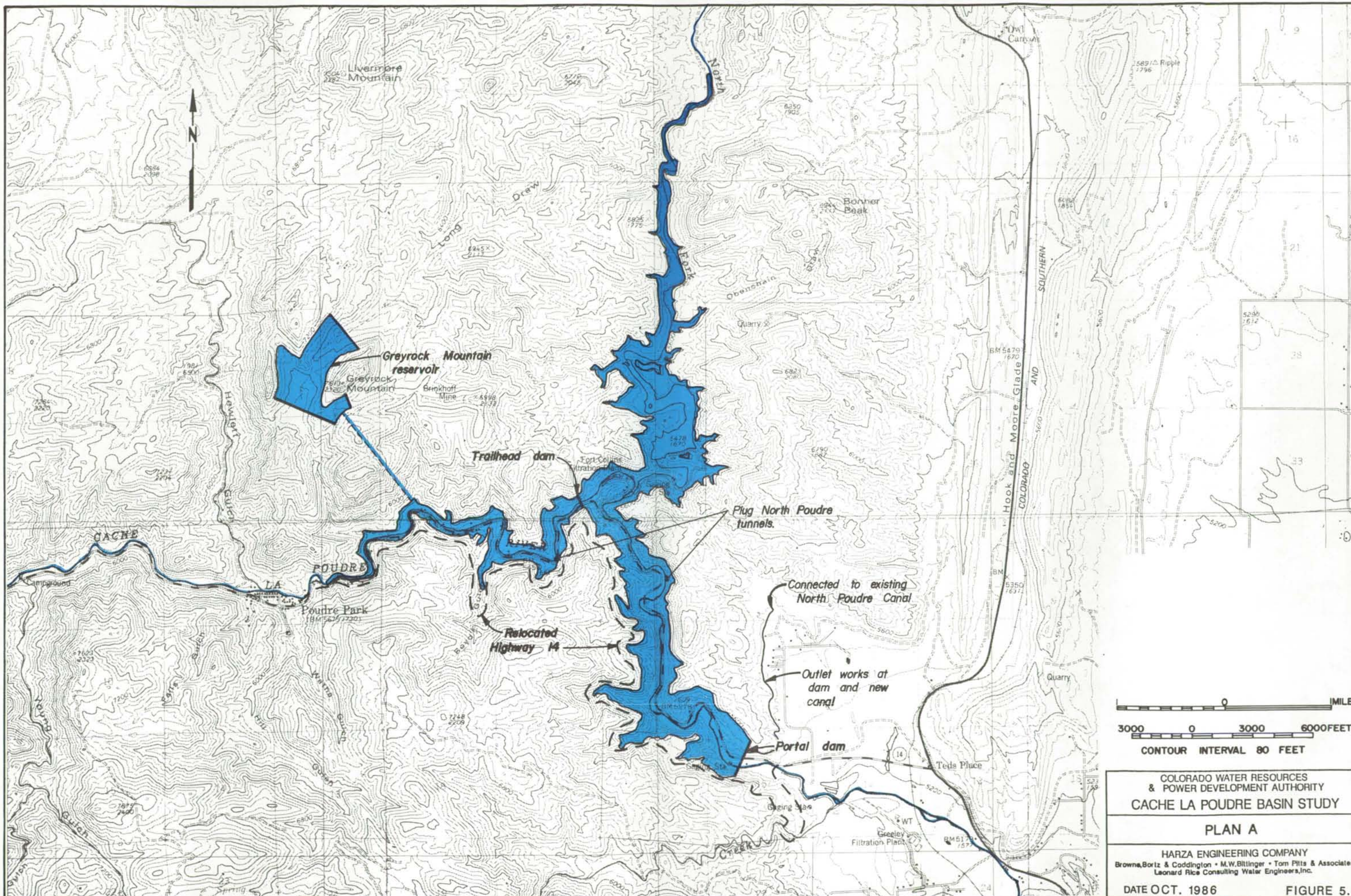
FIGURE 5.3



Greyrock Mountain reservoir
Trailhead dam
Plug North Poudre tunnels.
Connected to existing North Poudre Canal
Relocated Highway 14
Outlet works at dam and new canal
Portal dam
Livermore Mountain
Greyrock Mountain
Bonner Peak
Poudre Park
CACHE LA POUDRE
North Fork
Long Draw
Hewlett Gulch
Hook and Moore Glade
COLORADO AND SOUTHERN
Teds Place
Greeley Filtration Plant
MILE
3000 0 3000 6000 FEET
CONTOUR INTERVAL 80 FEET
COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY
CACHE LA POUDRE BASIN STUDY
PLAN A
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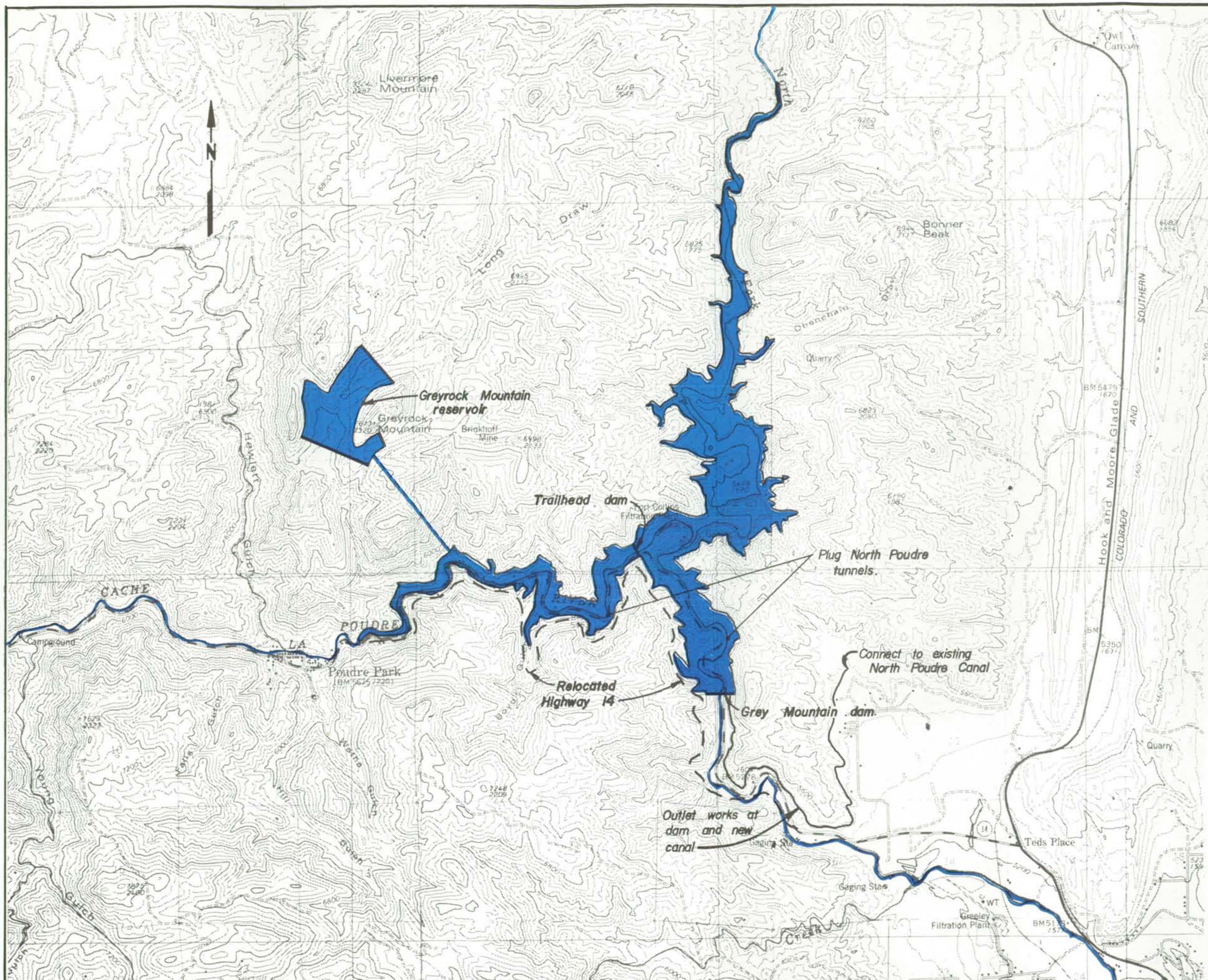
DATE OCT. 1986
FIGURE 5.4



