MIDDLE BOULDER CREEK WATER SOURCE MANAGEMENT WORK PLAN

BOULDER, COLORADO

City of Boulder

Prepared by the Water Resources Staff of the Utilities Division of the city of Boulder, with support from:

GEI Consultants, Inc.
Hydrosphere Resource Consultants
Western Environmental Analysts
Steven P. Walker

Brown & Caldwell
ERO Resources Corp.
GBSM
Kris Kranzush

Version 1, July 23, 2002
Project 00364

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BOULDER, COLORADO

July 23, 2002

Submitted to:

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Project 00364

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EXECUTIVE SUMMARY

Background

On March 7, 2001, the city of Boulder purchased Barker Dam, Barker Meadow Reservoir, the Barker Gravity Pipeline, Kossler Reservoir, the pipeline from Kossler Reservoir to Boulder Canyon Hydroelectric Plant, and the Boulder Canyon Hydroelectric Plant from Xcel Energy (Public Service Company of Colorado) for $12.4 million. Combined, the purchased facilities and the accompanying land constitute the Boulder Canyon Hydroelectric Project (Barker system). Boulder purchased the Boulder Canyon Hydroelectric Project using a portion of the proceeds from the sale of Windy Gap Project units in 1991. All remaining funds from the Windy Gap sale will be used to repair and upgrade the Barker system. The main purpose for the purchase of the these facilities was to enhance Boulder's municipal water supply and to allow the city to make necessary repairs to the Barker system.

Boulder's Management Priorities

The primary purpose of Barker Meadow Reservoir is to store Boulder's municipal water for delivery to Boulder's Betasso Water Treatment Plant. Boulder's municipal water supply goals are to provide an adequate, reliable, high quality water supply for Boulder's present and projected build-out population, even during times of moderately severe drought. Because of the unpredictable variability of water supply, Boulder needs to remain flexible and innovative in the management of its water supplies and should continue to emphasize conservation and protection of its water resources.

Boulder's water quality goals include protection of the quality of waters at their source as a part of a multiple barrier approach to drinking water quality protection. Boulder seeks to maximize source water protection by encouraging cooperation among the landowners and land users in the watersheds supplying the city's water. Management of watersheds, reservoirs, and water delivery facilities can compliment water treatment to provide a buffer that helps prevent harmful substances from passing through the treatment process into finished drinking water.

Boulder's Secondary Goals

Secondary goals associated with the Barker system include hydropower generation, recreation, instream flows, and environmental enhancement. Hydropower generation is an effective way to conserve fossil fuels and can be accomplished as a byproduct to delivering water to the Betasso Water Treatment Plant. Boulder also seeks to provide for reasonable and safe recreational activities that are compatible with and do not compromise the primary goal of providing reliable, high quality drinking water for the city of Boulder. The current FERC license for Boulder Canyon Hydro Project provides for shoreline fishing, picnicking and other leisure opportunities at Barker Reservoir that do not involve body contact with the stored drinking water supply.

Another important goal is to innovatively manage the city-owned water supplies to enhance and protect the natural environment in the Middle Boulder Creek watershed. As part of this enhancement, the city is committed to maintaining instream flows in Middle Boulder Creek below Barker Dam and is working cooperatively with the Colorado Water Conservation Board to meet this goal. The instream flow program will be an extension of the successful instream flow program that the city has jointly implemented with the Colorado Water Conservation Board on North Boulder Creek and Main Boulder Creek.

Purpose of the Work Plan

To help the city accomplish its primary and secondary goals for the Barker system and the city's overall water supply system, the Water Resources work group within the city's Public Works/Utilities Division developed the Middle Boulder Creek Water Source Management Work Plan (Work Plan). The purpose of the Work Plan was to compile existing information pertaining to the Barker system and the Middle Boulder Creek watershed, evaluate the information and make recommendations. The scope for the Work Plan did not include conducting new studies or creating new data. An important part of the information gathering process was to facilitate stakeholder involvement and present ways for the public to submit comments and concerns regarding the Middle Boulder Creek watershed. When gaps in information were identified, the management planning team recommended possible studies or sources of information to fill the existing gaps. Based on the information collected in the planning process, the work plan recommends management decisions and work efforts for the immediate future. The Work Plan is inherently dynamic and flexible, and will evolve as more is learned about the Middle Boulder Creek watershed.

Work Plan Team

The city of Boulder assembled a team of experts consisting of eight consulting firms or agents to assist in the development of the Work Plan. The Work Plan was developed through the city's Utilities Division under the project management of Carol Ellinghouse, Water Resources Coordinator. Critical project support was provided by Joanna Stansbury, Water Resources Specialist; Jane Nelson, Public Works Communication Coordinator; June Busse, Utilities Project Manager specializing in raw water systems and hydropower; Amy Struthers, Water Quality Supervisor, and other key city employees. GEI Consultants, Inc. (GEI) was the lead consultant. GEI and Water Resources staff shared complimentary roles in managing the project, implementing the public process, and producing the Work Plan.

The Project Team consisted of GEI, city staff and seven subconsultants specializing as follows (in alphabetical order):

- Bill Lewis: limnology (study of freshwater lakes)
- Brown & Caldwell: water quality and GIS
- ERO Resources Co.: habitat, environmental issues, and GIS
- GBSM: public process
- Hydrosphere: hydrology, water supply system operations, and water rights
- Kris Kranzush: historic and cultural issues, safety and security, and Community Liaison
- Steve Walker: recreation

Scope of Work

The initial stages of the Work Plan Project involved development of project goals, objectives, and a scope of work. Project Team consultants were involved in the development process from its beginning stages. The scope of work guiding the Work Plan development process encompassed the following tasks. A more detailed scope of work is included in Appendix D.

1. Facilitate a Project Team scoping meeting and develop a scope of work and project budget.
2. Prepare a Middle Boulder Creek watershed Reference Index and Library.
3. Prepare a limnological model of Barker Meadow Reservoir.
4. Prepare a Betasso Water Treatment Plant Notification Plan for the Middle Boulder Creek watershed.
5. Prepare and implement an External Communication Plan, including a public involvement program.
6. Prepare and implement an Internal Communication Plan, including a participant-accessible Web site.
7. Compile existing information on Middle Boulder Creek watershed hydrology and water rights.
8. Evaluate Middle Boulder Creek recreational opportunities and their impacts on water quality, water quantity, and safety.
9. Evaluate historical and cultural resources associated with the Barker system.
10. Evaluate available Middle Boulder Creek watershed water quality information, including point-source and non-point-source pollutants and their pathways.
11. Evaluate hydropower facility operations and their impacts on water quality and quantities to develop short-term and long-term decision support tools and to produce a hydropower operations summary.
12. Evaluate reservoir drawdown requirements and the effects of maintaining a minimum reservoir pool elevation as a basis for future studies related to Barker Reservoir fishery habitat.
13. Review County, State, and Federal Regulations that pertain to the Barker system.
14. Coordinate with emergency response agencies to determine criteria for development of a Water Source Emergency Response Plan.
15. Evaluate watershed and ecological concerns to facilitate the development of Habitat Preservation and Maintenance Plans.
16. Integrate existing GIS maps of the watershed.
17. Facilitate and attend Project Team progress meetings.
18. Preparation and/or support of city staff in preparation of project progress reports, including four City Council reports.
19. Development and production of a final Middle Boulder Creek Water Source Management Work Plan.

Public Process

The objective of the public process was to involve all interested stakeholders and collect comments that could be used to shape the development of the Work Plan and help guide future management decisions. The public process played an important role in identifying issues and addressing concerns of the community regarding the change in ownership of the Barker system. The city provided multiple avenues for public input. Regardless of the avenue by which comments were received, all comments were considered equally and recorded into a database. Comments were not received as if they were votes, but rather as a means to gage general public sentiment on certain issues, and to identify issues that the planning team may have overlooked. Comments will be received on the Work Plan up until its presentation to City Council in the summer of 2002. The Planning Team intends that this plan should be inherently dynamic and should remain flexible.

The Work Plan Report

The bulk of the Work Plan relays existing information regarding the environment, system facilities, existing regulations, water quantity and quality, recreation, historical and cultural resources, safety, and operational issues. Some, but not all, of these sections address issues in the context of four conceptualized subbasins: the Barker Reservoir watershed inclusive of areas above Barker Dam, Kossler Reservoir, the Middle Boulder Creek corridor below Barker Dam, and Main Boulder Creek below the confluence of Middle and North Boulder Creeks.

Summary of Recommendations

The following list provides a summary of the Work Plan recommendations. Additional recommendations and greater detail are provided in Section 19. The recommendations are not listed in order of priority. Factors that should be considered when developing a schedule for implementing the recommendations include required interaction with other agencies, available budgets, and water supply priorities.

Operations

- Maximize use of direct flow water rights and direct use exchange rights.
- Develop a system based operations plan based on water quality, system reliability, cost, risk, and secondary project objectives like instream flow and recreation.
- Develop a multi-system based operations plan for drought management.
- Legally protect instream flows through agreements with the CWCB.
- Optimize hydropower generation as a secondary objective after optimizing the system for water supply and accommodating competing commitments like instream flow releases.

Operational Decision Support Tools

- Develop short-term and long-term decision support models.
- Develop and test a Betasso Water Treatment Plant Notification Plan.
- Explore the uses, benefits, reliability, and costs of remote sensing capabilities.

Water Quality

- Identify and monitor important contaminants.
- Establish baseline water quality measures.

- Model and track important relationships, including land use and water quality.
- Increase public awareness and water contamination prevention.
- Complete a joint study with the Town of Nederland for mitigating the impacts of the Nederland Wastewater Treatment Plant.
- Use GIS to improve modeling and tracking efforts.
- Conduct a series of targeted studies and investigations.

Recreation

- Prepare a recreation management plan for existing recreation uses at Barker Reservoir. Additionally, prepare a Barker Reservoir Boating Feasibility Study, an Ice Climbing Plan, and Recreational Fishing and Aquatic Habitat Enhancement Plans for Barker Reservoir, Middle Boulder Creek, and Main Boulder Creek.
- Work with the town of Nederland on plans for development at the west end of Barker Reservoir.
- Evaluate means to minimize use of undesired recreational access at project facilities.
- Maintain documentation of recreation decision-making, including public involvement, to facilitate the FERC relicensing process.
- Proceed cautiously, conducting all appropriate studies and hearings, before opening up any part of the Barker System to new secondary uses.

Environment and Land Management

- Protect healthy ecosystems.
- Restore degraded ecosystems as reasonable.
- Provide minimum instream flows in Middle Boulder Creek below Barker Dam in cooperation with the Colorado Water Conservation Board.
- Establish a coordinated land management effort between Utilities, Open Space Mountain Parks, Boulder County and the US Forest Service in the Tram Hill / Lost Gulch area.
- Establish a coordination group comprised of Utilities staff, Open Space Mountain Parks staff and others as necessary to develop joint land management policies and best management practices (BMPs) for integrating land management activities.

History and Culture

- Explore appropriate historical and cultural designations and listing for the Boulder Canyon Hydroelectric Project.

Safety and Security

- Support fire protection districts and wildland fire management efforts.
- Track security advisories and follow the recommendations of law enforcement agencies regarding heightened security during the current national action against terrorism.
- Continue emergency response planning.

- Improve security measures through training, adding personnel, and constructing security barriers.

Community Education and Facilities Enhancement

- Implement steps to educate the public regarding the importance of source water quality protection, the effects of animal excrement deposits near water sources, Barker Reservoir and Middle Boulder Creek recreational opportunities and restrictions, private property boundaries, watershed activity impacts, and the role of the public in thwarting vandals and terrorists.
- Improve the aesthetics and usefulness of Barker Reservoir's public facilities.
- Install and maintain bag dispensers for pet excrement.
- Ensure sufficient restroom facilities and trash receptacles at designated recreation sites.

Project Schedule

The preliminary draft Work Plan was presented to the Water Resources Advisory Board (WRAB) on March 18, 2002 and then was made available to the public. During the next three months, the management planning team continued its public process and acceptance of comments from interested stakeholders. Comments were also received from the WRAB. After the comment period, the planning team finalized the draft. On May 13, 2002, final draft recommendations from the Work Plan were approved by WRAB for presentation to City Council with a recommendation for adoption. The final draft was (will be) submitted to the Boulder City Council on July 23, 2002.

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LIST OF ABBREVIATIONS, ACRONYMS, SYMBOLS, AND UNITS

A.C.	Alternating current
af	acre-feet
AIChE	American Institute of Chemical Engineers
AIME	American Institute of Mining, Metallurgical and Petrolium Engineers
AMD	Acid mine discharge
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BCPOS	Boulder County Parks and Open Space
BES	Boulder emergency squad
BOCC	Boulder County Board of County Commissioners
BOD	Biochemical oxygen demand
BTEX	Benzene, toluene, ethylbenzene, and zylene
CA	Certificate of appropriateness
CBT	Colorado Big Thompson
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDPOR	Colorado Department of Parks and Recreation
CDPS	Colorado Discharge Permit System
CEAP	Community and Environmental Assessment Process
cfs	cubic feet per second
CIP	Capital Improvement Progect
CLG	Certified local government
CNHP	Colorado Natural Heritage Program
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
DOLE/OIS	Department of Labor and Employment, Oil Inspection Division
DWD	Denver Water Department
EAP	Emergency action plan
EOP	Emergency operations plan
EPA	Environmental Protection Agency
EPN	Emergency preparedness network
ERNS	Emergency response notification system
ESA	Endangered Species Act
FBI	Federal Bureau of Investigation
FD	Fire department
FERC	Federal Energy Regulatory Agency
FLPMA	Federal Land Policy Management Act
FWS	U.S. Fish and Wildlife Service
GEI	GEI Consultants, Inc.
GIS	Geographic information system
HAER	Historic American Engineering Record
HazMat	Hazardous Materials
HPAB	Boulder County Historic Preservation Advisory Board
ISDS	Individual sewage disposal system

kW	kilowatt
kWh	kilowatt hour
lbs	pounds
LRMP	Land resource management plan
LUST	Leaking underground storage tank
MACS	Multiple agency coordination system
MGD	millions of gallons per day
MW	megawatt
MWh	megawatt hour
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
ntu	Normal turbidity unit
PSCo	Public Service Company of Colorado
psi	pounds per square inch
PUC	Colorado Public Utilities Commission
RCRIS	Resource Conservation and Recovery Information System
RTD	Rural Transit Department
SCADA	System control and data acquisition
SEO	State Engineers Office
SH	State highway
SHPO	State Historic Preservation Officer
SWAP	Source water assessment and protection
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UST	Underground storage tank
VOO	Visual quality objective
WASH	Watershed approach to stream health
Work Plan	Middle Boulder Creek Water Source Management Work Plan (this report)
WQCC	Water Quality Control Committee
WQCD	[Colorado] Water Quality Control Division
WRAB	Water Resources Advisory Board
WTP	Water Treatment Plant
WWTP	Waste water treatment plant
µg/L	microgram per liter
^{O}F	Degrees Fahrenheit

1 Introduction

1.1 Objective

The objective of the Middle Boulder Creek Water Source Management Work Plan is to establish a management plan that:

- satisfies all city, county, state, and federal regulations;
- allows the city to provide its customers with readily available, high quality drinking water;
- satisfies Federal Energy Regulatory Commission (FERC) and Colorado Public Utilities Commission (PUC) requirements for hydroelectric power generation;
- addresses all stakeholders who advocate secondary uses of the watershed resources.

The purpose of the Middle Boulder Creek Water Source Management Work Plan is to define the opportunities and constraints associated with the city of Boulder's future, broader role in management of the Middle Boulder Creek Watershed. This increased role in management of this important, region-wide asset is being brought about by the city assuming ownership of the Boulder Canyon Hydroelectric Project, which includes Barker Meadow Reservoir, Barker Dam, Kossler Reservoir and Dams, the Barker Gravity Pipeline, and the Boulder Canyon Hydroelectric Plant (collectively referred to as the Barker system in this report). The management plan is intended to serve as a decision-support tool and a work plan to guide the city's future watershed management efforts.

The project will be successful if:

- Barker Reservoir is secure as a high quality, readily available drinking water source for the city of Boulder while satisfying all appropriate regulations;
- All stakeholders have had an opportunity to state their opinions and have their opinions considered in the development of the Management Plan;
- The city operation of the Boulder Canyon Hydroelectric Facilities is in accordance with the power generation requirements of the FERC and PUC;
- Boulder City Council accepts the final Management Work Plan; and
- The Boulder City Council approves recommendations based on the final Management Work Plan.

1.2 Scope of Work

The scope of work was developed jointly by city staff and the consultants. Primary tasks performed as part of the project include:

Scope of Work

The initial stages of the Work Plan Project involved development of project goals, objectives, and a scope of work. Project Team consultants were involved in the development process from its beginning stages. The scope of work guiding the Work Plan development process encompassed the following tasks. A more detailed scope of work is included in Appendix D.

- Completion of a Project Team scoping meeting, scope of work and project budget.
- Preparation of a Middle Boulder Creek Watershed Reference Index and Library.
- Preparation and implementation of an External Communication Plan including a public involvement program.
- Preparation and implementation of an Internal Communication Plan including an intranet Web page.
- Compilation of watershed hydrology and water rights data based on existing information.
- Evaluation of recreation opportunities and their impacts on water quality, water quantity, and safety.
- Evaluation of historic and cultural resources of the Boulder Canyon Hydroelectric Project.
- Evaluation of water quality information available for the Middle Boulder Creek Watershed, including point-source and non-point-source pollutants and their pathways.
- Evaluation of the impacts of hydropower facility operations on the water quality and quantity for Barker Reservoir, Kossler Reservoir, and Middle Boulder Creek downstream of Barker Dam.
- Evaluation of reservoir drawdown requirements and the effects of maintaining a minimum reservoir pool elevation as a basis for future studies related to Barker Reservoir fishery habitat.
- Review of county, state, and federal regulations that pertain to the Barker system.
- Coordination of watershed planning efforts with emergency response agencies.
- Evaluation of watershed ecological concerns, especially threatened and endangered species, riparian/wetland areas, and instream flows.
- Integration of existing geographical information system watershed mapping.
- Attendance at Project Team progress meetings as needed.
- Review, evaluation, and documentation of the results of all other tasks resulting in the Development of the Middle Boulder Creek Water Source Management Work Plan.

1.3 Authorization

The work performed for this project was authorized by an Agreement for Consulting Services between the city of Boulder and GEI Consultants, Inc. dated February 8, 2001.

1.4 Team Selection

The city of Boulder's watershed management staff initiated this project through solicitation of Statements of Qualifications from interested consulting firms in March 2000. Based on review of the consultant responses, the city short-listed three consulting teams and performed interviews in August 2000. City staff selected GEI Consultants, Inc. as the firm to lead the project team, with support from several other consultants. The project team consultants with their primary role and area of expertise are as follows:

Consultant	Primary Role/Expertise
GEI Consultants, Inc.	Team Lead, Hydropower Operations
Brown & Caldwell	Water Quality
Hydrosphere	Water Rights
GBSM	Public Involvement
ERO Resources Corp.	Wetlands and Threatened and Endangered Species
Dr. Bill Lewis	Reservoir Limnology (study of freshwater lakes)
Steven P. Walker	Recreation Planning
Kris Kranzush	Historic and Cultural Resources

2 Overview

2.1 Prior Ownership of the Barker System

2.1.1 Background

In 1908, the Central Colorado Power Company began construction of Barker Dam and the Boulder Canyon Hydroelectric Plant to provide electricity to thriving mining camps and the booming city of Denver. Barker Dam and Barker Meadow Reservoir were named for the original owner of the land, Mrs. Hannah Barker. In 1913, the Colorado Power Company acquired Central Colorado Power Company. By 1924, the Colorado Power Company had merged with Public Service Company of Colorado (PSCo). In August 1997, PSCo merged with Southwestern Public Service Company, based in Amarillo, Texas, to form New Century Energies. On August 18, 2000, New Century Energies, based in Denver, merged with Northern States Power Companies, based in Minneapolis, Minnesota, to form Xcel Energy. The PSCo, Northern States Power Companies, and Southwestern Public Service Company brand names are still sometimes used. On March 7, 2001, the city of Boulder purchased the Boulder Canyon Hydroelectric Project (Barker System), including Barker Meadow Reservoir (Barker Reservoir), Barker Dam, the Barker Gravity Pipeline, Kossler Reservoir, the pipeline from Kossler Reservoir to Boulder Canyon Hydroelectric Plant, and the Boulder Canyon Hydroelectric Plant from PSCo (now Xcel Energy) for $12.4 million. The Barker System has been used to generate electricity annually since its original construction.

2.1.2 Agreements with City of Boulder

Since 1954, when a severe drought seriously challenged Boulder's ability to supply water to its citizens, the city has had a series of agreements with Public Service Company of Colorado (PSCo) allowing the city to use Barker Reservoir storage and its associated water transmission facilities. The city entered into temporary agreements with PSCo for water from Barker Reservoir to help the city weather the 1954-1956 drought. A 1959 agreement allowed the city to use any excess storage in Barker Reservoir that PSCo was unable to use. In 1961, the city was granted the right to use up to 4,000 acre-feet of storage in Barker Reservoir, transport this water in the PSCo pipelines and construct a new pipeline from the hydro plant to the planned Betasso Water Treatment Plant. A 1970 agreement allowed for a gradual increase in the city's storage at Barker to 8,000 acre-feet by 1978. A 1984 Barker Agreement gave the city of Boulder a perpetual right to use and the first right to acquire PSCo's interests in Barker Dam and Reservoir, the water transmission facilities and the hydroelectric plant. The city of Boulder acquired an interest in two-thirds of the storage space in Barker Reservoir and a one-third interest in the water conveyance capacity of the facilities by the agreement.

The Town of Nederland entered into an agreement with PSCo that allowed Nederland to use 40 acre-feet of storage space in Barker Reservoir to store water under the Town's water rights. Water stored in this space is used to augment water taken into the town’s water system upstream. This agreement was not transferable to Boulder at the time of the sale and no longer is viable. Boulder and Nederland are currently negotiating a new agreement to allow for a continued use of 40 acre-feet of storage space.

2.1.3 Xcel Energy's Management Practices and Priorities

Xcel Energy is a for-profit company that operated Barker Reservoir primarily for power production and secondarily to meet their water supply obligations to Boulder (see Section 2.1.2). The amount of power produced through the Barker system was 0.01%, or one ten-thousandth, of the total power production of the Xcel power system. Therefore, maintenance of the Boulder Canyon Hydro facilities was not a high priority to Xcel. Xcel used Barker and the Boulder Canyon Hydropower plant primarily for peaking power. Peaking power production meant that in high demand periods, mainly between 6:00 PM and 9:00 PM during winter months, Xcel would release large amounts of water from Kossler Reservoir for power generation at Boulder Canyon Hydro. This release resulted in high flows in Boulder Creek below the hydro plant at Orodell during these peaking periods.

2.2 Acquisition of the Barker System

2.2.1 Windy Gap Water Exchange

In 1967, six northern Colorado municipalities (Boulder, Estes Park, Fort Collins, Greeley, Longmont, and Loveland) joined together to develop a water project to augment their existing municipal water supplies. The project, initially known as the "Six Cities Project", became operational in 1985 and is now called the Windy Gap Project. The Project consists of a small diversion dam on the Colorado River that creates the 445 acre-foot Windy Gap Reservoir, a pumping plant, and a six-mile long pipeline to Lake Granby. The Project delivers water to municipal and industrial water users on the northern Front Range through the facilities of the Colorado-Big Thompson Project. There are 480 ownership units in the Windy Gap Project. Due to sales of units in the Windy Gap Project to new project participants, there are now ten project allottees.

Boulder has evaluated the need for Windy Gap water for its future municipal needs. In 1987, the city initiated a public review process to evaluate the water supplies that Boulder owned and discuss options for use of the water. The studies resulted in the Raw Water Master Plan that was presented to City Council in January 1989. One of the findings of the studies was that Boulder owned sufficient water supplies to meet projected municipal demands at buildout. A result of this finding was the adoption by Council of a recommendation that water use for instream flow and for agricultural preservation be made secondary goals of the water utility.

Although City Council did not recommend a permanent reduction in the yield of the city's water portfolio through sale of water, they did recognize that the Windy Gap water was the city's most expensive and least reliable water. Council recommended that staff attempt to reconfigure the city's water portfolio through sale of Windy Gap water and replacement of the water with water supplies and assets in the Boulder Creek basin that would be capable of multiple uses and would enhance the yield of existing systems. The city has pursued this goal through the sale of 43 of its original 80 units in the Windy Gap Project to the city of Broomfield in 1991, leaving 37 units still owned by Boulder. Boulder has used the proceeds from the sale to jointly purchase Caribou Ranch with Boulder County and to purchase Barker Reservoir and its associated facilities from

Xcel Energy (PSCo). All remaining funds from the Windy Gap sale will be used to repair and upgrade the Barker System.

2.2.2 Acquisition Agreements

As part of the purchase of Barker Reservoir, Boulder Canyon Hydroelectric Plant and associated pipelines, easements, rights-of-way and facilities from Xcel, Boulder received all of the records pertaining to these facilities. In addition, Boulder was allowed by the Federal Energy Regulatory Commission (FERC) and the PUC to assume the existing FERC license for Project 1005 (Boulder Canyon Hydroelectric Project) with its existing terms and conditions. Boulder also entered into a Power Purchase Agreement with Xcel Energy to sell all power generated by the city at Boulder Canyon Hydro to Xcel.

2.3 Boulder’s Management Priorities

2.3.1 Primary Goals

The primary purpose of Barker Reservoir is to store drinking water for the city of Boulder and serve as a forebay for direct water deliveries into pipelines leading into Boulder’s Betasso Water Treatment Plant. The water in storage is generally, and should continue to be, available for use year-round as needed. A portion of the water should remain available for use even in dry years and the high quality of the water should be protected to reduce the risks to human health. The facilities should serve to increase the barriers to harmful substances to prevent their passage through the treatment process. The facilities need to remain reliable and should succeed in providing Boulder with an adequate water supply. It is important that the management of the reservoir remains flexible to adjust to new and growing demands, and to ensure that the city can meet its treated water needs.

2.3.1.1 Municipal Water Supply

Boulder’s municipal water supply goals are to provide an adequate, reliable, high quality water supply, even during times of drought, for Boulder’s current needs and projected build-out population. In the 1950's, a severe drought, combined with exploding population growth, strained the limits of Boulder's Silver Lake and North Boulder Creek water supply. As a result, the city made plans to develop additional water supplies. These efforts resulted in the two added water sources in use by Boulder today--Barker Reservoir and the Colorado Big Thompson (CBT) system through Boulder Reservoir.

Presently, on an annual basis, about 40% of the city's water supply comes from the Silver Lake watershed and North Boulder Creek at Lakewood, 40% comes from Barker Reservoir and Middle Boulder Creek, and 20% comes from western slope diversions through the CBT and Windy Gap Projects into Boulder Reservoir facilities. The Silver Lake Watershed and Barker sources are, and will continue to be, used to the fullest extent reasonable every year, leaving some provision for drought conditions in quantities sufficient to fully meet municipal demand.

Like most western communities, Boulder depends on stored water most of the year. High stream flows from melting snow pack allow water to be diverted directly from the stream for only a few spring and summer months. Natural stream flow and water available for direct diversion in late summer, fall and winter is not sufficient to meet customer demands. The amount of water available to all users changes from year to year depending on how much snow falls in the mountains. Because of this unpredictable variability, Boulder needs to remain flexible and innovative in the management of its water supplies, and should continue to emphasize conservation and protection of its water resources.

2.3.1.2 Source Water Quality

Boulder's source water quality goals are to continue to find ways to protect the quality of waters at their source to the greatest extent possible. Source waters include all those tributary streams within a watershed, the main stream, reservoirs and the conveyances that bring water from the sources to the treatment plants. There are many potential water quality threats to these sources. Although treatment plants remove most contaminants, they cannot remove everything.

Current industry wide management trends are moving towards protecting water at its source and limiting the potential threats to water quality. Examples of threats can include erosion, human and animal waste, human and animal contact, mine tailing runoff, leaking septic systems, leaking underground storage tanks, or storm drainage. Pollutants from these sources can add heavy metals, chemicals, bacteria, protozoa, and biotoxins to the water supply and can cause a variety of health risks if not removed from the water before drinking. By reducing or preventing these contaminants from entering the water supply in the first place, treatment processes have a better chance of being effective and producing a higher quality drinking water (see Section 9).

2.3.1.3 Cooperative Approach to Source Water Protection

Boulder's goal is to maximize source water protection efforts by encouraging cooperation among the landowners and land users in the Middle Boulder Creek watershed whenever possible. All activities in the watershed have the potential to affect water quality. Since Boulder does not own the majority of the land in the watershed or control all of the activity in it, the city needs to work cooperatively with its watershed neighbors to protect this valuable resource.

2.3.2 Secondary Goals

2.3.2.1 Hydroelectric Power Generation

A secondary goal for the Barker system is hydroelectric power generation. Boulder acquired the Boulder Canyon Hydroelectric Plant with the purchase of the Barker System. Including hydroelectric facilities that Boulder already owned, Boulder now owns and operates seven hydroelectric facilities that generate power as a byproduct of the city's municipal water supply system. Previously, the city used pressure-reducing valves exclusively to dissipate the pressure produced by water flowing downhill through the city's water supply pipelines. However, beginning in the mid-1980's, the installation of turbines and generators parallel to the pressure-reducing valves has allowed the city to use the water pressure to generate electricity instead of being wasted.

Hydropower is a renewable, nonpolluting source of power. Seven thousand (7000) tons of coal would need to be burned each year to generate the power that Boulder's hydropower plants create. Boulder receives over $700,000 a year in revenue by selling the power it generates to Xcel Energy. Through these sales, the expense of constructing the hydro plants is recovered in 10-15 years and water utility bills are reduced for Boulder residents. Management of hydroelectric power is addressed in Sections 6.6, 7.6, and 18.

2.3.2.2 Instream Flows

The city is committed to maintaining instream flows in Middle Boulder Creek below Barker Dam and is working cooperatively with the Colorado Water Conservation Board (CWCB) to meet this goal. The instream flow program will be an extension of the successful instream flow program that the city has jointly implemented with the Colorado Water Conservation Board on Boulder Creek and North Boulder Creek. Historically, a portion of Middle Boulder Creek below Barker Dam dried up due to the manner in which PSCo operated its hydroelectric power generation plant. The city has modified the operation of Barker Reservoir to keep water in the creek below the dam. By preventing water flows in the creek from dropping below minimum flow level targets, the habitat below the dam will be greatly improved, and fish populations in this area are expected to become self-sustaining (see Sections 8.3 and 12.4).

2.3.2.3 Recreation

The city of Boulder seeks to provide for reasonable and safe recreation activities that are compatible with and do not compromise the primary goal for the city's water utility facilities of providing reliable, high quality drinking water for the city of Boulder. The Boulder Canyon Hydroelectric Project is a FERC licensed facility. FERC requires owners of licensed facilities to investigate opportunities for public recreation and to provide access for recreation where it is reasonable, feasible and compatible with other uses of the facilities. The current FERC license for Boulder Canyon Hydro provides for shoreline fishing, picnicking and other leisure opportunities at Barker Reservoir. Recreation is further addressed in Sections 10 through 14.

2.3.2.4 Environmental Protection and Enhancement

There are extensive, valuable natural resources in the Middle Boulder Creek watershed. It is the city's goal to use innovative management for the city-owned water supplies to enhance and protect the natural environment. The city seeks to encourage protection of plant and wildlife species and to maintain existing wetland and natural buffer areas for water quality protection. The city desires to work cooperatively with other federal, state and local entities with jurisdiction over natural resource management in the watershed. Environmental issues are further addressed in Sections 5 and 17.

2.4 Purpose of the Work Plan

2.4.1 Compile and Summarize Existing Information

One purpose of the Middle Boulder Creek Source Water Management Work Plan is to compile existing information pertaining to Barker Reservoir, related facilities, and the Middle Boulder

Creek watershed and make recommendations based on this information. This work plan was not intended to conduct new studies or create new data. A bibliography of existing information is given in Appendix B.

2.4.2 Facilitate Public Involvement

Another purpose of this planning process was to facilitate stakeholder involvement and present ways for the public to communicate comments and concerns regarding the Middle Boulder Creek watershed. Given the interconnectivity among topics in the plan and the importance of including the watershed neighbors in the planning process, stakeholder comment was seen as a primary planning goal.

The management planning team offered stakeholders multiple methods and opportunities to present their concerns and comments regarding the plan. Methods and opportunities included six public meetings, a Web site to access current information and to submit comments, a project phone line, a community liaison for personal contact, small community meetings upon request, and mail-in comment cards. Comments were also encouraged throughout the writing phase of the project, and notice was given that there would be an opportunity to provide public comment to City Council when the plan was presentation to Council. More information on the public process is given in Section 3.4.

2.4.3 Frame Issues

Given the broad scope and extent of this project, the work plan process was intended to identify relevant topics and recognize important issues within the watershed community concerning watershed management. After research with several agencies and public groups, the management planning team initially identified six main topics: water quality, hydropower, operations, recreation, environmental issues, and historical and cultural resources. These topics proved to encompass public concerns expressed at subsequent public meetings.

2.4.4 Recommend Additional Studies

Another purpose of the plan was to identify gaps in existing information as a byproduct of the information gathering stage. Once these gaps were identified, the management planning team recommended possible studies or sources of information to fill the existing gaps.

2.4.5 Recommend Management Decisions

Based on the information collected during the planning process, this work plan recommends management decisions for the immediate future. The management planning team recognizes that the Work Plan is inherently dynamic and flexible and will evolve as more is learned about the Middle Boulder Creek Watershed.

3 Development of the Work Plan

3.1 Project Team

The city of Boulder assembled a team of experts consisting of eight consulting firms or agents to assist in the development of the Work Plan. Figure 3.1 shows the project organizational chart for both city and consultant staffs.