1 0 1MILE
3000 0 3000 6000 FEET
CONTOUR INTERVAL 80 FEET

COLORADO WATER RESOURCES
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CACHE LA POUDRE BASIN STUDY

PLAN B

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FIGURE 5.5

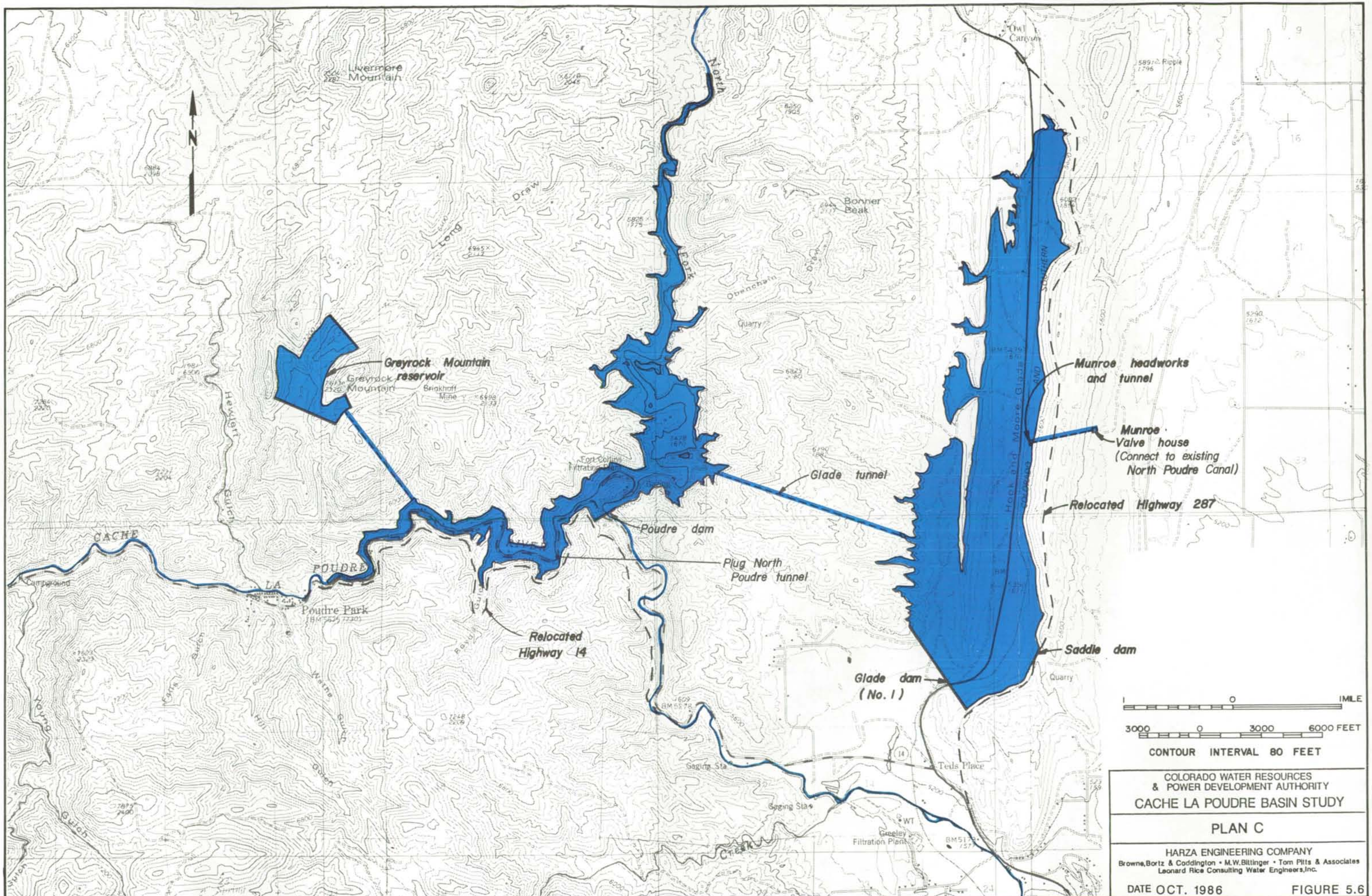
Greyrock Mountain reservoir
Munroe headworks and tunnel
Munroe Valve house (Connect to existing North Poudre Canal)
Glade tunnel
Relocated Highway 287
Poudre dam
Plug North Poudre tunnel
Relocated Highway 14
Saddle dam
Glade dam (No. 1)
Livermore Mountain
Greyrock Mountain
Bonner Peak
Long Draw
North Fork
Obenchain Draw
Hewlett Gulch
CACHE LA POUDRE
Poudre Park
Campground
Fort Collins Filtrating Plant
Hook and Moore Glade
Owl Canyon
Quarry
Teds Place
Gaging Sta
Greeley Filtration Plant
N
1 0 1 MILE
3000 0 3000 6000 FEET
CONTOUR INTERVAL 80 FEET
COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY
CACHE LA POUDRE BASIN STUDY
PLAN C
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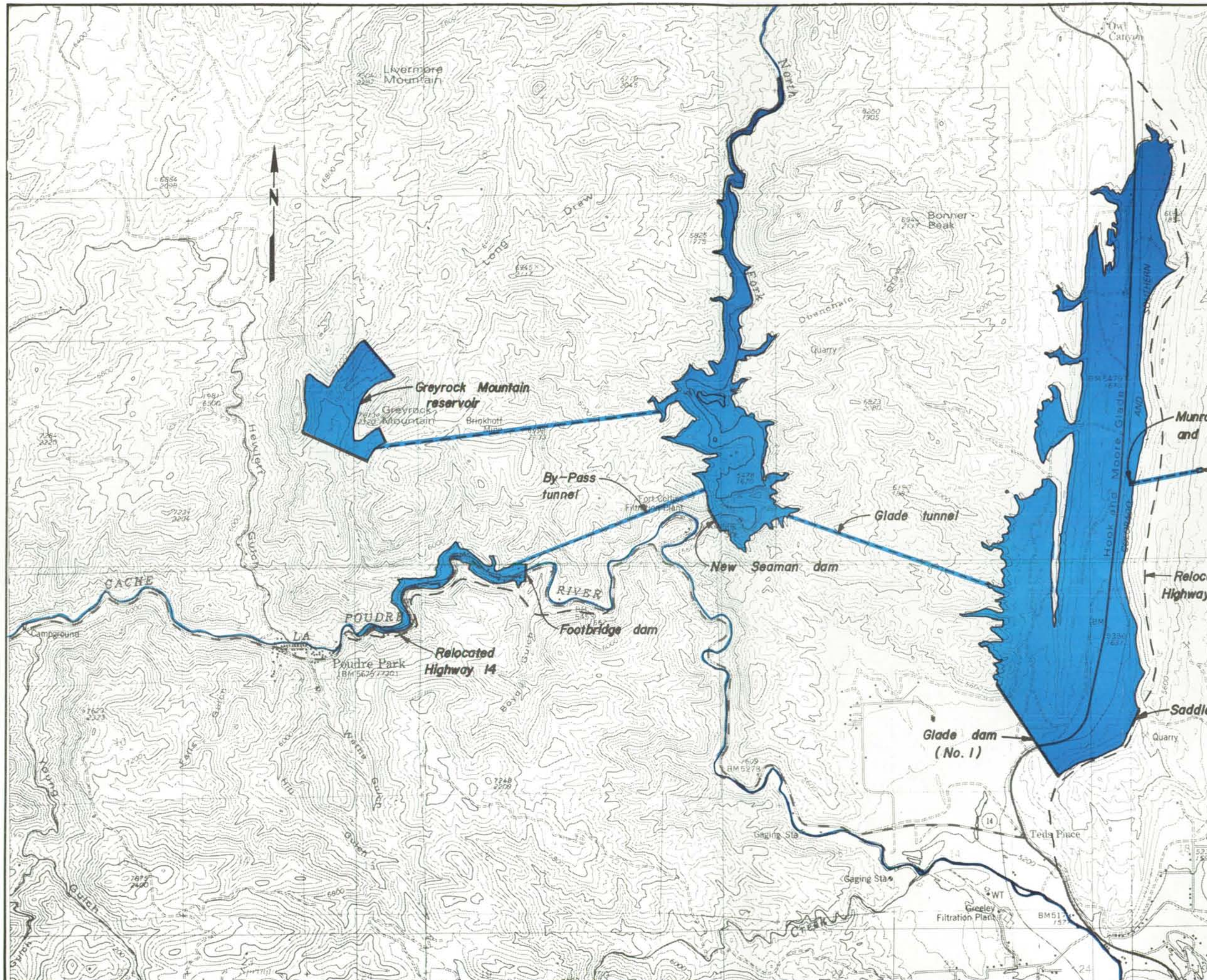
FIGURE 5.6



COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY

CACHE LA POUDRE BASIN STUDY

PLAN D

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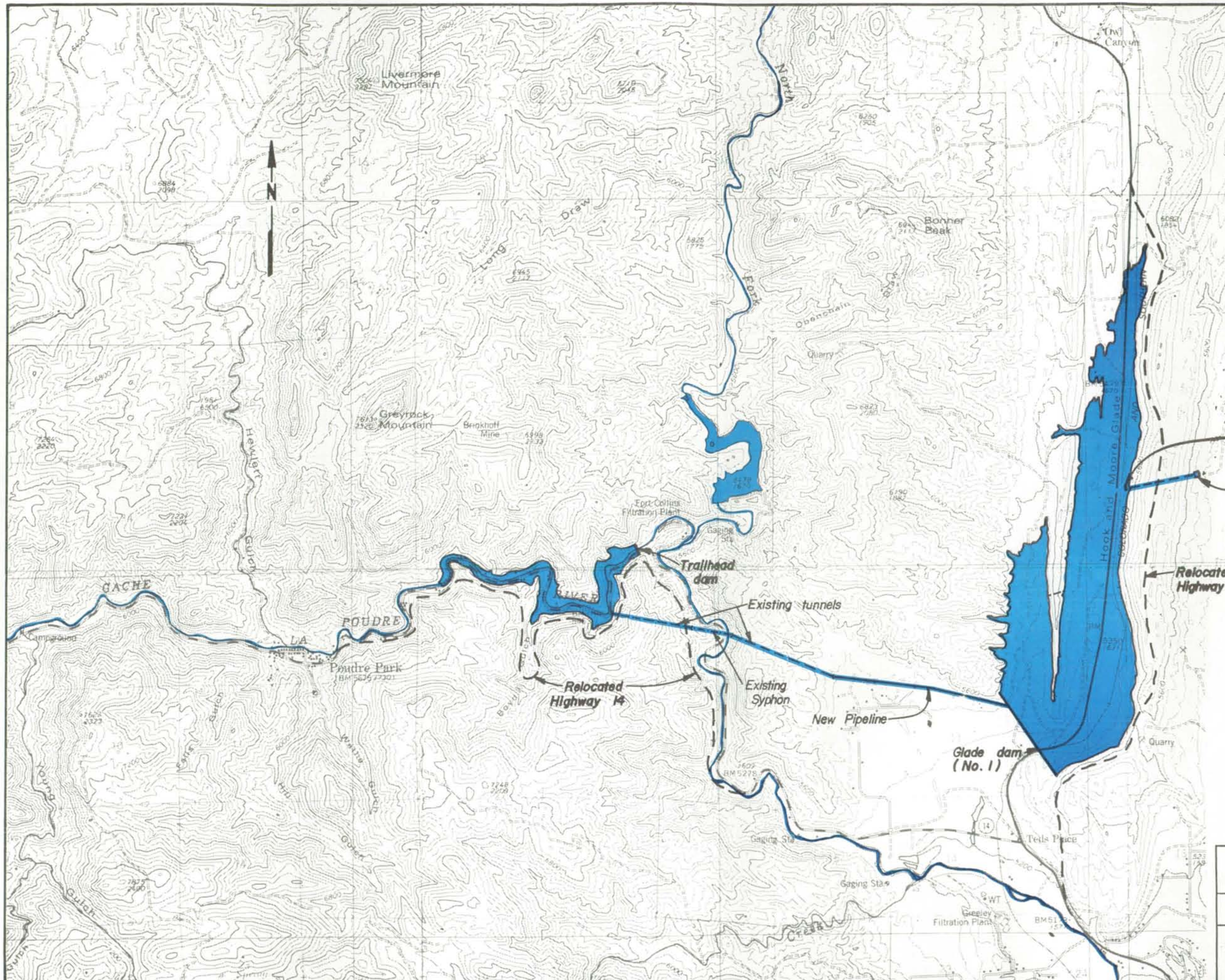

COLORADO WATER RESOURCES & POWER DEVELOPMENT AUTHORITY

CACHE LA POUDRE BASIN STUDY

PLAN E (TRAILHEAD AND GLADE)

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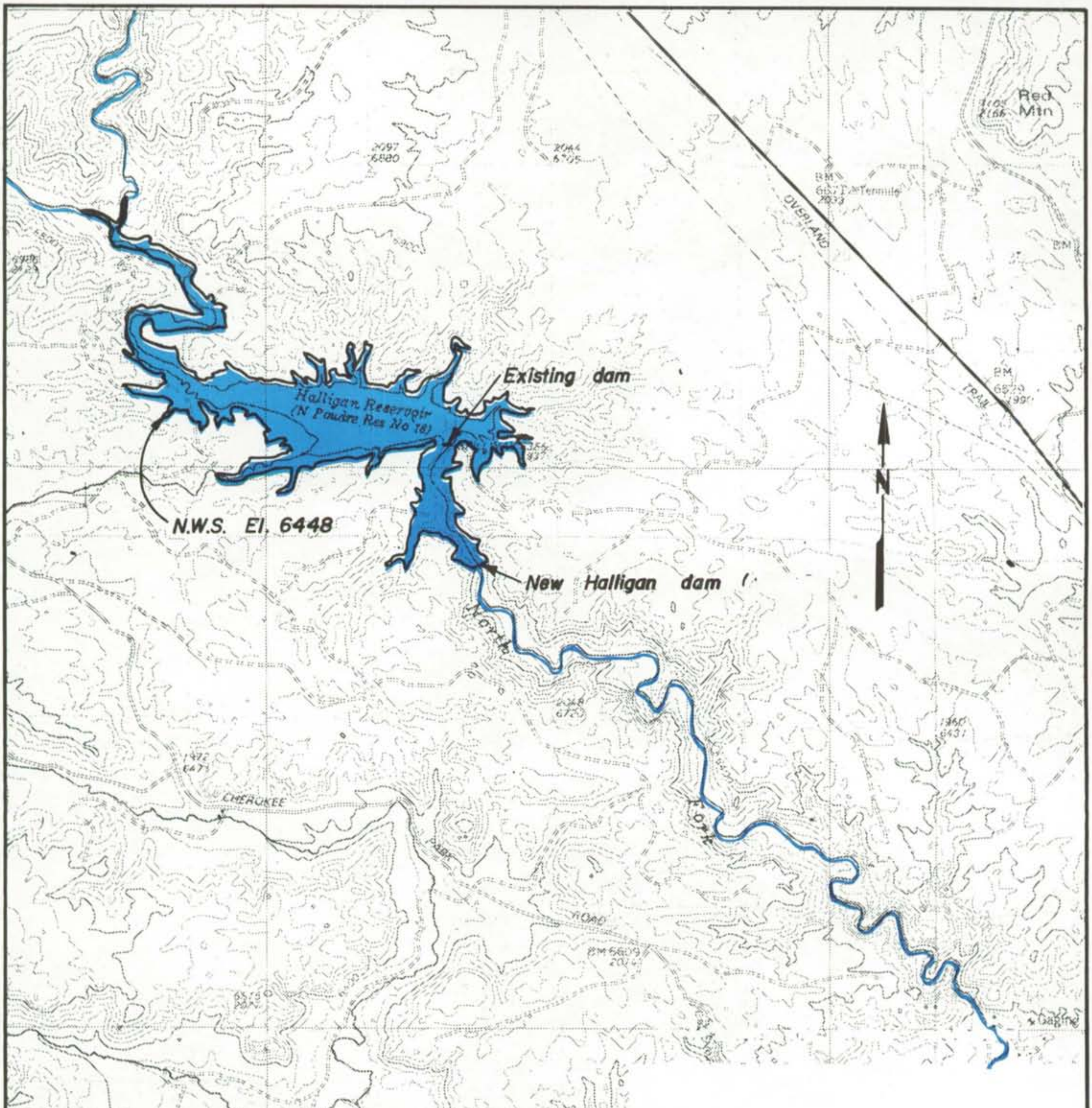
Browne,Bortz & Coddington • M.W.Bittinger • Tom Pitts & Associates Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986 Sh. 1 of 2 FIGURE 5.8



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CACHE LA POUDRE BASIN STUDY

PLAN E
(HALLIGAN)

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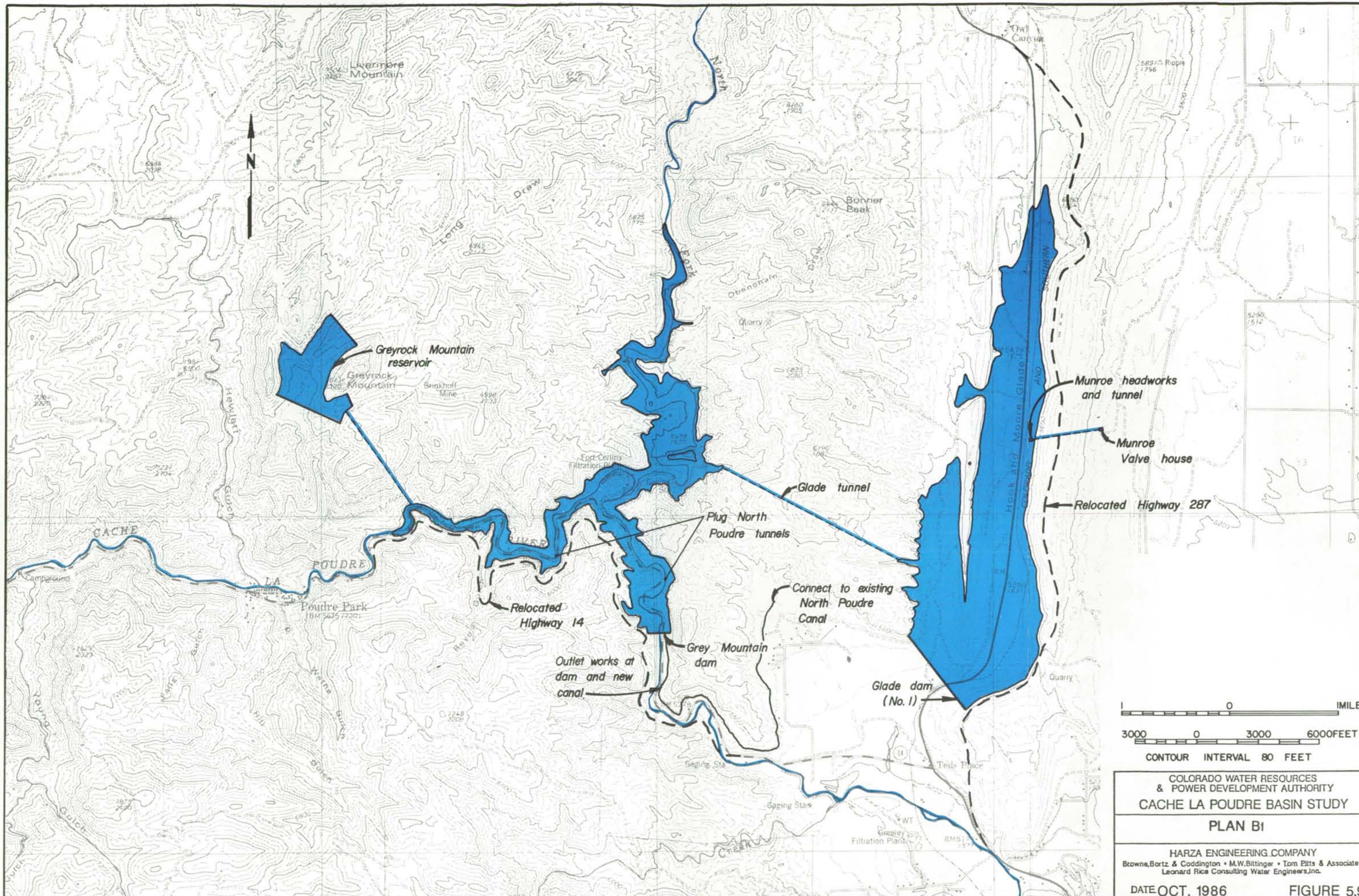
Leonard Rice Consulting Water Engineers,Inc.

DATE OCT. 1986 Sh. 2of2 FIGURE 5.8



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CACHE LA POUDRE BASIN STUDY
PLAN B1
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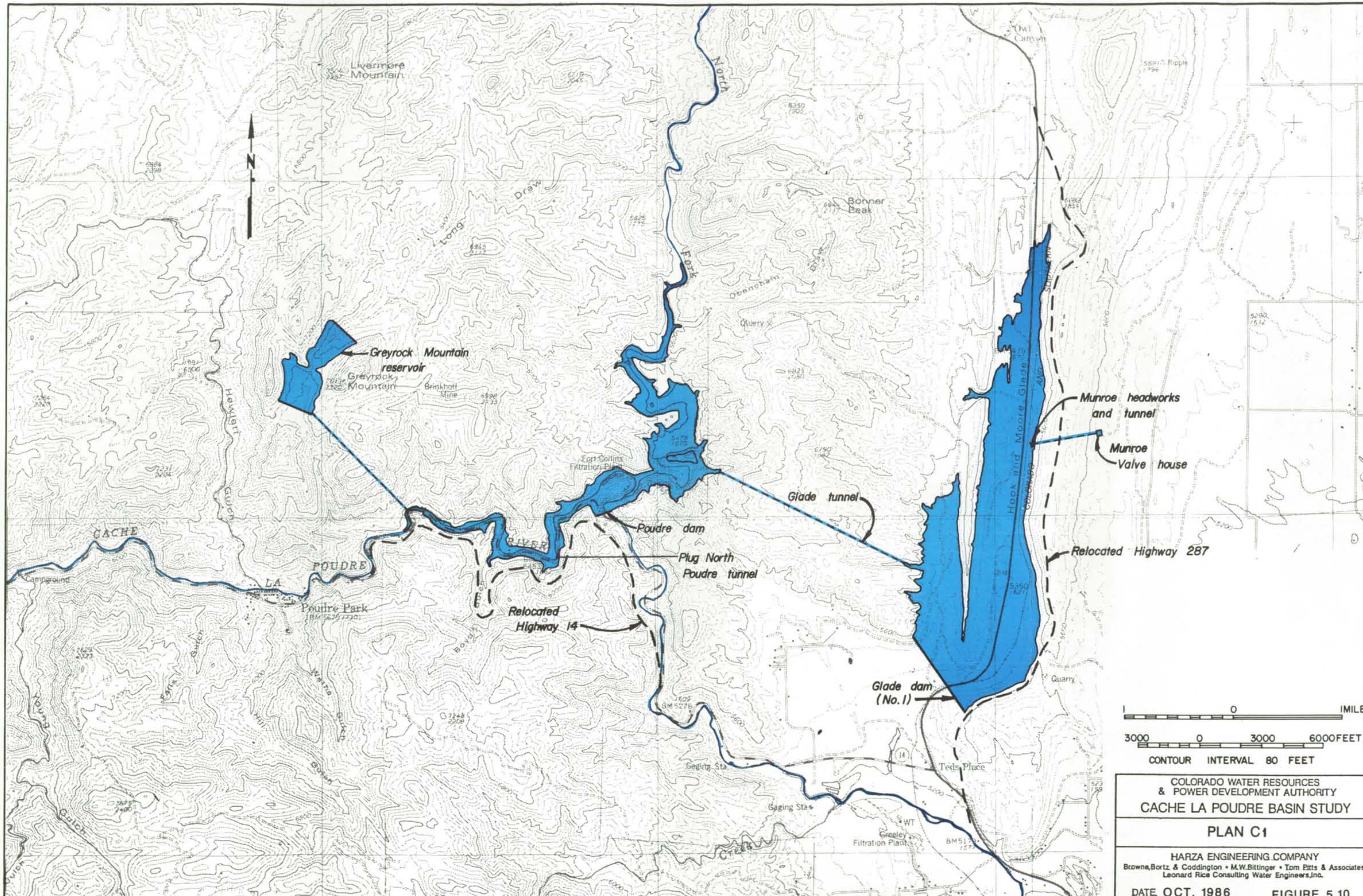
DATE OCT. 1986
FIGURE 5.9



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PLAN C1

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FIGURE 5.10

6.0 EVALUATION OF ALTERNATIVE PLANS

The seven alternative plans were evaluated systematically to identify positive and negative attributes. Technical, environmental, and economic factors were considered in the evaluation of alternatives.