The Work Plan was developed within the city's Utilities Division under the project management of Carol Ellinghouse, Coordinator of Water Resources. Assistance was provided by the Public Affairs Officer, the Project Manager of Hydropower, staff within the Water Quality Division, and other city employees. GEI Consultants, Inc. (GEI) was the lead consultant. GEI and staff in the Water Resources Department shared cooperative roles in managing the project, implementing the public process, and producing the Work Plan, with the city maintaining final authority.

GEI and city staff were assisted by seven subconsultants (listed in alphabetical order) specializing as follows:

- Bill Lewis: limnology
- Brown & Caldwell: water quality and GIS
- ERO Resources Co.: habitat, environmental issues, and GIS
- GBSM: public process
- Hydrosphere: hydrology, water supply system operations and water rights
- Kris Kranzush: historic and cultural issues, safety and security, and Community Liaison
- Steve Walker: recreation

3.2 Timeline

The following list provides key dates in the nearly two-year development of the Work Plan:

October 5, 2000	Lead consultant notified that its consulting team selected.
November 2, 2000	Project Team kickoff meeting to refine the scope of work.
February 8, 2001	Agreement for Consulting Services with a revised scope of work.
March 7, 2001	City closes on the purchase of Barker Reservoir
April 2, 2001	Project Overview Public Meeting
May 18, 2001	Presentation to Boulder County Historic Preservation Advisory Board
June 14, 2001	Water Quality Public Meeting
July 25, 2001	Presentation to the Watershed Forum
August 2, 2001	Recreation Public Meeting
August 29, 2001	Hydropower and Watershed Operations Public Meeting
January 28, 2002	Presentation to the Water Resources Advisory Board (WRAB)
March 6, 2002	Preliminary Draft Work Plan printed for WRAB review and comment
March 18, 2002	Draft Work Plan printed for public review and comment
May 13, 2002	WRAB Board member comments and comments from public attending WRAB meeting

May 31, 2002	Deadline for public comments and comments from city staff to be considered for the report
July 23, 2002	Work Plan finalized and presented to the Boulder City Council

3.3 Team Process

3.3.1 Development of Project Goals, Objectives, and Scope of Work

The initial stages of the Work Plan Project involved development of project goals, objectives, and a scope of work. Project Team consultants were intentionally involved in the development processes. Initial scope boundaries were explored and refined during consultant interviewing and selection. Once the consulting team was selected, the entire Project Team, consisting of city and consultant personnel, met on November 2, 2000, to begin refining key project goals, objectives, and scope boundaries. GEI facilitated the meeting.

A number of working documents were derived from the November 2, 2000, meeting and smaller work groups that followed. Appendix C includes lists of functional outcome goals; tasks and outcomes; events, documents, and systems; and issues and vulnerabilities that relate to the Barker system and the Middle Boulder Creek Watershed. Many items on these lists fall outside of the final scope of work for the Work Plan and are included as a decision-making tool for future project development and screening.

The scope of work has remained flexible to meet the needs of the project. Appendix D contains the final written version of the scope of work, which was adopted in February of 2001 and includes summaries of project goals, tasks, and objectives. Additional refinements to the scope of work have followed.

3.3.2 Project Management

The Project Team developed and utilized a number of project management and production tools. These tools included a team communication plan, work breakdown structure, internal budgets, team Web site, Work Plan outline, and various memos to standardize and coordinate team assignments. The city hosted a series of meetings involving city staff, GEI, and selected sub-consultants to facilitate development and approval of these products, manage project progress and decisions, prepare for public meetings, and evaluate public feedback following public meetings.

3.4 Public Process

3.4.1 Objective

The objectives of the public process were to involve all interested stakeholders and collect comments that could be used to shape the development of the work plan and influence future management decisions. The public process played an important role in identifying issues and addressing concerns of the community regarding the change in ownership of the Barker system.

3.4.2 Program Development

The management planning team recognized the importance of stakeholder comments and solicited involvement in many ways (see Section 3.4).

The public process was designed to gather comments from all interested stakeholders within the city of Boulder, the Town of Nederland, and the larger Middle Boulder Creek Watershed; therefore, public meetings were held in both Boulder and Nederland. Those who attended the meetings were given the opportunity to comment in writing and orally. By having written and spoken comment sessions, the management planning team hoped to solicit comments from those people who may not have felt comfortable speaking publicly, as well as those people interested in speaking their concerns. The public was assured that written and oral comments would be given the same consideration.

The primary purpose of the purchase of Barker Reservoir and associated facilities was to provide a reliable and high quality drinking water supply. Therefore, the management team chose to have the first meeting after the kick off meeting relate to water quality. The subsequent meetings focused on recreation, historical preservation, and hydropower and operations. Although six topics were identified at the beginning of the process and are addressed in the report, the public meeting topics were selected based on public comments and interest. Each of the public meetings is described in more detail below.

Regardless of the method that comments were delivered, all comments were treated equally and recorded into a database. Comments were not received as if they were votes, but rather to gain an understanding of general public sentiment on certain issues and to identify issues that the planning team may have overlooked. Although the last date for comments to be considered for the final report was May 31, any comments received after that date were collected until the plan was presented to City Council on July 23, 2002. The Planning Team realizes that this plan should be inherently dynamic and should remain flexible.

3.4.2.1 Project Overview Public Meeting

City staff held the first public meeting on Monday, April 2, 2001, at Boulder High School. Forty-three individuals came to the meeting. There were opportunities throughout the meeting to talk with staff and consultants, submit written comments, and review informational boards and handouts. The information boards and handouts covered six topics: hydropower, environment, water quality, recreation, historical and cultural resources, and systems operations. Most of the attendees were from Nederland and Boulder Canyon. The city received more than 25 written responses, primarily concerning recreation.

3.4.2.2 Presentation to Boulder County Historic Preservation Advisory Board

The city sponsored a field trip to Barker Dam and the Boulder Canyon Hydroelectric Plant for the Boulder County Historic Preservation Advisory Board (HPAB) on May 18, 2001. HPAB advises the Boulder County Commissioners on historic preservation matters. HPAB advice includes recommending whether to approve, approve with conditions, or deny a variety of County permits that involve historic sites, including building and demolition permit applications.

The Utilities Division made a brief, informational presentation to the Boulder County HPAB at its regularly scheduled meeting on June 7, 2001 concerning the proposed Barker Gravity Pipeline repairs and the dam outlet works modification alternatives. City staff explained the pipeline repairs that would begin this year and gave an overview of the outlet works alternatives. A preferred alternative had not yet been selected. No issues or concerns were raised by the HPAB with regard to either proposal. Boulder County records audiotapes of HPAB meetings, which are available to the public on request.

The gravity pipeline repairs are considered maintenance by Boulder County, and no specific permits were required to complete this work. The proposed outlet works modification may require separate Boulder County permits prior to implementation. The HPAB may, at the discretion of the Land Use Department, review proposed modifications at the time permit applications are received. The HPAB usually reviews building permit applications for structures greater than 50 years in age to determine whether the structure has historic significance and if the proposed action would adversely affect that significance. The HPAB meets the first Thursday of each month.

3.4.2.3 Water Quality Public Meeting

The second public meeting focused on water quality and was held on Thursday, June 14, 2001, at the Boulderado Hotel in Boulder. Fifteen individuals came to this meeting. Following a water quality presentation given by a panel of three professional water specialists, there was a question and comment period, which gave participants the opportunity to speak their concerns. The panelists answered questions regarding water quality risks as they relate to trails, non-motorized boating on Barker, vegetation surrounding Barker reservoir and more. This public meeting was filmed and aired by Channel 8, and a copy of this presentation was placed in the Boulder Public Library for circulation. The written summary of the question and answer session was posted on the project Web site and is included in Appendix E.

3.4.2.4 Presentation to the Watershed Forum

The Planning Team gave a presentation at the Boulder Creek Watershed Forum on July 25, 2001. The presentation was similar to the water quality meeting on June 14, 2001. The planning team thought it was important to present to this possibly broader audience. Over 30 people were in attendance. The presentation was filmed and aired on Channel 8 and is available at the Boulder Public Library.

3.4.2.5 Recreation Public Meeting

The third public meeting addressed recreational issues. The meeting was held on Thursday, August 2, 2001, at the Nederland Community Center. Since the management planning team had received a large number of comments regarding recreation from people in the Nederland area, the planning team felt it was appropriate to hold the meeting in that community. Approximately 60 individuals attended. Following a brief recreation presentation given by the project team's recreation specialist, there was a question and answer period giving participants the opportunity to ask about the project. City staff and members of the consultant team answered questions regarding boating on Barker Reservoir, camping in Boulder Canyon, fishing, instream flows and more. Following this question period there was a comment period where approximately 20 people voiced their opinions. The main focus of the comments was on non-motorized boating. People spoke both for and against boating, although more people who spoke at this meeting were in favor of non-motorized boating than against it. Other comments included concerns about dogs and dog waste around the reservoir, paying a fee to access the reservoir, trash associated with increased recreation, fishing opportunities and the possible relocation of Nederland's wastewater treatment plant. The presentation and question and answer portion of this meeting was recorded and aired by Channel 8, and a video copy is available at the Boulder Public Library. In addition, a written summary of the question and answer session was posted on the project Web site and is included in Appendix E.

3.4.2.6 Hydropower and Watershed Operations Public Meeting

The fourth public meeting in a series of four focused on hydropower and operations. The meeting was held on Wednesday, August 29, 2001, at the Boulder Public Library Auditorium. The management planning team chose to hold the meeting at this location because it is in Boulder, but is still reasonably close to Boulder Creek Canyon and Nederland. Approximately 23 individuals attended this meeting.

Following presentations given by the project team, there was a question period giving participants the opportunity to ask about the project. City staff and members of the consultant team answered questions regarding instream flow levels, Barker trail safety, the relocation of the Nederland wastewater treatment plant, funding sources for facilities maintenance, and water rate increases. Following this question period, there was time allowed for comments but none were made.

This meeting was recorded and aired by Channel 8 and a video copy of this presentation is available at the Boulder Public Library. In addition, a written summary of the question and answer session is posted on the project Web site and is included in Appendix E.

3.4.3 Public Input

Encouraging and facilitating public comments on the Middle Boulder Creek Source Water Management Work Plan was a primary objective of the planning study. To meet this objective, the team developed a multi-faceted comment solicitation program to allow as many people as possible to easily provide input into the plan:

- Public meetings (See 3.4.2, above) with opportunities to ask questions or make comments either verbally or in writing and to talk directly to the project team members
- Small group meetings
- A designated Community Liaison on the planning the team, to give interested members of the public a point of contact and to direct comments to the appropriate team member
- A project telephone number to call with questions and comments
- An email comment link from the project Web site
- Preprinted comment cards to mail to the Utilities Division
- A project address to which to send letters

All comments and respondent contact information were entered into a Microsoft Access© database which allowed comments to be sorted by a variety of variables. Thus, each team member could request public comments pertinent to a specific area of concern. The database was maintained by Utilities Division staff. A summary of comments received by primary area of interest is shown in Table 3.4.3.

TABLE 3.4.3
PUBLIC COMMENTS BY PRIMARY AREA OF INTEREST

Comments	Number Received
Water Quality (11)	
Concerns regarding pet waste near Barker Reservoir	4
Camping in Boulder Canyon (lack of sanitary facilities)	4
Concerns regarding Nederland's Wastewater Treatment Plant effluent	3
Effects of recreation on water quality (including a comment with pathogen concerns)	3
• Collaborative efforts are needed to reduce adding risks to water quality • Collaborative open space purchases could act as stream buffers • Land use planning needs to be reviewed in the watershed	One each
System Operations (8)	
Kossler access concerns (locked gates, public access, private property concerns)	4+
Barker Gravity Pipeline usage (for access, see Recreation)	2
• Concerns regarding measuring gages • Concerns that someone may be taking water illegally from Fourmile Canyon Creek	One each
Safety (8)	
Fire protection concerns (taxes for protection, camping along the creek, fire protection)	5
General safety concerns (emergency response)	3
Recreation (91)	
In support of non-motorized boating (including 4 for windsurfing and 13 that do not favor concessions or commercialization)	54
Not in support of boating (including 6 that list their reasons as safety-cold water and wind, trash, traffic, etc.)	19
In support of winter stream flows below Barker Dam for kayaking	6
Hiking trail near reservoir. (This includes 4 that would like a trail on the south side of the reservoir. Other concerns pertained to existing trail conditions and status.)	6
Traffic concerns	4

NOTE: Table 3.4.3 is a summary of comments received during the Work Plan development and public processes. The number in parenthesis to the right of each topic is the total number of people that commented on a particular topic. Since many people had multiple comments, the number of comments may be greater than the number of people who commented.

The project Web site was a valuable tool to disseminate project information to the public and encourage public comment. The project Web site was visited 399 times between May 2001 and October 2001. There was also extensive use of the email comment option. E-mailed comments from the project Web site were forwarded directly to the Community Liaison for response.

The project phone line was very useful to people who had questions about the Barker System and/or the management planning effort. Many callers expressed their appreciation for assistance in getting answers to questions. Several callers had heard about the project phone number from friends and called to request assistance in matters not related to the Barker System or the management plan.

Regardless of source, most comments were individually answered.

Small group meetings were arranged when neighbors or a group with a focused primary concern requested them. One such meeting was held for residents of the Kossler Reservoir area. In addition, Utilities Division staff provided the Boulder County Historic Preservation Advisory Board with a facility tour.

3.4.4 Public Comment on Draft Work Plan

The public had multiple opportunities to comment on the draft Work Plan. The Web site, phone line, and community liaison were available for receiving comments from the time of the draft's public release on March 19th up until its submittal to Boulder City Council in July of 2002. The last date comments were ensured considered for inclusion in the Work Plan was May 31. Comments could be made using the following methods:

- Call Kris Kranzush, Community Liaison at 303-441-4219
- Email barker-info@ci.boulder.co.us.
- Write to the City of Boulder, Barker Management Work Plan, 1739 Broadway, PO Box 791, Boulder, CO 80306
- Comment at the May 13 WRAB meeting.

Regardless of the method of submittal, all comments were treated equally.

The public also had opportunities to make comments at both Water Resource Advisory Board and City Council meetings. The Water Resources Advisory Board and City Council agendas are printed in the "News From City Hall" in the Sunday *Daily Camera* prior to the Monday and Tuesday meetings. Boulder City Council agendas, calendars and other information can be found at http://www.ci.boulder.co.us/council.htm. Meetings relevant to the Work Plan will also be noticed in the *Mountain Ear*.

3.5 Boulder City Council

Five Weekly Information Packets were sent to City Council as a part of this planning process and are included in Appendix A. Members of both City Council and the Water Resources Advisory Board (WRAB) were invited to all public meetings and were extended the same commenting opportunities as members of the public.

3.6 Presentation of Recommendations to Boulder City Council for adoption

Version 1 of this final Work Plan, dated June 20, 2002, which includes all revisions of the Draft Work Plan based on WRAB and public comments, is submitted to Boulder City Council on July 9, 2002, for final approval of recommendations based on the Work Plan.

Presentations of the Work Plan development process were made to WRAB on January 28, 2002. On May 13, WRAB voted unanimously to approve the Work Plan recommendations and to recommend them to the Boulder City Council. WRAB's recommendation to the Boulder City Council was designated to remain in effect if the Work Plan Development Team chose to make minor additions or modifications to the recommendations.

4 System Overview

The Middle Boulder Creek watershed, shown on Figure 4.1, is a major part of the Boulder Creek basin. It has a drainage area of about 40 square miles with land elevations ranging from 6,900 feet near Boulder Falls to 13,397 feet at the summit of South Arapaho Peak. Watershed precipitation averages about 27 inches per year while the natural stream flow leaving the watershed at the point where Middle Boulder Creek joins Main Boulder Creek averages about 43,000 acre-feet. Stream flow accounts for 66% of the watershed's precipitation, with the balance going to evaporation, transpiration and groundwater recharge. While the Middle Boulder Creek watershed represents only 10% of the total area of the Boulder Creek basin, it produces over 25% of Boulder Creek's natural flow.

Lands within the watershed are primarily montane and subalpine forests and alpine tundra. Most of the watershed is located within the Roosevelt National Forest. The watershed also includes the towns of Nederland and Eldora and parts of the Lake Eldora ski area. Reservoirs located in the watershed include Barker Reservoir (approximately 11,700 acre-feet), Jasper Reservoir (326 acre-feet), Peterson Lake (260 acre-feet) and Skyscraper Reservoir (146 acre-feet).

The Barker system, shown on Figure 4.2, includes Barker Dam and Reservoir, Barker Gravity Pipeline, Kossler Reservoir, Boulder Canyon Hydro Penstock, Boulder City Pipeline #3 and Boulder Canyon Hydroelectric plant. Boulder City Pipeline #3 is considered to consist of the Barker Gravity Pipeline, the Boulder Canyon Hydro Penstock and the pipeline running from Boulder Canyon Hydro up to Betasso Water Treatment Plant. Barker Reservoir is an on-stream reservoir that receives the entire flow of Middle Boulder Creek. Water is released from Barker Reservoir via the Barker Dam outlet works, which delivers water to the Barker Gravity Pipeline or to Middle Boulder Creek below the dam. During periods of high flow when the reservoir is full, water also passes over the spillway at Barker Dam directly to Middle Boulder Creek. The Barker Gravity Pipeline flows to Kossler Reservoir. Kossler Reservoir releases water into the Boulder Canyon Hydro Penstock, which delivers water either to the Boulder Canyon Hydro plant or to the lower portion of Boulder City Pipeline #3. Water entering the Boulder Canyon Hydro plant is used to generate electricity and is discharged to Boulder Creek just below the plant. Water entering the lower portion of Boulder City Pipeline #3 is delivered to the city's Betasso Water Treatment Plant (WTP).

Middle Boulder Creek is an important water supply source for the city of Boulder, providing about 40% of the city's annual water supply. The city gets its water supply from three primary sources: Middle Boulder Creek via the Barker Gravity Pipeline, North Boulder Creek and the Silver Lake Watershed via the Silver Lake and Lakewood Pipelines, and the Colorado River via the Colorado-Big Thompson (CBT) and Windy Gap projects. Water from Middle and North Boulder Creeks is delivered to the city's Betasso Water Treatment Plant while CBT and Windy Gap water is delivered to the city's Boulder Reservoir Water Treatment Plant.

Boulder uses the Barker system to divert water for immediate use and to store in Barker Reservoir for later use. Most of Boulder's water rights at Barker are very junior and are normally in priority only during May and June in average to above-average runoff years.

However, Boulder also has an exchange right that allows the city to divert water into Barker Reservoir or the Barker Gravity Pipeline at times when Boulder's junior water rights would be out of priority in exchange for release of a like amount of Boulder's CBT, Windy Gap, or Baseline Reservoir water to Boulder Creek.

5 Sub-Basins

5.1 Introduction

For purposes of planning and management, the Middle Boulder Creek watershed can be conceptualized as four sub-basins or segments:

1. Barker watershed—that portion of the watershed that drains into Barker Reservoir, including Middle Boulder Creek upstream from Barker Dam.
2. Kossler Reservoir—located on a ridge between South Boulder Creek and Main Boulder Creek. The reservoir has a very small watershed and is fed almost entirely by the Barker Gravity Pipeline.
3. Middle Boulder Creek—that portion of the watershed between Barker Dam and the confluence of Middle Boulder Creek and North Boulder Creek.
4. Main Boulder Creek—although Main Boulder Creek is technically downstream from the Middle Boulder Creek Watershed, flows in Main Boulder Creek are affected by Middle Boulder Creek facility operations and are thus partially governed by this Work Plan.

5.2 Barker Watershed

5.2.1 Description

The Barker watershed encompasses about 40 square miles ranging in elevation from 13,397 feet at the Continental Divide to 6,900 feet at the Middle Boulder Creek Confluence with Main Boulder Creek. The watershed includes the Towns of Nederland and Eldora, as well as numerous smaller settlements (see Figure 4.1). The area was originally settled by gold and silver miners in the late 1800s. The watershed is predominantly federal land (Arapaho and Roosevelt National Forest), with numerous private holdings. The watershed boundaries are approximated by Hurricane Hill-Barker Dam-Tungsten Mountain to the east, Tennessee Mountain-Bryan Mountain-Guinn Mountain to the south, the Continental Divide from Rollins pass to South Arapaho Peak to the west, and Bald Mountain-Caribou Hill-Caribou Road-Ridge Road to the north. The Indian Peaks Wilderness occupies the western quarter of the watershed.

5.2.2 Climate

Annual precipitation is dominated by winter and spring snowfall and summer convective thunderstorms. Snow accumulation begins anytime from early October to late November, and spring runoff normally begins in May or early June. Seasonal temperature variations are related to elevation, with shorter summer and longer winter periods at higher elevations. The Continental Divide commonly experiences extreme weather conditions with temperatures below –30°F and winds in excess of 100 mph. Average monthly minimum and maximum air temperatures and precipitation amounts at Nederland are shown in Table 5.2.2.

TABLE 5.2.2
MEAN MONTHLY CLIMATE DATA FOR NEDERLAND, YEARS 1970 - 1988

Climate Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min. Temp. (°F)	10.2	13.8	16.4	22.5	29.3	37.1	42.6	41.2	33.8	25.3	17.5	12.5
Max. Temp. (°F)	34.9	38.2	41.5	48.9	57.8	69.2	75.2	73.1	65.5	55.6	43.1	37.0
Precipitation (in)	0.5	0.6	1.3	2.2	2.7	1.7	2.4	2.0	1.7	1.0	1.1	0.7

5.2.3 Environmental Setting

Barker Reservoir lies within the montane life zone of the eastern flank of the Rocky Mountain Front Range. Its watershed grades upward into the subalpine life zone toward the Continental Divide to the west, and is characterized by a mix of upper montane, subalpine, and alpine plant communities consisting of aspen, Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), tundra, and rock outcrops. Shoreline vegetation around Barker Reservoir is limited due to the steep terrain and fluctuations in reservoir levels. Section 17.1 provides a more detailed description of the Barker watershed environment.

5.2.4 Water Resources and Uses

The annual pattern of winter snowfall and spring snowmelt runoff dominates the hydrology of this portion of the Middle Boulder Creek watershed, with convective storms providing locally significant events during summer months. The flow of Middle Boulder Creek as it enters Barker Reservoir has been measured by the stream gage on Middle Boulder Creek at Nederland, Colorado. This gage has been in operation since June 1, 1907. As measured by this gage, average annual inflow into Barker Reservoir is about 40,000 af and has ranged from 18,900 AF in 1954 to 60,250 AF in 1957. Peak flows into Barker Reservoir typically average around 260 cfs during June, but may be as high as 600 cfs in very high runoff years or during extreme summer precipitation events. Flows typically taper off to around 30 cfs by the end of August, and drop to base flow levels of about 5 cfs during January and February, although winter flows less than 3 cfs have occasionally been recorded. Significant tributaries include Jasper Creek, and the North and South Forks of Middle Boulder Creek, which join to form Middle Boulder Creek near the Hessie town site.

Major water uses have historically been diversions for hydropower generation by PSCo and diversions for municipal purposes by the city of Boulder, which have both occurred at Barker Reservoir. Other water uses in the basin consist of private domestic wells and municipal diversions from Middle Boulder Creek above Barker Reservoir by the town of Nederland. Daily records exist for diversions at Barker Reservoir and Barker Reservoir storage levels. Water quantity and water quality are described in greater detail in Sections 8 and 9. Aquatic habitats and recreational fisheries are described in greater detail in Sections 10, 11, and 17.

5.2.5 Land Resources and Uses

The Barker watershed, which is about 40 square miles, is well forested and includes the Indian Peaks Wilderness, several historical mining sites, the towns of Nederland and Eldora, and the Eldora Ski Resort (see Section 5.2).

5.2.5.1 Ownership

Seventy percent of the Barker watershed is within the Roosevelt National Forest, forty percent of which is designated as the Indian Peaks Wilderness. Both of these areas are managed by the U.S. Forest Service (USFS). Private land comprises approximately five percent of the watershed and is primarily concentrated upstream of and around the Town of Nederland; in the Eldora Ski Area; and along tributaries such as North Beaver Creek, Coon Track Creek, and the North Fork of Middle Boulder Creek.

5.2.5.2 Development

The majority of development in the Barker Watershed occurs around the Town of Nederland. Nederland has seen significant growth over the past decade. U.S. Census data show that the population of Nederland increased from 1,099 in 1990 to 1,394 in 2000, an increase of 27 percent. Although the large portion of federally owned lands in the watershed will limit development, private land development will concentrate closest to Barker Reservoir and along tributaries. In addition, development also includes the conversion of once seasonal residences to year-round residences.

5.2.5.3 Mining

The Town of Nederland and the surrounding area have been home to mining since the early 1900s. Tungsten, a steel-hardening alloy, was milled at the Caribou Mill beginning in 1905. The Caribou Mill was subsequently replaced with the Wolf Tongue Mill, which has not operated since the early 1970s. During the turn of the century, the Caribou District in the Middle Boulder Creek Valley was active with heavy mining for gold and silver. However, the majority of mining operations have been abandoned. The watershed includes over 30 historical mining operations, including a quarry/gravel pit mine on Middle Boulder Creek between Eldora and Nederland.

5.2.5.4 Recreation

Dispersed (undeveloped/backcountry) recreation activities are very popular in the watershed, particularly in the portion of the Roosevelt National Forest designated as the Indian Peaks Wilderness. Indian Peaks is one of the most frequently visited wildernesses in the state due to its proximity to the Denver-Boulder metropolitan area. About ten percent of the wilderness falls within the Middle Boulder Creek Watershed. Dispersed recreation also occurs outside the wilderness boundary in the remaining portions of the Roosevelt National Forest. Two USFS trailheads in the watershed accommodate about 24,250 hikers per year. Popular activities include scenic viewing, hiking, climbing, backpacking, picnicking, mountain biking, nature appreciation, fishing, horseback riding, four wheel driving, cross-country skiing, snowshoeing and snowmobiling. Neither motorized activities nor mountain biking are allowed within the wilderness. The Eldora Ski Area is located on both private and federally owned land. Approximately 245,000 skiers visit Eldora each year.

5.2.5.5 Silviculture

Silviculture activities are minimal and concentrated around the Eldora Ski Area.

5.2.6 Related Topics

- Barker Reservoir – see Section 6.1.
- Barker Dam – see Section 6.2.
- Water Quantity – see Section 8.
- Water Quality – see Section 9.
- Recreation – see Section 11.
- Historic and Archaeological Resources – see Section 15.

5.2.7 Known Issues

- Fire Management – see Sections 9.4.2.8, 9.9.2, and 16.4.3.2.
- Traffic – see Sections 5.4.5.2, 9.4.2.3, and 9.4.2.10.
- Wastewater and Individual Sewage disposal Systems – See Sections 9.3.2, 9.4.1.1, 9.4.2.1, and 9.4.3.1
- Development and Stormwater Runoff – see Sections 9.4.2.3, 9.4.2.13, and 9.4.2.14.

5.3 Kossler Watershed

5.3.1 Description

Kossler Reservoir is the staging reservoir for water delivered from Barker Reservoir to the Betasso WTP or the Boulder Canyon Hydro plant. Kossler is situated at an elevation of about 7,600 feet, just south of Flagstaff Road (County Road 77, about 1.5 miles west of the summit of Green Mountain; see Figure 4.2). Kossler is located on a ridge between South Boulder and Main Boulder Creek. There is almost no land tributary to Kossler; the reservoir is fed entirely by the Barker Gravity Pipeline. Kossler is surrounded by private property and some private homes.

5.3.2 Climate

While there is no on-site monitoring of meteorological data at Kossler Reservoir, climate at Kossler Reservoir is similar to that observed at Barker Reservoir and the town of Nederland, but slightly warmer given its lower elevation. Refer to Tables 5.1 and 5.3 for representative weather data.

5.3.3 Environmental Setting

The area around the Kossler Watershed contains a rich mosaic of mountain habitats. Ponderosa pine and Douglas-fir forests are interspersed with open meadows and aspen groves. Various small streams dissect the hills before joining either Middle or South Boulder Creeks. In the stream riparian areas, there is a diversity of plants and a variety of songbirds. Elk (*Cervus elaphus*) migrate to the area from higher elevations during the winter, and mule deer (*Odocoileus hemionus*) are year-round residents. Section 17.3 provides a more detailed description of the Kossler Watershed environment.

5.3.4 Water Resources and Uses

Kossler Reservoir is supplied by water from the Barker Gravity Pipeline and delivers water to the Boulder Canyon Hydro plant and the Betasso WTP through the Boulder Canyon Hydro Penstock. Kossler has historically been kept full during May through October. During this period, PSCo operated the Boulder Canyon Hydro plant on a run-of-the-river basis and did not make drastic drawdowns to Kossler Reservoir. From November through April, PSCo's peaking hydropower operations caused significant daily fluctuations in Kossler water levels, as PSCo would operate the hydro plant at peak capacity for a few hours each evening, then close the penstock and allow Kossler to refill. PSCo has maintained daily records of Kossler Reservoir gage height, inflows and outflows since 1937.

Water quantity and water quality are described in greater detail in Sections 8 and 9.

5.3.5 Land Uses

County Road 77 (Flagstaff Road) runs along the north side of Kossler Reservoir, which is located at the divide of the Middle and South Boulder Creek Watersheds. Due to its location at the ridgeline of the watershed, the reservoir has a very small watershed, on the order of 40 acres (see Section 17.3).

5.3.5.1 Ownership

The Kossler Reservoir has a small watershed, which is primarily owned by the city of Boulder.

5.3.5.2 Development

The watershed has limited development, which is not anticipated to increase. A chain-link fence with restricted entrance protects the reservoir.

5.3.6 Related Topics

- Barker Pipeline – see Section 6.3.
- Boulder Canyon Hydro – see Section 6.6.
- Betasso Water Treatment Plant – see Section 6.7.
- Facility Operations – see Sections 18.5 and 18.6.
- Water Quality – see Section 9.
- Recreation – see Section 14.
- Historic and Archaeological Resources – see Section 15.

5.3.7 Known Issues

- Fire Management – see Sections 9.4.2.8, 9.9.2, and 16.4.3.2.
- Access – see Sections 9.4.2.10 and 14.

5.4 Middle Boulder Creek Downstream from Barker Dam

5.4.1 Description

Middle Boulder Creek below Barker Dam flows eastward through a narrow (one to two mile wide), sometimes deeply incised canyon for approximately six miles before it joins North Boulder Creek just below Boulder Falls. Downstream of the confluence, the creek is known as Main Boulder Creek or simply Boulder Creek (see Section 5.5). Middle Boulder Creek drops from an elevation of 8040 at the toe of Barker Dam to about 6880 ft at the North Boulder Creek confluence. This portion of the Middle Boulder Creek watershed has a drainage area of about nine square miles. It is bounded approximately by Ridge Road on the north and a line about one-half mile north of Magnolia Road on the south. This portion of the watershed has very little developed land and there are no incorporated towns in this area. The Barker Gravity Pipeline, which feeds Kossler Reservoir, runs along the southern ridgeline of this canyon. Leakage from the Barker Gravity Pipeline returns to Middle Boulder Creek along this reach.

5.4.2 Climate

Climate is increasingly temperate as one moves east in this area, away from the alpine and sub-alpine areas near the Continental Divide. Seasons are similar to those described previously, although snowfall is significantly less, and summer convective storms make up a larger proportion of annual precipitation. Temperature ranges are from daytime highs in the 80s during summer to sub-zero conditions in winter. The narrow canyon causes significant shading of solar radiation during winter months, keeping daytime temperatures low, particularly on north-facing slopes of the canyon.

5.4.3 Environmental Setting

Montane riparian forests primarily characterize the forested community along Middle Boulder Creek downstream from Barker Dam. The forested community is dominated by narrowleaf cottonwood (*Populus tremuloides*), blue spruce (*Picea pungens*), and Engelmann spruce (*Picea engelmannii*). The shrub understory consists of willow (*Salix* sp.), river birch (*Betula fontinalis*), alder (*Alnus incana*), mountain maple (*Acer glabrum*), chokecherry (*Padus virginiana*), and ninebark (*Physocarpus monogynus*). Middle Boulder Creek supports a diversity of riparian habitat throughout its course. Section 17.4 provides a more detailed description of Middle Boulder Creek downstream from Barker Dam.

5.4.4 Water Resources and Uses

The primary source of stream flow in this segment of Middle Boulder Creek is outflow from Barker Reservoir. PSCo has recorded daily flows in Middle Boulder Creek at a point approximately 800 feet below Barker Reservoir since the late 1930's using its 'channel weir', also called the "800-foot weir." However, recorded flows at the weir are incomplete and the weir's accuracy has been questioned. Flows below Barker can also be reconstructed using PSCo's daily data for the Nederland gage, Barker Reservoir contents and Barker Gravity Pipeline flows, all of which are relatively complete.

This section of Middle Boulder Creek experiences a significantly altered flow regime compared to upstream of Barker Reservoir, due to the reservoir's operations. During May through August, the stream flow below Barker Reservoir generally follows a snowmelt-driven flow regime, although flows are significantly reduced due to diversions at Barker. Very rapid increases in flow typically occur in mid-June of years with average and above-average snow pack when Barker Reservoir begins to spill. During September through April, there has historically been virtually no stream flow below Barker due to diversions for PSCo's hydropower operations. Since Boulder acquired Barker Reservoir in March of 2001, the city began bypassing a minimum of 3 cfs below Barker. As it runs downstream from Barker Dam, Middle Boulder Creek gains small amounts of additional flow from local runoff, groundwater inflow and leakage from the Barker Gravity Pipeline.