6.1 TECHNICAL EVALUATION

The primary criteria used to measure the technical performance of the alternative plans include:

- Water storage and yield;
- Power output;
- Flood control opportunities;
- Water management flexibility;
- Operational reliability; and
- Risk of delay and increased cost during construction.

6.1.1 Water Storage and Yield

The plans involve various storage amounts and corresponding firm yields of new water. Approximately 274,000 af of storage would be required to develop a firm yield of 25,000 af/yr from storable native flows and 24,000 af/yr from additional Windy Gap and C-BT water. The storage amount of 274,000 af was viewed as a target storage amount in the initial plan formulations. Lesser storage volumes also were considered in several of the plans.

6.1.2 Power Output

Revenues from a pumped-storage development may help to pay the costs of water development to benefit the Basin and the northern Colorado region. A technically excellent site for a pumped-storage hydroelectric project exists downstream from Poudre Park. An upper reservoir at Greyrock Mountain and a lower reservoir on the mainstem or the North Fork would be required. The size of the pumped-storage development would depend on the eventual market for power produced. Power from a large development (1800 MW) would be marketed primarily outside of Colorado, although some of the power likely would be marketed in Colorado. Power from a smaller development (e.g., 450 MW) could be marketed in the Rocky Mountain region by the time such a project could be on-line in the year 2000.

6.1.3 Flood Control Opportunities

Reservoirs associated with each plan could be designed to provide flood control benefits. Maximum flood control benefits could be achieved with reservoirs regulating both the mainstem and the North Fork. If only one branch of the river is regulated, flood control opportunities would be diminished greatly. Flood control opportunity is rated "High" for all plans except Plans D and E. These plans do not include reservoirs of sufficient capacity to control both mainstem and North Fork flows.

6.1.4 Water Management Flexibility

A new reservoir in the Basin, in addition to providing yield from native storable flow and new Windy Gap and C-BT water, will enhance the flexibility of managing water resources in the Basin as well as in the region served by the NCWCD. Those plans involving larger storage volumes are considered to provide greater water management flexibility than those involving lesser volumes. Plans C, D, and B1 provide the target storage amount of 274,000 af and Plan A (259,000 af) comes close. Therefore, these plans are rated equal in terms of enhanced water management. Plans B, E, and C1 provide about one-half or less of the storage available under the plans with larger reservoir storage. In terms of enhancing water management opportunities, these plans are rated lower than Plans A, C, D, and B1.

6.1.5 Operational Reliability

Operational reliability of the alternative plans pertains to both the non-structural and structural elements of each plan. Since the non-structural elements are common to each of the plans, their operational reliability would be the same for each plan. Operational reliability of the structural plan elements has been evaluated on the basis of such factors as efficiency of reservoir operation and the degree to which storable flows can be controlled to obtain the estimated yields of additional water.

All spillways were assumed to have ungated crests and are designed to pass the probable maximum flood (PMF) without overtopping the dams. The PMF is the estimated flood that would result if all factors that contribute to a flood were to reach the most critical combination of values that could occur simultaneously. The use of ungated crests eliminates the possibilities of equipment failure and improper operation. Design capacities based on PMF's assures that the dams will not be overtopped and, therefore, will not be subject to failure due to overtopping. Thus the operational reliability of all spillways is excellent.

Operational reliability of the power facilities is considered to be the same for all plans because the designs would be essentially the same. All plans would require close control of lower reservoir and storage reservoir releases but no plan is seen to require special attention in this regard.

The timely identification and diversion of storable flows is an important aspect of operational reliability. Storable flows are erratic in their occurrence and often permit little time to detect and plan for their diversion. Plans A, B, B1, C, and C1, each of which includes a reservoir that controls both mainstem and North Fork flows, greatly facilitate the capture of storable flows because all flows (storable and non-storable) are under control until specific action is taken for their release. In the case of Plans D and E the opposite is true. Both of these plans would require prompt adjustment of tunnel intake gates to divert storable flows. The operational reliability of Plans D and E is therefore less than that for Plans A, B, B1, C and C1 in this regard.

6.1.6 Risk of Construction Delay and Cost Increase

An attempt has also been made to evaluate the risk of construction delays. The number of major structures comprising a plan and unusual or generally difficult construction methods were among the factors considered Evaluation of this risk can only be comparative in nature given that the structural layouts are still at a prefeasibility level.

Risk can be approximately related to the number of major structures comprising each plan. Power facilities, that is upper reservoir construction, water conductors, and powerstation, are common to all except Plan E, and therefore have not been considered in the comparison.

The level of geologic information now available does not permit differentiation of potential risks at each site. Based on limited available data, there are no known flaws that would prevent any of the sites from being used for their intended structures.

Plans A and B would appear to offer the least risk with regard to construction delay and cost overrun. Only two elements are involved in each. Plan B would have to be rated slightly better than Plan A because construction quantities are less and some core drilling has been carried out at the Grey Mountain site. As part of this Study, core drilling and seismic refraction/auger hole investigation programs were conducted at the Glade damsite which is common to many alternatives. This program was carried out because of uncertainties with regard to depth to rock and foundation conditions. Based on these preliminary investigations it is concluded that Glade is a suitable damsite.

Plans C, B1, C1, and E all have three major structural elements and all but Plan E are considered to be subject to more risk than Plans A and B. Plan E would have a much smaller Trailhead Dam than Plans A and B. The North Poudre Conveyance, which would be modified under Plan E, is an existing facility, and installation of a new lining should involve minimal risk. Glade Dam is common to all plans in this group. Thus, Plan E is considered to have less potential risk than Plans C, B1, and C1. It is also considered to have less risk than Plans A and B. Plan C1 is essentially the same as Plan C, the only difference being the heights of Poudre and Glade Dams. This is the only basis for considering Plan C1 (lower dams) to involve slightly less risk for delay than Plan C (higher dams). Plan C and Plan B1, when compared with Plans A and B, have an additional element, Glade Tunnel. It is not possible at the present level of study to assign a greater or lesser risk to Glade Dam than to Portal or Grey Mountain Dams. Poudre Dam in Plan C is very similar to Trailhead Dam in Plans A and B.

Plan D has five major structural elements, two tunnels and three dams, and must be considered to involve more potential risk for delay and increased costs than any of the other plans. In addition, the water conductors for its power project are about twice as long as those associated with the other plans. This reinforces the conclusion regarding relative risks of Plan D.

6.2 ENVIRONMENTAL EVALUATION

6.2.1 Evaluation Process

Environmental evaluation in this study has focused on identification of impacts, issues of public concern as identified in various meetings, identification of means of offsetting impacts, and enhancement opportunities related to the environment that would be affected by each plan alternative. The evaluation was conducted at a prefeasibility level, and utilizes available information.

The environmental evaluation examines impacts of alternative plans on seven broad environmental categories: recreation, land use, vegetation, aquatic life, wildlife, cultural resources, and water quality. These broad categories address the environmental concerns in the National Environmental Policy Act (NEPA).

Within the recreation category, indicators include the number of miles of whitewater boating, angling (including designated "Wild Trout" waters), hiking, and scenic driving. Indicators for the land use category include the number of private homesites, miles of highway and utility construction and relocation, and the amount of range and/or agricultural acreage. Vegetation category indicators include the number of miles of riparian vegetation and the existence of threatened and endangered plant species. Indicators for aquatic life and wildlife categories likewise include the presence of threatened and endangered species as well as critical ranges and migration routes of certain species. Indicators for the cultural resources category consist of the number of known historic and prehistoric sites. Water quality category indicators include changes in water temperature, levels of dissolved oxygen, and eutrophication potential.

As indicated in Section 2.5, the Cache la Poudre from the headwaters to the canyon mouth is not considered to be a high quality fishery, due primarily to very low natural wintertime flows. Larger fish cannot survive under prolonged low-flow conditions because of poor habitat conditions. Opportunities exist to enhance the fishery and other recreational activities with a new water storage project.

6.2.2 Environmental Evaluation Summary

The plans have been ranked with respect to each other for environmental impacts. In ranking the alternatives, impacts to the mainstem of the Cache la Poudre River were given greater weight than impacts to the North Fork of the Cache la Poudre River or off-stream impacts. Almost all public comment was directed at impacts of the alternative plans on the mainstem of the Cache la Poudre River. Impacts to the North Fork are relatively uniform among most alternatives, almost all of which involve some reservoir and stream inundation. The majority of present recreational opportunities occur on the mainstem of the Poudre. The portion of the North Fork that would be affected by alternative plans is closed to public access.

Table 6.1 displays the relative environmental impacts of alternatives planned within each environmental category. Those plans having the same impact are given the same rank. For example, Alternatives D and E both impact the same number of known cultural resources and are both ranked number 3. A ranking of 1 indicates the most environmental impact, and a ranking of 5 indicates the least environmental impact.

TABLE 6.1
Relative Environmental Impact of
Alternative Plans By Environmental Category

	Ranking of Alternative Plans[1]				
Environmental Category	A	B, B1	C, C1	D	E
Recreation	1	2	3	5	4
Land Use	1	2	3	5	4
Vegetation	1	2	3	5	4
Aquatic Life	1	2	3	5	4
Wildlife	1	2	3	5	4
Cultural Resources	1	4	2	3	3
Water Quality	1	1	2	3	4

(1) Ranking of "1" indicates the highest relative environmental impact; ranking of "5" indicates the lowest relative environmental impact.

Table 6.2 shows the overall ranking of the alternative plans in terms of environmental impact.

TABLE 6.2
Overall Ranking of Alternative Plans by Environmental Impact

Ranking	Alternative Plan
1st	A
2nd	B, B1
3rd	C, C1
4th	E
5th	D

It should be noted that these impact rankings are relative to each other, and do not imply, for example, that Alternative A has five times the impact of Alternative D.

Well in advance of project construction, detailed environmental studies would be conducted in compliance with NEPA regulations and with Federal Energy Regulatory Commission (FERC) regulations if hydropower is included. On-site biological surveys would be conducted to identify and quantify aquatic and terrestrial wildlife resources, and their habitats, which could be affected by the project elements. Field surveys of recreational use would be conducted to identify project impacts. Historical and archaeological resources would be located through intense ground surveys. Water quality monitoring programs and water quality modeling would enable prediction of changes in water quality that would be caused by project operation. Following these assessments, mitigation needs and enhancement opportunities would be evaluated, and specific programs developed. Environmental data would be used to prepare an environmental assessment for submittal to the lead agency for the Environmental Impact Statement. Following this submittal, the lead agency would prepare the Environmental Impact Statement in compliance with NEPA, which includes requirements for public input.

The Platte River in central and eastern Nebraska is used as nesting area and feeding habitat by two bird species protected under the Federal Endangered Species Act (the least tern and piping plover). A 59-mile reach of the Platte River in central Nebraska is designated as critical habitat for the whooping crane, an endangered species. The bald eagle utilizes the Platte River as overwintering habitat. The effects of additional water storage in the Platte Basin upstream from this habitat are being studied by a Federal/State Coordinating Committee. The study will document habitat needs and identify ways to meet those needs that are not in conflict with future water development. Results from the study are expected by late 1987 well before feasibility studies for a water project in the Poudre Basin would be completed.

6.2.3 Enhancement Opportunities

Each of the alternative plans would offer new opportunities for flatwater recreation, such as boating, angling, and swimming, camping, picnicking, and development of commercial establishments at the reservoir sites. The Colorado Outdoor Recreation Plan indicates the need for new flatwater recreational opportunities in the Study Area. The popularity of Horsetooth Reservoir and other nearby reservoirs suggests that any new reservoir will receive extensive use.

A mainstem reservoir on the Poudre has the potential to become an outstanding fishery, as indicated by what has occurred at Spinney Mountain Reservoir on the South Platte River south of Denver. Spinney Mountain Reservoir has a statewide reputation and is producing trophy-sized trout, both in the reservoir and upstream of the reservoir during Spring and Fall spawning runs. Glade Reservoir would offer tremendously expanded opportunities for fishing and recreation, comparable to those at Horsetooth Reservoir, which attracts 178,000 visitors per year according to data of the U.S. Bureau of Reclamation.

Although many legal and institutional issues would have to be resolved, reservoir construction provides for the future opportunity to enhance stream fisheries both above and below a mainstem reservoir with increased flow releases during winter months. While it is premature to propose specific mitigation or enhancement measures, releases from high mountain reservoirs potentially could be made during the winter months to avoid fish kills that now occur. These releases could be stored in the new mainstem facility for subsequent downstream use. With proper management, a new storage reservoir also could create an excellent tailwater fishery that could extend through Fort Collins. This latter enhancement probably would require modification of sections of degraded stream channel that exist at certain locations below the canyon mouth through Fort Collins and arrangements to store flow maintenance releases in a plains reservoir. Both enhancements will require the resolution of water rights concerns and additional storage capacity in the proposed reservoirs. Further, no studies have been made as yet to determine how much water would be needed to undertake these enhancements and whether this water could be made available when needed. These topics would be addressed in the next phase.

Alternatives B and C offer opportunities to provide whitewater boating below the reservoirs if water is available for flow releases and existing put-in and take-out sites are improved. Preliminary studies indicate that reservoir releases could be used to extend the whitewater boating season and/or to improve the quality of the whitewater boating experience by providing higher flows at specified times. Again, water rights concerns would need to be resolved prior to implementing this enhancement.

High mountain reservoir releases and creation of a tailwater fishery would enhance the recreational experience on over 60 miles of stream. The largest reservoir on the mainstem would inundate about eight miles of stream on the mainstem of the Poudre.

Private homesites and land would be purchased at fair market value and existing highway and utility corridors could be relocated, with the visual impact reduced through careful attention to site planning.

Existing cultural sites could be excavated and recorded or isolated from project construction and/or operation. Downstream water quality impacts could be reduced by providing multiple-level intake structures at the dams. These structures enable water to be withdrawn from various levels within a reservoir in order to provide releases that have acceptable temperature and dissolved oxygen levels.

Environmental impacts and enhancement opportunities for each alternative plan are tabulated in Section 6.4.

6.3 ECONOMIC EVALUATION

The economic performance of each plan was evaluated based on a present value analysis of economic benefits and economic costs, both expressed in constant 1986 dollars. Benefits from implementing each plan would be derived from: the sale of capacity and energy produced by the pumped-storage installation (except in the case of Plan E) and any small conventional, run-of-river hydropower produced at the dams; sale of water; recreation opportunities afforded by the new reservoirs; possible replaced stream recreation at another location, particularly downstream from a mainstem dam; land development around reservoirs; and flood control. Economic costs for implementing each plan would include construction costs, annual operation, maintenance, and replacement (O,M&R), lost recreation opportunities, real estate, and other environmental losses. Costs of bond issuance are not included in the economic analysis.

A pumped-storage project takes advantage of low-cost, off-peak energy for pumping and generates much higher value energy during peak demand periods. Off-peak energy has a value of nearly 2 cents per kWh while on-peak energy has a value of slightly over 8 cents per kWh. This cost differential between off-peak and on-peak energy provides the economic benefits attributable to pumped-storage.

The value of agricultural water provided by a new water management facility would range from $30 per af during normal and wet years to $250 per af during a drought. If used for M&I purposes water developed with a new water management facility would have substantially higher value. Water values in the greater Denver area have reached $500 per af and higher.

The economic benefit-cost analysis attempted to quantify all of the benefits and costs; however, certain benefits, namely replaced stream recreation, land development, and flood control, were not quantified. If these benefits are to be realized in full, project participants will need to make specific commitments to these functions that could, in turn, increase implementation costs. Costs associated with environmental losses (other than recreation) cannot be quantified. Placing a value on losses such as the aesthetic characteristics of the lower canyon, is subject to considerable personal judgement.

Results of the benefit-cost analysis are presented in Table 6.3.

TABLE 6.3
Summary of Economic Analysis

Plan	Construction Cost ($ Million)	Present Values ($ Million) Benefits	Present Values ($ Million) Costs	Real Rate of Return (%)
A	1590	3190	1470	8.1
B	1300	3160	1220	9.5
C	1510	3290	1390	8.7
D	1650	3270	1500	8.1
E	280	30	320	Negative
B1	1530	3190	1420	8.4
C1	630	920	720	4.7

Internal rate of return is a financial measure of the attractiveness of a particular dollar investment. It measures the return on invested dollars for each plan that is attributable to the benefits associated with each plan. Plan B offers the highest rate of return at 9.5 percent; Plan C is second highest with an 8.7 percent rate of return. The lowest positive rate is Plan C1 at 4.7 percent. Hence, any of the plans except Plan E offer opportunities for debt financing. The rates of return in Table 6.3 are real rates that exclude inflation. If inflation were 5 percent, the actual rate of return for Plan B would be 14.5 percent. A real interest rate was applied to keep all cost and benefit estimates, including debt service, in 1986 dollars.

6.4 SUMMARY OF EVALUATION

The performance of each plan in terms of the technical, environmental, and economic factors discussed in preceeding sections is summarized in Tables 6.4 through 6.10 in matrix format.

TABLE 6.4

SUMMARY EVALUATION OF ALTERNATIVE PLAN A

Environmental Factors

Technical Factors

- Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total shortage (449,000 af) by 44 percent.
- Structural plan elements increase water supplies 46,000 af per year of which 24,000 af would be new water from the Windy Gap and C-BT projects.
- Portal reservoir provides 259,000 af of live storage. This excludes waters behind Trailhead Dam and essentially equals the storage objective of 274,000 af.
- Trailhead Dam permits independent operation of Portal reservoir (water supply) and Trailhead reservoir (lower hydropower reservoir).
- Portal reservoir could provide flood control for the plains.
- Portal reservoir would enhance water management opportunities in the Basin and region.
- Portal reservoir could control winter releases from high mountain reservoirs to enhance upstream fishery and release flows to enhance downstream boating and fishery.
- Timely identification and diversion of storable flows is facilitated because Portal reservoir controls mainstem and North Fork flows.
- The hydropower pumped-storage facility with 1800 MW installed capacity provides twelve hour continuous output of 21,600 MWh and an annual average energy production of 3150 GWh. The average gross head would be approximately 1330 ft and the ratio of horizontal length of water conductor to head is 4.9 to 1.

Impacts

- The three reservoirs would inundate about 2710 surface acres. This alternative would inundate the most miles of the Poudre River, including about 8.3 miles of the mainstem and 3.0 miles of the North Fork.
- Major impacts to land use would include the inundation of 20 to 30 private homesites, about 12.9 miles of state highway and public utilities, and the construction of about 3.9 miles of new access road.
- No threatened and endangered species of fish, wildlife, or plant have been found within the project sites. No critical habitats would be affected by the reservoirs, although about 10.5 miles of riparian habitat along mainstem and North Fork would be inundated.
- Construction and operation of the reservoirs could cause adverse changes in water quality, including modified temperatures, lowered dissolved oxygen, and reservoir eutrophication.
- Major impacts to recreation would be the loss of about 4.7 miles of whitewater boating, 10.5 miles of stream angling, and the elimination of about 0.5 miles of hiking and 6.0 miles of scenic driving. (Current estimates of minimum annual use include 5000 whitewater boaters, 2000 angling days, and 6000 hiking visits.)
- At least 13 historic and prehistoric sites would either be inundated or disturbed by the construction of the reservoirs.

Mitigation Measures and Enhancement Opportunities

- The existing state highway and private utilities would be relocated south of the main reservoir site.
- Private homesites and property would be purchased at fair market value.
- Water quality problems could be minimized through (1) dams with multiple level water outlets and (2) reduced water retention time in the reservoirs.
- Whitewater boating above the Portal Reservoir could be enhanced through the construction of new put-in and take-out sites for the general public near Mishawaka and Poudre Park.
- With a mainstem storage reservoir, water releases from high mountain reservoirs could enhance stream angling above reservoir during fall and winter months. Angling below the dam could also be enhanced year around through added water releases. Public access sites (parking and trail system) for fishing could be constructed along reservoir and river.
- Development of additional recreational facilities on the upstream Wild and Scenic river segments.
- Access to existing Greyrock Trail could be from a bridge across the reservoir or a new segment near Poudre Park. Trail segments near Greyrock Reservoir would be relocated, or an entirely new trail could be constructed to the east.
- Existing cultural sites would be excavated and recorded or isolated from project construction or operation.

Economic Factors

- Present value benefits exceed costs for Plan A by $1,720 million based upon a three percent real discount rate.
- The real internal rate of return is 8.1 percent. This high rate of return suggests financial feasibility at real interest rates approaching eight percent.
- Annual revenues from pumped-storage would approximate $175 million. Another $1.9 million in conventional hydropower revenues would be generated each year.
- Annual benefits from additional water supplies would average $3.0 million. Water management opportunities within the basin would be enhanced.
- Annual benefits from flat water recreation are estimated to be $0.6 million; the value of lost stream recreation is estimated to be $0.2 million per year. Enhancement of other stream recreation might be possible.
- Little opportunity for land development is evident. Significant flood control benefits could be offered.

TABLE 6.4 (Cont'd.)

SUMMARY EVALUATION OF ALTERNATIVE PLAN A

Environmental Factors

Technical Factors	Impacts	Mitigation Measures and Enhancement Opportunities	Economic Factors
		• Reservoirs would create new opportunities for angling in the reservoir and for boating, hiking, camping, and picnicking development operated either by public agencies or private concessionaires. • Other potential enhancement options that might be considered if a project were implemented in the Basin include: 1. Development of a river corridor park to enhance the fishery and public access. 2. Development of recreational facilities on the North Fork. 3. Develop a Poudre Canyon Resource Center that would provide facilities for conferences and retreats, conservation education, and reservoir water quality research. 4. Prepare a comprehensive river recreation management plan for the Poudre River. 5. Develop unique public access and facilities along the reservoir and river specifically for the physically disabled. 6. Fund tourism and recreation research and promotions to increase awareness of other local attractions and services. 7. Provide low interest loans to commercial rafting operations to permit their relocation or retraining/re-equipping for other recreational services.	