There are no significant surface water rights in this reach of the creek. Some fishing and kayaking activities occur along this section of the creek, although not as great as further downstream. Water quantity and water quality are described in greater detail in Sections 8 and 9. Aquatic habitats and recreational fisheries are described in greater detail in Sections 12.4 and 17.4.

5.4.5 Land Uses

5.4.5.1 Ownership

Below Barker Reservoir, the watershed is relatively narrow with residential development along tributaries and County Roads 122 and 128. The largest portion of these watershed lands is owned by Boulder County Parks and Open Space (32 percent) and the USFS (34 percent).

5.4.5.2 Traffic

State Highway (SH) 119 parallels Boulder Creek through the canyon, providing a major transportation corridor and access for residents and visitors between the city of Boulder, the Town of Nederland, the Peak to Peak Highway, and the Indian Peaks Wilderness. Traffic and parking along the creek continues to increase over time with the increasing population in Boulder and Nederland. Designated parking areas provide access to recreation areas, but parking can be limited for day visitors. Informal pull-off areas have developed along the length of SH 119. Over the past ten years, the average daily number of cars using SH 119 increased by over 70 percent. During approximately the same period, the number of residents in Nederland and Boulder increased by 27 and 14 percent, respectively. SH 119 traffic counts in the years 1990 and 1999/2000 are summarized in Table 5.4.5.2.

TABLE 5.4.5.2
HIGHWAY 119 TRAFFIC COUNTS, 1990 AND 1999/2000

Year	Annual Daily Average Traffic Counts[1] (Number of cars)	Population[2]		
		City of Boulder	Town of Nederland	Boulder County
1990	2,700	83,312	1,099	225,339
1999/2000	4,668	94,673	1,394	291,288
Increase	73%	14%	27%	29%

NOTES:

(1) Colorado Department of Transportation, 1999.
(2) U.S. Census, 2000.

5.4.5.3 Recreational Access

Recreation activities along Middle Boulder Creek include picnicking, scenic viewing, limited hiking, fishing, and nature appreciation. Access to Middle Boulder Creek varies from relatively easy to very difficult as a result of steep terrain and limited parking along SH 119 (see Section 12).

5.4.6 Related Topics

- Barker Reservoir – see Section 6.1.
- Barker Dam – see Section 6.2.
- Water Quantity – see Section 8.
- Water Quality – see Section 9.
- Facility Operations – see Section 18.
- Recreation – see Section 12.

5.4.7 Known Issues

- Fire Management – see Sections 9.4.2.8, 9.9.2, and 16.4.3.2.
- Camping – see Sections 9.4.2.12.3 and 12.7.
- Traffic – see Sections 5.4.5.2, 9.3.2.3, and 9.4.2.10.
- Instream Flows – see Sections 8.3, 12.4, and 18.4.
- Aquatic Habitat – see Section 17.4.3.
- Ice Climbing – see Section 12.3.

5.5 Main Boulder Creek

5.5.1 Description

Main Boulder Creek (or simply Boulder Creek) begins at the confluence of Middle and North Boulder Creeks just below Boulder Falls, approximately 8 miles upstream from the mouth of Boulder Canyon, and about 6 miles below Barker Dam. Highway 119 parallels the creek as it passes through Boulder Canyon. The creek runs east-northeast from an elevation of 6880 ft at the confluence, dropping to 5500 ft through the city of Boulder, then running southeast of Longmont, where it joins the St. Vrain River at an elevation of 4900 ft. The entire Boulder Creek watershed has a drainage area of about 439 square miles. Municipalities located within the watershed include Boulder, Lafayette, Louisville, Superior, Erie and Nederland.

5.5.2 Climate

Climate is much warmer at Main Boulder Creek than in the western part of the Boulder Creek watershed. There is winter snowfall, but not in amounts great enough to generate large spring runoff patterns (other than those entering from the North and Middle Boulder Creek watersheds upstream). Precipitation is dominated by short-lived events, with convective storms occurring from spring through fall. Average monthly air temperature and precipitation data for the city of Boulder are shown in Table 5.5.2. Winds are predominantly from the west, sometimes in excess of 100 mph during late winter and early spring. These ‘Chinook’ winds often bring unseasonably warm temperatures, caused by adiabatic heating as air descends some 8,000 ft from the continental divide.

TABLE 5.5.2
MEAN MONTHLY CLIMATE DATA FOR BOULDER, YEARS 1948 - 1998

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Temp (^{O}F)	20.1	23.6	27.8	35.6	44.6	53.1	58.6	57.5	49.1	39.2	28.6	22.9
Max Temp (^{O}F)	45.1	48.5	53.8	62.4	71.7	81.9	87.3	85.6	77.7	67.3	53.4	47.0
Precipitation (in)	0.7	0.8	1.7	2.4	3.1	2.2	1.9	1.5	1.6	1.3	1.2	0.7

5.5.3 Environmental Setting

The uplands along Main Boulder Creek are dominated by ponderosa pine woodlands on south-facing slopes, lower montane coniferous forest on north-facing slopes and deep canyons, aspen forests in moist intermittent drainages, and mixed grasslands. Nearby barren rock outcrops and cliffs support lichen and moss communities. Riparian and wetland communities are limited but are found along Boulder Creek, tributary drainages, and at seeps and springs.

5.5.4 Water Resources and Uses

Significant tributaries to Boulder Creek include Four Mile Creek, Bear Creek, South Boulder Creek, Dry Creek and Coal Creek. Boulder Creek also receives flow contributions from the Boulder Canyon Hydro plant, the Boulder Creek Supply Canal, Baseline Reservoir, Valmont Reservoir, Panama Reservoir, several municipal wastewater treatment plants, irrigation return flows and stormwater runoff.

Irrigation is the primary water use along Main Boulder Creek. There are 13 significant irrigation diversion points on the Creek (from upstream to downstream): Silver Lake Ditch, Anderson Ditch, Farmers Ditch, the "12th Street Diversion" at Broadway, Butte Mill Ditch, Green Ditch, Leggett Ditch, Lower Boulder Ditch, Boulder and Weld Ditch, Howell Ditch, Godding, Plumb and Dailey Ditch, Idaho Creek Ditches, and Rural Ditch.

Municipal and industrial use of water from Main Boulder Creek is relatively limited. The Wellman Canal diverts water from Boulder Creek at 28th Street for the primary purpose of supplying water to the Valmont Reservoir complex, which is used for power generation cooling by Xcel Energy Company. Boulder diverts a small amount of water to its Boulder Reservoir WTP the via the Farmers ditch. Lafayette has occasionally diverted water from Boulder Creek via the Lower Boulder Ditch for municipal purposes.

Main Boulder Creek provides for a large number of recreation activities in an attractive setting. Eben G. Fine Park is located along the creek near the mouth of the canyon and provides quality visitor amenities. Activities in the park include fishing, tubing, kayaking, wading, scenic viewing, nature appreciation and picnicking. The creek is also a significant visual resource.

Water quantity and water quality are described in greater detail in Sections 8 and 9. Aquatic habitats and recreational fisheries are described in greater detail in Sections 13.1 and 17.4.

5.5.5 Land Uses

5.5.5.1 Ownership

Ownership of private lands and development adjacent to Boulder Creek increases within the Main Boulder Creek watershed as the creek approaches the city of Boulder. Private ownership of lands higher in the watershed occurs mostly in the Sugarloaf and Magnolia Mountain areas. Portions of the watershed, close to the city, also include Boulder Mountain Parks and city and county open space lands.

5.5.5.2 Development

Development adjacent to the creek increases closer to the city of Boulder. Development higher in the watershed is focused in the Sugarloaf and Magnolia Mountain areas. However, building restrictions in these areas limit housing density.

5.5.5.3 Instream Flows

Prior to development of instream flow programs for Boulder Creek, diversions for irrigation, storage and power generation frequently resulted in periods of zero flow within certain segments of Boulder Creek, particularly between Broadway and 75th Street, usually during August through April.

In 1973, the Colorado Water Conservation Board (CWCB) obtained a 15 cubic feet per second (cfs) instream flow right on Boulder Creek between the Orodell gage and 75th Street. While this right is very junior in priority, it served to prevent further reductions in stream flows during low flow periods caused by new water development projects or changes in water rights.

In the early 1990’s, Boulder entered into agreements with the CWCB whereby Boulder dedicated some of its senior water rights to help maintain instream flows in Boulder Creek. In 1993, the Division 1 Water Court entered a decree that changed these water rights to allow for instream flow as an alternate use. These agreements and decree are the basis for the Boulder Creek instream flow program (the Instream Flow Program).

As a result of the Instream Flow Program, flows in Boulder Creek between Orodell and 75th Street have rarely dropped below 4 cfs during August and September or below 1.5 cfs during October through April.

5.5.5.4 Recreational Access

Main Boulder Creek is highly accessible via the Boulder Creek Path and Eben G. Fine Park, Boulder's premiere creek-side park. There are also some access points along SH 119 (Canyon Boulevard in Boulder) including a tubing put-in location (see Section 13).

5.5.6 Related Topics

- Barker Reservoir – see Section 6.1.
- Barker Dam – see Section 6.2.
- Water Quantity – see Section 8.
- Instream Flows – see Sections 8.3, 12.4, and 18.4.
- Recreation – see Section 13.

5.5.7 Known Issues

- Kayaking – see Section 13.
- Peaking Flows – see Sections 13 and 18.5.4.1.
- Aquatic Habitat – see Section 13.

5.6 Existing Source Material of Special Relevance to Sub-Basins

5.6.1 Middle Boulder Creek Watershed

Brown and Caldwell, Camp Dresser & McKee, Inc. 2000. *Boulder Creek Watershed Geographic Information System Data.* Boulder Creek Watershed Study – Phase II.

Brown and Caldwell. 1992. *Water Source Impact Assessment.* Developed for the city of Boulder.

Brown and Caldwell, Camp Dresser & McKee, Inc. 2000. *Boulder Creek Watershed Study – Phase II*. Developed for the city of Boulder.

Colorado Department of Transportation. 1999. *Traffic Counts 1990-1999.*

Public Service Company of Colorado, system records currently being inventoried.

U.S. Census. 2000. *U.S. Census Data.* Internet address: http://www.co.boulder.co.us/lu/demographics/census2000.htm.

USFS 2000. Visitation Data.

6 System Facilities

6.1 Barker Reservoir

6.1.1 Description

Barker Reservoir is located on Middle Boulder Creek near the Town of Nederland, Boulder County, Colorado. The reservoir has a surface area of approximately 200 acres (FERC, 1995) and can hold approximately 11,700 af of water. There is a weir at the west end of the reservoir that measures the inflow of Middle Boulder Creek and records this on a chart. Barker Reservoir serves primarily as a drinking water source for the city of Boulder.

The Middle Boulder Creek watershed, of which Barker Reservoir is a part, is located in a mountain region. Areas that average 10,000 feet in elevation average 30 inches of precipitation per year, whereas lower elevations (average 5,000 feet in elevation) average 12 inches per year (Patterson, 1980). Most of the Middle Boulder Creek watershed lies in the Roosevelt National Forest, including the westernmost region, which is designated the Indian Peaks Wilderness (see Section 17.1).

6.1.2 Known Issues

- Water quality – see Sections 9.3, 9.4, and 9.6.
- Boating – see Section 11.6
- Located next to Hwy 119 – see Section 9.3.2.10
- The Town of Nederland's wastewater treatment plant effluent – see Section 9.4.1.1
- Periodic draw down of Barker Reservoir – see Sections 18.3.2.8 and 16.2.1.
- Drought Pool – see Section 18.3.2.3.2.
- Security concerns since September 11th – see Sections 7.2.2, 9.9.6, and 16.2.7.
- Sampling, data collection – see Section 9.2.
- Fish stocking – see Section 11.3
- Wildfire threat – see Section 16.4.3.2
-

6.2 Barker Dam

6.2.1 Description

Barker Dam was built in 1909 and is located 11.5 miles west of the Betasso Water Treatment Plant. The dam is 175 feet high with a crest of 720 feet and is made of cyclopean concrete. It has 2 (two) 36" diameter floodgates that discharge down the spillway and into Middle Boulder Creek. The outlet works include 10 outlet gates on the upstream face of the dam that discharge into a vertical, stair-step shaft in the dam that can release flows to Middle Boulder Creek and the Barker Gravity Pipeline. The city of Boulder is currently investigating improvements to the outlet works. As part of this investigation, the city is considering sealing 7 of the 10 original outlet gates and constructing new reservoir intake pipes.

6.2.2 Historic Upgrades and Current Condition

In 1946 - 1947, PSCo modified the outlet works on Barker Dam as well as made improvements to the upstream face of the dam. In 1971, the spillway was modified and cosmetic improvements were made to the downstream face of the dam (see Section 2.2.2). The dam was secured in the 1980s with post-tensioned anchors to increase the factor of safety. Other than these modifications, PSCo provided only routine maintenance.

The dam is currently in good condition and has passed its most recent (2002) FERC and State Engineering Office (SEO) inspections. The downstream face of the dam is cosmetically flawed, but the structure of the dam is sound.

6.2.3 Spillways and Outlets

The original spillway on Barker Dam was 40 feet wide and designed to carry about 1000 cfs. Even though 1000 cfs has never been spilled, in 1971, the spillway was enlarged to pass the Probable Maximum Flood. There were plans to remove a portion of the top of the dam north of the original spillway, however, the original spillway was left and a new 125-foot wide ogee crest was constructed. One center pier divides the spillway and supports a bridge 5 feet above the crest of the spillway. To contain flow over the extended spillway, the spillway has a curved channel with a warped floor (FERC, 1979). The new spillway will pass flood flows generated by a theoretical storm event located over the basin upstream of Barker Reservoir for a period of six hours. This storm would generate 2.45 inches of precipitation with peak flood outflows of 4,544 cfs.

The reservoir has historically been drained approximately every 5 years to facilitate inspection of the outlet works. The need to drain the reservoir compromises the reliability of Barker Reservoir as a source of water supply. A new planned bypass to facilitate outlet works releases is in progress, as explained in the next section.

6.2.4 Planned Improvements

A plan for new outlet works is currently under investigation. The plan being investigated includes three new reservoir intakes and a new intake shaft that would be separate from the existing outlet works. These proposed new outlet works would be capable of discharging 200 cfs to Middle Boulder Creek and 50 cfs to the Barker Gravity Pipeline under normal reservoir operations. The actual capacity of the outlet works will vary with the reservoir water surface elevation. Review and approval of the new outlet works by the Office of the State Engineer and by the Federal Energy Regulatory Commission is required.

6.2.5 Farmer's Gate

The farmer's gate is located on the south side of Barker Dam. This gate can pass approximately 250 cfs. The gate provides the capability to release water to downstream senior appropriators when there is a call on the river and junior water rights divertable at Barker are out of priority. Water can also be delivered to meet the call of downstream appropriators by discharging water to the creek at Boulder Canyon Hydro when the hydro is operating and capacity for generation exists in Barker Gravity Pipeline.

6.2.6 Known Issues

- Periodic draining of Barker Reservoir.
- Confined entry spaces. See section 16.4.5.

6.3 Barker Gravity Pipeline

6.3.1 Description

The Barker Gravity Pipeline is a buried 36" diameter concrete gravity flow pipeline that has a current capacity of about 43 cfs. The slope of the gravity pipeline is approximately 5% over 11.7 miles. The pipeline includes 5 tunnels and 7 inverted siphons. The pipeline is currently in disrepair and has several substantial leaks that account for approximately 10 % total water loss.

6.3.2 Ongoing and Planned Improvements

At times when the Barker Gravity Pipeline is not needed to deliver water to meet municipal demand, the city of Boulder intends to repair the gravity pipeline. These repairs are anticipated to take approximately five years.

6.3.3 Known Issues

- Ice Climbing Flow Releases – see Section 12.3.
- Penstock Corrosion Protection – see Section 6.3.
- Operations – see Section 18.3.1.7.
- Hiking Trails and Access to the pipeline – see Section 12.6.
- Wildlife Habitat – see Section 17.2.

6.4 Kossler Reservoir

6.4.1 Description

Kossler Reservoir is the forebay for the Boulder Canyon Hydroelectric Plant and is located 2 miles south of the plant. The Barker Gravity Pipeline ends at the southwest side of Kossler where there is a weir and a measuring device. The penstock gate house is located on the north side of the reservoir where there is another measuring device. Kossler has a total volume of 165 acre-feet and can be drawn down from maximum level to minimum level in seven hours of full generation at Boulder Canyon Hydro (FERC, 1979). Kossler Reservoir is closed to public access and recreation (see Sections 14 and 17.3).

6.4.2 Known Issues

- Sensitive wildlife and vegetation species – see Section 17.3.
- Restricted area – see Section 14.1.

- Fire protection – see Section 16.4.3.2.

6.5 Kossler Dams

6.5.1 Description

Kossler Reservoir is a crater type reservoir formed by one main dam and two small dams. The main dam is a 45-feet long, 20-foot high embankment, with an 8-feet wide crest. The upstream face of the main dam is covered with concrete (FERC, 1979). The two small dams are irregularly shaped, low embankments that fill in low areas along the reservoir rim.

6.5.2 Spillways and Outlets

There is no spillway on Kossler Dam as the reservoir has a limited natural drainage area, is filled via controlled releases, and is used as a regulating reservoir. The steel penstock to the Boulder Canyon Hydro Plant serves as the reservoir outlet. The penstock drops approximately 1,835 feet from Kossler Reservoir to the Boulder Canyon Hydro Plant.

6.5.3 Remediation

Current maintenance plans for Kossler Dam include removal of several trees near the embankment. A FERC inspection in 2001 found the dam to be in good condition. The city is currently preparing an emergency response plan for this reservoir.

6.5.4 Known Issues

- Sensitive species– see Section 17.3.

6.6 Boulder Canyon Hydro

6.6.1 Description

The Boulder Canyon Hydropower Plant, licensed by FERC, is located in Boulder Canyon along Boulder Creek and State Highway 119, approximately 3.25 miles west of Boulder. The hydro's generating units consist of two Pelton impulse wheels connected to two General Electric A.C. generators, both originally installed in 1909. These generators were rebuilt in 1936, which increased the rating of each generator to 10,000 kW at 80% power factor. Total plant rating is therefore 20,000 kW (FERC, 1979).

The penstock to Boulder Canyon Hydro consists of 9,340 feet of riveted steel pipe of varying diameter and unique construction (see Section 15.1). After the water delivered from the penstock is used to generate power, it is then discharged into Boulder Creek.

6.6.2 Condition

The Boulder Canyon Hydroelectric Plant was a small part of Public Service Company's power grid (less than 0.01% of their total power production), and therefore, maintenance at the plant was not a high priority for PSCo. There are numerous repairs needed at this hydroplant.

In late 2000, prior to the closing on the city's purchase of the Boulder Canyon Hydro Project from PSCo, the windings on one of the generator units grounded out. This event caused extensive damage to the generator and left it inoperable. There is currently only one turbine generator functioning in the plant, and there are no plans to repair the broken generator at this time. Current capacity at Boulder Canyon Hydro is 10 MW.

6.6.3 Ongoing and Planned Improvements

The city of Boulder has rehabilitated the overhead crane in the hydro plant since the purchase of the facility in March of 2001. The city also contracted with GE for cleaning of the 10,000 kW generator in 2001. A major leak in the wye joint of the pipe leading to the functioning turbine was repacked and sealed in early 2002. Routine maintenance is ongoing. Security has been increased at this facility since the terrorist attacks within the United Stated on September 11, 2001.

6.6.4 Contractual Obligations

The city is required to sell the energy produced at Boulder Canyon Hydro Plant to Xcel Energy in compliance with the 2000 Power Purchase Agreement between the city of Boulder and Public Service Company of Colorado. The city is also required by the Public Utilities Commission to attempt to produce the same amounts of energy as were historically produced at the Boulder Canyon plant in June, July and August. See the Power Purchase Agreement for more specific contractual obligations.

6.6.5 Peaking Power Operations

The city of Boulder purchased the Boulder Canyon Hydroelectric project to gain more control over the maintenance of the facilities and to increase the amount of reservoir storage space available for Boulder's municipal water supply. Previously, up to one-third of the water stored in Barker Reservoir was used solely to generate hydropower at the Boulder Canyon Hydro. PSCo placed most of this water in storage during the spring snowmelt of each year. The water was held for later release to generate peaking power within the PSCo power grid, most typically by releasing surges of water through the hydro plant to Boulder Creek on winter evenings. Since the city's purchase of the reservoir and associated facilities, the city has begun to use almost all of Barker Reservoir storage primarily as a municipal water supply with secondary power generation at the city's other six hydroelectric plants located within the municipal water system. Although the city will still generate power at Boulder Canyon Hydro Plant, the peak flows that flushed into Boulder Creek below the hydro plant due to PSCo's power peaking operations will no longer exist. The city of Boulder will rarely be generating peaking power since very little storage space in Barker Reservoir will be dedicated to storing water solely for peaking generation (see Section 13.1).

6.6.6 Run-of-River Operations

Historically, PSCo operated the Boulder Canyon Hydro on a run-of-river basis from about mid-April until November of each year. This means that they ran the hydro at a fairly constant power production level based on delivery of a continuous flow of water through the turbines derived from a continuous diversion of the water flowing from Middle Boulder Creek into Barker Reservoir. The water used to drive the turbines in this manner was most often diverted under PSCo's 1905 direct flow water right. This right was in priority whenever the river was running high due to snowmelt or storms or when water was required to be delivered to senior downstream appropriators below the Orodell discharge point. The 1905 direct flow right is a non-consumptive hydropower water right, so PSCo could run water that was called through Barker Reservoir for senior calls through the turbines before its release without harming any downstream appropriator.

The city of Boulder will continue to generate hydropower at Boulder Canyon Hydro on a run-of-river basis. This will occur only to the degree that there is capacity remaining in the Barker Gravity Pipeline after municipal water demands have been satisfied. Run-of-river operations can continue when the direct flow hydropower right acquired by the city from PSCo is in priority and/or when water must be delivered downstream to meet senior calls (see Section 2.3). These operations may sometimes be supplemented by releases of water stored under the Barker system storage right.

6.6.7 Balancing Water Supply Needs with Hydropower and Instream Flows

The city's first priority and obligation for use of its water utility assets is to provide a safe and reliable municipal water supply to its customers. However, the city also has contractual obligations to produce hydropower (see Section 7.6) and is committed to maintaining sufficient instream flows in Middle Boulder Creek. Boulder is currently working with the Colorado Water Conservation Board (CWCB) on a program to provide consistent instream flows in Middle Boulder Creek below Barker Dam (see Sections 12.4 and 18.4).

6.6.8 Known Issues

- Age and condition of facilities – see Sections 6.6 and 15.1.
- Peaking power and surge flows – see Sections 6.6.5, 13, and 18.5.4.1.
- Operations – see Sections 6.6.6, 18.
- Hydroelectric Power – see Section 2.3.2.1.
- Failed generator – see Section 6.6.2.

6.7 Betasso Water Treatment Plant

6.7.1 Description

Betasso Water Treatment Plant is one of two water treatment plants owned and operated by the city of Boulder. Betasso Water Treatment Plant (WTP) is the city's primary plant. It is located in the foothills west of Boulder. The Betasso plant processes water from the Barker and North

Boulder Creek systems. The Boulder Reservoir WTP is located northeast of Boulder and treats water delivered from the western slope through the CBT system.

Both water treatment plants are available for operation 24 hours per day, 365 days of the year. The Betasso WTP is almost always in service and flow through the plant can be adjusted up or down to meet demands. Throughout the treatment process, water is sampled and tested every two hours. This sampling is performed to make sure the plant processes are working properly and to guarantee that the water is potable before it leaves the plant. Potable water is defined as drinking water that satisfies all federal and state standards (city of Boulder, 2001a,b).

The Betasso WTP currently has the capability to treat a peak flow of approximately 40 mgd to the level required to meet current regulatory requirements based on a recent plant evaluation. When combined with replacement of the Lakewood Pipeline (planned by 2004) a capacity of 50 mgd could be achieved through improved performance of the flocculation/sedimentation processes. A treatment capacity of 50 mgd often meets or exceeds the amount of water developed under the city's current water rights. Consequently, a reliable treatment capacity of 50 mgd was set as the goal for the Betasso Water Treatment Plant (City of Boulder, 2001c).

6.7.2 Barker Reservoir Water Deliveries

Barker Reservoir water that is delivered to the Betasso Water Treatment Plant is transported through the Barker Pipeline to Kossler Reservoir, then through the Boulder Canyon penstock, and finally through a Howell-Bunger Valve at the treatment plant. The Howell-Bunger Valve is a pressure-reducing valve that is used to bring water being delivered through the penstock to atmospheric pressure at times when the Betasso hydro plant is not operating (see Section 6.8.1). Water arriving at Betasso through the penstock has a pressure of 500 psi. This water pressure must be dissipated either through the pressure-reducing valve or through the Betasso hydro plant prior to treatment.

6.7.3 Ongoing and Planned Improvements

Improvements to systems for handling water-treatment-process residuals at Betasso WTP are underway. Improvements to the existing solids handling facilities and the settling basins at the Betasso Water Treatment Plant began in 2000. The project includes improvements to the sludge drying beds and backwash system. The project provides for the equalization and treatment of backwash water and the capability to filter to waste, as well as improvements to the efficiency of the settling basins and effectiveness of the coagulant mixing.

In 2001, construction was completed on the conversion of the north drying beds to a sludge lagoon system, with miscellaneous improvements to the existing south lagoon. A new concrete backwash recycle equalization tank and a new recycle pretreatment building, with dissolved air flotation pretreatment process equipment, were also included. The existing backwash recovery tank was converted to a filter to waste tank. During 2002, new sludge collectors will be installed in the sedimentation basins.

6.7.4 Operational Choices

When Barker Reservoir water is delivered through the Barker system to Betasso WTP, the water is capable of being treated for drinking water and it can produce hydropower revenue. Generally, water will preferentially pass through Betasso Hydro to maximize revenue from power production; the Howell-Bunger Valve will only be used if the Betasso hydro plant is not operational or if it is advantageous to do so under the terms of the existing Power Purchase Agreement.

6.7.5 Impacts on Municipal Water Quality

The treatment processes employed at Betasso Water Treatment Plant are used to greatly improve the quality of our water supply to produce drinking water. However, these processes cannot remove all pollutants that could enter the water supply. Although the Betasso Water Treatment Plant produces potable water that meets all Federal and State standards, there are still risks involved in water treatment. The best way to protect a water source is to prevent pollutants from entering the water supply in the watershed (see Section 9.3).

6.7.6 Known Issues

- Water Supply – see Section 8.
- Drought Management – see Sections 18.3.
- Water Quality – see Section 9.
- Operations – see Section 18.
- Emergency Response Plan – see Section 16.

6.8 Hydroelectric Power Generation Coincident with Municipal Water Supply

6.8.1 Description

The city of Boulder owns and operates seven hydroelectric facilities: Boulder Canyon, Sunshine, Maxwell, Kohler, Lakewood, Silver Lake, and Betasso Hydropower plants. Boulder's power system generates enough electricity to supply more than 14% of the city's homes (based on a residential customer who uses 5600 kWh/year) and receives over $700,000 a year in revenue from hydropower generation. Hydropower is a renewable, nonpolluting source of power. Seven thousand tons of coal would need to be burned each year to generate the power that Boulder's hydropower plants produce.

This program to develop the city's hydropower plants started in the 1980's and is a byproduct of the municipal water delivery system. Pressure develops in a pipeline through the force of gravity when there is a drop in elevation from one point on the pipeline to another. This pressure needs to be reduced before entering into the water treatment plant and customers' homes. The city's water supply pipelines previously used pressure-reducing valves to dissipate this energy; however, since the installation of turbines and generators, the pressure generates power instead of being wasted.

6.8.2 Condition

The majority of the hydropower plants are in good working order. There is continuous maintenance to these facilities, and security at these facilities has been increased since the terrorist attacks of September 11, 2001.

6.8.3 Ongoing and Planned Improvements

There are several repairs planned for the hydropower plants in 2002. Kohler Hydro is scheduled to have a generator rebuilt next spring. Boulder Canyon Hydro is in need of several repairs (see Section 6.6.2). Maxwell Hydropower plant is scheduled for an overhaul in 2002.

6.8.4 Known Issues

- Operations – see Section 18.
- Security – see Section 16

6.9 Gaging Stations

The State of Colorado, Division of Water Resources, administers one gaging station on Middle Boulder Creek, "Middle Boulder Creek at Nederland" (BOCMIDCO), and one gaging station below the confluence of North Boulder and Middle Boulder Creeks, "Boulder Creek near Orodell" (BOCOROCO). Both of these gages transmit real-time stream flow data on the Colorado State Engineer's Web site at http://dwr.state.co.us/Hydrology/flow_search.asp. The city also has several measuring devices above and below Barker Reservoir (see Section 6.9).

6.10 SCADA system

There is a System Control and Data Acquisition (SCADA) system that collects lake elevation and flow data at Kossler Reservoir. This data is transmitted to Boulder Canyon Hydro Plant and to Betasso Water Treatment Plant. As part of the proposed outlet works modifications on Barker Dam, there may be improvements to a SCADA system at Barker Reservoir.

6.11 Existing Source Material of Special Relevance to System Facilities

6.11.1 Barker Reservoir

Patterson, Charles G. 1980. *Geochemistry of Boulder Creek, Boulder Jefferson and Gilpin Counties, Colorado,* University of Colorado Masters Thesis, Department of Geological Sciences.

Federal Energy Regulatory Commission, 1979. *Operating License for Boulder Canyon Hydroelectric Project*, acquired by the city of Boulder during purchase of the Project.

Federal Energy Regulatory Commission, 1995. *Operation Report (for Boulder Canyon Hydroelective Project),* San Francisco Regional Office.

6.11.2 Betasso Water Treatment Plant

City of Boulder, 2001a. Web site address http://www.ci.boulder.co.us/publicworks/depts/utilities/water treatment/about.htm

City of Boulder, 2001b. Web site address http://www.ci.boulder.co.us/publicworks/depts/utilities/water_quality/drinking/fact_sheets/2.htm.

Hydrosphere. Undated. *City of Boulder Treated Water Master Plan*, prepared for the city of Boulder.

7 Contracts, Laws, Regulations

7.1 Regulators

The city of Boulder's operations within the Middle Boulder Creek watershed are governed by regulators at the local, county, state, and federal levels. Table 7.1 summarizes the jurisdiction of the regulators in the watershed with special significance to the Boulder Canyon Hydroelectric Project.

TABLE 7.1
REGULATORS WITH JURISDICTION
IN THE MIDDLE BOULDER CREEK WATERSHED

Tier	Regulator	Jurisdiction
Federal	U.S. Forest Service	Special use permits
	Fed. Energy Regulatory Commission	Licensing of Barker and Kossler Dams and facilities
	Environmental Protection Agency	Water and Air
	Fed. Emergency Management Agency	Disaster assistance
	U.S. Army Corps of Engineers	Wetlands and Waters of the U.S.
	U.S. Fish and Wildlife Service	Threatened and Endangered Species
Colorado	State Engineer	Dam safety; water resources; water rights
	Dept. of Public Health & Environment	Source Water Assessment Program; drinking water; air pollution; wastewater; stormwater
	State Historical Preservation Office	Historical facilities
	Department of Transportation	State Highway 119
	Division of Wildlife	Hunting and Fishing
	Water Conservation Board	Instream flows
	Mine Land Reclamation Board	Mines
County	Boulder County	Land use; health (septic systems and air quality); Sheriff; transportation; BOCC; Boulder Valley Comprehensive Plan
City	City of Boulder	Management Work Plan; Boulder Water; Municipal Wetlands Permitting
	Town of Nederland	Nederland Waste Water Treatment Plant

7.2 Federal Regulators

Federal agencies with regulatory authority fall into three categories: facility regulators, such as the Federal Energy Regulatory Commission which licenses the Boulder Canyon Hydroelectric Project; agencies with resource concerns, such as the U.S. Army Corps of Engineers with jurisdiction over wetlands; and land managing agencies with management responsibility for property, such as the USFS.

7.2.1 Clean Water Act (33 U.S.C. s/s 1251 et. seq., 1977)

The term *Clean Water Act* (CWA) generally refers to the 1977 amendments to the Federal Water Pollution Control Act of 1972, a legislative act that set up the administrative structure for regulating discharges of pollutants to U.S. waters. The CWA sets the basic organization for regulating water pollution nationwide, including the discharge of pollutants from large industrial plants and sewage treatment facilities. Under the act, the release of all such pollutants, called point-source discharge, are permitted under the state's Colorado Discharge Permit System, which has primacy to implement federally mandated sewage treatment standards. The CWA also establishes guidelines for reducing nonpoint pollution, the runoff of toxic matter such as fertilizer, animal waste, motor oil, and pesticides from farms, streets and lawns into bodies of water. The CWA governs the permitted point source discharges, including the Nederland Wastewater Treatment Plant at the west end of Barker Reservoir.

The CWA gives the Environmental Protection Agency responsibility for establishing and maintaining water quality standards, and the states are responsible for enforcing them. The CWA authorizes the federal government to fund sewage treatment facilities and programs to reduce water pollution. Individual states develop and maintain the fund authorized by the CWA. The act encourages citizens and government to sue any person or organization that violates the CWA provisions (see Section 9.4).

The U.S. Army Corps of Engineers administers a permit program under Section 404 of the CWA, which regulates excavation and discharge of fill material into waters of the U.S., including wetlands. The Environmental Protection Agency (EPA) maintains veto power over the issuance of 404 permits.

7.2.2 Safe Drinking Water Act (42 U.S.C. s/s 300f et seq., 1974)

The Safe Drinking Water Act was established to protect the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designated for drinking use, whether from above ground or underground sources.

The act authorizes EPA to establish safe standards for safe drinking water and requires all owners or operators of public water systems to comply with primary (health-related) standards. State governments, which assume this primacy from EPA, also encourage attainment of secondary standards. The Safe Drinking Water Act is pertinent to all public water supplies in the basin, including the city of Boulder's water supplies in the Middle Boulder Creek basin.

The U.S. Congress is currently debating the amendment of the Safe Drinking Water Act to address terrorist and other intentional acts. If passed, the amendments will require that the city of Boulder complete a vulnerability assessment to identify the types of sabotage that could substantially disrupt the city's ability to provide a safe and reliable drinking water supply and an emergency response plan identifying procedures to be followed in the event of a terrorist attack on the water supply. The amendment will also authorize the federal government to review current and future methods to prevent, detect and respond to the intentional introduction of contaminants into community water systems and source water.

7.2.3 National Environmental Policy Act (42 U.S.C. s/s 4321 et seq., 1969)

The National Environmental Policy Act (NEPA) was one of the first laws ever written that establishes the broad national framework for protecting the environment. NEPA's basic policy is to assure that all branches of the federal government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment. For major federal actions, which include funding and authorizations as well as projects or programs proposed and undertaken by an agency of the federal government, assessments of the likelihood of impacts from alternative courses of action (e.g. Environmental Assessments or Environmental Impact Statements) are required. FERC licensing of the Boulder Canyon Hydroelectric Project, including project use of power reservations through USFS-managed lands, requires compliance with the National Environmental Policy Act.

7.2.4 Federal Power Act (16 U.S.C. s/s 792 et. seq., 1920; 41 stat 1063, as amended)

The Federal Power Act of 1920 created the Federal Power Commission to regulate the interstate activities of the electric power and natural gas industries. The Federal Power Commission at first confined itself to licensing hydroelectric projects located on U.S. government lands or navigable waters. A new Federal Power Act in 1935 incorporated the original Act and also gave the commission certain responsibilities relating to the adequacy and reliability of the nation's electric power supply and authority over the interstate transmission of electric energy and the wholesale rates for its sale. It also granted the commission authority to regulate securities, mergers, consolidations, acquisitions and accounts of electric utilities subject to its jurisdiction. The commission was responsible for seeking ways to meet the electric energy demands of the nation with minimum adverse environmental impact on air, land and water resources. It also ensured that the hydroelectric projects it licensed included recreation areas to enhance or preserve the beauty of the project grounds and waters. In 1978, the Federal Power Commission was abolished, and its duties were taken over by the Federal Energy Regulatory Commission (FERC).

Boulder Canyon Hydroelectric Project was licensed as Project No. 1005. The existing FERC license was transferred from PSCo to the city at the time of the city's purchase of the project in 2001.

Since September 11, 2001, FERC has contacted all owners of licensed and exempt hydroelectric facilities to classify all hydroelectric facilities under FERC jurisdiction in terms of vulnerability to potential threats to public safety and security and to suggest a variety of added security measures to safeguard the nation's hydroelectric facilities (see Section 16.2.7).

7.2.5 Federal Land Policy Management Act (43 U.S.C. s/s 1701, 1761-1777)

The Federal Land Policy Management Act (FLPMA) establishes public land policy and guidelines for its administration and provides for the management, protection, development and enhancement of public lands. In the Middle Boulder Creek watershed, the USFS uses a Forest Plan and issues authorizations such as Special Use Permits to users of National Forest lands to regulate uses and meet its obligations under FLPMA. The Boulder Canyon Hydroelectric Project occupies lands reserved out from National Forest lands under a power reservation and the provisions of FLPMA apply to USFS-managed lands adjacent to the project boundaries. As the new owner of the Boulder Canyon Hydroelectric Project, the city will need to coordinate the operations under the FERC license with the USFS management of adjacent lands.

7.2.6 National Historic Preservation Act (16 U.S.C. 470, 1966, as amended through 1992)

The National Historic Preservation Act of 1966 declared the nation's interest in preserving the historical and cultural foundations of the nation. Section 106 of the Act requires federal agencies to review the effects on significant cultural resources of projects that they finance, permit or own. Significant cultural resources are those that are listed or eligible for listing on the National Register. FERC licensing of the Boulder Canyon Hydroelectric Project and project use of National Forest System lands require compliance with the National Historic Preservation Act (see Section 15.2.1).

7.2.7 American Indian Religious Freedom Act (42 U.S.C. 1996) /Executive Order 13007 (May 24, 1996)

The American Indian Religious Freedom Act acknowledges prior infringement on the right of freedom of religion for Native Americans and establishes as federal policy protecting and preserving the inherent right of individual Native Americans to believe, express, and exercise their traditional religions. Executive Order 13007 is the President's order that agencies of the federal government review their policies and procedures in consultation with traditional native religious leaders, required by the American Indian Religious Freedom Act. These two documents protect Native American access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites. Procedures to ensure that reasonable notice is provided of proposed federal actions or land management policies that may restrict future access to or ceremonial use of, or adversely affect the physical integrity of, sacred sites. Where appropriate, the confidentiality of sacred sites is protected.

7.2.8 Endangered Species Act (7 U.S.C. 136; 16 U.S.C. 460 et seq., 1973)

The Endangered Species Act (ESA) requires the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service within the Department of the Interior is responsible for the protection of species listed under the ESA. An endangered species is one that is in imminent danger of extinction. Threatened species are those likely to become endangered if steps are not taken to protect them.

The Endangered Species Act gives the federal government the power to identify and classify species as threatened or endangered, to enforce laws that prohibit harming or possessing such wildlife, to oversee population recovery programs for listed species, and to protect or establish safe habitats for these plants and animals.

Species of concern in the Middle Boulder Creek watershed include the lynx, Preble's meadow jumping mouse, Ute ladies-tresses orchid, and western boreal toad (see Sections 17.1.4 and 17.3.3). Agencies of the federal government consult with the U.S. Fish and Wildlife Service to comment on the impacts of federal actions upon threatened and endangered species. The U.S. Fish and Wildlife Service may specify mitigation for impacts. Therefore, the U.S. Fish and Wildlife Service will be consulted for FERC licensing and USFS authorization of use of National Forest System lands.

7.2.9 FERC Boulder Canyon Hydro License (15 FERC ¶ 62,115)

The current FERC license for the Boulder Canyon Hydroelectric Project was issued to Public Service Company of Colorado (PSCo) on April 28, 1981 and will expire on August 31, 2009. In its approval of the transfer of ownership of the project from PSCo to the city, FERC stipulated that the current license and conditions would remain in effect for the term of the license.

The FERC Office of Hydropower Licensing is responsible for administering the hydropower program. The Division of Licensing and Compliance processes and analyzes applications for licenses, including re-licenses, and monitors compliance with terms and conditions.

FERC's role in regulating hydroelectric power projects includes issuing licenses for hydroelectric project for periods up to 50 years, after reviewing the engineering, environmental, and economic aspects of the proposal; preparing or accepting an environmental analysis document for the project; recommending measures to mitigate adverse effects; reviewing the comments and recommendations submitted by other government agencies, organization and the public; and determining that the proposed project is best adapted to a comprehensive plan for improving or developing a waterway for beneficial public uses.

When a project requires re-licensing, which is also referred to as a "new license," the licensee must file a notice of intent to re-license at least 5 years before an existing license expires. At least two years before the existing license expires, the licensee must file an application for a new license. The procedures for re-licensing a hydroelectric project are almost identical to those followed for obtaining an original license.

FERC requires licensees to prepare emergency action plans and conduct exercises to evaluate the effectiveness of and update these plans. The city's Emergency Action Plan for the Boulder Canyon Hydroelectric Project was developed in close coordination with emergency services providers and emergency management experts for the project area and was submitted in May 2001 and updated in August 2001. The city plans test exercises for the emergency action plan for April and May of 2002.

7.3 State Regulators

7.3.1 Water Rights

The use of water in Colorado is governed by the prior appropriation system, which can be simply described as "first in time, first in right." An appropriation is made when a person physically takes water from a stream or underground aquifer and places that water to a recognized beneficial use. The first person to do this is considered to have the first (or "senior") right to use water within a stream system. Once adjudicated through Water Court and given a decree establishing its priority, this water right is administered as the senior water right among all others on the stream. This water right must be satisfied before any other water rights with more junior priorities are filled. Subsequent water rights are satisfied in the order of their date of appropriation.

Water can only be appropriated if it can be demonstrated that it will be diverted and used for a beneficial purpose. Beneficial use is the use of a reasonable amount of water necessary to accomplish the purpose of the appropriation, without waste. Some common types of beneficial use are: domestic, household use, irrigation, municipal, power generation, wildlife, recreation and mining.

Codification of the prior appropriation doctrine into law and creation of the office of the State Engineer occurred around 1880. The State is now split into seven Water Divisions, delineated by the major river basins in the state. These Divisions were further split into approximately 80 river districts, again based on major sub-basins within each Division basin. Middle Boulder Creek lies in District 6 (Boulder Creek Basin), Division 1 (South Platte Basin).

The State Engineer is responsible for administering the allocation of water to every water right. The State Engineer has also been empowered to require and administer well permits; to regulate the spacing of wells and set limits on production rates; to administer the laws of the state regarding the distribution of the surface waters, including underground waters; to manage non-tributary ground water; and to regulate water quality for well construction, exchanges and substitute water supply plans.

Of particular interest to Boulder in the Middle Boulder Creek basin is the determination of instream flow requirements and potential adjudication of instream flow rights by the CWCB (see Section 7.3.2 below). An overview of Boulder's Middle Boulder Creek water rights is presented in Section 8.2 and Table 8.2.

7.3.2 CWCB Requirements for Instream Flow

In 1973, Senate Bill 97 gave the Colorado Water Conservation Board the legal right to appropriate, acquire, and protect instream flow and natural lake level water rights to preserve the natural environment to a reasonable degree. Since its creation, the CWCB has appropriated instream flow water rights on more than 8,000 miles of streams and 486 natural lakes in the state. In Colorado, the CWCB is the only agency that can effectively protect instream flows because it is the only political body that can hold water rights for the purposes of instream flow. Water merely left in a stream by the city or other water rights holders can be appropriated by others for beneficial uses and diverted out of the stream.

Most water appropriated by the CWCB is done so under very junior water rights. For this reason, CWCB files objections to potentially injurious water right applications and works with water right applicants to resolve potential injury by developing terms and conditions to protect CWCB rights.

CWCB may acquire more senior water rights for instream flow through purchase or donation. In 1990 and 1992, the city of Boulder donated several water rights to the CWCB to establish instream flows on Boulder and North Boulder Creeks. The city, in cooperation with the CWCB, is in the process of determining instream flow needs for Middle Boulder Creek (see Sections 8.3 and 12.4, 12.5, and 17.4.3.1).

The CWCB may also enter into leases or long-term contracts for water with federal, state and local governments and private concerns.

7.3.3 Public Utilities Commission

The purpose of the Colorado Public Utilities Commission (PUC) is to achieve a regulatory environment that provides safe and reliable utility services to all on just and reasonable terms. The PUC strives to assure that the public receives utility services at affordable prices while assuring that utilities have the opportunity to receive a reasonable return on their investments.

The Colorado PUC reviewed the proposed sale of the Boulder Canyon Hydroelectric Project to the city of Boulder and approved the transfer with conditions that were developed to ensure that new ownership would involve no adverse impacts to the energy-using public. Conditions of approval of the sale included:

- From the effective date (March 7, 2001) through midnight December 31, 2003, Boulder has agreed that it will use best efforts to generate electricity at the Boulder Project at all times, subject to:

    - the operational availability of the facility.
    - the legal and physical availability of water for generation.
    - repairs to the gravity pipeline
    - transfer of the SCADA control system.
    - repair of the dam gates at Barker Dam.
    - other repairs that may be required for the prudent operation of the Boulder municipal water system or to meet the requirements of any governmental agency with jurisdiction over the Boulder Canyon Hydroelectric Project.

- Boulder has also agreed that it will use best efforts to maximize production of electricity from the city's other hydroelectric facilities utilizing the additional water that is now available due to Boulder's acquisition of the system.

- Boulder has agreed to use best efforts to produce 100 percent of the historical average monthly on-peak generation by PSCo at Boulder Canyon Hydro for the period 1994-1999 for the months of June, July and August for the years 2001, 2002 and 2003 from the combination of generation at Boulder Canyon Hydro and the incremental increase in generation at Boulder's other hydroelectric facilities. The historical averages for Boulder Canyon Hydro are:

    - 570 MWh for June
    - 266 MWh for July
    - 444 MWh for August

- In calculating the amount of electricity produced, Boulder may use generation by the Boulder Canyon Hydroelectric Project plus the energy produced at its Betasso, Orodell, Sunshine, Maxwell and Kohler Hydroelectric Plants to the degree it exceeds the average production for those months for the period 1994-1999. These averages are:

  - 1,893242 kWh for June
  - 2,403,522 kWh for July
  - 2,221,802 kWh for August

- If Boulder fails to produce the required electricity during these months and the Boulder Canyon Project was available for operation, water was legally and physically available for generation, and the plant was not in operation for reasons other than unplanned component failures, PSCo will not make the Monthly Fixed Payment of $2,083.33 to the city.

- Boulder agreed to sell the electrical output of the Boulder Canyon Project to PSCo commencing on the date Boulder took control of the project and continuing through the terms of the FERC license, August 31, 2009, subject to certain early termination rights.

- The electricity generated at the Boulder Canyon Project will be purchased by PSCo at the rate of $35/MW for on-peak generation in the summer peak months, and $18/MW for on peak generation in all other months or any off peak generation in any month. PSCo is not obligated to pay for generation in excess of 87,840 MWh per year.

- In May 2001, 2002, and 2003, Boulder will report to PUC staff, the Office of Consumer Counsel and PSCO any planned maintenance which will cause the plant to be off-line during the months of June, July and August.

- Boulder will comply with a series of reporting requirements concerning energy production during the months of June, July and August of the years 2001, 2002 and 2003.

7.3.4 Colorado Division of Water Resources, Dam Safety Program

The Dam Safety program of the Colorado Division of Water Resources conducts design and review, construction inspection and dam safety analyses for all dams greater than 10 feet in vertical height to the bottom of the spillway, or greater than 20 surface acres or 100 af in capacity at the high-water-line. The Dam Safety Program determines the kind and extent of engineering programs needed to accomplish program objectives and to assure they are being met.

The Dam Safety Program requires that dam owners prepare and maintain an emergency preparedness plan to deal with emergency situations. In the case of Barker Dam, the city has prepared an Emergency Action Plan, in accordance with FERC requirements, that meets the state's emergency preparedness plan requirements. The Dam Safety Branch is notified in the event of emergency to participate in the state's emergency response.

7.3.5 Colorado Department of Public Health and Environment (CDPHE)

The Colorado Department of Public Health and Environment contains four environmental divisions:

- Air Pollution Control Division
- Consumer Protection Division
- Hazardous Materials and Waste Management Division
- Water Quality Control Division

The Water Quality Control Division is of the highest pertinence to this management plan. The Colorado Water Quality Control Division regulates the discharge of pollutants into the state's surface and ground waters and enforces the Primary Drinking Water Regulations.

Protection and maintenance of water quality is achieved by:

- Issuing permits specifying the amounts and types of pollutants that may be discharged without violating water quality standards.
- Providing grants and loans for wastewater treatment facility construction.
- Certifying operators of water and wastewater facilities.
- Maintaining field surveillance monitoring efforts.

In accordance with the Colorado Water Quality Control Act, the Division also provides staff support to the Water Quality Control Commission (WQCC). The WQCC seeks to develop and maintain a comprehensive and effective program for the protection of Colorado surface and ground water quality through an open process with full public involvement. The WQCC is responsible for developing specific state water quality policies in a manner that implements the broad policies set forth in the Colorado Water Quality Control Act. The WQCC adopts water quality classifications and standards for surface and ground waters of the state, as well as various regulations aimed at achieving compliance with those classifications and standards.

7.3.6 Certified Local Governments – Historic Preservation

The passage of H.B. 1041 by the Colorado State Legislature in 1974 gave local governments authority to designate and regulate historic and archaeological areas of statewide interest. In 1991, the Board of County Commissioners approved an amendment to the Zoning Resolution which required a permit for demolition, remodel, or other alterations of structures 50 years of age and older. Historic preservation regulations are contained in Section 15 of the Boulder County Land Use Code.

Both the city of Boulder and Boulder County are Certified Local Governments (CLGs) with regard to historic resource issues. A CLG is a local government having a partnership agreement with the State Historic Preservation Officer (SHPO) and National Park Service (NPS). A CLG's ordinance and historic preservation commission must meet certain standards. The partnership agreement obligates a CLG to develop a plan to inventory the historic resources within its jurisdiction and to develop local historic preservation programs. In exchange, the SHPO annually passes through ten percent of its federal funding to the CLG's. These grants are currently without a match requirement. CLG's are part of the review and negotiation process when federal funds or involvement are used on a project with potential effects to historic resources.

7.4 County

7.4.1 Land Use Regulations and Code

The Boulder County Land Use Code is enacted pursuant to the Colorado Revised Statutes to protect and promote the health, safety, and general welfare of the present and future inhabitants of Boulder County and to guide future growth, development and distribution of land uses within Boulder County. Enactment, amendment and administration of the Land Use Code are in accordance with and serve to implement the goals and policies of the Boulder County Comprehensive Plan.

The city and Boulder County developed the Boulder Valley Comprehensive Plan to guide and accomplish a coordinated, adjusted and harmonious development of the County, which, in accordance with present and future needs and resources, will best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants. It is also intended to promote efficiency and economy in the process of development, including distribution of the population and land uses such as urbanization, trade, industry, habitation, recreation, agriculture and forestry to improve overall quality of life within the Boulder Valley and reduce waste of physical, financial and human resources which result from either excessive congestion or excessive scattering of population. The Boulder Valley Comprehensive Plan includes the area bounded by the mountains on the west, Davidson Mesa and Coal Creek on the southeast, the county line on the south, Gunbarrel Hill on the northeast, and the ridge between Mesa Reservoir and Boulder Reservoir and the area west of Left Hand Valley Reservoir on the north.

A basic premise of the Boulder Valley Comprehensive Plan is that adequate urban facilities and services are prerequisite for new urban development and that within the Boulder Valley, the city is the provider of choice for urban services. On the basis of that premise, service standards are set as minimum requirements or thresholds for facilities and services that must be delivered to existing or new urban development to be considered adequate.

7.4.2 Health Department

The Boulder County Health Department mission is to protect, promote and enhance the health and well being of all people and the environment of Boulder County. The Health Department's Air Quality Program and Water Quality program are of relevance to the Middle Boulder Creek watershed and Boulder Canyon Hydroelectric Project.

The Air Quality Program exists to prevent or reduce releases of air pollutants beyond specified limits. City of Boulder projects in Boulder County that involve ground disturbance are usually coordinated through the Health Department to ensure adequate dust suppression measures to prevent serious air quality deterioration due to air-borne particulate matter.

The Water Quality Program reviews individual sewage disposal system (ISDS) applications and responds to ISDS complaints. Potential ISDS impacts to water quality are discussed in Section 9.4.2.1. The Water Quality Program also evaluates residential water and waste water systems and coordinates the Watershed Approach to Stream Health (WASH) Project, a county-wide project to reduce impacts of storm water runoff.

7.4.3 Boulder County Parks and Open Space

Boulder County Parks and Open Space (BCPOS) manages over 61,000 acres within the county. More than half of the open space properties are agricultural leasebacks, conservation easements or natural habitats that are not open for public recreational use. Areas open for public use are subject to rules and regulations that promote environmental preservation, reduce fire risk, and enhance user safety.

BCPOS areas of relevance to the Boulder Canyon Hydroelectric Project are the Platt Rogers Memorial Park, Reynolds Ranch and Rogers Property (located south and east of Barker Reservoir). The management plan for these areas (approved November 2000) identifies six management areas (two conservation areas and four scenic backdrop areas conducive to passive recreation activities and subject to standard county rules and regulations). Recreational use will be directed away from conservation areas and they will be considered for wildlife closures.

7.4.4 Emergency Services (Annual Operating Plan)

The Boulder County Annual Operating Plan sets forth the standard operating procedures, mutual policies and responsibilities to implement cooperative wildland fire suppression on all lands within Boulder County. Participants are the Boulder County Sheriff's Office, USFS, Bureau of Land Management, National Park Service and Colorado State Forest Service. The annual operating plan specifies procedures for resources requests, incident management, fire investigation and cost reimbursement, among other things, which are followed by all Boulder County fire departments.

7.5 City of Boulder

7.5.1 Obligations to Boulder Water Rate Payers

As a public utility, Boulder Water has a legal and moral obligation to manage the Boulder Canyon Hydroelectric Project in such a way as to maximize the return on the ratepayers' investment. Electricity production and water supply should be managed with consideration for profitability and efficiency. Applicable business principles also obligate Boulder Water to follow professional standards when considering or awarding contracts, including contracts that might govern facilities maintenance, professional studies, concessions, or recreation.

7.5.2 Raw and Treated Water Supply Reliability Criteria

The city has adopted a water supply reliability goal of meeting essential water needs (the amount of water needed to ensure public health and safety) with a system failure frequency of no more than once in 100 years. Essential needs for the city, including a 5 MGD fire-fighting reserve above the rate of water use, currently range between approximately 16.5 and 19 MGD.[1] If the existing Lakewood Pipeline and the Barker system failed concurrently, essential needs could not be met by the 8.5 MGD capacity of the Boulder Reservoir WTP alone. Reconstruction of the Lakewood Pipeline would reduce the probability of a simultaneous failure of the Lakewood Pipeline and Barker system. Similarly, if a simultaneous failure of other raw water delivery systems occurred, essential needs may not be met adequately by the 14 MGD capacity of the existing Lakewood Pipeline. By restoring the Lakewood Pipeline capacity to the historical level of 20 MGD, essential needs could be met by this water supply should the other water delivery systems fail.

From 1993 through 1998, peak day water usage ranged from 37.56 MGD to 44.39 MGD, and averaged 43.00 MGD. The record for highest daily water use was set in July 1989, when water use reached 50.5 MGD. Peak-day water demand in Boulder is currently estimated at 50 to 55 MGD. This demand is satisfied by the combined water supplies of the Silver Lake Watershed and North Boulder Creek (currently 14 MGD due to the reduction of Lakewood Pipeline capacity resulting from pipeline deterioration), Barker Reservoir (32 MGD), and Boulder Reservoir (8.5 MGD). The combined capacity of 56 MGD may not allow for the 10 percent system reserve that has been identified as a reliability goal for the municipal water system. Restoring the Lakewood Pipeline to its historical capacity of 20 MGD will enable the city to meet the reliability criteria for system reserve capacity.

7.5.3 Open Space and Mountain Parks Properties

The city of Boulder's Open Space and Mountain Parks Department preserves and protects the natural environment and natural resources of over 41,000 acres of land within Boulder County and fosters and sustains the natural values of the land for current and future generations.

Section 176 of the city of Boulder Charter defines the purposes of land acquisition as Open Space as follows:

- Preservation or restoration of natural areas characterized by or including terrain, geologic formations, flora or fauna that is unusual, spectacular, historically important, scientifically valuable, or unique, or that represent outstanding or rare examples of native species;
- Preservation of water resources in their natural or traditional state, scenic areas or vistas, wildlife habitats, or fragile ecosystems;
- Preservation of land for passive recreation use, such as hiking, photography or nature studies, and if specifically designated, bicycling, horseback riding, or fishing;
- Preservation of agricultural uses and land suitable for agricultural production;
- Utilization of land for shaping the development of the city, limiting urban sprawl and disciplining growth;
- Utilization of non-urban land for spatial definition of urban areas;

[1] Essential water need is estimated on the basis of average daily water demand for the November through March period, when outdoor water use is minimal. For 1993 through 1996, average daily demand during these months ranged from 11.64 MGD to 14.95 MGD, and averaged 13.19 MGD.

- Utilization of land to prevent encroachment on floodplains, and;
- Preservation of land for its aesthetic or passive recreational value and its contribution to the quality of life of the community.

The Open Space and Mountain Parks Department manages the Tram Hill property and the Flagstaff Mountain area of the Boulder Mountain Parks property near the Boulder Canyon Hydroelectric Project penstock and the hydroelectric plant. The Flagstaff Mountain area contains numerous trails and visitor facilities. The Tram Hill property contains no trails at the present time. Management concerns for the Tram Hill property include the protection of sensitive plant habitat. Vegetation mapping, including forest stands, for the Tram Hill / Lost Gulch area is available from Open Space Mountain Parks and Utilities. The maps were created using aerial photos and field checks (see Appendix A).

7.5.4 Municipal Permitting Requirements

7.5.4.1 Introduction

Certain city processes are required for city projects regardless of whether they are located within city boundaries. Requirements for the Boulder Canyon Hydroelectric Project facilities are described in the next two sub-sections.

7.5.4.2 CEAP

The Community and Environmental Assessment Process (CEAP) is a formal review process to consider the impacts of public development projects. CEAP review consists of: a project description; a discussion of the Boulder Valley Comprehensive Plan and master plan goals that the project will address; a review of the impacts of the project in checklist form, and; a description of the proposed impact mitigation measures and their associated costs.

CEAPs occur during the project planning and preliminary design phase of the Project Planning and Approval Process. After funds have been appropriated for project planning in the capital improvement project (CIP) budget, a CEAP is conducted for selected major project alternatives to determine its preferred type, location and conceptual design. The emphasis of the CEAP analysis at this stage of project planning is a general scooping of impacts and associated impact avoidance/mitigation strategies, in order to allow comparative impact assessment of major alternatives. The CEAP also provides the opportunity to balance multiple community goals through a public project by looking at a project within the context of the Boulder Valley Comprehensive Plan and master plans. The CEAP allows “fatal flaws” inherent in the conceptual design of a project to be discovered, thereby suggesting elimination of certain alternatives.

The CEAP documentation is submitted to Planning and Development Services for development review. If a site review or subdivision is required for the project, the appropriate applications are submitted concurrently with the CEAP. (Certain permits, as discussed below, are obtained in later phases of the project and are not submitted with the CEAP). The project manager then provides public notice of the CEAP application.

The Development Review Committee (DRC) reviews the CEAP, comments on the assessment and develops a recommendation. The project manager may redesign the project to address DRC comments and prepares a recommendation including DRC and public comments for advisory board review. The advisory board may approve the project and CEAP findings, suggest modifications, or deny approval. If modification to the project or CEAP is significant, it is resubmitted to Planning and Development Services for development review. The same process is continued until the project is accepted in concept by the advisory board. A revisiting of no-build and non-capital alternatives may be necessary if community and environmental impacts are deemed unacceptable. Advisory board decisions on the CEAP are subject to City Council call-up.

Most of the anticipated projects related to the Boulder Canyon Hydroelectric Project facilities are classified as maintenance rather than major capital improvements. Maintenance activities generally do not require a CEAP.

7.5.4.3 Wetlands

Development within a floodplain will frequently involve temporary or permanent impacts to wetlands and therefore will require a Municipal Wetlands Permit. The City Manager (through the Floodplain and Wetlands Coordinator) reviews and decides on all applications. The city notifies owners of properties within 300 feet of the project boundary and other interested parties who have requested notification. These people have 14 days to comment on the proposal. The Floodplain and Wetlands Coordinator posts notice of the wetland permit application with the comment deadline. The application may be approved, denied, or referred to the Planning Board for decision. Floodplain and Wetlands Coordinator decisions are subject to call-up by the Planning Board. Decisions not appealed or called up become final 14 days following notification.

7.6 Agreements with Xcel Energy

The city of Boulder Power Purchase Agreement with Xcel Energy specifies the terms and conditions governing the city's sale of power from the Boulder Canyon Hydroelectric Project to Xcel. The agreement extends from the date the city took possession of the facilities (March 7, 2001) until August 31, 2009. Should the city elect to decommission the project prior to August 31, 2009, the city is obligated to provide Xcel with three years advance notice of decommissioning and termination.

7.7 Conclusions

There are a large number of federal, state and local agencies with jurisdictions that affect the management and operation of the Boulder Canyon Hydroelectric Project and surrounding land uses and facilities within the Middle Boulder Creek watershed. Therefore, it will be necessary to coordinate with a variety of agencies concerning future management decisions for the Boulder Canyon project. As the city moves forward with management decisions for its facilities, it will be important to remain flexible and dynamic to be responsive to changing priorities and policies of numerous agencies and to consider the overlapping jurisdictions and interrelatedness of a variety of regulatory agencies.

7.8 Existing Source Material of Special Relevance to Contracts, Laws, and Regulations

7.8.1 Federal

Federal Regulatory Energy Commission, *Hydropower, Water Power- Use and Regulation of a Renewable Resource*, www.ferc.fed.us/hydro.

U.S. Department of Agriculture, Forest Service, Arapaho-Roosevelt National Forests, www.fs.fed.us/r2/arnf.

U.S. Environmental Protection Agency, Region 5, *Major Environmental Laws,* www.epa.gov/region 5.

Any federal law may be researched through www.legal.gsa.gov. Information on the regulations of individual agencies is available at www.access.gpo.gov/nara/cfr/index.htm.

7.8.2 State

Colorado Department of Public Health and Environment, www.cdphe.state.co.us.

Colorado Division of Minerals and Geology, www.mining.state.co.us.

Colorado Division of Water Resources, www.water.state.co.us.

Colorado Public Utilities Commission, www.dora.state.co.us/puc.

Colorado Water Conservation Board, www.cwcb.state.co.us.

Office of Archaeology and Historic Preservation, Colorado Historical Society, www.coloradohistory-oahp.org.

Any state law may be researched through www.intellinetusa.com/statmgr.htm.

7.8.3 County

Boulder County, www.co.boulder.co.us

7.8.4 City of Boulder

City of Boulder, www.ci.boulder.co.us

Information specific to the Barker Management Plan is available at www.ci.boulder.co.us/publicworks/depts/utilities/projects/barker-res/index.htm.

8 Water Quantity

8.1 Historical Stream Flows

Stream flows on Middle Boulder Creek have historically been recorded at the inlet to Barker Reservoir (the Nederland gage) and the outlet from Barker Reservoir (the PSCo 'channel weir' or 'eight-hundred foot weir'). Stream flows in downstream segments of Boulder Creek have been recorded below the Boulder Canyon Hydro plant discharge (the Orodell gage), at 75th Street and at the mouth of Boulder Creek.

The Nederland gage has recorded the flow of Middle Boulder Creek since June 1, 1907. Since there are very few upstream water diversions and no transbasin imports, flows at the Nederland gage basically represent the natural flow of Middle Boulder Creek upstream of Barker Reservoir. Natural flow reconstruction studies done by Hydrosphere show that flows at the Nederland gage represent about 93% of the natural stream flow of the entire Middle Boulder Creek basin from its headwaters to the confluence with North Boulder Creek.

Stream flows at the Nederland gage are dominated by spring snowmelt and summer rain events. About 70% of the annual flow volume occurs in the months of May through July. Peak flows into Barker Reservoir typically average around 260 cfs during June, but may be as high as 600 cfs in very high runoff years or during extreme summer precipitation events. Flows typically taper off to around 30 cfs by the end of August, and drop to base flow of about 5 cfs during January and February, although winter flows less than 3 cfs have occasionally been recorded. As measured by this gage, annual inflows into Barker Reservoir average about 40,000 af but vary considerably, ranging from 18,900 af in 1954 to 60,250 af in 1957.

Stream flows below Barker are significantly lower and reflect the historical operation of the Barker system. During May through mid-September, stream flows below Barker Reservoir generally follow a snowmelt-driven flow regime, although flows are significantly reduced due to diversions at Barker. Very rapid streamflow increases below Barker Dam typically occur in mid-June when Barker Reservoir begins to spill. During October through April, there has historically been virtually no stream flow below Barker due PSCo's hydropower operations. Since Boulder acquired Barker Reservoir in March of 2001, the city began bypassing a minimum of 3 cfs below Barker. Based on PSCo records, outflows from Barker Reservoir to the creek below the dam average only about 17,600 AF per year, or 44% of inflows.

Table 8.1 shows the average monthly flows at the Nederland gage and below Barker Dam. Daily flows for a typical year (1988) are shown graphically on Figure 8.1.

As it runs downstream from Barker Dam, Middle Boulder Creek gains small amounts of additional flow from local runoff, groundwater inflow and leakage from the Barker Gravity Pipeline. While the flows at the mouth of Middle Boulder Creek have not been directly measured, flow reconstruction studies done by Hydrosphere show that the segment of Middle Boulder Creek between Barker Dam and the confluence of North Boulder Creek gains an average of about 2,500 af of water annually, with most of the gain occurring during the months of April through June.

TABLE 8.1
MEAN MONTHLY STREAM FLOWS AT NEDERLAND AND BELOW BARKER
(cubic feet per second)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
At Nederland[1]	5.5	5.1	6.5	23	127	243	135	53	25	18	11	7.2
Below Barker[2]	0.0	0.0	0.2	0.7	39	127	90	26	4.5	2.6	1.1	0.0

NOTES:

1. Calendar years 1907 - 2000
2. Calendar years 1988 – 2000
3. Typical flows below Barker are zero during October through April; non-zero average values represent infrequent flow occurrences due to Barker Gravity Pipeline maintenance and draining of Barker Reservoir.

8.2 Water Rights

Water rights within Colorado, including the Middle Boulder Creek watershed, are administered according to Colorado's doctrine of prior appropriation, which is often summarized as "first in time, first in right". Thus the natural flow of streams is allocated according to the relative priorities of water rights with the available flow first going to satisfy the most senior right before more junior rights can divert water. Under this system, water rights can also be changed as to their location of diversion and type of use, provided that such changes do not result in injury to any other water rights that exist at the time of the change. The State Engineer maintains a detailed tabulation of all water rights in the South Platte basin, including Boulder Creek.