TABLE 6.5

SUMMARY EVALUATION OF ALTERNATIVE PLAN B

Environmental Factors

Technical Factors

- Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total shortage (449,000 af) by 44 percent.
- Structural plan elements increase water supplies 29,000 af per year which would be new water from the Windy Gap and C-BT projects (24,000 af) and some new yield from native storable flows.
- Structural plan elements do not satisfy the water supply storage objective of 274,000. Plan B could be expanded later to include Glade reservoir and satisfy the storage requirement.
- Trailhead Dam permits independent operation of Grey Mountain reservoir (water supply) and Trailhead reservoir (lower hydropower reservoir).
- Grey Mountain reservoir could provide flood control for the plains.
- Grey Mountain reservoir would enhance water management opportunities in the Basin and the region but to a lesser extent than Plan A.
- Grey Mountain Reservoir could control winter releases from high mountain reservoirs to enhance upstream fishery and release flows to enhance downstream boating and fishery.
- Timely identification and diversion of storable flows facilitated because Grey Mountain reservoir controls mainstem and North Fork flows.
- The hydropower pumped-storage facility with 1800 MW installed capacity provides a twelve hour continuous output of 21,600 MWh and an annual energy production of 3150 GWh. The average gross head is approximately 1390 ft and the ratio of the horizontal length of water conductors to head is 4.9 to 1.

Impacts

- The three reservoirs would inundate about 2160 surface acres, including about 6.4 miles of the mainstem and 3.0 miles of the North Fork.
- Major impacts to land use, vegetation, wildlife, water quality, recreation, and cultural resources are essentially the same as in Alternative A, but to a lesser extent. In comparison, the Grey Mountain Reservoir would inundate fewer miles of whitewater boating (3.6 miles), stream angling (9.4 miles), and riparian habitat (9.0 miles), and fewer cultural sites (11 historic and 4 prehistoric).

Mitigation Measures and Enhancement Opportunities

- Major enhancement options are essentially the same as in Alternative A.
- In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public could also be constructed below the Grey Mountain Reservoir, if adequate water releases can be timed to provide periods of weekend rafting.

Economic Factors

- Present value benefits exceed costs for Plan B by $1,940 million based upon a three percent real discount rate.
- The real internal rate of return for Plan B is 9.5 percent. Financial analysis indicates total capital requirements of $1,538 million. Annual payments including O&M would total $88 million based upon a three percent real interest rate and 30 year repayment period. Repayment analysis indicates financial feasibility at real interest rates as high as seven percent.
- Annual revenues from pumped-storage would be about $175 million. Conventional hydropower revenues would be approximately $1.6 million per year.
- Annual benefits from additional water supplies would average $1.9 million. Water management opportunities would be somewhat enhanced.
- Flat water recreation benefits are estimated to be $0.4 million per year while lost stream recreation is estimated to represent a $0.2 million annual cost. Enhancement of other stream recreation might be possible.
- Little opportunity for land development is evident; significant flood control benefits could be offered.

TABLE 6.6

SUMMARY EVALUATION OF ALTERNATIVE PLAN C

Environmental Factors

Technical Factors

- Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total shortage (449,000 af) by 44 percent.
- Structural plan elements increase water supplies 49,000 af per year of which 24,000 af per year would be new water from the Windy Gap and C-BT Projects.
- Structural plan elements satisfy the water supply storage objective of 274,000 af. Poudre Reservoir has 43,000 af of space assigned to water supply storage and 18,000 af of space assigned to the hydropower project. Glade Reservoir has 231,000 af of live storage for water supply.
- Poudre Reservoir could provide flood control for the plains.
- Poudre and Glade Reservoirs would enhance water management opportunities in the Basin and the region.
- Poudre Reservoir could release flows to enhance downstream boating and fishery.
- Timely identification and diversion of storable flows will be facilitated because Poudre Reservoir controls mainstem and North Fork flows.
- The hydropower pumped-storage facility with 1860 MW installed capacity provides a twelve-hour continuous output of 22,300 MWh and an annual energy production of 3260 GWh. Average gross head is 1410 ft and the ratio of horizontal length of water conductor to head is 4.9 to 1.

Impacts

- The three reservoirs would inundate about 3525 surface acres, including about 4.7 miles of the mainstem and 3.0 miles of the North Fork. About 2600 of the total acres inundated are located off of the Poudre River at the Glade site.
- Major impacts to land use, vegetation, wildlife, water quality, recreation, and cultural resources are also essentially the same as in Alternative A, but to a lesser degree. In comparison, the Poudre Reservoir would inundate fewer miles of whitewater boating (2.2 miles), stream angling (7.7 miles), riparian habitat (7.5 miles), and fewer cultural sites (13 historic and 6 prehistoric). However, it would also inundate more miles of state and federal highway and public utilities (17.9 miles) and about 2000 acres of agricultural and/or range land associated with the Glade Reservoir site.

Mitigation Measures and Enhancement Opportunities

- Major enhancement options are essentially the same as in Alternative A.
- In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public and commercial outfitters could also be constructed below the Poudre Reservoir.
- The Glade Reservoir would create more flatwater recreational opportunities, including a mixed warm and cold water fishery, boating, camping, and picnicking.

Economic Factors

- Present value benefits exceed costs for Plan C by $1.899 million based upon a three percent real discount rate.
- Plan C achieves a real rate of return of 8.7 percent. Financial analysis indicates capital requirements of $1,780 million. Annual payments of $101 million would be required under a three percent real interest rate and 30 year repayment period. Based upon revenue potential, the project could be financed at real interest rates of at least seven percent.
- Annual revenues from pumped-storage total $181 million. This is higher than Plans A and B because of greater installed capacity. Conventional hydropower might produce $1.3 million in annual revenues.
- Annual benefits from additional water supplies would average $3.2 million. Enhanced opportunities for water management would be created.
- Flat water recreation benefits are estimated to be $0.8 million per year. Lost benefits related to stream recreation are estimated to be $0.1 million per year. Enhancement of other stream recreation might be possible.
- Opportunities for land development at Glade Reservoir are evident. Significant flood control benefits could be achieved.

TABLE 6.7

SUMMARY EVALUATION OF ALTERNATIVE PLAN D

Environmental Factors

Technical Factors

- Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total shortage (449,000 af) by 44 percent.
- Structural plan elements increase water supplies 49,000 af per year of which 24,000 af per year would be new water from the Windy Gap and C-BT Projects.
- Structural elements satisfy the water supply storage objective of 274,000 af. New Seaman has 20,000 af of space assigned for water supply storage and 18,000 af of space assigned to the hydropower project. Glade Reservoir has 254,000 af of live storage for water supply.
- New Seaman Reservoir could provide flood control for North Fork flows. Mainstem flows would remain uncontrolled.
- New Seaman and Glade Reservoirs would enhance water management opportunities in the Basin and the region.
- New Seaman Reservoir could control winter releases from high mountain reservoirs to enhance upstream fishery and release flows to enhance downstream boating and fishery.
- Timely identification and diversion of storable flows will be difficult because Footbridge Reservoir cannot provide temporary control of mainstem flows. Waste can be expected. New Seaman Reservoir will facilitate identification and diversion of storable North Fork flows.
- The hydropower pumped-storage facility with 1860 MW installed capacity provides a twelve-hour continuous output of 22,300 MWh and an annual energy production of 3260 GWh. Average gross head would be approximately 1380 ft and the ratio of horizontal length of water conductor to head is 10.9 to 1.

Impacts

- The four reservoirs would inundate about 3310 surface acres, and would inundate the fewest miles of the Poudre River, including about 2.0 miles of the mainstem and 3.0 miles of the North Fork. Like Alternative C, about 2600 of the total acres inundated are located off of the Poudre River at the Glade site.
- Major impacts to land use, vegetation, wildlife, water quality, recreation, and cultural resources are also essentially the same as for Alternative A, but to a lesser degree. In comparison, the New Seaman Reservoir would inundate about 14.3 miles of state and federal highways and public utilities, 2000 acres of agricultural and/or range land, and 6.0 miles of stream angling and riparian habitat. Fewer cultural sites would be affected (12 historic and 6 prehistoric) and the fewest miles of whitewater boating (1.7 miles).

Mitigation Measures and Enhancement Opportunities

- Major enhancement options are essentially the same as in Alternative A, except that major reservoir opportunities would be shifted to those possible at Glade Reservoir.
- In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public and commercial outfitters could also be constructed below the New Seaman Reservoir (if water releases are in the area of 1500 cfs).
- The Glade Reservoir would create flatwater recreational opportunities, including a mixed warm and cold water fishery.

Economic Factors

- At $1650 million, this is the most expensive of the four major hydropower generation plans.
- Present value benefits exceed costs for Plan D by $1,770 million based upon a real discount of three percent.
- The real internal rate of return for Plan D is 8.1 percent. This rate of return indicates favorable financing potential.
- Annual revenues from pumped-storage would total $181 million. Limited conventional hydropower potential is evident; annual revenues might average $0.6 million.
- Benefits from additional water supplies would average $3.2 million per year. Because of limited main stem storage, opportunities for improved water management might be less than for other plans.
- Flat water recreation benefits are estimated to be $0.8 million per year, while lost stream recreation is estimated to be $0.1 million per year. Enhancement of other stream recreation might be possible.
- Opportunities for land development at Glade Reservoir are evident. Potential flood control benefits are minimal because of limited main stem storage.

TABLE 6.8

SUMMARY EVALUATION OF ALTERNATIVE PLAN E

Technical Factors	Environmental Factors: Impacts	Environmental Factors: Mitigation Measures and Enhancement Opportunities	Economic Factors
• Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total storage (449,000 af) by 44 percent. • Structural plan elements increase water supplies 17,000 af per year, comprising 10,000 af derived from the mainstem diversions to Glade reservoir and 7,000 af derived from North Fork flows stored at New Halligan reservoir. • Structural elements do not satisfy the water supply objective of 274,000 af. Glade reservoir provides 60,000 af of live storage and New Halligan reservoir provides 59,000 af of live storage. • Trailhead Dam acts as a diversion structure. It could be raised in the future in hydropower were installed. • No flood control of mainstem flows. New Halligan reservoir could be operated for flood control of North Fork flows. • Glade and Halligan reservoirs would enhance water management opportunities but to a lesser extent than Plans A, C, and D. • Glade reservoir could control winter releases from high mountain reservoirs to enhance upstream fishery on the mainstem. Releases from Glade reservoir could enhance fishery beginning at a point approximately 2 miles downstream from the mouth of the canyon. Enhancement of flows for boating and fishery downstream from the confluence can only be achieved by releases from New Halligan reservoir. • Timely identification and diversion of mainstem storable flows will be difficult because Trailhead reservoir cannot provide temporary control of mainstem flows. Waste can be expected. • Hydropower would not be included initially in this Plan. It could be added later.	• The three reservoirs would inundate about 3770 surface acres, including about 3.7 miles of the mainstem and 1.0 mile of the North Fork. Like Alternative C, about 2400 of the total acres inundated are located off of the Poudre River at the Glade site. • Major impacts to land use, wildlife, water quality, recreation, and cultural resources are also essentially the same as for Alternative A, but to a lesser degree. In comparison, this alternative would inundate about 13.6 miles of state and federal highways and public utilities, 6.0 miles of stream angling and riparian habitat, and 2.2 miles of whitewater boating. It would affect the fewest miles of stream angling (5.5 miles) and riparian habitat (4.7 miles). It would affect the most acreage of agricultural and/or range land (about 3000 acres).	• Major enhancement options are essentially the same as in Alternative A, except that major reservoir opportunities would be shifted to those possible at Glade Reservoir. • In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public and commercial outfitters could also be constructed below the present Fort Collins water treatment facility. • The Glade and Halligan Reservoirs would create more flatwater opportunities, including a mixed warm and cold water fishery, boating, camping, and picnicking.	• Present value costs of Plan E exceed benefits by $289 million at a three percent real discount rate. Costs were found to exceed benefits even at a zero discount rate. • A negative internal rate of return is evident for Plan E. The project could not be financed without additional sources of revenue. • No pumped-storage facilities are included in the plan. About $0.3 million in conventional hydropower revenues could be generated each year. • Annual benefits from additional water supplies would average $1.1 million. Because of limited main stem storage, opportunities for improved water management would be less than for other plans. • Flat water recreation benefits are estimated to be $0.4 million per year. Lost stream recreation represents economic costs of approximately $0.1 million per year. Enhancement of other stream recreation might be possible. • Lands might be developed at Glade Reservoir. Flood control benefits would be less than other plans due to limited main stem storage.

TABLE 6.9

SUMMARY EVALUATION OF ALTERNATIVE PLAN B1

Technical Factors

- Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total shortage (449,000 af) by 44 percent.
- Structural plan elements increase water supplies by 49,000 af per year which would be new water from the Windy Gap and C-BT projects (24,000 af) and from native storable flows (25,000 af).
- Structural plan elements satisfy the target water supply storage objective of 274,000 af. Grey Mountain Reservoir provides 60,000 af live storage and Glade Reservoir provides 214,000 af of live storage. In addition Grey Mountain Reservoir provides 18,000 af of storage for the hydropower project.
- Grey Mountain reservoir could provide flood control for the plains.
- Grey Mountain and Glade reservoirs would enhance water management opportunities for the Basin and the region.
- Grey Mountain reservoir could release flows to enhance downstream boating and fishery.
- Timely identification and diversion of storable flows will be facilitated because Grey Mountain reservoir controls mainstem and North Fork flows.
- The hydropower pumped-storage facility with 1800 MW installed capacity provides a twelve-hour continuous output of 21,600 MWh and an annual energy production of 3150 GWh. The average gross head is approximately 1390 ft and the ratio of the horizontal length of water conductors to head is 4.9 to 1.

Environmental Factors

Impacts

- The mainstem reservoir would inundate somewhat less surface area on the mainstem but more off-channel than the reservoirs in Plan B. About 6.4 miles of the mainstem and 3.0 miles of the North Fork would be affected.
- Major impacts to land use, vegetation, wildlife, water quality, recreation, and cultural resources are essentially the same as in Alternative A, but to a lesser extent. In comparison, the Grey Mountain Reservoir would inundate fewer miles of whitewater boating (3.6 miles), stream angling (9.4 miles), and riparian habitat (9.0 miles), and fewer cultural sites (11 historic and 4 prehistoric).

Mitigation Measures and Enhancement Opportunities

- Major enhancement options are essentially the same as in Alternative A.
- In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public could also be constructed below the Grey Mountain Reservoir, if adequate water releases can be timed to provide period of weekend rafting.

Economic Factors

- Present value benefits exceed costs for Plan B1 by $1,770 million based upon a three percent real discount rate.
- Plan B1 achieves a real rate of return of 8.4 percent. This suggests financial feasibility of the project.
- Annual revenues from pumped-storage would total $175 million. Conventional hydropower revenues are estimated to be $1.6 million per year.
- Benefits from additional water supplies would average $3.2 million per year. Water management opportunities would be enhanced.
- Flat water recreation benefits are estimated to be $0.7 million per year while lost stream recreation is estimated to be $0.2 million annually. Enhancement of other stream recreation might be possible.
- Opportunities for land development at Glade Reservoir are evident. Significant flood control benefits could be achieved.

TABLE 6.10

SUMMARY EVALUATION OF ALTERNATIVE PLAN C1

Technical Factors	Environmental Factors: Impacts	Environmental Factors: Mitigation Measures and Enhancement Opportunities	Economic Factors
• Non-structural plan elements provide approximately 198,000 af during a 1-in-25 year drought of 4 years duration, thus reducing the total storage (449,000 af) by 44 percent. • Structural plan elements increase water supplies by 24,000 af per year which would be new water from the Windy Gap and C-BT Projects. • Structural plan elements satisfy the target water supply storage objective of 274,000 af. Poudre Reservoir has 43,000 af of space assigned to water supply storage and 18,000 af of space assigned to the hydropower project. Glade Reservoir has 231,000 af of live storage for water supply. • Poudre Reservoir could provide flood control for the plains. • Poudre and Glade Reservoirs would enhance water management opportunities but to a lesser extent than Plans A, C, D, and B1. • Poudre Reservoir could release flows to enhance downstream boating and fishery. • Timely identification and diversion of storable flows will be facilitated because Poudre Reservoir controls mainstem and North Fork flows. • The hydropower pumped-storage facility with 460 MW installed capacity provides a twelve-hour continuous output of 5520 MWh and an annual energy production of 806 GWh. Average gross head is 1390 ft and the ratio of horizontal length of water conductor to head is 4.9 to 1.	• The three reservoirs would inundate somewhat less surface area than Plan C but would affect about 4.7 miles of the mainstem and 3.0 miles of the North Fork. Most of the inundated area would be located off of the Poudre River at the Glade site. • Major impacts to land use, vegetation, wildlife, water quality, recreation, and cultural resources are also essentially the same as in Alternative A, but to a lesser degree. In comparison, the Poudre Reservoir would inundate fewer miles of whitewater boating (2.2 miles), stream angling (7.7 miles), riparian habitat (7.5 miles), and fewer cultural sites (13 historic and 6 prehistoric). However, it would also inundate more miles of state and federal highway and public utilities (17.9 miles) and 2000 acres of agricultural and/or range land associated with the Glade Reservoir site.	• Major enhancement options are essentially the same as in Alternative A. • In addition to the new whitewater boating sites above the reservoir, new put-in and take-out sites for the general public and commercial outfitters could also be constructed below the Poudre Reservoir. • The Glade Reservoir would create more flatwater recreational opportunities, including a mixed warm and cold water fishery, boating, camping, and picnicking.	• Present value benefits exceed costs for Plan C1 by $197 million based upon a three percent real discount rate. • The real internal rate of return for Plan C1 is 4.7 percent. Financial analysis indicates total capital requirements of $719 million. Annual payment of $46 million would be required. Comparison of payments with project revenues suggest financial feasibility at a real interest rate of three percent. The project might not be feasible under higher real interest rates, however. • Annual revenues from a scaled down pumped-storage facility would be about $45 million. Revenues from conventional hydropower would average $1.3 million per year. Because of the smaller project size, operation could begin several years earlier than the large plans, increasing the present value benefits over the study period. • Annual benefits from additional water/supplies would average $1.6 million per year. Water management opportunities within the basin would be enhanced. • Flat water recreation benefits are estimated to be $0.6 million per year while lost stream recreation is estimated to be $0.1 million per year. Enhancement of other stream recreation might be possible. • Opportunities for land development at Glade Reservoir are evident. Significant flood control benefits could be achieved.

6.5 PREFERRED PLANS

The Authority required that two plans be selected; a preferred plan and an alternative. Plan C has been recommended as the preferred plan and Plan B has been recommended as the alternative. These recommendations have been reviewed in detail with the Authority and have been discussed with the Advisory Committee at two meetings both of which were attended by the public.

All plans have been analyzed and evaluated on the basis of their technical, environmental and economic characteristics. No single plan has been found which ranks first in each of the three evaluation categories. Some plans rank higher technically or environmentally, others are more attractive in their economic aspects. Selection therefore has been based on obtaining the best balance of technical, environmental, and economic aspects.

6.5.1 Preferred Plan

Plan C, comprising Poudre Reservoir, Glade Tunnel and Reservoir, and the pumped-storage project, represents the best balance between technical, environmental, and economic factors. It has been recommended as the preferred plan.

Principal reasons for selecting Plan C are:

1. Satisfies the target storage objective of 274,000 af.
2. Permits optimum arrangement of the pumped-storage features.
3. Leaves mainstem below the confluence essentially unaffected.
4. Tailwater fluctuations due to power operation are less than or equal to those for other plans.
5. Flood control of both the mainstem and North Fork flows is possible.
6. Possible to enhance upstream and downstream recreational opportunities.

7. Only one dam is needed on the river in the canyon. Other plans require two dams.
8. Plan C is economically feasible and offers the second highest rate of return.

Plan C has neither the most nor the least potential environmental impact of the seven plans. Alternative C would inundate 460 acres (4.7 miles) of the mainstem of the Cache la Poudre River, 600 acres (3.0 miles) of the North Fork of the Poudre, and 2600 acres off-channel at the Glade Reservoir site.

Poudre Reservoir would directly impact about 2.2 miles of whitewater boating (currently about 5000 user days according to the Colorado Division of Parks and Outdoor Recreation) and 6.0 miles of angling (currently about 2000 user days according to the Colorado Division of Wildlife)--including 1.7 miles of designated "Wild Trout" water. It would require the relocation of about 5.0 miles of scenic driving (Colorado Highway 14) and a 0.5 mile segment of hiking along Greyrocks Trail (currently about 6000 user days). A total of 7.5 miles of riparian vegetation would be eliminated.

Plan C would require significant highway and utility relocations of 17.9 miles, including both the Poudre and Glade sites, and would require the purchase of 33 private homes.

As part of the prefeasibility study, a subsurface investigation program was conducted at the Glade damsite. Three drill holes (NX size), totalling 336 feet in length, and 2500 feet of seismic refraction survey, supported by auger hole drilling, were completed. Although more subsurface investigations would be needed for the feasibility phase, Glade is considered to be a suitable damsite based on current information.

6.5.2 Alternative Plan

Plan B has been recommended as the alternative to Plan C. Storage provided under Plan B would, as a minimum, be sufficient to capture either storable native flows or additional Windy Gap plus C-BT diversions and also lend itself to future water storage expansion. The principal reasons for selecting Plan B as the alternative rather than one of the other plans are:

1. Provides sufficient storage for either storable flows or new Windy Gap plus C-BT diversions.
2. Storage capacity could be increased in the future by the addition of Glade Reservoir.
3. Permits optimum arrangement of the pumped-storage features.
4. Flood control of both mainstem and North Fork flows is possible.
5. Possible to enhance upstream and downstream recreational opportunities.
6. Requires a significantly lower initial investment of capital.
7. Plan B is economically feasible and offers the highest rate of return of any plan studied.