Boulder owns most of the water rights in the Middle Boulder Creek watershed; however, much of the water originating from the basin above Barker Reservoir must be passed to satisfy more senior water rights on main Boulder Creek. During the 1960's and 1970's, when Boulder began using Barker for water supply, the city adjudicated several storage, direct flow and exchange rights that allowed the city to divert water at Barker for municipal purposes. In the 1980's and 1990's, Boulder acquired and changed several senior irrigation rights for diversion at Barker Reservoir for municipal. The city later conveyed some of these rights to the Colorado Water Conservation Board to help provide instream flows to Boulder Creek under an arrangement that allows Boulder to use these rights for municipal purposes when they are not needed for instream flow. With its purchase of the Barker System, Boulder also acquired the water rights that were originally used for hydropower generation at the Barker system.

In addition to its water rights at Barker, Boulder also owns the storage right for Skyscraper Reservoir, which is located on Woodland Creek upstream of Barker. Skyscraper Reservoir was historically used to irrigate lands within the city of Boulder. Since Boulder acquired the Reservoir in the early 1980's, the city has not often operated the reservoir because of its remote location within the Indian Peaks Wilderness Area. Therefore, the reservoir often is left full year-round...

Other significant water right holders in the Middle Boulder Creek watershed include the Town of Nederland, the Eldora ski area and Mr. Jim Guercio. Table 8.2 summarizes the significant water rights in the Middle Boulder Creek watershed.

In general, Middle Boulder Creek water rights are junior to water rights that divert from Main Boulder Creek. Therefore, the city can normally divert water only during May through July of above-average years on most of its Middle Boulder Creek water rights. Notable exceptions are Boulder's exchange rights, which allow Boulder to divert water at Barker over more extended periods, and Boulder's changed irrigation rights, which are usually in priority for municipal use from May through July in nearly all years.

Downstream senior water rights on Main Boulder Creek are primarily associated with irrigation diversions. There are 14 significant diversion points on Main Boulder Creek (from upstream to downstream): Silver Lake Ditch, Anderson Ditch, Farmers Ditch, the Broadway headgate, Wellman Ditch (28th Street), Butte Mill Ditch, Green Ditch, Leggett Ditch, Lower Boulder Ditch, Boulder and Weld Ditch, Howell Ditch, Godding, Plumb and Dailey Ditch, Idaho Creek Ditches, and Rural Ditch.

TABLE 8.2
MIDDLE BOULDER CREEK WATER RIGHTS

Name	Appropriation Date	Adjudication Date	Amount	Use(s)	Case Number	Owner
Boulder Power Pipeline	9/9/1905	3/13/1907	50 cfs	Hydropower	5563	Boulder
Barker Meadow Reservoir	12/18/1906	11/03/1909	11,687 af	Hydropower	5563	Boulder
Barker Meadow Res. (refill)	12/31/1929	9/28/1953	3,163 af	Hydropower	12111	Boulder
Boulder City Pipeline No. 3	05/15/1956	03/04/1964	50 cfs	Municipal	82CW83 (W-76)	Boulder
Barker Meadow Reservoir	5/15/1956	3/4/1964	4,000 af	Muni., ISF	W-2359-72	Boulder
Barker Meadow Reservoir	04/22/1966	12/31/1972	4,000 af	Muni., ISF	W-2361-72, -79	Boulder
Barker Meadow Reservoir	11/17/1999	12/31/1999	3,687 af	Municipal	99CW217 (pending)	Boulder
Barker Meadow Reservoir (refill)	11/17/1999	12/31/1999	3,687 af	Municipal	99CW217 (pending)	Boulder
Windy Gap Exchange	12/20/2000	12/31/2000	200 cfs	Municipal	2000CW226 (pending)	Boulder
Kossler Reservoir	11/17/1906	11/03/1909	128.9 af	Hydropower	5563	Boulder
Anderson Ditch	10/1/1860	6/2/1882	2.4 cfs	Muni., ISF	W-7570, 90CW193	CWCB
Harden Ditch	6/1/1862	6/2/1882	1.8 cfs	Muni., ISF	W-8520, 90CW193	CWCB
McCarty Ditch	6/1/1862	6/2/1882	0.643 cfs	Muni., ISF	W-7570, 90CW193	CWCB
Smith & Goss Ditch	11/15/1859	6/2/1882	0.451 cfs	Muni., ISF	W-7570, 90CW193	CWCB
North Boulder Farmers Ditch	6/1/1862	6/2/1882	1.23 cfs	Municipal	94CW285	Boulder
North Boulder Farmers Ditch	6/1/1863	6/2/1882	4.26 cfs	Municipal	94CW285	Boulder
North Boulder Farmers Ditch	6/1/1862	6/2/1882	0.045 cfs	Municipal	W 7413	Nederland
North Boulder Farmers Ditch	6/1/1863	6/2/1882	0.155 cfs	Municipal	W 7413	Nederland
Lower Boulder Ditch	10/1/1859	6/2/1882	0.875 cfs	Municipal	94CW284	Boulder
Lower Boulder Ditch	10/1/1870	6/2/1882	4.31 cfs	Municipal	94CW284	Boulder
Skyscraper Reservoir	7/24/1940	9/28/1953	146.4 af	Irrigation	12111	Boulder
Jasper Reservoir	7/25/1896	3/13/1907	325 af	Irrigation	4842, 84CW204	Jim Guercio
Peterson Lake	7/1/1961	12/31/1982	221 af	Multiple	82CW239	Eldora Ski Corp
Peterson Lake	4/27/1976	12/31/1982	38 af	Multiple	82CW239	Eldora Ski Corp
Baseline Reservoir Exchange	12/31 1954	12/31/1974	50 cfs	Municipal	W 7852	Boulder
Boulder Res.-CBT Exchange	12/31 1954	12/31/1974	250 cfs	Municipal	W 7852	Boulder
N. B. Farmers Effluent Exch.	12/29/1994	12/31/1994	4.5 cfs	Municipal	94CW285	Boulder
Lower Boulder Ditch Exchange	12/30/1993	12/31/1994	5.185 cfs	Municipal	94CW284	Boulder
Baseline Reservoir Exchange	7/17/1994	12/31/1994	50 cfs	Municipal	94CW284	Boulder
Middle Boulder Creek instream flow (upstream of Barker)	7/11/1978	12/31/1978	12 cfs	ISF	W 9375	CWCB

8.3 Instream Flows

8.3.1 Introduction

As previously discussed, there are almost no diversions upstream of Barker Reservoir. The flow regimes of Middle Boulder Creek stream segments upstream of Barker Reservoir are generally pristine. The CWCB owns an instream flow right for 12 cfs on Middle Boulder Creek from the confluence of its North and South Forks to the inlet to Barker Reservoir. Historically, CWCB has not had an instream flow right in Middle Boulder Creek below Barker Dam and those reaches have often run dry, as described below.

8.3.2 Under Prior Ownership

As a PSCo-owned facility, Barker Reservoir diverted as much flow as possible either into storage or directly through the Barker Gravity Pipeline (run-of-river) for hydropower production. PSCo's primary year-round operating rule was to divert Barker Reservoir inflows directly through the Barker Gravity Pipeline for run-of-river hydropower production, up to the limit of the available capacity in the Barker Gravity Pipeline. PSCo stored water in Barker Reservoir only when the Barker Gravity Pipeline was full and Barker Reservoir's storage rights were in priority, typically during April and May. PSCo released water from Barker Reservoir for hydropower generation at times when Barker Reservoir inflow was insufficient to fill the Barker Gravity Pipeline. As a result, the annual stream flow in Middle Boulder Creek below Barker Dam averaged only about 44% of the annual inflow to Barker. The stream flow was most severely depleted from mid-September through April, when the flow below Barker Dam was usually zero. In late May through August, Middle Boulder Creek below Barker Dam would have flows only when the Barker Gravity Pipeline was full and either senior calls downstream needed fulfillment or Barker Dam was spilling or its storage rights were out of priority. Historical monthly stream flows below Barker Dam are summarized in Table 8.1 above.

8.3.3 Proposed

Boulder is committed to restoring instream flows in Middle Boulder Creek below Barker Dam to a level sufficient to reasonably protect aquatic habitat and maintain viable fish populations. Boulder is working cooperatively with the Colorado Water Conservation Board to meet this goal. The instream flow program will be an extension of the successful instream flow program that the city has jointly implemented with the Colorado Water Conservation Board on Boulder Creek and North Boulder Creek. Since it acquired the Barker system, Boulder has released a minimum of 3 cfs from Barker Reservoir to Middle Boulder Creek as an interim measure until final instream flow targets and long-term instream flow protection agreements can be reached with the CWCB.

8.4 Conclusions

- The physical availability of water is driven primarily by the snowmelt-runoff cycle and is highly variable from year to year. Because of the variability in timing and magnitude of runoff, it is crucial to have a storage facility such as Barker to capture water during peak flow in May-July for distribution later in the year.

- Boulder owns most of the water rights in the Middle Boulder Creek watershed. As a group, these water rights are relatively junior compared to downstream Boulder Creek water rights. Barker's storage rights are usually in priority to store water only during May through mid-June. Barker's direct flow hydropower right is almost always in priority because this right is non-consumptive in nature and its exercise does not harm downstream rights.
- Under PSCo ownership and operational control, Boulder Creek generally dried up below Barker Dam from September through April. The city of Boulder is working towards an agreement with CWCB that will provide year-round flows in the future.

8.5 Existing Source Material of Special Relevance to Water Quantity

Hydrosphere. 1988. *Raw Water Master Plan,* prepared for the city of Boulder (currently under revision).

Hydrosphere. 2001. *Boulder Creek Instream Flow Program Operations Manual.* Prepared for the city of Boulder.

Hydrosphere. Undated. Boulder Creek XLCRAM Model.

Hydrosphere. Undated. *Drought Recognition and Response Plan,* currently under development for the city of Boulder.

Hydrosphere. Undated. *Raw Water Operations Manual,* currently under development for the city of Boulder.

Loose records: as part of the Barker purchase, the city of Boulder acquired approximately 30 file boxes of paper records pertaining to the Boulder Canyon Hydroelectric Project. The records are currently being inventoried. Categories of information available from these records include:

- Facilities: Dam, Barker Gravity Pipeline, Boulder Canyon Hydroelectric Plant, Nederland Gage, Penstock, Water Pipeline, Barker Reservoir, Kossler Reservoir, river gage at Boulder Canyon Hydroelectric Plant.
- Land Ownership: Barker Reservoir, Barker Gravity Pipeline, Kossler Reservoir, Boulder Canyon Hydroelectric Plant.
- Operations
- Regulations and Permits: FERC, U.S. Forest Service.
- Water Rights
- Legal and Administrative Documents: negotiations, contracts, storage lease.

9 Water Quality

9.1 Introduction

Local, state, and federal entities monitor water quality in the Middle Boulder Creek Watershed to gain an understanding of the health and condition of streams and reservoirs in support of designated uses such as drinking water supply, maintaining aquatic life, and recreation. For example, the city of Boulder monitors water quality to ensure the water is treatable for safe drinking water, to assist in identifying treatment needs, and to identify and track potential pollution sources. The Colorado Water Quality Control Division (WQCD) evaluates water quality data to determine if waters are supporting designated uses and identify sources of pollution.

The primary surface waters in the watershed include the watershed streams and storage reservoirs such as Barker and Kossler Reservoirs. The natural flow of streams can affect water quality through dilution, attenuation, and transport of contaminants. Reservoirs retain flow, which can cause contaminants to settle out, concentrate or increase as in the production of algae. Both natural and man-made factors impact water quality in the Middle Boulder Creek Watershed. Natural impacts include rainfall and snowmelt, temperature, and erosion. Man-made impacts include mining, wastewater discharge, urban development and associated runoff, and simple contact with the water and watershed.

9.2 Water Quality Testing

9.2.1 Background

Water quality information includes the chemical, biological and physical components of water systems. Chemical data have traditionally been the focus of the Clean Water Act and Safe Drinking Water Act. Typical chemical constituents include hardness, suspended solids, dissolved oxygen, pH, organic material, nutrients, and metals. Chemical quality can both positively and negatively affect water quality, depending on the quantities present. At low levels, some constituents can serve as micronutrients that support aquatic life, but at higher levels these constituents can become toxic. Biological data typically refers to macroinvertebrate and fish data. Microbiological organisms are monitored to provide an indication of pathogens for the safety of drinking water and swimming. These organisms include fecal coliform bacteria, which indicate the presence of human and/or animal waste, as well as specific pathogens (e.g., *Giardia, Cryptosporidium*). Physical conditions relate to flow, sediment, and habitat.

Water quality regulations continue to evolve to integrate chemical, biological, and physical components. In addition, as we learn more about health concerns and discover new contaminants, water quality standards continue to become more stringent. Water quality monitoring provides insight into how the water quality is changing over time and along the length of the stream or reservoir, as well as compliance with water quality goals and standards. Water quality data, in conjunction with watershed activities, also helps identify and track potential pollutant sources.

9.2.2 Testing Programs

The city of Boulder is the primary entity that collects water quality data in the watershed. The U.S. Geological Survey (USGS) and the Colorado WQCD collected water quality data in the past for special studies. Water quality monitoring locations are presented on Figure 9.1.

9.2.2.1 City of Boulder

The city of Boulder routinely monitors water quality in Middle Boulder Creek and Barker and Kossler Reservoirs, which supply the Betasso Water Treatment Plant. The city has performed monthly monitoring in the watershed for the past eight to 15 years. Prior to the city's purchase of Barker Reservoir, city staff was only able to monitor the reservoir once per year. The city now monitors Barker Reservoir one to two times per month. The city uses the watershed and reservoir data to gain an understanding of the background water quality, treatment capabilities, and temporal and spatial changes in water quality.

The city monitors the following locations:

- Middle Boulder Creek at Nederland WTP
- Middle Boulder Creek at Weir
- North Beaver Creek at Middle Boulder Creek
- Nederland Wastewater Treatment Plant Effluent
- Barker Reservoir
- Middle Boulder Creek Above North Boulder Creek Confluence
- North Boulder Creek at Boulder Falls
- Boulder Creek at Orodell
- Boulder Creek at Eben G. Fine Park

Water quality constituents generally of interest to the city drinking water supply are those that may cause a human health risk, taste and odor problems, or make water difficult to treat. For example, high levels of nutrients can case algae blooms. Algae can clog filters in the drinking water treatment plant, cause taste and odor problems, and lead to the formation of disinfection by-products that are human health concerns. Pathogens that cannot be removed in treatment can cause disease in humans. The city's routine monthly monitoring tests for the following primary water quality indicators:

<u>Field Indicators</u>
Temperature
Dissolved oxygen
Specific Conductance
pH
Clarity (in the reservoir)
Flow

Laboratory Indicators
Turbidity
Alkalinity
Hardness
Organic carbon
Suspended and dissolved solids
Fecal coliforms
Nutrients (e.g., nitrate, ammonia, phosphorus)
Metals
Algae and chlorophyll (in the reservoir)

In addition to routine monitoring, the city also performs special studies and has periodically monitored for a large suite of constituents that includes organic chemicals (e.g., synthetic organic chemicals, pesticides/herbicides, MTBE), radioactivity, and pathogens.

9.2.2.2 Millennium Baseline Study

The Boulder Area Sustainability Information Network (BASIN), the U.S. Geological Survey, and the city of Boulder performed the Boulder Creek Millennium Baseline Study in the summer and fall of 2000. The millennium study monitored over 200 constituents, including organic chemicals, pharmaceuticals, and metals. This data is intended to provide a baseline data set for a large suite of constituents and assist in determining natural and human impacts. To maintain continuity, the sampling sites for this targeted study included many of the city's sites and include:

- Middle Boulder Creek Above the Town of Eldora
- Middle Boulder Creek at Nederland WTP
- Middle Boulder Creek at Weir
- North Boulder Creek Diversion to Lakewood Reservoir
- Como Creek Where it Enters Lakewood Reservoir
- Middle Boulder Creek Above North Boulder Creek Confluence
- North Boulder Creek at Boulder Falls

9.2.2.3 Colorado WQCD

The WQCD last collected water quality data in Middle Boulder Creek below Barker Reservoir in 1998 as part of the basin's triennial review process.

9.2.3 Data Analysis, Reporting, and Decision-Making Process

The city performs the most in-depth review of water quality data in the watershed. The city's current data analysis procedure includes an initial review to identify any anomalies, followed by a more detailed evaluation to get an understanding of baseline conditions and trends in the streams and in Barker Reservoir. The city evaluates long-term temporal trends, seasonal trends, and compares data to similar watersheds. City staff reviews the data biannually or on a seasonal basis to address any changing needs and to support decisions related to treatability issues and identifying potential contaminant sources.

The BASIN Web site posts the majority of water quality data available in the watershed (bcn.boulder.co.us/basin). The city also provides summary information in the Utilities Annual Report.

9.3 Barker Reservoir

9.3.1 Introduction

Barker Reservoir is a point of collection, mixing, and temporary storage for an extensive hydrologic network covering 40 square miles (see Figure 4.1). The hydrologic network includes headwater streams over a range of elevations that are collected in progressively larger channels culminating in Middle Boulder Creek, which is the main source of water for the reservoir. The network is connected to groundwater to such an extent that the quality of groundwater cannot be considered as separate from the quality of surface waters entering Barker Reservoir. In addition, the reservoir receives direct flows from small gulches or tributaries, the largest of which is Beaver Creek. Surface runoff to stream channels, gulches, or overland during the wettest weather yields water to the reservoir from natural vegetated surfaces as well as urban residential areas and their infrastructure, including roads. In addition, Barker Reservoir receives effluent from the Nederland Wastewater Treatment Plant, which discharges directly into Barker Reservoir when the reservoir is full, and into Middle Boulder Creek approximately 50 yards upstream of Barker Reservoir when the reservoir is low. Although this flow is a byproduct of water management, it is a part of the hydrologic system of the reservoir.

The quality of water entering Barker Reservoir and the quality of the water in the reservoir itself have been affected by human activities, as explained herein. The Barker Reservoir management plan would be incomplete without a detailed consideration of the types of changes in water quality that have occurred over time, the causes of these changes, the significance of the changes for the uses or values that are attached to the water, the feasibility of reversing or moderating changes that are viewed to be adverse, and the possibilities for reducing any anticipated changes in the future that might be considered undesirable. A good basis for evaluating each of these issues is the water quality monitoring program of the city of Boulder, which has been of excellent scope and quality, as well as special studies that have been supported by the city or by others.

In the absence of human influence, montane waters of Colorado generally contain very low amounts of dissolved solids, small amounts of critical nutrients and suspended solids, and small amounts of both dissolved and particulate organic matter. When impounded either naturally or by the construction of dams, these waters form lakes that are designated oligotrophic (sparsely nourished) because they have high transparency and support low abundances of suspended algae. Such waters are ideal for the support of salmonid fishes and are widely appreciated for their esthetic appeal; they also are excellent water supplies for municipal purposes.

Human influences on montane waters include temporary or permanent conversion of land cover, nutrient enrichment by means of point and non-point sources of waste disposal, mining, and atmospheric pollution as well as contamination of water with fecal matter associated with livestock, pets, or humans. Sometimes these influences are so small as to be undetectable in a water quality record, while at other times they are responsible for major changes in water quality and aquatic life. An examination of the water quality data collected by the city of Boulder for Barker Reservoir and its tributaries will show the degree to which Barker Reservoir has been altered by human activity and will suggest ways in which management can deal with past changes in water quality and anticipate future changes.

9.3.2 Overview

The waters of Barker Reservoir are well suited for a diversity of uses that demand high quality water, including support of cold water aquatic life, domestic supply, recreation, and, indirectly, downstream agricultural uses. The waters are measurably impaired, however, by human presence. The most disturbing cause of impairment has to do with nutrient loading (nitrogen and phosphorus released to the reservoir). The amounts of these critical nutrients entering the reservoir are two or more times higher than they would be in the absence of human activity. The most concentrated source of nutrients is the Nederland Wastewater Treatment Plant, but numerous other sources are present as well. Escalation of nutrient loading of the reservoir, which could accompany increase in population density or increase in activity level is the watershed, could begin to impair uses of the reservoir. Nutrient control is highly advisable.

Pathogenicity of Barker Reservoir waters poses a risk for domestic water supply and potentially for contact recreation. Although contamination does occur, as shown by monitoring, there is no evidence that it is unusually high for water that receives incidental human and animal contact. Reduction of risk is advisable, however, and with proper consideration of multiple interests in use of the water, should be pursued through management.

Impairment of Beaver Creek watershed is evident through numerous water quality indicators of disturbance. Storm loading from this watershed could be disadvantageous. In addition, the bottom of Barker Reservoir shows through its chemical profiles selective accumulation of water from sources that contain higher concentrations of pollutants than the surface water. This is an undesirable situation and should be analyzed further and mitigated if possible.

9.3.3 A Framework for Management of Water Quality

Water quality in the United States is protected under guidance from federal legislation, which primarily includes the Clean Water Act and the Safe Drinking Water Act. The Clean Water Act in particular provides a useful framework for evaluating water quality. While local concerns may lead to an extension of this framework, it provides a good point of departure for management and evaluation.

Under guidance from the Clean Water Act through the EPA, the State of Colorado classifies all surface waters according to their uses (beneficial uses). The State recognizes four broad categories of use, and attaches to some of these uses subcategories as necessary to achieve greater specificity. In addition, the State recognizes that specific sites may be subject to special uses that require site-specific protection. Table 9.3.3 gives the four categories of use that are recognized by the State and offers an interpretation of these as they apply to Barker Reservoir and its tributaries.

Each of the use designations shown in Table 9.3.3 for Barker Reservoir and its tributaries can be matched with specific water-quality standards that the State has defined as essential in protecting the individual uses. For example, the cold water aquatic life designation is accompanied by numerous limits on concentrations, of chemical constituents (metals, organic substances, gases, etc.) that represent thresholds of tolerance for cold water aquatic life. Thus the framework shown in Table 9.3.3 corresponds to some very specific requirements that have already been identified by the State for the preservation of uses. These are minimum requirements for the preservation of use; management can pursue even stricter thresholds according to site-specific judgments of feasibility and value in pursuing goals that are stricter than those designated by the State.

TABLE 9.3.3
SURFACE WATER CATEGORIES OF USE

Category of Use	Designation for Barker Reservoir and Tributaries	Implication
Water supply	Designated for domestic supply	Quality suitable for continuous treatment and distribution for human consumption
Support of aquatic life	Support of cold water aquatic life, class 1	Quality suitable for support of trout and other forms of aquatic life requiring cold water and very high water quality
Recreation	Support of recreation, class 1a.	Quality suitable for human contact without treatment
Agriculture	Support of agriculture (downstream)	Quality suitable for livestock and irrigation

NOTE: Table 9.3.3 is an outline of the framework for assessing and managing water quality for Barker Reservoir and its tributary watersheds. The main categories listed in the first column are used by the State of Colorado for evaluating all surface waters. The second column gives specific designations of these categories that apply to Barker Reservoir and its tributaries, and the final column offers some interpretation of the categories.

The State lacks standards for some water quality constituents that are important to the value of water. Most important in this regard is concentrations of nutrients (primarily applicable to nitrogen and phosphorus), which affect the growth of plants in water, including algae. Under EPA guidance, the State will be considering limits on nutrient concentrations in the future; nutrients must be considered a management issue from the viewpoint of aesthetics and indirect effects on water treatment costs and welfare of aquatic life in Barker Reservoir and its tributaries.

9.4 Potential Causes of Water-Quality Impairment

Potential causes of water-quality impairment can be derived from information on waste disposal and land use in the Barker Reservoir watershed. Extensive studies of numerous montane watersheds in Colorado provide indications as to the nature and extent of water quality impairment that can be expected from various categories of activities. The water quality monitoring data gathered by the city of Boulder, as well as special studies, then can be used in quantifying and verifying the extent of water quality changes that have occurred under human influence.

9.4.1 Point-Source Pollutants and Their Pathways

9.4.1.1 Disposal of Treated Effluent

Wastewater generated in relatively densely populated areas is primarily treated at a wastewater treatment plant, such as Nederland and Lake Eldora. Wastewater treatment systems can contaminate surface water through direct discharge or failure. Potential concerns with collection lines include damage to manhole covers (e.g., hit by snowplows), which can allow debris into the pipeline and cause backup and overflow.

Permitted facilities in the watershed include the municipal discharges of Nederland and Lake Eldora, and the Wolf Tongue Mine and Mogul Tunnel mining discharges. Each of these has a National Pollutant Discharge Elimination System (NPDES) permit, which the WQCD oversees through the Colorado Discharge Permit System (CDPS).

The Town of Nederland discharges treated wastewater in the form of secondary effluent to Middle Boulder Creek, upstream of Barker Reservoir. The Lake Eldora and Wolf Tongue mine discharges are further upstream in the watershed. Where the amount of secondary effluent is large relative to the volume of the receiving water, the list of potential concerns for water quality impairment is extensive, and very restrictive regulation of the quality of the effluent may occur through the State permitting process. Where the volume of effluent is a very small proportion of the flow of the receiving water, the list of concerns is reduced due to the large amount of dilution that occurs when the effluent enters the receiving water. The volume of discharge for Nederland effluent is very small in comparison to the total flow to Barker Reservoir (less than 1% of the total). Thus, many potential concerns are muted by the strong dilution of the effluent. Some concerns remain, however, even in the presence of large amounts of dilution.

The holding of water in lakes contributes to a drastic reduction in pathogenicity, thanks to settling and die-off. Thus, Barker Reservoir provides some natural protection of the water supply from pathogens. Unfortunately, however, the reservoir is rather small, and thus the holding times may amount to only a few weeks at times of the year when water is moving rapidly. One even greater concern is that under some circumstances effluent may pass selectively to the bottom of the reservoir, or may pass selectively into an intermediate layer in the water column, and thus not become distributed fully in the water column. Under these circumstances, it would be possible for the outflow from the reservoir to contain more effluent than might otherwise be expected.

Constituents of Concern: The secondary effluent from the Nederland wastewater treatment plant contains very high concentrations of critical nutrients (nitrogen, phosphorus). By stimulating the growth of algae, these critical nutrients may greatly alter the character of lakes, for reasons that are explained in more detail below in connection with the monitoring data. The potential of even a relatively small volume of secondary effluent to alter the nutrient content of montane waters, which characteristically have very low concentrations of nutrients, is illustrated by the data in

Table 9.4.1.1, which gives the contrasting concentrations of critical nutrients for Nederland effluent and Middle Boulder Creek. The data in Table 9.4.1.1, which shows both concentrations and loads (pounds delivered per year), indicate that the nutrient budget

TABLE 9.4.1.1
PHOSPHOROUS SOURCE CONCENTRATIONS TO BARKER RESERVOIR

Source	Total Phosphorus, Year 2001		
	Concentration (µg/L)	Load (lbs/yr)	% of Load
Middle Boulder Creek	6	555	30
Beaver Creek	15	46	2
Nederland Effluent	4780	1222	67

UNITS:

µg/L micrograms per liter
lbs/yr pounds per year

of Barker Reservoir is substantially affected by nutrients from the Nederland effluent, even though the volume of water associated with the effluent is less than 1% of the total water entering the reservoir. Thus, the Nederland effluent must be considered a potential cause of water quality impairment in the reservoir as a result of the presence of nutrients at high concentrations in the effluent. The extent to which this influence has actually impaired water quality can be determined from water quality analyses, as indicated in Section 9.6.

Constituents in municipal effluent can be divided into those that pose an immediate health risk and those that may pose a long-term health risk. An immediate health risk is posed by pathogenic organisms. Municipal effluent may contain pathogenic microbial organisms such as bacteria, pathogenic cysts, and viruses. In addition, nitrates are a concern for infants. A long-term health risk is posed by metals and toxic organics present in the wastewater.

Nederland effluent contains substantially more organic matter than the other tributary flows to Barker Reservoir. Even though this is the case, the concentrations of organic matter in the treated effluent are not large enough to cause substantial effects because of the small volume of flow. Also, the amounts of metals and other substances in the effluent may be higher than in the tributary flows, but as in the case of organic matter, dilution is very extensive and offsets these concerns. Thus, at least with our present state of knowledge, the main management concerns for the Nederland effluent relate to nutrient loading and pathogenicity.

Pathogens are another concern associated with wastewaters, even when they are strongly diluted. Secondary effluent is disinfected prior to discharge. Thus, many pathogens are eliminated entirely from the effluent stream prior to discharge to a receiving water. Unfortunately, some pathogens that have resistant forms are not easily treated with disinfectants and may escape to the receiving water. In addition, disinfection systems may fail temporarily. Although this is rare, it is an obvious possibility in any engineered system. Finally, our understanding of pathogenic agents in water is still developing rather rapidly, and the future could show pathogenic challenges associated with wastewater that we do not yet fully appreciate.

The primary concern from mining sites includes metals and pH. Impacts from mining are discussed in more detail in Section 9.4.2.2.

9.4.1.2 Solid/Hazardous Waste

Disposal facilities are a concern because they often generate leachate, which may contaminate surface waters and groundwater. The Eldora Landfill has been found to impact groundwater. Illegal dumping of domestic waste in ditches, ravines, and remote areas is also an issue (see Section 9.4.2.16). The Resource Conservation and Recovery Information System (RCRIS) maintains information on sites that generate, transport, store, treat, and/or dispose of hazardous wastes. Generators of hazardous waste are also a concern and they are classified in the RCRIS database as either a large or small quantity generator according to the amount of waste generated. The watershed includes four RCRIS sites above Barker Reservoir (Boulder Creek Watershed Study, 2000). Industry in the watershed is minimal and consists of businesses such as gas stations, auto body/paint shop, and a vehicle repair shop.

Constituents of Concern: The primary concern with solid waste disposal is related to inappropriate disposal of chemical (e.g., household chemicals) and petroleum liquid wastes (e.g., motor oil) that can be introduced to surface waters. The waste collection sites can also introduce litter and large debris such as household furniture and appliances. RCRIS sites can include inorganic and organic chemicals.

9.4.1.3 Leaking Underground Storage Tanks

Underground storage tanks (USTs) are often used to store petroleum products for fueling. Over time, the tanks can rupture or degrade, allowing their contents to leak into the surrounding soils. These leaking USTs (LUSTs), can impact groundwater and leach to surrounding surface waters.

The Department of Labor and Employment, Oil Inspection Section (DOLE/OIS) permits and inspects USTs in Colorado. This department also tracks and documents LUSTs and their cleanup and closure. The watershed has 11 USTs and no LUSTs, primarily in the Eldora and Nederland areas.

Constituents of Concern: The contaminants of concern from LUSTs include benzene, toluene, ethylbenzene, xylene (BTEX); other petroleum hydrocarbons; and possibly lead from leaded fuels.

9.4.2 Non-Point-Source Pollutants and Their Pathways

9.4.2.1 Individual Sewage Disposal Systems

Individual sewage disposal systems, which are often designated as septic systems, are commonplace in the mountains of Colorado. Wherever human population is sparsely distributed, and particularly in areas where the running of pipelines is difficult or expensive, this State permits the creation of an ISDS to serve typically a single residence, but sometimes more than one residence. A typical ISDS consists of a tank with a volume of approximately 1000 gallons that receives raw sewage from a residence. The raw sewage passes into the tank and coarse material settles to a front compartment of the chamber. Liquid components flow to the next compartment, which is connected to a leach field consisting of underground perforated pipes that distribute the effluent from the tank over an area of 1000 to a few thousand square feet. The leach field is designed so that water percolates readily through gravel and then into soil well above the water table.

The tank and the leach field promote natural processes that break down organic matter. In essence, they are an engineered composting system for liquid waste containing large amounts of organic matter. The organic matter, under the influence of microbes, becomes CO_2 and water, both of which are harmlessly liberated to the atmosphere. Decomposition mineralizes other components of organic matter, and thus releases nitrogen, phosphorus, and other elements that were previously tied up in organic matter. Much of the phosphorus is bound to soil particles and may be used by microbes or other organisms that are present below the leach field. Some phosphorus does escape leach fields, however, as documented for a number of montane watersheds in Colorado (Lewis, et al, 1984). Nitrogen, particularly in the form of nitrate, is less readily adsorbed and may pass completely through the soil without being adsorbed. Phosphorus or nitrogen that escapes the leach field area may run over bedrock or through subsoil layers to the nearest stream. In this way, ISDS systems are potential sources of nutrients and pathogens for surface waters.

The significance of nutrients from ISDS to receiving waters depends on a number of site-specific factors. Where the background concentrations of nutrients are very high, contributions from ISDS systems may be trivial as a component of the background concentrations. Where concentrations are very low, as they are in many parts of Colorado, including the Barker Reservoir watershed, ISDS may have a measurable influence on the total nutrient content of surface waters.

Contributions of nutrients and pathogens from ISDS to surface waters can be minimized in a number of ways. Correct engineering and correct installation are perhaps most important. Current practices for installation of septic systems generally meet requirements for good performance of septic systems, but older septic systems may have been installed under very poor circumstances (excessively high groundwater, soils that do not leach well, rocky substrate, excessive slope, etc.). Additionally, residences may have been converted from seasonal use to year-round use, possibly overloading the capacity of the system. Maintenance of septic systems is necessary because the systems accumulate non-biodegradable material to such an extent that they fill up and must be pumped every two to three years. Failure to maintain the system may impede its performance. Also, septic systems have a lifespan and may eventually exceed the capacity of the leach field. Although this typically does not happen in less than 20 years, its eventual occurrence would nullify many of the functions of the ISDS. Thus, one management consideration is related to proper installation, maintenance, and lifespan review for ISDS. Malfunctioning systems can export not only nutrients, but also pathogens if wastewater reaches daylight without passing through the leach field first.

A detailed inventory of ISDS in the Barker Reservoir watershed is not yet available, although it is known that the watershed has numerous ISDS. Supervision of ISDS installation and maintenance ranges from good to nil in various parts of Colorado. Management of these processes typically occurs through local government. The keys to good management typically involve improved awareness and public support of proper ISDS installation and maintenance on grounds that the public does benefit from these practices. In addition, some communities limit the installation of ISDS by requiring that new construction hook up to central sewer wherever an extension of sewer line is at all feasible. These obviously are management considerations for Barker Reservoir. They relate mainly to the functions of local government, but could easily involve the public at large as well.

Constituents of Concern: Septic systems may contain pathogenic microbial organisms such as bacteria, pathogenic cysts, and viruses. In addition, nitrates are a concern for infants. A long-term health risk can be posed by metals and toxic organics potentially present in wastewater.

9.4.2.2 Mining and Milling

The Town of Nederland and the surrounding area have been home to mining since the early 1900s. The Caribou Mill was erected in 1905 and subsequently replaced with the Wolf Tongue Mill, which has not operated since the early 1970s. Tungsten, a steel-hardening alloy, was the only mineral milled at this site. Tailings piles still exist and border the Middle Boulder Creek stream channel. The area was also active for gold and silver. However, the majority of mining operations have been abandoned. The watershed includes over 30 historical mining operations and two quarry/gravel pit mines (North Boulder Creek below Silver Lake and Middle Boulder Creek between Eldora and Nederland). Approximately 16 inactive mines account for a total of 12 acres of disturbed land and tailings piles in the Caribou District on the north side of the Middle Boulder Creek Valley. Another 17 inactive mines near Nederland and Eldora account for 10 acres of disturbed land and mill tailings piles (Brown and Caldwell, 1992).

Constituents of Concern: Acid mine drainage is formed primarily from the oxidation of pyrite sulfide ores within mine tunnels and at the surface of used waste rock piles. This reaction can produce sulfuric acid with a pH as low as 3. The low pH dissolves metals in the surrounding rock, generating a discharge containing high dissolved metals concentrations. Acid mine drainage can contain elevated levels of aluminum, arsenic, copper, cadmium, iron, manganese, and zinc, and usually lower concentrations of other metals such as nickel, lead, and chromium. Acid mine drainage is also discharged from waste rock piles when rainfall or stream flow contact the pile. As dissolved metals are transported away from the mine, the pH increases as the mine drainage is diluted from contact with other water. Some percent of the metals then precipitate out and metal concentration in the receiving stream decreases. Much of the concern with acid mine drainage is with the threat to aquatic life immediately downstream of the discharge.

Discharges from inactive mines can constitute a significantly greater threat to water quality than discharges from active mining operations, which are required to manage their discharge (e.g., through NPDES permit). Adverse effects on water quality generally associated with mining and milling include release of heavy metals in soluble forms, introduction of mercury as a byproduct of ore processing, acidification of drainage water caused by oxidation of pyrite, and precipitation of iron and magnesium oxides, with adverse effects on aquatic organisms. Generally, these adverse effects are most pronounced very close to the direct range from mined areas, and rapidly become less conspicuous as dilution water is added from other types of drainage. Except for mercury, which is a potential threat to human health primarily associated with the consumption of fish, the adverse effects of mine drainage fall most heavily on uses associated with the support of aquatic life. Fishes and other organisms are much more sensitive to heavy metals in dissolved form than humans are, and thus set the most demanding standards for heavy metals. Much the same is true of pH and metal oxide deposition, although metal oxides can interfere with water treatment processes if they are present in quantity.

Compaction of soils from sand and gravel mining machinery can reduce the permeability of soils and can increase runoff. Suspended solids resulting from erosion is the main concern in terms of pollution to surface waters. Suspended solids results in increased turbidity levels. Metals and hydrocarbons resulting from the heavy machinery used in these operations can also be carried into surface waters.

9.4.2.3 Urban Drainage, Residential Drainage, and Roads

Urban runoff and runoff from residential areas may affect water quality. Because hard surfaces (e.g., paved areas, roofs) have virtually no adsorption capacity, even small amounts of rainfall may generate overland flow that, upon entering storm sewers, can reach surface waters very quickly and carry with it all deposits on the drainage surfaces in question. In addition, areas that have been devegetated or inadequately vegetated, particularly in the highly sloped terrain of the watershed, can carry substantial sediment loads as well as nutrients to streams. Typically such effects are pulsed in relation to precipitation events. However, runoff also continues in developed areas throughout the dry season as a result of irrigation and wash-off practices. The watershed does not have an enclosed stormwater system and all runoff is transported by natural drainage. Paved streets have been kept to a minimum in Nederland, which can allow increased infiltration of rain and snowmelt and decreased runoff.

The most adverse effects are likely to fall on streams, as resident aquatic organisms may be impaired in abundance by sediments, which interfere with respiration and sometimes block the small living spaces within the substrate that are important to aquatic organisms. In general, lakes are less affected by these sources of water quality impairment because particulate material of an inorganic nature (silt, clay) is removed quickly from a still water column by gravity. Some nutrient loading may be attributed to these distributed (non-point) sources associated with living places and roads, but typically it is of low magnitude compared to other sources except in intensely developed areas.

A comprehensive water quality management program in any area of urban development, however small, should include some consideration of routing and retention for storm flows. Storm flow regulations for larger urban areas now are becoming quite restrictive in the sense that retention of storm water is consistently required as a condition for new development, and, through the EPA, efforts are being made to retrofit large urban areas with retention capabilities. While the scale of urban development in the Barker watershed is quite small, the majority of the development is directly upstream of Barker Reservoir. Best management practices for retention of storm flow in new development is certainly of relevance, and retrofitting of existing development also would be desirable.

Constituents of Concern: Heavy metals, especially copper, lead, and zinc are the most prevalent constituents in urban runoff. Arsenic, cadmium, chromium, and nickel are also common constituents. Synthetic organic chemicals (e.g., pesticides) are periodically detected in urban runoff at lower concentrations than metals. Oil and grease and hydrocarbons, primarily from vehicle and road use, are common constituents in runoff. Runoff also typically carries fecal coliform bacteria, nutrients, and organic carbon. The principal short-term impacts of urban runoff on drinking water supplies are temporary elevated levels of turbidity and pathogens in receiving waters during and immediately after precipitation events.

9.4.2.4 Atmospheric Deposition

Throughout much of the United States, atmospheric deposition has changed greatly in chemical composition, primarily as a result of the combustion of fossil fuels. Along the Front Range, and extending up to the Continental Divide, atmospheric deposition (including wet precipitation and dry deposition) is acidified and enriched with nitrate and to a lesser extent with sulfate as a result of the release of oxides of nitrogen and sulfur through the combustion of fossil fuels by automobiles and by power plants (Lewis et al, 1984). The degree of change in precipitation chemistry is not so drastic, however, as it is in the heavily urbanized eastern United States.

Acidification of precipitation can be directly damaging to inland waters by changing the conditions for growth and development of aquatic organisms, and sometimes even by causing liberation of metals from soils. It appears that, at the present time, this degree of alteration has not yet occurred in the watershed, except perhaps at the very highest elevations during brief periods in spring when channels are carrying large amounts of snow melt. A previous study in the neighboring Silver Lake watershed (north of Middle Boulder Creek watershed) found slightly elevated metals concentrations, but the levels decreased after flowing through lakes. A second effect, however, is enrichment of water and soils with unusual amounts of nitrate. The effects of this change could be to alter the composition of aquatic and terrestrial floras and thus to alter other processes as a result. These problems are under intensive study but there are no generalizations yet.

Atmospheric deposition is a regional matter rather than a local one, and is not under the direct control of any local land management or resource management authority. Furthermore, it is likely in the Barker Reservoir watershed that this threat to water quality is much more minor than others already mentioned above.

Constituents of Concern: Trace metals and pH are a concern for soils and surface water. Nitrate and sulfate are secondary concerns.

9.4.2.5 Silviculture and Grazing

Land management practices include a wide variety of dispersed activities in watersheds. Aside from the direct effects of development, one can find measurable effects on water quality that are traceable to conversion of native land cover to other forms of land cover (e.g., conversion of forest to pasture), and also from agricultural practice, grazing, and timber management. Of these types of management practices, timber management and livestock management perhaps are the two most important other than direct residential and urban development in the Barker Reservoir watershed.

Timber management, much of which is conducted under supervision of the U.S. Forest Service, includes thinning, clear cutting, and prescribed burning. All of these practices have the potential to liberate sediments and nutrients, but studies at other locations of similar topography in Colorado indicate that the effects will be small to moderate except in the case of clear cutting, which may produce strong effects on water quality for a year or two following clear cutting (Lewis and Saunders, 1994). In response to concerns over water quality, the U.S. Forest Service has been implementing more stringent requirements for contracting clear cutters, and this trend may moderate the effects of timber management on water quality.

Livestock grazing is likely to cause liberation of nutrients, even when it is fairly dispersed, and under the worst conditions may cause physical degradation of stream channels and erosion. At the densities that are typical for open range in the Barker Reservoir watershed, drastic effects are unlikely, but interaction with the decision makers on use of open range would be desirable as a component of water quality management.

Constituents of Concern: Sediment and related soil nutrients from erosion are the primary concern of fire in the watershed.

9.4.2.6 Humans and Domestic Animals

Humans and domestic animals have a constant presence near Barker Reservoir and its tributary waters. While fecal matter from pets and danger of pathogen transmission from either pets or direct contact of water with humans is worth considering, these challenges to water quality are probably minor in comparison to most of the other items listed above. Quantities of nutrients transmitted from domestic animals at sources are trivial compared to other loadings. Pathogens are always a concern and the safest practice is to avoid human contact or animal contact with waters that are destined for domestic water supply, but may be outweighed by other interests.

Recreation activities in the Middle Boulder Creek watershed include scenic viewing, hiking, climbing, backpacking, picnicking, mountain biking, nature appreciation, fishing, horseback riding, four-wheel driving, cross-country skiing, snowshoeing and snowmobiling (see Sections 10, 11, 12 and 13).

Constituents of Concern: Contact with water during recreational use is a potential source of microbiological contaminants (viruses, pathogens, and bacteria) to the streams and lakes. Runoff from recreational area parking lots may contribute sediment, metals, and hydrocarbons to streams via runoff. In addition, human waste on the land from camping, biking, hiking, etc. is a concern because it can introduce pathogens to streams via runoff.

9.4.2.7 Erosion

Elevated erosion and increased sediment loading result from the movement of soil by water and wind. The erosion potential of areas within the watershed canyons is dependent on the local soil characteristics and underlying geology of the area. Areas in the watershed have a high potential for erosion due to local physical features of topography, altitude, slope exposure, and vegetative cover.

Constituents of Concern: Concerns related to soil erosion are the migration and deposition of soils into surface waters, with subsequent stream channel and substrate degradation. Sediment from nonpoint sources is the most widespread pollutant of surface water. Total suspended solids and turbidity are water quality indicators relating to sediment, but the effects of sediment on ecosystems can also be characterized. Suspended sediment alters aquatic environments by reducing light and limiting the productivity of water, and by affecting aquatic food supply and reproduction by blanketing stream bottoms. In addition, pollutants, such as bacteria, nutrients, and organic material, adhere to suspended particles. High turbidity levels are also a concern for drinking water treatment, because particles transport pollutants and can cause problems with filters.

Water quality monitoring and treatment operations regularly identify elevated organic carbon, turbidity, and suspended solids during spring runoff.

9.4.2.8 Fire

Wildfire, while not a direct byproduct of timber management, is a component of the mix of land use practices and can have stronger effects on water quality than deliberate management practices. Wildfire burns with higher intensity, thus causing more extensive loss of organic protection for the soil surface and leading to much higher rates of erosion and nutrient transport than prescribed fire. Thus, one strategy for management of forests in the Barker Reservoir watershed might involve a collaboration with the forest managers with the objective of reinforcing constantly the local interests in water quality, while recognizing that some form of forest management must be practiced (see Section 9.4.2.5 and 16.4.3).

Fires in the watershed can contribute large loads of suspended solids and organic matter to the water supply system during and immediately after the fire, and for some period of time until the fire area is stabilized with vegetation. Fires strip the soil of its organic protective cover, leaving the soil bare and vulnerable to erosion. Soils may also become hydrophobic and repel water, casing an increase in overland flow and erosion. The watershed has limited fire history, but there is high potential due to vegetation fuel types (see Section 16.4.3.1 and 16.4.3.2).

Constituents of Concern: Erosion from wildfires increases sediment transportation in runoff. The increased sediment can affect aquatic life and the resultant high turbidity causes disinfection and filter clogging problems at water treatment plants.

9.4.2.9 Household Hazardous Waste

Homeowners use a variety of chemicals in the cleaning and maintenance of their homes, yards, gardens, and automobiles. Household wastes can enter the water system when they are disposed of improperly, including pouring chemicals into storm drains, household drains or on land where they can enter waterways through runoff. Proper use and disposal of these materials is one of the keys to preventing contamination to waters.

Constituents of Concern: Organic chemicals, pesticides, fertilizers, hydrocarbons, oil and grease.

9.4.2.10 Motor Vehicles and Transportation Corridors

Transportation corridors are potential sources of contamination to surface waters through their potential for fuel spills and spills of transported items. In addition, winter maintenance of roads can introduce pollutants to soil and water.

Highways 119 and 72 are the major transportation corridors through the watershed, along with access roads to the Eldora Ski Area. The watershed also includes many road maintenance facilities.

Constituents of Concern: Construction and maintenance activities, general vehicular traffic and hazardous material spills can introduce chemicals and sediments from roadways. Construction activities such as road widening, re-alignment and re-surfacing have the potential for accelerating natural erosion and sedimentation processes. Excessive erosion and sedimentation can introduce suspended solids, nutrients and metals into adjacent streams and lakes. Wintertime maintenance activities can introduce sediment and salts into surface waters. In some locations de-icing/anti-icing chemicals, such as magnesium chloride, are applied to the road surface to aid in maintaining safe driving conditions. These de-icing agents have the potential of introducing increased salinity (mag-chloride, sodium chloride), nutrients (phosphorus), and metals (zinc, lead) into nearby surface waters during runoff conditions. County or rural roads that are unpaved or have gravel shoulders can contribute sediment, nutrient, and metal loading into ditches, tributaries and nearby streams. Normal vehicular traffic can contribute oil and grease and gasoline into the watershed.

9.4.2.11 Natural Sources

Wildlife pose a potential threat to water quality because they may contribute pathogenic organisms to the water supply. The large amount of undeveloped land in the watershed makes this source a particular concern. Other natural sources of possible contamination include naturally occurring minerals, metals, and radiation inherent in some geologic formations.

Constituents of Concern: Wild and domestic animal populations may contribute pathogenic organisms such as *Giardia* and *Cryptosporidium*, bacteria, and viruses. Naturally occurring metals and radionuclides are also a concern.

9.4.2.12 Recreation

9.4.2.12.1 Biking

Mountain biking is the most popular form of cycling in the Middle Boulder Creek watershed. It is not permitted in the Indian Peaks Wilderness. Touring bicycles also are popular on SH 119 in Boulder Canyon. Mountain biking is a water quality concern as riders can compact or denude vegetation on or off trails and cause soil erosion. Soil compaction reduces water infiltration and therefore increases run-off velocities causing more soil to be displaced. Human waste also is a problem in backcountry areas where there are no restrooms.

Constituents of Concern: Trail use, particularly trails not designed for mountain bikes or off-trail use can contribute to sediment loading. Additional sediment loading can also carry constituents such as nutrients and microbiological/pathogens.

9.4.2.12.2 Boating

Boating is not permitted on Barker Reservoir. Motorized boating already has been eliminated as even a future possibility by Boulder staff and city council. Both proponents and opponents to boating on the reservoir have issued detailed and general pros and cons to the future of boating. Kayaking is a popular activity in Main Boulder Creek where a constructed kayak course exists in Eben G. Fine Park (see Section 13.1).

Constituents of Concern: Non-motorized boating itself does not directly introduce contaminants. However, secondary impacts from boating include the introduction of sediments from shoreline access if boat ramps are not used and potential for introduction of pathogens from direct body contact. Shoreline access can reduce protective vegetation and a natural buffer to contaminants such as sediment and constituents that can adhere to sediment (e.g., nutrients, pathogens). The increased access also increases the potential for human waste issues. Boating can also introduce nonindigenous and nuisance species into the reservoir. These species can include aquatic, terrestrial, and plant species that can be introduced, via boats, from other lakes and reservoirs. Nonindigenous species can disturb native species through predation or displacement, clog intake pipes for municipal water supply and can pose human health risks.

9.4.2.12.3 Picnicking and Camping Areas

Picnicking occurs in dispersed undeveloped areas in the Arapaho and Roosevelt National Forests, at Chipeta Park in Nederland near the Middle Boulder Creek inlet, the west and north sides of Barker Reservoir, a few sites along Middle Boulder Creek downstream of Barker Dam and at Eben G. Fine Park in Boulder near the mouth of the canyon.

Camping occurs at designated dispersed sites in the Indian Peaks Wilderness and within the Arapaho and Roosevelt National Forests. Camping is not permitted at Barker Reservoir or along Middle Boulder Creek in Boulder Canyon downstream of the dam. Camping violations are relatively common in the canyon.

Bacterial contamination and types of pollution from areas impacted by camping tends to relate to the type of camping. Limited research has shown more instances and greater amounts of water pollution were found to occur in campgrounds utilized by motorized campers than in campgrounds utilized by backpack campers. A significant difference was found between the water-quality impacts (bacterial increases) observed at campgrounds accessible by foot path, paved road, and unpaved road, with the least number and degree of bacterial increases in areas only accessible by foot path (Aukerman and Springer, 1976).

Visual surveys conducted in backcountry camping areas have found significantly greater fecal material at sites with overnight campers. A visual survey found wastes near a creek even though there was a latrine nearby (Farag, 1998; see Section 10.3).

Constituents of Concern: Picnicking and camping areas, if near streams or lakes, allow access to water that can lead to stream bank erosion and sediment deposition, as well as pathogen introduction from direct water contact. The U.S. Forest Service does not allow camping within 100 feet of streams or lakes; this is difficult, however, to enforce. Camping can contribute to pollutants caused by motorized access as well as introducing general garbage and litter. Backcountry camping can introduce pathogens, particularly if hiking and camping along streams and lakes.

9.4.2.12.4 Cross Country Skiing/Snowshoeing

The upper Middle Boulder Creek watershed is a popular destination for cross-country skiing and snowshoeing. There also are groomed slopes at Eldora Ski Area for cross-country skiers. Cross-country skiing and snowshoeing are not resource intensive activities and often impacts are limited to human waste in backcountry areas. The fact that it is a winter sport allows snow pack and the delay of runoff to potentially provide for attenuation of pathogens prior to runoff.

Constituents of Concern: Pathogens.

9.4.2.12.5 Fishing

Some backcountry fishing occurs at lakes and reservoirs in the upper watershed as well as Middle Boulder Creek. Limited shoreline fishing occurs at Barker Reservoir as well as along Middle Boulder Creek downstream of the Barker dam. Fishing is popular in Main Boulder Creek. These activities can compact soil and reduce vegetation along water banks. Deterioration of lake, reservoir and stream banks can increase sediment loading and reduce buffering capacity provided vegetation to mitigate runoff to waters (see Section 11.7).

Constituents of Concern: Total and dissolved suspended solids and nutrients.

9.4.2.12.6 Hiking

Both trail and dispersed (backcountry) hiking are popular within the Middle Boulder Creek watershed. Water quality concerns include erosion from compacted soils, human waste in backcountry areas, and the introduction of pathogens in to source waters (see Sections 10 and 11).

Constituents of Concern: Pathogens, total and dissolved solids.

9.4.2.12.7 Horseback Riding

Similar to hiking, horseback riding also can result in compacted soils, human and animal waste in backcountry areas, and the introduction of pathogens to source waters.

Constituents of Concern: Pathogens and nutrients.

9.4.2.13 Construction

Construction relates to man-made changes in the natural cover or topography of the land, including grading, cutting and filling, building, paving, excavating and any other activities that may contribute to soil erosion or sedimentation in waters or discharge of pollutants. Land disturbance activities can include new development and expansion or alteration of residential and commercial sites. The majority of the watershed is undeveloped, and the existing and future development will primarily concentrate around Nederland, Eldora and the major transportation corridors.

Constituents of Concern: Sediment loading is the primary concern related to construction activities. Specific constituents include total suspended and dissolved solids. In addition the disturbance of the land can also impact nutrient and organic carbon loading. To a lesser degree, construction can also introduce hydrocarbons from fuel storage and machinery used in construction, as well as the introduction of fertilizers used during revegetation.

9.4.2.14 Residential Areas

In residential development, pervious, undeveloped areas are converted to land uses that typically have increased areas of impervious surfaces, such as rooftops, driveways, and roads. This results in increased runoff rates, volumes and pollutant loadings. In addition, residential areas introduce wastewater and solid waste. Similar issues are discussed in Sections 9.4.2.1, 9.4.2.3, and 9.4.2.6.

Constituents of Concern: Total suspended and dissolved solids, nutrients, organic chemicals, pathogens, hydrocarbons.

9.4.2.15 Ski Area

Ski areas have similar issues to residential areas. Ski areas bring motor vehicles and people into the watershed and must address urban runoff from resort and parking areas, as well as wastewater collection, grounds maintenance, and fuel storage. Storage of snow removal from large parking areas can also compact and degrade natural vegetation that can provide buffering between paved areas and waterways.

Constituents of Concern: Total suspended and dissolved solids, nutrients, organic chemicals, pathogens, hydrocarbons.

9.4.2.16 Unauthorized Activities

Examples of unauthorized activities include dumping or spills of chemicals, paints, or any other toxic material in a surface water, or disposal of residential or commercial refuse into conveyance channels. Illegal dumpsites are a common type of unauthorized activity. Although these activities often involve land disposal, they are a concern because they often generate leachate, which may contaminate surface waters and groundwater.

The Colorado Department of Health and Environment maintains the Emergency Response Notification System (ERNS) database, which documents reported releases of hazardous or questionable substances. Accidental spills and releases of hazardous materials are common, and the amount of release can range from parts per million to hundreds of gallons. Many spills are small and in contained areas. The ERNS listing is a means of pinpointing otherwise unidentified impacts to a stream. Response to these reports is typically rapid and well documented.

Constituents of Concern: Illegal dumpsites vary from the dumping of relatively innocuous large household goods to the dumping of refuse chemicals. Illegal dumpsites have the potential to be of concern, depending on their proximity to waters and the specific nature of the material disposed of at the dump site. Illegal dumpsites may create leachate similar to that from permitted solid waste disposal sites. Spills generally consist of fuel releases from traffic accidents, leaks from faulty seals or broken pipes, and midnight/illegal dumping of hazardous materials.

9.4.3 Effects of Impairment on Specific Water Uses

The information on potential causes of impairment can be combined with the list of uses to be protected as a means of demonstrating the likelihood that specific kinds of water quality impairment will affect specific kinds of uses. Table 9.4.3 is a summary of that information. As shown by Table 9.4.3, the support of aquatic life, recreation, and domestic water supply are the three most demanding uses in the sense that they are sensitive to a wide variety of relatively

TABLE 9.4.3
EFFECTS OF IMPAIRMENT ON SPECIFIC WATER USES

Impairment of Use	Use[1]
Eutrophication	DWS, R, A
Toxins	DWS, AWS, R, A
Pathogens	DWS, R
Tastes and Odors	DWS, R
Manganese, Iron	DWS
Suspended Solids	DWS, R, A
Dissolved Organic Matter	DWS

NOTE:

1. DWS: Domestic Water Supply; AWS: Agricultural Water Supply; R: Recreation; A: Aquatic Life

subtle impairments of water quality that can come from a variety of sources. In contrast, agricultural uses are unlikely to be impaired by any degree of water quality alteration that would occur under present or near future circumstances in the waters of Barker Reservoir or its tributaries. Recreational uses, if aesthetics are included, are mostly sensitive to pathogens and nutrients, but much less so to toxins that would be important at relatively low levels for aquatic life or domestic water supply.

The data in Table 9.4.3 indicates that protection of one type often offers protection for one or more additional types of uses as well. Thus, efforts to maintain concentrations of heavy metals that are consistent with sensitive forms of aquatic life that occupy the cold waters of Barker Reservoir and its tributaries also contribute to the maintenance of water quality for domestic supply purposes. In other words, it is seldom necessary to assign priorities to uses for purposes of water quality protection; efforts to preserve or maintain water quality often serve multiple purposes.

9.4.3.1 Nutrient Enrichment

Enrichment of surface waters with nutrients is one of the most pervasive water quality problems in Colorado and in the United States as a whole. The water quality regulatory systems of the United States properly put their initial emphasis on control of substances that are toxic or cause outright mortality or suppression of aquatic life or present a health hazard for human consumption of water. The effects of nutrients are not comparable to those of toxins because the undesirable effects of nutrients are indirect. Even so, nutrients impair inland waters, and this type of impairment is deleterious to many uses, especially water supply and aquatic life but also recreation and, under some circumstances, even agricultural supply. For this reason, the EPA is pushing the development of nutrient control by the states, and Colorado will be affected by this move in the future. In the meantime, it is advisable for water managers to attempt to control the movement of nitrogen and phosphorus from anthropogenic sources into surface waters whenever possible, for the benefit of water quality.

As shown by the foregoing section, humans mobilize nitrogen and phosphorus in many different ways. Direct disposal of treated municipal waste, as in the case of the Nederland effluent entering Barker Reservoir, is a potent source of nutrients. Indirect sources also contribute, however, as in the case of septic systems (ISDS) or urban and residential runoff. Even land management practices, such as timber harvesting or conversion of one type of vegetative cover to another, can result in a net mobilization of nitrogen and phosphorus.

Nitrogen and phosphorus are required for growth by all living organisms. Although other elements also are required, nitrogen and phosphorus tend to be the elements in shortest supply, and thus they often control the growth of organisms. Animals obtain their nitrogen and phosphorus supplies from plants, but plants must obtain their nitrogen and phosphorus supplies from water or soil. Thus, the supply of nitrogen and phosphorus to water and soil has a direct effect on the amount of plant growth.

In general, waters fertilized with nitrogen and phosphorus will show an increase in the amount of aquatic vegetation directly proportional to the amount of nitrogen and phosphorus that is supplied. In streams, addition of nitrogen and phosphorus may result in the development of noticeable amounts of attached algae, which is evident to the casual observer as something that looks like moss (and erroneously called so, although it is algae). This heavy growth may displace the characteristic communities of unfertilized waters, and in this sense is an upset in the balance of nature.

For lakes, addition of nitrogen and phosphorus can be much more severe than for streams. If very shallow, lakes may respond to the addition of these nutrients by the growth of aquatic weeds such as cattail in great profusion. More often, and especially for lakes that are more than a few feet deep, the addition of nutrients stimulates growth of suspended algae (phytoplankton), which are perceived to the casual observer as green color in the water. Thus, stimulation of algal growth in lakes is the immediate byproduct of the addition of phosphorus and nitrogen to most lakes.

Mountain waters, and thus mountain lakes, typically have very low amounts of phosphorus and nitrogen in their natural condition. For this reason, the waters contain only small amounts of phytoplankton. Waters containing small amounts of phytoplankton are clear and have a blue color. These characteristics are valued in mountain waters. The addition of nutrients, resulting in the growth of algae, reduces the transparency of the water and converts its color from blue to bluegreen or green. In the most egregious cases of enrichment, the water may have a soupy, strongly green appearance. Alterations in lakes caused by phosphorus and nitrogen extend beyond change of color and reduced transparency. The cluster of changes, as well as the process of change itself, are termed eutrophication. Thus, nutrients cause eutrophication. A eutrophic lake, which means one in which nutrients are abundant, produces more organic matter (mostly in the form of algae) than its unenriched counterpart. This organic matter moves toward the bottom of the lake as the suspended organisms die. During the summer, when the bottom of the lake is isolated from the upper waters by season temperature layering, the self-generated organic matter from the lake causes loss of oxygen from deep water through the process of microbial decomposition, which demands oxygen. Loss of oxygen may lead to reduction of fish habitat or, in extreme cases, even mass mortality of fishes when the lake mixes fully again in the fall.

Lakes that are heavily enriched may experience complete oxygen depletion of oxygen in the bottom waters, followed by a cluster of additional biogeochemical changes that are undesirable. Loss of oxygen leads to release of manganese and iron from the sediments into the water. Intake of this water by a water treatment facility presents the issue of iron and manganese removal, which is difficult and often not successful. In addition, lakes losing oxygen on the bottom often show a phenomenon called internal nutrient loading. Nutrients, and particularly phosphorus, are liberated from the sediments in large quantities when oxygen is depleted from the sediment surface. Thus the lake fertilizes itself, exacerbating the problem of external loading with nutrients. Reversal of internal loading is not always successful, and therefore should be avoided.

Large amounts of algae in the water column present problems for water treatment, and may also generate odors that are detectable in treated water for consumption or may be detectable at the site by recreationalists. Large algal growths (blooms) also create periodic population crashes leading to rafting of decaying algae near shorelines. While these conditions typically only occur in the extreme cases of eutrophication, they are the end point in a series of degradations that are generally opposed by the public or by water users of any kind. Finally, under extreme eutrophication, the presence of algae-bearing toxins can be an issue. These toxins pass through standard water treatment, and have effects that are yet largely unknown.

Although the disadvantages of eutrophication are incremental, even a small amount of eutrophication causes notable changes in the characteristics of lakes and in the utility of water stored in lakes. Therefore, management is well advised to work continually against the mobilization of nutrients through interception of waste flows containing nutrients, treatment or diversion of point sources of nutrients, control of land use practices in such a way as to minimize nutrient release, and containment of urban storm flows.

9.4.3.2 Toxins

Toxins fall into two large groups: inorganic and organic. Under the inorganic category, one common concern is for heavy metals and some non-metallic substances that typically are grouped with heavy metals (selenium). Metals that are commonly of concern either for domestic supply or for support of aquatic life in Colorado include iron, manganese, copper, zinc, cadmium, lead, silver, mercury, and selenium. Other metals may be of importance at specific sites.

Toxins generally affect the aquatic life and domestic supply uses of water. In high quantities, toxins also could affect recreation and agricultural uses, but the sensitivity of the domestic supply and aquatic life use is so much higher than the sensitivity of recreation and agricultural uses that domestic supply and aquatic supply life uses are typically the dominant concern.

For protection of aquatic life, the dissolved form of metals is most important and the State regulations are based on the concentration of the dissolved form. Hardness of water (calcium and magnesium content) protects aquatic life against some dissolved metals. Therefore, hardness is taken into account when evaluating concentrations of metals for toxicity. The same metals that are regulated for protection of aquatic life generally are regulated also for protection of domestic supply, but the requirements for domestic supply typically are less stringent than those for aquatic life.

As indicated in the preceding section, metals may originate from mining, which perhaps is the most common source in Colorado, but also may come from sewage disposal. In general, mining is the more difficult source to manage because it typically produces a more dispersed source and is more difficult to remediate, whereas treatment plants that have unacceptably high metals content can be reengineered or managed for reduction of metals output.

Metals also can be liberated from the environment itself as a result of eutrophication. This is particularly true of iron and manganese, which leave sediments in lakes that lose oxygen on the bottom. Thus, eutrophication is an indirect cause of metals pollution in lake waters.

Some inorganic substances other than metal are subject to regulation for the protection of uses. The most common ones of concern within Colorado include nitrate and ammonia. Nitrate is regulated for the protection of human health at 10 mg/L for domestic supplies. This limit may be an issue in certain waters of the plains, which contain high concentrations of nitrate. In the Barker Reservoir area, where concentrations are much lower, nitrate is not a special concern.

Ammonia is regulated strictly for the protection of aquatic life and also for the protection of domestic supply. The regulations for aquatic life are quite stringent. Ammonia is present in very low quantities everywhere within the Barker hydrologic system except the Nederland effluent, which discharges substantial quantities of ammonia. Because of the small flow of the Nederland effluent proportionate to total flow to Barker Reservoir, however, the Nederland effluent does not cause notably high concentrations of ammonia in Barker Reservoir as a whole. Also, ammonia is subject to conversion to nitrate by natural microbial mechanisms, and this probably occurs rapidly in the lake. Algae also take up ammonia, and thus render it harmless. Even so, the rate of mixing of the strong ammonia source at the Nederland effluent discharge may be an issue in the future as the State of Colorado takes up regulations on maximum allowable areas for mixing zones for regulated substances.

A second type of toxin is organic. Solvents such as benzene and biocides (e.g. herbicides, pesticides) are regulated very stringently. These substances may be found in small amounts in point sources of wastewater discharge, but typically are diluted substantially in receiving waters and do not become an issue except where dilution is minimal. Other sources in the watershed include commercial/industrial and residential. Because of the requirements of the Safe Drinking Water Act, the city of Boulder tests drinking water for a variety of organic substances. Thus, any unsuspected presence of these substances in the waters of the Barker Reservoir or its watershed would probably be noticed first by the city of Boulder water utility.

9.4.3.3 Pathogens

Pathogens are organisms that cause disease in other organisms. Aquatic forms generally fall into four categories: bacteria, viruses, protozoans, and parasitic worms. The parasitic worms, although problematic in many parts of the world, are not so in Colorado or in the U.S. generally because of public health practices which have broken the life cycles of these organisms. Bacteria such as *E. coli* are present in all surface waters because they can originate from fecal material of virtually any vertebrate. The management of bacteria in drinking water supplies has been extensively studied and is very well developed in the U.S. Chlorine, which effectively kills bacteria, is introduced during waste disposal and also during the water treatment process. Even so, contamination of surface waters by animals or humans can interfere with the use of water, as shown by the closing of swimming beaches in Colorado because of fecal contamination. Ideally, both recreators and domestic water providers would seek to maintain surface water as free as possible of fecal contamination. Providers of domestic water can treat fecal coliforms, double protection (a clean source plus effective treatment) is greater insurance against health risk than single protection (treatment alone).