Plan B ranks second in terms of overall adverse environmental impact. It would inundate 800 acres on the mainstem of the Poudre River (6.4 miles), and 850 acres on the North Fork of the Poudre. A total of 1.4 miles of primary whitewater boating would be eliminated, and 2.2 miles of other whitewater boating. Wild trout stream totaling 3.4 miles would be inundated, along with 6.0 miles of other cold-water angling, including cold water angling on the North Fork of the Poudre. About 6.0 miles of Colorado Highway 14 would be relocated, and 0.5 miles of the Greyrocks Hiking Trail would have to be relocated.

About 25 residences would need to be purchased, and 9.0 miles of riparian vegetation would be impacted by this alternative. A total of 15 known historic and prehistoric sites would be affected by facilities in Plan B.

6.5.3 Other Plans

Plans A and B1 were eliminated because neither represented a reasonable alternative to Plan C. Both are essentially equal to Plan C in storage and power characteristics but inferior with regard to environmental impacts and rate of return.

Plan D was eliminated because of its consequences on the pumped-storage project. It provides the lower reservoir for the pumped-storage project on the North Fork instead of the mainstem thus approximately doubling the length of water conductors. The direct cost of the power facility would be increased by about 10 percent. The economic viability of Plan D is dependent on the attractiveness of the power facility in comparison to many other potential projects being proposed to utility companies. A plan that is dependent on a weakened pumped-storage facility is therefore not a reasonable alternative to Plan C. For this reason, Plan D was not selected.

Plan C1 represents an initial stage of Plan C in which installed power capacity is reduced to meet only regional needs after the year 2000 and storage capacity is sufficient for either storable flows or Windy Gap plus C-BT diversions but not both. The concept of staged development of Plan C could be investigated during feasibility studies.

Plan E provides a total of 119,000 af of storage in Glade Reservoir and Halligan Reservoir of which 60,000 af is at Glade. This capacity is insufficient for additional Windy Gap and C-BT diversions.

6.6 FINANCIAL ANALYSIS OF THE PREFERRED PLAN

Total construction costs for Plan C are $1,510 million (1986 dollars) over a 13-year period. Interest is accrued throughout this period. Revenue bonds might be issued in the year 2000 with the costs of the bond reserve fund and bond issuance incurred in that year. The outstanding principal would total $1,780 million in the year 2000. Based on a 30-year repayment period and a three percent real interest rate (eight percent nominal interest rate less five percent inflation), annual debt service payments of $89 million (in 1986 dollars) would be required. Annual O&M costs would total $15 million but $3 million in interest would be earned each year on the bond reserve fund, resulting in net annual O&M payments of $12 million. Total annual payment would be $101 million. Assuming constant annual payment, outstanding principal declines to $1,370 million by 2010, $824 million by 2020, and $87 million by 2030. Debt service in that last year would be met from use of the bond reserve fund.

Preliminary analysis indicates that pumped-storage and conventional hydropower could carry the entire $101 million annual payment burden for Plan C. Conventional hydropower revenues might contribute $1.3 million per year toward repayment, while the burden on pumped-storage would total $99.7 million per year. This annual burden would represent 55 percent of pumped-storage revenues. Under this scenario, the Basin would receive at least $5.2 million in net benefits per year from additional water supplies and quantified recreation benefits.

Project financing also was analyzed using different real interest rates. For example, payments of $171 million are required under a seven percent real interest rate (12 percent nominal rate less five percent inflation). The $182 million in projected revenues from pumped-storage and conventional hydropower support annual payments for Plan C even under a seven percent real interest rate.

6.7 FINANCING REALITIES FOR PROJECTS IN THE CACHE LA POUDRE BASIN

It is extremely important that the water users in the Basin strengthen their cooperative spirit to develop their water resource options in the Basin that best fulfill the needs consistent with financing opportunities. It will only result in many years of delay and increased costs if both sides of an opposing viewpoint are not willing to constructively discuss those issues, as successfully carried out in the Advisory Committee Meetings, and hopefully arrive at an acceptable compromise.

The Authority is empowered to sell revenue bonds that must be serviced from the revenue stream derived from a project. These financial arrangements are consistent with the present water development conditions in Colorado; namely, <u>a project must essentially be able to carry itself financially</u>. In Colorado there is no present major state subsidy available for developing large water projects. Federal involvement in water project development has declined substantially. However, there may be future opportunities to subsidize water users with the joint development of pumped-storage hydropower in the Basin. It is important to note that the project may be financable through the sale of revenue bonds. There would be no additional ad valorem taxes for this project from the Northern Colorado Water Conservancy District's tax base.

Some discussion during the Study centered on capturing as much water as possible. However, if additional storage capacity is provided to capture more water during a wet year, the cost per af of yield starts going up very rapidly due to the large storage space, or carry over storage, that may only be filled once every 10 to 20 years. It is apparent that the costs of developing new structural facilities at over $500 per af per year are well beyond the repayment ability of agricultural water users.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The Cache la Poudre Basin Planning Study was initiated in mid-1985 and performed over a 16-month period by a consulting team under the management of the Colorado Water Resources and Power Development Authority. The overall purpose of this endeavor was to establish whether a need will exist for water in the Basin over the foreseeable future; and if such a need exists, what would be the general nature of the non-structural measures and structural project components that might optimize water and power resource development in an environmentally sound manner. A key component of the study was to ascertain whether conventional or pumped-storage hydropower could be integrated into a water storage project to contribute to repayment of water project costs.

The Cache la Poudre Basin Planning Study fully incorporates previous resource planning efforts in the region, especially the Wild and Scenic River Designation. Structural project alternatives have only been examined for those stretches of the river that, through compromise with environmental and other interests, have not been precluded from consideration for water and hydropower development.

7.1 MAJOR FINDINGS AND CONCLUSIONS

The Cache la Poudre Basin Study accomplished the objectives established at the outset. The key findings are summarized below:

- In average runoff years, existing water supplies will likely be sufficient to meet needs under most future development scenarios in the Basin. This is likely because agricultural water supplies will continue to be transferred to expanding municipal and industrial uses in the Basin. However, under a 1-in-25 year drought, a 250,000 af shortage of consumptive use is projected, translating into a $40 to $150 million economic loss to the Basin depending upon how these shortages are managed.

- Developable water resources exist from four sources: storable native flows, additional diversions from the West Slope (Windy Gap and C-BT), groundwater, and return flows. In aggregate, additional developable water supplies amount to about 100,000 af per year.

- Given the present surpluses of power, there is no current need for additional electricity generation for Colorado or the Rocky Mountain Region. After the year 2000, new peaking power production facilities will be needed; the most economically efficient alternatives are expected to be developed first. It appears that a pumped-storage hydroelectric facility in the Basin could meet these future demands.

- A broad spectrum of non-structural water resource development alternatives were evaluated as part of this study. A number of these deserve further detailed analysis, and others are viable as emergency measures. Twelve non-structural measures have been found to be the most promising. A number of these measures, however, will require important commitments by water management institutions in the Basin. Certain ones will require complementary structural water resource development to achieve maximum benefit.

- A number of structural water resource development alternatives were identified and analyzed. These led to the formulation of seven alternative plans covering a range of water storage capacities and hydroelectric generating capacities. With extensive public input, these plans were carefully evaluated from technical, environmental, and economic standpoints.

- Plan C comprised of Poudre Reservoir, on the mainstem, and Glade Reservoir, located off-channel, represents the best combination of structural measures based on technical, economic, and environmental analyses. Certain environmental losses would occur under this preferred plan, including habitat, recreational resources, and other inundation losses. However, new recreational opportunities could be created and existing recreation could be significantly enhanced. New water supplies would be available to the Basin, and important flood control benefits could be achieved. The plan is also consistent with the Federal Wild and Scenic River designation.

- Economic benefits substantially exceed costs, both from a total project and Basin perspective. The economic rate of return is sufficiently attractive to anticipate interest from financial backers assuming the pumped-storage feature will attract major utility financial commitments. Potential revenues from the large pumped-storage hydropower component could pay a major portion of project costs.

7.2 RECOMMENDATIONS

It is recommended that both Plan C and the best alternative plan, Plan B, be carried to the feasibility level, the second step in the development process. Should financial support for this next step materialize, a number of critical issues identified in this Study can be thoroughly explored.

7.2.1 The Feasibility Study Process

The feasibility study process would begin with the identification of and financial commitment from project proponents. In most instances, the project proponents for a major undertaking of this nature would be drawn from among the project beneficiaries. These were identified as part of the prefeasibility study to include electric utilities and their customers, Basin water users, flood control beneficiaries, recreational water users, and the State of Colorado. Funding for a feasibility study could come, in part, from water users in the Basin, the NCWCD, and the State of Colorado via the Authority. It is expected, however, that the bulk of the funding would need to come from electric utilities wishing to participate in the hydropower development.

The hydropower beneficiaries would only fund the feasibility study if the perceived benefit from future power resources was significant. Depending upon the outcome of the feasibility study, ultimate bond financing could be achieved only with long-term, irrevocable commitments from the utility backers and thus avoiding the need for pledging the tax base in the Basin.

7.2.2 Feasibility Study Overview

The recommended feasibility study would probably take as long as two to three years to complete. The cost of the feasibility study would vary depending on permitting and licensing requirements but it could cost up to $10 million. In essence, this level of study would provide considerable detail about the project and a complete examination of the major issues expressed about the project by the public and the various interest groups.

Much more work must be accomplished to assess the viability of each plan element within a full-scale feasibility study. For example, little groundwater data are available, particularly with respect to current pumping amounts and water quality. A data collection effort initiated in the near future would provide baseline data needed in a full-scale feasibility study. Aerial mapping in the vicinity of potential damsites could also be conducted now to support later activities.

Initial investigations indicate that revenues from the pumped-storage hydropower operation would be necessary to support project costs. This basinwide study did not fully examine whether the power market could absorb this power or whether this project is more attractive than competing new power facilities. In the final analysis, electric utilities that could utilize this power would have to come forward to ensure payment of project costs before any facilities could be constructed.

Cost estimates for new transmission lines were not included in the plan evaluations. New transmission lines were assumed to provide benefits in excess of their costs. They would generate revenues through interregional marketing of power and their construction may be feasible even without a pumped-storage component.

Insufficient information is available to assess the full positive and negative effects of the preferred plan on the local environment, particularly recreational activities. Additional baseline data on the environment and existing recreational uses of the Poudre River are necessary. This data collection effort has been initiated by the NCWCD for the Poudre River below Poudre Park. This information should be reviewed at the start of the feasibility study and additional data should be collected if necessary.

7.2.3 Summary

This basinwide study defined a combination of structural and non-structural measures for the sound development of water and hydropower resources in the Cache la Poudre Basin. Non-structural measures were selected by screening 32 potential elements. Recommended structural facilities were selected from more than 30 elements, including storage, conveyance, and hydroelectric power facilities. In summary, the preliminary analysis demonstrates the strong technical and economic feasibility of the recommended plans. Environmental effects associated with implementing each plan and potential environmental enhancement opportunities were identified at a preliminary level of detail. Future investigations can now move beyond the basinwide view to evaluate Plans C and B in much greater detail.