Viruses and protozoans are more problematic for treatment than bacteria. These can originate either from humans or from other vertebrates. Viruses are small and it has been shown that they can pass through conventional treatment processes. The risk associated with viruses is that they may show health effects that are difficult to detect because effects may be delayed, often for many years. Thus the general strategy is to keep exposure to a minimum by protecting the water supply from unnecessary contact with fecal matter. Protozoans have more obvious effects. *Giardia* and *Cryptosporidium* are the most widely recognized organisms in this category. Both of these organisms can be transmitted as cysts, which constitute resting stages that are very difficult to deal with by standard treatment practices. It has been shown that many surface waters in the United States contain measurable amounts of these organisms, and outbreaks in the human population are well known. The two countermeasures include special treatment practices designed specifically to remove these organisms, and protection of source water from contamination.

9.4.3.4 Sediments

Sediments derived from erosion typically are dominated by inorganic material, especially silt and clay. Sediments are quite mobile under wet conditions, especially where land surfaces have been damaged or where there is pavement. Sediments can be quite harmful to streams. They interfere with the respiration of aquatic organisms and block the internal spaces within streambeds where organisms live.

Sediments often are less threatening to lakes than streams, given that sediments tend to move from the water column to the substrate of a lake. Sedimentation, if pronounced, does change the depth distribution of lakes, however, and this may be undesirable from the viewpoint of water storage, aesthetics, or support of aquatic life. Sediments also may carry contaminants that otherwise would not be very mobile. Heavy metals can be attached to sediments, and thus enter a lake by this means, and phosphorus often is carried effectively by fine sediments. Thus management always should include at least standard best practices to intercept waterborne sediments and remove them wherever possible.

9.4.3.5 Organic Matter

Organic matter derived from treatment facilities or other sources can threaten the welfare of both running waters and lakes by depleting the available oxygen in the water. For point sources, however, State permitting practices typically limit the amount of organic matter in the form of Biochemical Oxygen Demand (BOD) that can be discharged so that the net effect on the environment is minimal. Organic matter also refers to total organic carbon, which can be a precursor to potentially harmful disinfection byproducts in the water treatment process. Thus, while the Nederland effluent contains substantially more organic matter than Middle Boulder Creek, the total amount, when dilution is taken into account, is not sufficient to have a large effect on Barker Reservoir. Organic matter is more likely to be an issue when minimal dilution is available.

Lakes generate new organic matter when they are supplied with large amounts of nutrients. Thus, in a sense, the eutrophication issue is also an issue of organic matter.

9.5 Water Quality without Human Influence

Middle Boulder Creek provides a high quality water supply for multiple beneficial uses. City-owned land, Boulder County Open Space, and wilderness designation provide highly protected areas in a large portion of the watershed to help minimize human influences. Data indicate that water quality can degrade as water travels down the watershed where human influences increase (e.g., access, development, and traffic). However, even without human influence, water quality can degrade related to different uses. For example, spring snowmelt can cause significant increases in turbidity and wildlife can introduce pathogens into the water system.

The good quality of this high mountain water supply and the development of drinking water treatment and disinfection often lead to a belief that treatment can handle any pollution that might be introduced. However, we now have more growth and development, more uses in the high watershed, more household and commercial chemicals available, and we know more about the risks these factors introduce. In addition, unknown risks have increased. These risks range from the ease of world travel and transport of pathogens to new research suggesting over-the-counter and prescription drugs we take may show up downstream of our wastewater treatment plants and septic systems, and we don't know the potential effects on the environment or drinking water. Given that the watershed will continue to have many human influences, protecting the watershed and water sources must be emphasized.

9.6 Existing Water Quality

To assess the existing water quality in the Barker Reservoir watershed, three aspects were examined: existing water quality data, the State of Colorado list of impaired waters (303(d) list developed by the WQCD), and the location of the waters within the watershed. When compared to criteria that are established to protect water uses, such as drinking water sources or aquatic life, the measured constituent levels fall below the criteria limits. Water quality criteria are set based on protecting the beneficial uses of a water body (e.g.; recreation, aquatic life, water supply). Since the existing water quality data values fall below the criteria, the streams and reservoirs in the watershed are meeting their beneficial uses for measured constituents.

Section 303(d) of the Clean Water Act requires the State to compile a list of impaired waters biennially, called the 303(d) list. This list identifies waters that do not or are not expected to meet applicable water quality standards. The applicable water quality standards are based on beneficial uses for the waterbody. None of the waterbodies within the Middle Boulder Creek watershed are included in the current 303(d) list, and are not designated as impaired.

Not all constituents that could be of concern for the watershed are regulated or accounted for in the 303(d) listing process. For example, fecal coliforms are regulated in the raw water as an indicator of pathogens, but individual pathogens such as *Giardia*, *Cryptosporidium*, S*almonella*, and viruses are not regulated in raw water. Phosphorus and total organic carbon are not regulated in the watershed streams, but phosphorus is a concern for eutrophication in the reservoir and organic carbon is a concern for water treatment operations. Drinking water regulations apply to pathogens and total organic carbon and more restrictive drinking water standards may be more difficult to achieve consistently even though streams and reservoirs meet current stream and reservoir water quality standards. For additional information, the location of waters within the watershed can be used to assess water quality based on exposure to pollutant sources.

The watershed lands in the Indian Peaks Wilderness have more restrictions on access and activities, which can help protect water quality at the headwaters. Closer to Barker Reservoir and downstream from the reservoir, human and animal access, traffic, and development have noticeable impacts. For example the Nederland Wastewater Treatment Plant effluent doubles the concentration of phosphorus in Barker Reservoir (Lewis, 2000). BASIN presents the existing water quality data as an index[2] showing degrading water quality as it moves downstream.

A vulnerability analysis following the Water Quality Control Division procedures for a Source Water Assessment and Protection (SWAP) program indicates the waters in the watershed above

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[2] An index is a representation of multiple water quality constituents in a single water quality grade.

Barker Reservoir are highly susceptible to a variety of natural and man-made threats. As part of its SWAP program, the state assesses risk to a drinking water intake by defining sensitivity zones. The sensitivity zones incorporate the distance of a potential contaminant source to both the drainage system and to a drinking water intake. Contaminant sources in Zone 1 are closest to the streams and water bodies that drain to an intake and pose the highest risk. Zone 1 is defined as either 1,000 feet from the stream or lake or the 100-year flood plain, Zone 2 extends a quarter mile beyond Zone 1, and Zone 3 is the remainder of the watershed. In relating contaminant sources to drinking water intakes or points of diversion, the state identifies contaminant sources as "near (<15 miles upstream)" and "far (>15 miles upstream)." The entire watershed above the city of Boulder drinking water intake is within 15 miles and is considered in the "near" zone designated by the state, which increases the water supply vulnerability rating. The WQCD is currently developing SWAP programs for all water systems in the state, which will provide supplemental information. The state is currently completing watershed delineations and after receiving input from water systems will complete all SWAPs in 2003.

Contaminants are generally from either point or nonpoint sources (Brown and Caldwell, 2000). Point sources are conveyed from a well-defined source (e.g., wastewater treatment plant, mine discharge). Nonpoint sources are less confined in their generation and discharge, but can have a significant cumulative impact on surface water quality (e.g., stormwater runoff, erosion from a forest fire). The vulnerability assessment for the Barker Reservoir watershed rated the water supply as highly vulnerable to over half of the contaminant sources in the watershed. Point and nonpoint contaminant sources in the watershed are presented on Figure 9.2.

9.6.1 Current Status of Barker Reservoir and Tributary Waters

Barker Reservoir has an area of approximately 200 acres at full storage capacity. Its maximum depth is 130 feet, and its total storage capacity is approximately 11,700 acre-feet. Thus, Barker can be classified as a reservoir of moderate size and high relative depth (due to the steep topography). The reservoir is small in relation to the size of the drainage area above it, and thus does not retain water very long (mean retention time is a few months, but varies greatly from year to year).

The physical characteristics of Barker Reservoir are determined in part by management practice. The lake serves hydroelectric and water supply purposes and also may experience withdrawals related to water rights. In general, the lake is allowed to fill during the spring (Figure 9.3), when the maximum flows are available from Middle Boulder Creek (Figure 9.4), and the water is drawn off gradually over an interval extending from June or July to the following May. The degree of drawdown, however, differs drastically from year to year depending on water availability and water demand. As shown in Figure 9.3, the lake can be essentially empty of water during the most severe cases of drawdown.

9.6.1.1 General Water Chemistry Characteristics of the Reservoir and Tributaries

General water quality indicators that sometimes are useful in water quality evaluations include hardness, alkalinity, pH, total dissolved solids (often as measured by specific conductance), and total suspended solids. Information on these constituents is available for the three main tributary flows (Middle Boulder Creek, Beaver Creek, Nederland effluent) and for Barker Reservoir. The monitoring information for 2001 is summarized in Table 9.6.1.1 for these locations. The table shows simple means of the monitoring data for a one-year interval. Discharge-weighted means, which would be useful in estimating annual load, would be slightly different from the means shown in Table 9.6.1.1.

Barker Reservoir can be characterized as a water body with moderately low hardness and alkalinity, and with a moderate pH. The pH is slightly lower in the bottom of the water column than in the upper part of the water column because photosynthesis, which raises pH, occurs only in the upper water column. The amounts of total dissolved solids and total suspended solids in the lake are quite low. Waters with this chemical profile typically make a good municipal supply and are good for recreation and aquatic life, provided that they do not contain excessive toxins and nutrients.

It is clear from contrasting the monitoring data for different locations that Middle Boulder Creek has the water of lowest alkalinity, suspended solids, and dissolved solids. Because Middle Boulder Creek is by far the largest water source, it sets the general chemistry for the reservoir. Beaver Creek shows higher conductance, higher suspended solids, and higher alkalinity than Middle Boulder Creek. These are signs of differences in disturbance between Beaver Creek and Middle Boulder Creek, but may also involve basic geological differences. Nederland effluent, as is characteristic of effluents generally, contains higher amounts of dissolved and suspended solids than Middle Boulder Creek, but the amount of water involved is relatively small.

TABLE 9.6.1.1
MEAN BARKER RESERVOIR WATER QUALITY INFORMATION - 2001

	Flow cfs	TSS mg/L	TDS mg/L	Alkalinity mg/L	Hardness mg/L	pH	TP µg/L	NO_3^{-N} mg/L	NH_3^{-N} mg/L	DO mg/L	DFe mg/L	DMn mg/L	TOC mg/L	Fecal Coliform #/100ml
Beaver Creek	1.9	9.7	95.9	54.2	66.9	7.9	17.3	0.03	0	9.2	0.15	0.02	2.3	18.6
Middle Boulder Creek	64.2	1.2	27.3	16.9	19.4	7.6	5.3	0.12	0	9.5	0.06	0.00	1.7	3.7
Nederland Effluent	0.2	39.4	362.1	137.6	90.1	7.0	4744.3	0.67	22.4	2.2	0.21	0.05	23.2	1223.3
Barker Reservoir (bottom)	-	1.7	28.1	15.5	18.5	7.1	38.3	0.16	0	5.1	0.46	0.10	3.4	0
Barker Reservoir (top)	-	1.9	24.3	20.7	16.7	7.7	15.2	0.07	0	8.0	0.07	0.03	2.3	3.0

ABBREVIATIONS:

TSS Total Suspended Solids
TDS Total Dissolved Solids
TP Total Phosphorus
DO Dissolved Oxygen
TOC Total Organic Carbon

9.6.1.2 Nutrients

As explained in the preceding section of this report, phosphorus and nitrogen have potentially a considerable effect on the general quality of reservoirs. The background concentrations of phosphorus and nitrogen are expected to be very low in watersheds such as that of Barker Reservoir. Concentrations of total phosphorus and nitrate in Middle Boulder Creek in fact are quite low. The exact background expected in this situation has not been estimated carefully, but probably would be close to 5 µg/L total phosphorus and 50-100 µg/L inorganic N. Thus, Middle Boulder Creek shows little sign of impairment with regard to phosphorus or nitrogen concentrations. In contrast, Beaver Creek shows elevated concentrations of phosphorus. We can speculate that these are associated with disturbance, but no careful study has been made of the sources of phosphorus in Beaver Creek.

Most striking with respect to nutrients is the Nederland effluent. As already mentioned, the Nederland effluent has concentrations of phosphorus and nitrogen that greatly exceed the concentrations in the lake. Even though only a small amount of the total water reaching Barker Reservoir originates at the treatment plant, about two-thirds of the phosphorus coming to the lake originates at the treatment plant, as does about 40% of the inorganic nitrogen. Thus, Barker Reservoir shows concentrations of phosphorus that are approximately twice as high as would be expected in the absence of the Nederland effluent, and also is enriched with nitrogen from the Nederland effluent.

9.6.1.3 Dissolved Oxygen and Chlorophyll

Concentrations of dissolved oxygen in the tributary flows are near saturation, as would be expected. Even in tributaries that have quite a bit of biological activity, rapid exchange with the atmosphere caused by turbulence of stream flow usually maintains oxygen concentrations near saturation.

The surface waters of Barker Reservoir typically are near saturation for dissolved oxygen. Once again, this is expected because of contact with the atmosphere. Deep waters, however, show a depression in mean concentrations. In fact, a record of the time course of dissolved oxygen concentrations in the reservoir shows that the oxygen concentrations declined steadily between early summer and fall (Figure 9.6). This decline coincides with the interval of water column stratification. During stratification (June-October), the bottom waters are not in contact with the surface. Furthermore, these bottom waters are dark and therefore do not support photosynthesis, which would generate oxygen. Thus, as in all stratified lakes, there is consumption of oxygen in the deep water. The rate of consumption is related to the productivity of the lake, i.e., its ability to generate organic matter. In lakes that are unenriched with nutrients, the organic matter generation may be very small, and oxygen decline during stratification may be quite weak. Thus, the bottom waters maintain abundant oxygen. At the other end of the spectrum, lakes that are eutrophic may lose all oxygen, and show very large chemical changes in deep water as a result. Barker Reservoir is intermediate on this spectrum. It comes close to losing all oxygen near the bottom, but has not quite reached the point at which prolonged anoxia is occurring.

Figure 9.6 makes a case for vigilant control of nutrient loading to Barker Reservoir, and reversal of nutrient loading trends if at all possible. The obvious beginning point for control would be diversion of the Nederland effluent, which is the single largest contributor of nutrients to the lake.

Chlorophyll is a companion variable to dissolved oxygen because it indicates the response of suspended algae to nutrient enrichment. During year 2001, algal growth was only moderate, as indicated by Table 9.6.1.1 (chlorophyll is an extract of phytoplankton and indicates the amount of phytoplankton). During the previous year (2000), however, the peak chlorophyll concentrations were twice as high. Thus there is interannual variability. Future monitoring will show the causes of this variability.

The chlorophyll concentrations that have been observed in Barker Reservoir are not alarmingly high. As indicated by the nutrient concentrations, however, the lake has the potential to produce considerably more chlorophyll than it produced in year 2001. Hydrologic and other factors may affect interannual variability, but the reservoir is at risk for unacceptably high phytoplankton concentrations unless the nutrient loading is reversed.

Counts of algae in the reservoir showed no significant numbers of nuisance algae at this time. Nuisance algae are those that are notorious for causing tastes and odor problems at water treatment plants and that cause floating scums. Monitoring for nuisance algae is an important component of the management plan.

9.6.1.4 Metals

Information on iron and manganese is shown in Table 9.6.1.1. Both of these metals are present in only small amounts in the reservoir and in Middle Boulder Creek. Although mining extended up Middle Boulder Creek, the historic influences apparently are not very great. In contrast, Beaver Creek shows much higher concentrations, indicating a continuing influence from historic mining. As is typical, effluent from the Nederland Wastewater Treatment Plant contains more iron and manganese than is found in most surface waters, including Middle Boulder Creek.

Other metals also have been measured in the reservoir and in the tributary flows. In general, the patterns follow those of iron and manganese: the likelihood for measurable quantities of heavy metals is greater for Beaver Creek and for effluent than it is for Middle Boulder Creek. Fortunately, the very large flow of Middle Boulder Creek as compared with the other two water sources provides sufficient dilution to prevent the waters in the reservoir from exceeding standards that are established to protect all uses. It should be noted that data on metals has only been collected since 2000 for Barker Reservoir and its tributaries.

9.6.1.5 Dissolved Organic Carbon

Dissolved organic carbon, when present in large amounts, can be an issue for water treatment because it forms potentially carcinogenic combinations with chlorine, which is used in disinfection. Dissolved organic carbon can be of natural origin or it can be of anthropogenic origin. Dissolved organic carbon concentrations in Middle Boulder Creek are moderately high but not extremely so; this is almost certainly a natural consequence of processes occurring in the montane forests. Beaver Creek shows similar concentrations. Effluent has higher concentrations, as expected, but the volume is not sufficient to raise the mean concentrations in Barker Reservoir very much.

9.7 Projected Population Impacts and Watershed Uses

Population in Boulder County has continued to increase significantly; the county population increased 29 percent between 1990 and 2000 and the Nederland population increased 27 percent in the same period (U.S. Census Bureau, 2000 data). This continued population increase in the watershed and neighboring communities can have significant direct and indirect impacts on the watershed resources. Increased traffic, development (impervious areas), and easier access to once remote areas increases the potential for water quality impacts. However, long-term water quality data is limited, particularly for Barker Reservoir, which is downstream of the most developed area in the watershed.

9.8 Projected Water Quality

The water quality in the watershed is typically of high quality. However, with increasing pressures from growth and more restrictive water quality regulations, effective management strategies will need to be continued and updated to minimize or mitigate water quality degradation.

9.9 Potential Water Quality Emergencies

Although the watershed currently maintains high quality water, unexpected spills or emergencies could threaten water quality if they are not properly addressed. Emergency response requires planning and coordination with multiple entities such as the Town of Nederland, Boulder County Hazardous Materials Response Team, and the U.S. Forest Service (see Section 16).

The Boulder County Emergency Operations Plan (EOP) rates the hazard potential for various types of emergencies based on the following factors:

- Historically, the hazard has affected the jurisdiction;
- Probability of occurrence;
- Possibility of loss of life or property and;
- Weather patterns or geographical considerations.

The County has a Multiple Agency Coordinating System (MACS) that is an information and resource support service intended to facilitate integrated action on emergencies involving multiple jurisdictions. It is designed to serve as a coordinating mechanism in Boulder County for all types of incidents that pose a threat to public safety, including fire, flood, wind, or hazardous materials/toxic substance spills (EOP, 2000).

9.9.1 Flood control

The Boulder County EOP rates flooding and flash flooding as a medium hazard. Boulder County has a sophisticated flood warning and detection system made up of stream and rain gauges throughout all the drainage areas in Boulder, as well as lesser streams throughout County. These gauges are connected to a computer in the Boulder Regional Communications Center that sound an alarm when significant amounts are recorded.

9.9.2 Wildfire

The Boulder County EOP rates wildfire as a medium hazard. The County has a Wildfire Hazard Identification and Mitigation System task force that uses a GIS based tool to assist in the identification of hazards in the wildland/urban interface. The result of this information is a hazard rating map for identifying risks and monitoring mitigation activities, as well as actual wildfire modeling. The County hired a full-time Wildfire Mitigation Coordinator in 1995.

The County also has an Emergency Warning and Evacuation Service (EWES) and is part of the Fire fighting Emergency Preparedness Network (EPN). The existing 9-1-1 database of telephone numbers and addresses is used in combination with detailed maps to help determine the geographic boundaries. The system is capable of calling up to 2,000 numbers in one minute. It is designed to deliver recorded information to endangered people in advance of a disaster or any major event (see Section 16.4.3).

9.9.3 WWTP failure at Nederland

A failure at the Nederland WWTP could have significant impacts on Barker Reservoir and the city's water supply depending on the type of failure. A failure could include the release of raw or partially treated sewage to the reservoir. The proximity of the WWTP to the reservoir and lack of buffer make a WWTP failure a significant concern. The WWTP has experienced violations of its discharge permit as current as the past six months, which can cause water quality degradation at both chronic and acute levels. Discharge permit violations are reported by the facility to the WQCD. Immediate emergency response actions for a failure would involve the Town of Nederland, the city of Boulder, Boulder County Health Department, and the WQCD (see Section 9.4.1.1).

9.9.4 Hazardous waste spill

The county EOP rates hazardous waste spills as a low hazard. Major chemical or hazardous waste spills can occur at any facility that uses or stores chemicals or from vehicles transporting hazardous materials. Boulder County has a trained HazMat team that responds to incidents in the county.

9.9.5 Acid mine discharge (AMD)

Acid mine drainage impacts overall water quality by decreasing pH and increasing the concentration of metals in the water. However, it is very unlikely that an emergency situation would be caused by acid mine drainage. While flood conditions would produce a higher volume of mine runoff and could possibly cause containment structures to overtop, the flow would be diluted and would not likely result in emergency levels of pollutants in the water. An emergency could arise from a breach in a mine runoff containment or detention pond, jeopardizing the aquatic life and the quality of drinking water for the nearby streams and Barker Reservoir. In this case the Colorado Division of Wildlife and the Water Quality Control Division would be contacted.

9.9.6 Sabotage/Terrorism/Vandalism

Sabotage, terrorism, and vandalism are site specific incidents that can occur anywhere in the watershed and may include an incident of biological, nuclear, incendiary, chemical, and/or explosive agents. The EOP identifies the responsibilities of the MACS entities for these types of incidents.

During heightened alert following the September 11, 2001 terrorist attack on New York and Washington, D.C., the city increased security measures of its high mountain reservoirs.

9.10 Conclusions

The Middle Boulder Creek Watershed has limited access and a designated Wilderness in the upper portion of the watershed, which can reduce the potential for many types of water quality impacts. However, the lower portions of the watershed have increasingly more impact from increasing pressures of development, access, and traffic. These human influences increase wastewater and septic discharges, introduce chemical and fuel use, and increase access that can introduce contaminants and impact protective vegetation. Water quality monitoring data indicates water quality impacts lower in the watershed.

More stringent water quality regulations continue to develop and unknown risks increase in conjunction with increased activity in the watershed. To maintain water quality, protection efforts should focus on keeping contaminants out of the water supply, rather than trying to remove them downstream. In addition, the city is implementing more intensive monitoring in the reservoir to assist in identifying potential water quality concerns early and tracking potential contaminant sources. The city aims to maintain multiple uses in the watershed while protecting water quality to maintain superior drinking water. This will require coordination and planning among the multiple stakeholders within the watershed.

9.11 Recommendations

Recommendations related to water quality target continued water quality monitoring and studies to establish baseline water quality and track existing and potential impacts from watershed land uses. In addition, increasing public education and awareness is key to cooperative watershed and water quality protection. Recommendations pertaining to water quality can be broadly summarized as follows:

- Identify and monitor important contaminants.
- Establish baseline water quality measures.
- Model and track important relationships, including land use and water quality.
- Increase public awareness and water contamination prevention.
- Complete a joint study with the Town of Nederland for mitigating the impacts of the Nederland Wastewater Treatment Plant.

- Use GIS to improve modeling and tracking efforts.
- Conduct a series of targeted studies and investigations.

Additional recommendations and more detailed recommendations are presented in Section 19.

Successful accomplishment of many of the recommendations will require collaboration between the city of Boulder, residents of the watershed, and various governments or governmental agencies. Table 9.11 summarize both cooperative and more unilateral actions that the city of Boulder should consider to maintain water quality in the Middle Boulder Creek watershed.

TABLE 9.11
RECOMMENDED ACTIONS FOR MAINTAINING WATER QUALITY IN MIDDLE BOULDER CREEK WATERSHED

Description	Anticipated Benefits Via Control of Constituents in the Column Headings			
	Nutrients	Toxins	Pathogens	Sediments
Work with the town of Nederland to achieve diversion of the Nederland effluent from the Barker Reservoir watershed.	X	X	X	
Work with the town of Nederland and Boulder County Health Department to assure quality in installation, maintenance, and monitoring of ISDS.	X		X	
Work with the town of Nederland and the County Health Department and sanitation authorities toward a plan for discouraging excessive additional installation of ISDS.	X		X	
Work with the town of Nederland and other authorities as necessary to achieve best management practices for urban and residential runoff control in the Barker Reservoir water shed.	X	X	X	X
Develop a water quality improvement plan for Beaver Creek watershed.		X		X
Consider destratification of Barker Reservoir if deep water oxygen conditions cannot be improved in Barker Reservoir in the future.	X			
Continue monitoring reservoir and tributary waters.	X	X	X	X
Establish a program of special studies of one- to two-year duration designed to answer specific questions related to water quality.	X	X	X	X

9.12 Existing Source Material of Special Relevance to Water Quality

9.12.1 Water Quality Testing

BASIN. 2000. Internet address: http://bcn.boulder.co.us/basin/data.

Colorado Department of Public Health and Environment (CDPHE), Water Quality Control Division. 2001. Personal Communication with Eric Oppelt, September.

9.12.2 Potential Causes of Water Quality Impairment

Lewis, W.M. Jr., M.C. Grant, and J.F. Saunders, III. 1984. "Chemical patterns of atmospheric deposition in the State of Colorado," *Water Resources Research* 20: 1691-1704.

Lewis, W.M. Jr. and J. F. Saunders, III. 1994. *Effects of Timber Harvesting on the Phosphorus Yield from Watershed Segments in Summit County, Colorado,* Summit Water Quality Committee.

9.12.3 Existing Water Quality

Aukerman, R., W. Springer. 1976. *Effects of Recreation on Water Quality in Wildlands.*

CDPHE. 2000. *Colorado Source Water Assessment and Protection Program Plan.*

CDPHE. 2000. *Water Quality Limited Segments Still Requiring TMDLs: Colorado's Draft 2000 303(d) List*.

Farag, A. 1998. *Water Quality in the Backcountry of Grand Teton National Park.* USGS Biological Resources Division, Environmental and Contaminants Research Center. Jackson, Wyoming.

Lewis, William. 2000. *Interpretation of Monitoring Data on Middle Boulder Creek and Barker Reservoir.*

9.12.4 Projected Population Impacts and Watershed Uses

U.S. Census. 2000. *U.S. Census Data.* Inernet address: http://www.co.boulder.co.us/lu/demographics/census2000.htm

9.12.5 Potential Water Quality Emergencies

Boulder County Sherriff's Office. 2001. *Emergency Operations Plan*. Internet address: http://www.co.boulder.co.us/sheriff/oem.htm

10 Recreation: Watershed Upstream of Barker Reservoir

10.1 Introduction

Much of the Middle Boulder Creek watershed upstream of Barker Reservoir lies within the Roosevelt National Forest. The national forest lands are subject to the multiple resource management mandates of the U.S. Forest Service (USFS) with recreation as an important use (see Figure 10.1). In addition to USFS trails and trailheads, there are three developed campgrounds within the watershed: Buckingham at Fourth of July, Rainbow Lake near FR 298, and Kelly Dahl four miles south of Nederland on SH 119. The two trailheads are Fourth of July and Hessie.

In 1997 the USFS completed the most current land and resource management plan and accompanying environmental impact statement for the Arapaho and Roosevelt National Forests (U.S. Forest Service, 2001) The four plan priorities include:

- Ensuring the long-term health of the land and restoring ecosystems.
- Providing a mix of high-quality recreation opportunities within the capability of the land.
- Providing sufficient quantities of clean water to the extent possible for domestic, industrial and agricultural use within the capabilities of the land and maintaining aquatic and riparian habitat.
- Promoting goals and objectives that contribute to the economic and social vitality of local communities, providing opportunities for partnerships, and improving service to the American public.

Dispersed (undeveloped/backcountry) recreation activities are very popular in the watershed and much of the forest is within the Indian Peaks Wilderness, designated in 1978. The wilderness designation was, in part, a response to heavy recreation use throughout the watershed and to the north. Indian Peaks is one of the most frequently visited wildernesses in the state due to its proximity to the Denver-Boulder metropolitan area (U.S. Forest Service, Roosevelt National Forest Land and Resource Management Plan, 1997). Dispersed recreation also occurs on the Arapaho and Roosevelt National Forests outside of the wilderness boundary.

The USFS reports that the Indian Peaks Wilderness receives about 100,000 visitors annually (U.S. Forest Service, 2001). Approximately 50 percent of the visitation is in the Brainard Lake area north of the Middle Boulder Creek Watershed. About 10 percent of the wilderness (13,350 acres) falls within the Middler Boulder Creek watershed. The USFS reports that the Hessie Trailhead has received about 11,000 visitors annually over the last 8 years. The Fourth of July Trailhead has received about 13,250 visitors annually over the last 8 years. These reports are based on electronic field counters.

The Indian Peaks Wilderness falls under the U.S. Forest Service Management Area Prescription Allocation 1.1 (U.S. Forest Service, 1997). Prescription 1.1. is the most restrictive of all prescriptive allocations. The following activities are not permitted: timber cutting, motorized recreation, grazing, and mineral, oil or gas extraction. The wilderness is managed for primitive or semi-primitive year-round backcountry recreation use. No camping is allowed within 100 feet of lake shores, stream banks, or trails. The USFS continues to monitor levels and impacts of dispersed recreation use in the wilderness and will implement a more restrictive permit system if deemed necessary. The USFS has identified the Hessie Trailhead as needing relocation.

Forest lands outside the wilderness and within the Arapaho and Roosevelt National Forests include management prescriptions for potential wilderness, backcountry and dispersed recreation, intermixed uses and the Eldora Ski Area.

10.2 Existing Opportunities

Recreation activities include scenic viewing, hiking, climbing, backpacking, picnicking, mountain biking, nature appreciation, fishing, horseback riding, four-wheel driving, cross-country skiing, snowshoeing and snowmobiling. Mountain biking, four-wheel driving and snowmobiling are not permitted within the Indian Peaks Wilderness. There is motorized access to Jasper Reservoir, and there are two backcountry huts: Guinn Mountain Hut and Tennessee Mountain Cabin. Dispersed recreation use within the wilderness has increased dramatically over the last 25 years (U.S. Forest Service, 2001).

Protecting natural resources is an ongoing effort and backpackers in the Indian Peaks Wilderness must obtain permits for dispersed camping from June 1 to September 15 of each year (since 1984). Signs to this effect are posted at several locations within the watershed.

Some recreation in the Middle Boulder Creek watershed occurs on private land. The Eldora Ski Area is a small popular downhill facility. The ski runs are located both on private and USFS land. It owes much of its success to its convenient proximity to the Denver-Boulder metropolitan area and its avoidance of congested I-70 weekend traffic. Approximately 245,000 skiers visit Eldora each year (Eldora Ski Area, 2001).

Streams above Barker Reservoir support brook trout, rainbow trout, brown trout, and native suckers and minnows. Some fishing occurs. Colorado Department of Water (CDOW) sampling in 1993 about 3 miles above the inlet to Barker Reservoir resulted in a minimum population estimate of about 90 rainbow trout and 110 brook trout per acre (CDOW, 1993). Middle Boulder Creek and its tributaries are historical habitat for native greenback cutthroat trout.

10.3 Visual Resources

Upstream of Barker Reservoir the watershed includes all lands within the Middle Boulder Creek drainage from the Continental Divide to the Middle Boulder Creek inlet to Barker Reservoir. Much of the land is federally owned and managed by Arapaho and Roosevelt National Forests staff. It is very mountainous and heavily timbered in many locations. Land uses include the multiple resources of the Arapaho and Roosevelt National Forests, private residences, come commercial development, mines and mining-related features, and the communities of Nederland and Eldora. This visually diverse area comprises everything from pristine landscapes to heavily disturbed mining sites to rural community development.

Lands within the national forest fall under the jurisdiction of the forest's land resource management plan (LRMP). Aspects relative to visual resources are discussed in the LRMP's section on visual resource management. Every land management prescription includes a visual quality objective (VQO). The VQO addresses the amount of permissible modification from natural appearance, from retention (maximum preservation) to maximum modification (maximum disturbance allowed). In 1996 the USFS implemented a new visual resource management system - Landscape Aesthetics: A Handbook for Scenery Management. The most significant change in methodologies is the understanding that certain human-induced modifications are attractive to many people, for example historic farm and ranch structures and old mining and milling sites. The Indian Peaks Wilderness is managed for retention or the maximum preservation of natural and cultural visual resources.

10.4 Issues

There are several issues relating to recreation in the watershed:

- Increasing visitation and related visitor activity may adversely impact water quality in the Middle Boulder Creek watershed over time. Adverse impacts may include soil erosion, the introduction of pathogens into the Middle Boulder Creek watershed, the cumulative impacts of human waste and human-caused wildfires.
- There is little research or site-specific investigation for the Middle Boulder Creek watershed or others relating increasing visitation and water quality impacts.
- Much of the land in the watershed is federally managed. The city of Boulder has no direct control of land use management.

10.5 Impacts on Water Quality

Neither the city, nor any other entities have specifically measured water quality impacts from recreation in this watershed. Visitation in the watershed is increasing and may change in the distribution of use or uses may change by virtue of management actions. As outdoor recreation use has increased in recent decades, water quality monitoring has not increased proportionately. Additionally, understanding the impacts to water quality from recreational activities is a developing area of study. A better understanding of both monitoring and treatment capabilities is needed.

Dispersed or backcountry recreation (not developed sites) occurs throughout the Middle Boulder Creek watershed. Potential water quality impacts typically are more apparent in areas of high or concentrated use, for example trailheads, trail segments, areas close to creeks or water bodies, and frequently used dispersed camping sites. Humans can inadvertently introduce contaminants such as *Giardia* and viruses into the watershed and affect other watershed factors such as erosion. For example, forest fires can result in significant soil erosion and catastrophic impacts to water quality (see also Section 16.4.3.2). As discussed in Chapter 9, recreation can impact water quality. As recreation use increases, it may reach a point where the assimilative or cumulative capacity of the watershed is affected. This particularly is true in backcountry areas where restrooms and trash receptacles are not present or where natural buffers are impacted, for example riparian or wetland areas.

Recreational impacts are not limited to pathogen introduction into streams and creeks. Water quality impacts also include erosion from trails and roads where foot or tire traffic has compacted soil and denuded vegetation reducing riparian buffer area. While studies in other areas have shown that certain types of recreation can impact water quality, direct impacts and their extent have not been well documented. For example, a study at the Glen Canyon National Recreation Area showed that contamination routinely occurs where lake levels rise and inundate recently used campsites (Berghoff, 1998) Another study found higher bacterial densities in the summer but could not determine that recreation was the primary reason (Aukerman and Springer, 1976) Long-term monitoring programs may provide more conclusive evidence. In part, monitoring would help identify threshold levels of recreation impacts on water quality. Microbial source tracking, which classifies organisms based on their genetic fingerprints, is one means of identifying pathogen sources as human or animal or type of animal. We currently do not have a complete understanding of the water quality impacts of the existing recreation uses, and will need to continue to understand and evaluate recreation impacts as drinking water and water quality regulations become more stringent. This plan recommends ongoing water quality monitoring to evaluate the relationship between recreation and water quality.

10.6 Impacts on Water Quantity

Recreational activities per se in the watershed upstream of Barker Reservoir should have no significant impact on water quantity in the basin. However, new or expanded water-using activities in support of or resulting from recreation could reduce or alter the water supply flowing into Barker Reservoir. Examples of such activities include:

- snowmaking,
- ski area base development,
- backcountry ski huts,
- visitor centers,
- irrigated pasturage for horses,
- fishing/skating pond construction.

Water uses requiring a new or changed water right would be governed by Colorado's prior appropriation system, and would generally be allowed only to the degree that no injury occurs to existing water rights. This would limit new depletions to periods of free river conditions that typically occur only in May through July of wet years. However, additional recreational development could also result in more intensive use of existing water rights that may be senior to Boulder's water rights, resulting in impacts to the reliability of Boulder's water supply.

10.7 Impacts on Safety and Emergency Resources

Even with no change to existing recreational uses within the Middle Boulder Creek Watershed, increasing visitation and recreational pressures can be expected to impact existing safety and emergency resources. Typically, emergency services staffing and services lag behind levels of use and development in any given area. With increasing visitation, it can be anticipated that emergency responses to accidents, injuries, medical incidents, and search and rescue will also continue to increase.

Increased watershed visitation will also increase the risk of wildland fire in the watershed. Fire is somewhat unique because although it is point-specific in terms of origin, it has the ability to affect large areas, multiple jurisdictions and a variety of resources within and downstream of the burned area (see Section 16.4.3).

10.8 Conclusions

USFS recreation management decisions, as well as actions by private property owners may affect water quality in the watershed. It is unclear whether these affects will be cumulative or substantial over time. Increased visitation is likely to result in some level of natural resource degradation (see Section 17.5.2). Law enforcement also is difficult in backcountry areas. It is in the collective best interest of the USFS, Boulder County, the city of Boulder, the Town of Nederland and private property owners to monitor water quality in relation to recreation activities, both short- and long-term.

10.9 Recommendations

The city of Boulder should work in cooperation with Boulder County, the U.S. Forest Service and the Town of Nederland in monitoring water quantity and quality in the Middle Boulder Creek watershed. Additional recommendations and more detailed recommendations are presented in Section 19.

10.10 Existing Source Material of Special Relevance to Recreation: Barker Watershed, Excluding Barker Reservoir

Aukerman R., W . Springer. 1976. Effects of Recreation on Water Quality in Wildlands.

Berghoff, K. 1998. Beach Sediment Bacterial Contamination and Microbial Source Tracking Study—1997 Year End Summary Report.

Eldora Ski Area. 2001. personal communication.

USDA U.S. Forest Service. 1997. *Arapaho and Roosevelt National Forest Visitor's Map*.

USDA U.S. Forest Service. 1997. *Revision of the Land and Resource Management Plan and Environmental Impact Statement, Arapaho and Roosevelt National Forests.*

11 Recreation: Barker Reservoir and Surroundings

11.1 Existing Opportunities

Recreation activities at Barker Reservoir include scenic viewing, picnicking, shoreline fishing, walking/hiking and nature appreciation. Visitors also stop at the overlook of the dam – a popular activity. These activities are in compliance with the current FERC license issued on April 28, 1981. With the acquisition of the Barker system Boulder is required to comply with all provisions of the current license. The maintenance of scenic, recreational and environmental resources is a conjunctive planning goal. Recreation provisions include:

- Maintaining approved recreational uses and facilities,
- Supervision and control of all uses and occupancies allowed by Boulder, and,
- Maintaining all uses and occupancies in good repair and in accordance with state and local health and safety requirements.

PSCo's application for FERC licensing stated that existing facilities were being used to near capacity levels. FERC required PSCo to submit recreation visitation estimates every 5 years. PSCo would place a vehicle counter at the main parking lot at the west end of the reservoir. The most current records are not presently available. The proposed recreation plan included:

- Removing existing facilities that have been damaged by vandalism
- Repairing existing signs
- Installing additional signs to improve regulatory control
- Adding facilities to accommodate an increasing number of users to include a total of:
    - 28 trash receptacles
    - 3 pit toilets
    - 1 double-faced project sign
    - 12 picnic tables
    - 6 grills
    - Pedestrian access

This plan was partially implemented. There currently are:

- 3 trash dumpsters – 1 at the existing recreation site and 2 along SH 119 on the north side of the reservoir.
- 7 trash receptacles.
- 2 benches.
- 15 picnic tables (13 with fire grates, 3 that are wheelchair accessible)
- 3 new project signs (city of Boulder)

Several new regulatory signs have been posted by the city of Boulder. They say no boating, no swimming, no fires, no camping, no pets in the water; pets must be on leashes, no ice fishing and no hunting. Additional FERC recreation stipulations may be required if new recreation uses are permitted at Barker Reservoir. A number of stipulations specifically apply to boating. FERC's Guidelines for Public Safety at Hydropower Projects (FERC, 1992) provides safety directives.

11.2 Visual Resources

At approximately 200 surface acres when full (FERC, 1995), Barker Reservoir is relatively small. The reservoir floods what was once a meadow with hilly and mountainous terrain to both the north and south. Nederland, at the western end of the reservoir, lies on relatively flat terrain. The massive, concrete Barker Dam spans the narrow upper reaches of Boulder Canyon. Typically, the reservoir fills during the spring runoff, depending upon the availability of water that can be diverted under water rights in priority. The reservoir remains full until the water is needed, generally beginning in the late summer months. The reservoir will then be drawn down throughout the following winter as needed. A long-term storage pool may be maintained so that the reservoir is not often fully drained before the next spring fill may begin. The reservoir (with the exception of the dam) may appear like a natural lake when full because shoreline vegetation comes directly down to the water's edge. Steep, unvegetated rocky slopes rapidly appear as the pool elevation drops. Large rocky mudflats are exposed at the west end of the reservoir as the pool elevation declines because of the flat meadow-like terrain. The reservoir is surrounded by development; with the Town of Nederland to the west, the dam to the east, State Highway 119 to the north and a north-facing hillside to the south. Approximately 25 residential structures are visible on this hillside.

11.3 Fishing and Fishery Management

11.3.1 Available Information

Shoreline fishing is a fairly popular activity, though physical constraints make it difficult to access much of the shoreline. (See Section 11.5). In 1995 CDOW sampled Barker Reservoir and species included brook trout, rainbow trout, brown trout, splake (a cross between brook and lake trout) long nose sucker and white sucker (see Section 17.1.3).

CDOW stocks the reservoir with both fingerlings and larger fish as budgets and availability of fish allow. Historically, CDOW stocked the reservoir knowing that it would be drained (when under PSCo management) every 5 to 7 years for maintenance. CDOW would stock more fingerlings if Barker Reservoir were not drained, as there would be more time for fish to grow to catchable sizes. Stocking fingerlings also is less expensive. CDOW has annually stocked Barker Reservoir with 10,000 to 25,000 trout of various species for the past several years (CDOW, 2001). In 2000 CDOW stocked Barker with 10,000 rainbow fingerlings followed by another 10,000 in 2001. Brook, brown and lake trout are stocked as well as splake. CDOW would stock more deepwater species like kokanee and additional splake if boat fishing occurred. CDOW considers the relatively small amount of shoreline access a substantial limitation to the recreational fishery. Other public or private entities could augment stocking in coordination with CDOW.

Opportunities exist for specialized fishery habitat enhancement. These might include channel improvements at the inlet of Middle Boulder Creek, development of a kid's fishing pond

(CDOW Fishing is Fun grants) as well as a fly-casting area. CDOW also supports angler education programs, which could possibly be developed for Barker Reservoir.

11.3.2 Issues

Currently, Barker Reservoir is a fair shoreline fishery (CDOW, 2001). This is due to limited shoreline accessibility and periodic draining for maintenance. CDOW limits its stocking partly because of the lack of accessible shoreline and the corresponding demand for fishing.

11.4 West End Recreation Use

11.4.1 Available Information

The recreation area at the west end of the reservoir supports parking, scenic viewing, picnicking, hiking, shoreline fishing, and nature appreciation. It also is the only developed recreation site at Barker Reservoir (with the exception of the dam overlook). Use in this area is somewhat dependent on high pool elevations. This part of the reservoir is flat and pool elevation decreases create extensive rocky mudflats. There is also an anglers' parking lot to the immediate southwest of the reservoir near Chipeta Park and the Middle Boulder Creek inlet.

Nederland's recently adopted Open Space, Trails, Parks and Outdoor Recreation Master Plan (2001) recommends the development of a gateway park between the west end of Barker Reservoir and East 1st Street. This could involve the relocation of Nederland's wastewater treatment plant and cooperation with private property owners and the propane company operator. The plan also cites community support for a trail around Barker Reservoir and along Middle Boulder Creek downstream of the reservoir.

In late 2000, the city of Boulder and Nederland submitted a joint Colorado Heritage grant application to the Colorado Department of Local Affairs for a feasibility study. The study was to assess the feasibility of relocating Nederland's wastewater treatment plant and constructing a gateway park as recommended in the new Open Space Plan. It was determined that the grant application was ineligible to program guidelines and was not funded. Nederland and Boulder both would benefit from the redevelopment of this area. The Town of Nederland is currently finalizing conceptual design alternatives for a lakefront park with the assistance of the Colorado State University landscape architecture interns (Colorado State University Extension Service).

11.4.2 Issues

The west end of Barker Reservoir is unattractive for several reasons, including the lack of landscaping and consistent signage and the high visibility of the wastewater treatment plant and the propane company. Redevelopment of this area will require joint efforts of the city of Boulder, the Town of Nederland and residents.

11.5 Trails

11.5.1 Available Information

The trail along the north side of the reservoir climbs away from the shoreline starting at the west end recreation area and joins SH 119 at the current RTD bus stop about 0.1 miles west of the dam. Many people access the north shoreline in this area by parking near the two restrooms or along SH 119 and walking down the hillside on portions of the existing trail as well as informal social trails that have developed over time. The trail is 1.8 miles long including about 500 feet that passes the gaging station at the Middle Boulder Creek inlet.

Most of the south shore of Barker Reservoir is inaccessible. There is very limited trail access and the shoreline typically is rocky and steep. The existing trail that passes the gaging station at the inlet quickly diminishes into informal or social trails. People can fish the west shore at the existing recreation site when the reservoir is near full, and access is direct and easy.

A trail system on the Reynolds Ranch Open Space property provides access north of Magnolia Road and south of Barker Reservoir. Access includes both Boulder County and USFS designated trails. One county/forest trail comes within about 500 feet of the southeast shoreline of Barker Reservoir. The trail network provides key linkages from Nederland and USFS lands west of Reynolds Ranch to forests lands east of the ranch. Access locations from Nederland include two points within the Big Springs Subdivision and another at Doe Trail and Alpine Drive.

11.5.2 Issues

Access to the shoreline is difficult and this limits shoreline fishing and other casual recreation uses. The Nederland Open Space, Trails, Parks and Outdoor Recreation Master Plan conceptually supports the development of a trail on the south side of the reservoir. Any alignment of the trail would need to cross private and/or city of Boulder property

11.6 Boating

11.6.1 Overview

Boating is not a permitted recreation activity at Barker Reservoir. Additionally, the 1981 FERC license states "the combination of the fluctuating nature of the reservoir, the steep gradient shoreline, and the notorious high wind potential on Barker Reservoir, produce severe safety hazards and access problems for boating. Consequently, no boating or canoeing is allowed on the reservoir with which CDW (CDOW, Colorado Division of Wildlife) concurs." The license was written 20 years ago, is now dated, and needs revising. The license indicates that PSCo had intended to turn over recreation management to CDOW. However, CDOW never assumed management of public recreation resources from PSCo. CDOW stocks the reservoir but they manage no lands near it. PSCo assumed all recreation management, operations and maintenance responsibilities from the date of issuance of the license.

The license stipulates that the "licensee (now Boulder) shall have the authority to grant permission for certain types of uses and occupancy of projects lands monitored and waters and to convey certain interests in project lands and waters for certain other types of use and occupancy, without prior Commission approval. The licensee may exercise the authority only if the proposed use and occupancy is consistent with the purposes of protecting and enhancing the scenic, recreational, and other environmental values of the project." The addition of new recreation facilities or activities, including boating, does not necessarily require FERC approval. However, where safety concerns are considerable FERC can intervene and allow or disallow an activity. The current recreation management plan development for Gross Reservoir should be monitored, as there are similar issues to Barker Reservoir.

Chapter 8-3-17 (1981) of the Boulder Municipal Code regulates public conduct on all of Boulder's parks, open space and recreation lands. The code specifically addresses swimming and boating. With the exception of Boulder Reservoir, the city bans swimming and boating on any pond, lake, stream, or other body of water owned or controlled by the city. Any amendment to this code would require Boulder City Council approval.

11.6.2 Public Interest

Public interest in boating on Barker Reservoir has been a longstanding issue in Nederland and the region. Proponents and opponents to boating have brought many facets of the issue to attention. Some proponents suggest that boating would be a quality-of-life amenity to the Nederland community and larger service area. Some boating supporters believe boating would be economically beneficial to Nederland – that boaters would boost local retail sales and corresponding sales tax increases could fund community improvements. Some opponents claim that the reservoir is too dangerous for boating, citing wind, cold water and steep shorelines as the highest risk factors. Some proponents cite seemingly comparable boating facilities elsewhere and the lack of danger wind presents at these sites. Some opponents say boating will result in an adverse impact to the attractive quality and ambience of the reservoir and its surroundings.

FERC requires operators to maximize recreation opportunities at licensed projects to a reasonable extent. The current FERC license, which expires in 2009, will require substantial updating. Recreation is a key element in the re-licensing process and FERC requires a comprehensive public involvement process. Any governmental entity, private organization or individual may directly approach FERC regarding recreation provision at Barker Reservoir. This recreation assessment will provide early record to the FERC re-licensing process. This assessment and any future recreation studies associated with the Barker system may be used as baseline or supplemental studies for re-licensing. Boating proponents already have contacted FERC directly and boating will be assessed or reassessed as part of the re-licensing process. If Boulder were to permit boating on Barker Reservoir, the city or its recreation licensee would be obligated to meet many FERC safety standards and guidelines.

11.6.3 Boating Test Program

In 1999 an individual requested permission to conduct a non-motorized boating test program. The test program was to assess feasibility, safety, environmental concerns, and levels of interest for non-motorized boating on Barker Reservoir. Specifically, the applicant wanted to investigate

FERC license concerns about high winds and steep shorelines. The applicant wished to correlate recorded wind speeds simultaneously with boaters' experiences on the water. The applicant was required to have approval from PSCo, the city of Boulder, Boulder County and the Town of Nederland. The applicant also was required to obtain a liability insurance policy and implement a safety plan. The safety plan included review and input by the Boulder County Sheriff's Department, the Nederland Police Department and the Nederland Fire Protection District. The applicant received approval to conduct the test.

The testing period included eight weekend days between August 21, 1999 and September 19, 1999 (Nelson, 1999). Ninety-five boaters participated in the test and boats included kayaks, canoes, small sailboats, windsurfers and rowboats. Participants by type of boat were as follows:

- Kayaks 38%
- Canoes 24%
- Sailboats 24%
- Windsurfers 8%
- Rowboats, other 6%

Participants were required to register and sign liability waivers. A buoy line was installed a short distance from the dam and boaters were instructed to not come within 300 feet of the dam. A temporary gravel boat ramp was constructed at the west end of the reservoir. A power safety boat and observers also were required during the test.

There were no accidents or incidences during the test program and a significant majority of boaters rated their experience as positive or very positive. Participants also were queried about their willingness to pay. The following were their responses:

- No Fee 29%
- Less than $5.00 34%
- $5.00 to $10.00 36%
- Over $10.00 1%

The boating test program included the collection of wind data from two stations; one atop the Boating on Barker office in Nederland; another at the dam. Hourly average speeds, average maximum and highest maximum wind speeds were collected for each test day. Hourly averages ranged from 4 to 12 miles per hour. Average maximums ranged from 10 to 25 miles per hour. The highest maximum wind speeds ranged from a low of 12 miles per hour on September 18, 1999, to a high of 37 miles per hour on September 5, 1999.

The study concludes that winds ranged from calm to moderate about 95 percent of the time and were consistent with winds at other reservoirs where boating occurs. Gusts can exceed 38 miles per hour about 5 percent of the time, but such winds were not sustained and did not pose a problem. Strong winds appear to be unlikely during summer months. Determining the accuracy or credibility of the boating test program and its findings is not within the scope of this assessment.

11.6.4 Boating Feasibility Assessment

This plan recommends that a third-party boating feasibility assessment be conducted. This feasibility assessment would determine the pros and cons of allowing non-motorized boating on Barker Reservoir. Safety and water quality would be primary study factors. The plan should use existing information from comparable facilities to the greatest degree possible. The plan would be directed at the following questions:

- What is the demand for boating on Barker Reservoir when considering available comparable facilities elsewhere?
- What physical improvements are needed to provide boating on Barker Reservoir?
- Can the recreation provider assure that operations and maintenance requirements are met?
- Can boating be conducted safely and securely? Are emergency response and law enforcement capabilities in place? Are they affordable?
- What is the revenue generating potential in light of the fact that the city of Boulder Public Works is an enterprise utility and under state statutes is obligated to seek the best return on investments in assets owned by the utility for the benefit of water ratepayers of Boulder?
- How many boats would be allowed on Barker Reservoir at one time? What is the social carrying capacity of the reservoir? Would this even be an issue?
- Would boating result in adverse water quality impacts or concerns about pathogens that may not be easily measured or treatable?
- What kind of effect would boating have on visual resources?
- What is the public sentiment about boating? Does it vary locally and regionally?
- How do residents near the reservoir feel about increased recreation?

The fiscal or market analysis is very important and would be a significant factor in a boating assessment. Many municipal or state parks that offer boating speak of cost recovery – not revenue generated. Many operate at a deficit. For example, Bear Creek Lake Park (Lakewood, Colorado) is a somewhat comparable facility to Barker Reservoir, although it provides many more attractions. Park revenues are approximately $300,000 a year ($1.00 per visitor at 300,000 visitors). This represents only 40 percent of their actual operating costs (Clute, 2001). The Colorado Department of Parks and Outdoor Recreation (CDPOR) manages many lakes and reservoirs in Colorado. They target approximately 70 percent cost recovery as a goal (CDPOR, 2001). Only large intensively used state parks like Cherry Creek or Chatfield experience close to total cost recovery or some profit. These types of facilities strongly rely on developed, which can be a good revenue generator if managed properly.

11.7 Impacts on Water Quality

The absence of water-body contact recreation such as swimming or allowing pets in the water, as well as limited access to the reservoir, reduces potential water quality impacts. Bacterial contamination and types of pollution from human impacted lakes and reservoirs include fecal contamination, E. coli, viruses, pathogens, and turbidity. Various studies have traced the pathways by which these contaminants are released as a result of body contact recreation.

Intestinal pathogens can come from fecal release or skin surface (Gerba, 2000). In one study, all virus isolations were made during the peak of recreational activity, so the possibility of viruses coming from any other source other than humans was considered remote (Rose, et al., 1987). A study in Sierra Nevada, California documented a 28 percent increase incidence of cysts (*Giardia*) in areas that had greater human presence compared with areas that had lower human presence (Suk et al, 1987, referenced in Farag, 1998). Another study found that locally high concentrations of pathogens can occur, which are attributable to body contact recreation. Recreational use in summer months resulted in significant pathogen loading, chiefly confined to the upper water level of the reservoir (Anderson, et al.,1998).

As previously described, recreation at the reservoir is primarily limited to hiking, shoreline fishing, picnicking and scenic viewing. It is difficult to discern direct water quality impacts from recreation from other nonpoint sources. However, uncontrolled or poorly managed recreation may result in degradation of water quality and can conflict with other management practices needed to control water quality (American Water Works Association, 1987.) Additionally, water quality science is very dynamic and there are many unknowns pertaining to recreation impacts to water quality. For example, the detection methods for certain pathogens have limitations and continue to be improved. Although any human presence increases the threat to water quality, recreation activities and settings can be managed to minimize impacts through proper site and facility planning and design and the provision of adequate trash receptacles, restrooms, and enforcement.

Non-motorized boating on Barker Reservoir could result in minimum reservoir water quality impacts, but indirect factors such as improved access to the reservoir and surrounding areas can affect water quality. In a study at the Glen Canyon National Recreation Area the majority of beach violations for state bacteriological water quality standards most often occurred at heavily used camping beaches where both boat and vehicle access were possible (Berghoff, 1998). Boating can also introduce nonindigenous and nuisance species from other recreational lakes and reservoirs, which can disturb native species, clog water supply intake pipes and pose human health risks.

11.8 Impacts on Water Quantity

Recreation activities on and around Barker Reservoir should have no significant impact on water quantity in the reservoir. However, any changes to Barker Reservoir operations specifically made to accommodate or enhance recreation on the Reservoir may adversely affect the reliability and cost of Boulder's water supply and Barker hydropower generation potential. For example, keeping Barker fuller in late summer to accommodate boating could jeopardize Boulder's ability to meet its peak summer demands without expanding its delivery capacity from the Boulder Reservoir WTP. Any proposed modification to Barker Reservoir operations for recreational purposes should be evaluated and weighed against its impacts on Boulder's water supply and hydropower generation potential.

11.9 Impacts on Safety and Emergency Resources

Changes in current recreation activities at Barker Reservoir have the potential to significantly affect safety and emergency resources in the Barker vicinity. New uses such as boating, windsurfing, etc. should be carefully evaluated by the existing emergency services providers in terms of adequacy of current emergency services provisions. Reorganization and/or augmentation of existing resources may be needed to adequately provide for public safety (see Section 16.4.5). Questions which will require careful evaluation include:

- What types of emergency response will be required as a result of new recreation opportunities?
- What is the desired level of service for emergency response?
- Is/are the current provider(s) of the services capable of providing the response to acceptable standards?
- Should response be provided by new or additional agencies?
- What types of new training or equipment will be needed to provide the desired level of service?

11.10 Conclusions

Improved access, fishery enhancement projects and augmented stocking would substantially improve the recreational fishery at Barker Reservoir. The redevelopment of the west end of Barker Reservoir would solve many problems. The relocation of the wastewater treatment plant is a key project challenge. The trail on the north side of the reservoir is well defined and popular. There is no well-defined continuous trail along the south side. Most recreation occurs along the north side and west end of the reservoir. Very little occurs along the south side. The provision of boating is a complicated issue with numerous pros and cons. A third-party boating feasibility assessment should be conducted prior to any decision-making.

11.11 Recommendations

Recommendations pertaining to recreation at Barker Reservoir and surroundings can be broadly summarized as follows:

- Prepare a recreation management plan for existing recreation uses at Barker Reservoir. Additionally, prepare a Barker Reservoir Boating Feasibility Study and a Recreational Fishing and Aquatic Habitat Enhancement Plan for Barker Reservoir.
- Work with the town of Nederland on plans for development at the west end of Barker Reservoir.
- Maintain documentation of recreation decision-making, including public involvement, to facilitate the FERC relicensing process.

Additional recommendations and more detailed recommendations are presented in Section 19.

11.12 Existing Source Material of Special Relevance to Recreation: Barker Reservoir and Surroundings

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12 Recreation: Middle Boulder Creek and Barker Gravity Pipeline Corridors

12.1 Existing Opportunities

There are several recreation opportunities along Middle Boulder Creek and near the Barker Gravity Pipeline corridor. Middle Boulder Creek is the most significant recreation attraction in Boulder Canyon. There are several picnic grounds near the creek that were constructed in the late 1940s when the Bureau of Public Roads built the Boulder Canyon Highway. Most of the concrete tables and benches are in disrepair. Many of the sites are within the Colorado Department of Transportation right-of-way that frequently extends from the highway to the centerline of Middle Boulder Creek.

Land ownership and management is a mix of Boulder County Parks and Open Space (BCPOS), USFS, subdivisions or platted areas, or unincorporated county land. Camping in Boulder Canyon is prohibited. USFS lands are open for camping as long as the campsite is not continuously used for more than a few weeks. Campfires outside of developed campgrounds may be controlled on USFS lands. During most summers, Boulder County bans open burning (excluding fire contained within liquid-fueled stoves, fireplaces within buildings, charcoal grill fires at private residences and permanent fire pits or fire grates located in developed picnic campgrounds).

12.2 Visual Resources

The majority of the Barker Gravity Pipeline is buried, and thus not visible. Siphons and manholes are visible, but not from any lands used for designated recreational purposes.

The visibility of Middle Boulder Creek from State Highway 119 (SH 119) varies dramatically. In general, visibility of the creek from SH 119 is limited due to steep terrain and land features. Riparian and wetland vegetation also screen views of the creek from SH 119 at some locations. At some locations the creek is visually obvious; at other locations the creek is not visible. Where the creek is visible, it is an amenity that adds to the canyon's visual diversity that also includes large rocks and canyon walls.

12.3 Ice climbing

12.3.1 Available Information

Ice climbing occurs at two locations west of Castle Rock on Boulder County Parks and Open Space land (Platt Rogers Memorial Park) where a Barker pipeline leak has been manipulated to create ice climbing routes on nearby rocks. Ice climbing also occurs on Arapaho and Roosevelt National Forests land at a pipeline leak near Boulder Falls.

The ice climbing routes near Castle Rock are popular. However, restricted parking and visitor congestion limits use at times. Historically, there were only three or four routes, but over 10 new routes were created in 1996-97. The Boulder County Parks and Open Space Department recently completed a management plan for Platt Rogers Memorial Park (BCPOS, 2000). The plan supports the continuation of existing use, but does not favor expansion due to environmental concerns (soil erosion, vegetative impact, presence of raptors) as well as safe ingress and egress due to parking limitations and poor sight line distances on SH 119. The appropriateness of diverting water for artificial ice climbing is a concern of BCPOS. City of Boulder staff also has met with ice climbers and discussed the need for legal water diversion if use continues as a permitted activity.

In January 1999 a coalition of ice climbers filed for a special use permit with the Arapaho and Roosevelt National Forests to ice climb near Boulder Falls at a pipeline leak. The leak is being manipulated. Though the USFS denied the permit, some climbing continues. The permit denial was largely based on safety, parking and environmental concerns. The USFS (U.S. Forest Service, 2001) prefers that the leak is repaired and artificial ice climbing eliminated.

12.3.2 Issues

Boulder County Parks and Open Space Department and the USFS express natural resource and safety concerns related to ice climbing on lands they manage. The number of ice climbing routes recently has grown dramatically.

The lack of parking in Boulder Canyon will be an ongoing and increasing problem. The Colorado Department of Transportation has restricted parking at specific sites where shoulder width is either inadequate or sight distances are poor. Some of the sites are near popular recreation areas and some visitors become frustrated in search of legal parking. Many sites are posted as no parking, no parking between dusk and dawn or no parking from 11:00 PM to 5:00 AM.

12.4 Instream Flows

12.4.1 Available Information

PSCo did not maintain minimum instream flows in Middle Boulder Creek downstream of Barker Reservoir. The lack of these flows was a significant limitation to enhancing the aquatic habitat in the creek between Barker Dam and the confluence of Middle and North Boulder Creeks.

12.4.2 City Commitment

The city of Boulder has committed to providing minimum instream flows in Middle Boulder Creek though the amount has yet to be determined. A USFS study recommends 2 cfs in the winter and 4 cfs in the summer. Trout Unlimited recommends 4 to 9 cfs based on a different methodology. The city of Boulder, the Colorado Water Conservation Board and project participants are in the process of determining flow amounts.

12.5 Fishery Enhancement

12.5.1 Available Information

Middle Boulder Creek provides habitat for rainbow, brook and brown trout. Although diversion of water into the Barker pipeline substantially reduces stream flow in Middle Boulder Creek, healthy trout populations are present. The Colorado Division of Wildlife inventoried Middle Boulder Creek below Barker Reservoir in 1998 and found population estimates of 365 rainbow, 580 brook and 25 brown trout per acre. At a sampling site 2.5 miles upstream of the confluence with North Boulder Creek CDOW estimated populations of 90 rainbow and 135 brook trout per acre (CDOW, 1998) (see Section 17.4.3.1).

12.5.2 Opportunities for Fishery Enhancement

The maintenance of minimum instream flows could significantly benefit the Middle Boulder Creek fishery, especially during winter months. The flow would increase wetted areas and perimeters benefiting invertebrate habitat. Some segments of Middle Boulder Creek have steep gradients making habitat enhancement difficult. Other segments are relatively flat and suitable for enhancement. Boulder's commitment may result in both public and private sector efforts to improve the physical habitat in Middle Boulder Creek improving the fishery over time.

12.5.3 Issues

Middle Boulder Creek currently is a fair sport fishery. The determination and implementation of minimum flows will be a very positive action to enhance the fishery.

Determining an acceptable and appropriate instream flow with other project participants is a difficult process.

12.6 Trail Development

12.6.1 Available Information

There are several trails near Middle Boulder Creek and the Barker Pipeline that serve hikers, rock climbers, mountain bikers and equestrians. A detailed discussion of area trails may be found in the Platt Rogers Memorial Park, Reynolds Ranch and Rogers Property Resource Evaluation and Management Plans (BCPOS, 2000). See also Section 11.5.

At one time the Boulder County Land Use Plan recommended a trail along a segment of the Barker Pipeline. This recommendation has been deleted from the plan due largely to natural resource concerns and difficult terrain.

The pipeline corridor (easement) falls within a federal power withdrawal. This status does not allow the city of Boulder to provide a recreation easement along the corridor.

12.6.2 Issues

The expansion of existing trails or trail networks, including informal social trails, is a concern of both Boulder County Parks and Open Space and the USFS. Sensitive plant and animal species habitat and the presence of raptors largely are of concern (see Section 17.5.2).

Pipeline related roads and trails providing maintenance access are "attractive nuisances" and inadvertently encourage some hikers to access restricted areas. Some mountain bikers also are illegally using project roads and trails.

There also is concern that trails may impact private property. Some property owners are concerned about trespassing, fence damage, inappropriate behaviors and potential wildfires.

Trail planning near Middle Boulder Creek or the Barker Pipeline requires the cooperation of the city of Boulder, Boulder County, the Town of Nederland and the USFS.

12.7 Camping

12.7.1 Available Information

Camping is not permitted along Middle Boulder Creek in Boulder Canyon. There is a county sign at the mouth of Boulder Canyon that reads "No Camping Next 17 Miles." There is a county sign in Nederland heading east on SH 119 that reads "No Camping." The Boulder County Sheriff's Department encourages campers to move on. Dispersed camping is permitted in some areas of the Arapaho and Roosevelt National Forests and is regulated in the Indian Peaks Wilderness. Generally, camping is not permitted within 100 feet of creeks, trails or water bodies within the Arapaho and Roosevelt National Forests.

12.7.2 Issues

Middle Boulder Creek attracts camping. There are several informal pullouts near the creek where camping is occurring and these same areas still attract illegal use.

12.8 Impacts on Water Quality

Recreational impacts to water quality have not specifically been monitored in the watershed. Additionally, understanding impacts to water quality from recreation is a developing area of study. A better understanding of both monitoring and treatment capabilities is needed. However, studies at other facilities provide comparable information on potential recreation impacts to water quality. Limited parking and access to Middle Boulder Creek also limits recreation and potential water quality impacts in the lower part of the watershed. Potential water quality concerns include creek access locations and trails that parallel streams where damaged buffer vegetation and compacted soils can promote soil erosion. Camping near creeks and lakeshores also can trample vegetation and result in soil erosion. Unregulated fires also are a concern (see Section 16.4.3). Human waste within the watershed increases in camping and backcountry areas that lack restrooms or trash receptacles. The minimum instream flows and potential aquatic enhancements are likely to raise awareness about the significance of maintaining or enhancing water quality in Middle Boulder Creek (see Section 9).

12.9 Impacts on Water Quantity

Recreation activities below Barker Reservoir should have no significant impact on water quantity. However, changes in Barker System operations to specifically accommodate or enhance recreation may adversely affect the reliability and cost of Boulder's water supply and hydropower generation potential. Examples of such changes include:

- Barker Reservoir releases or bypasses in excess of agreed-upon instream flow requirements to support quality fishing or boating.
- Winter season operation of the Barker Gravity Pipeline outside of normal water supply system operating needs in order to support ice climbing.

Any proposed changes to water supply operations for recreational purposes, for example the establishment of a minimum conservation pool for fisheries, should be evaluated and weighed against their impacts on Boulder’s water supply water quality and hydropower generation potential.

Boulder is proceeding with urgently needed repairs to the Barker Gravity Pipeline, which will almost certainly reduce leaks from the pipeline and associated ice climbing opportunities in the Canyon. Leakage from the Barker Gravity Pipeline averages approximately 10% and appears to be as high as 15% under certain flow conditions, so these repairs should significantly increase Boulder’s water supply yield from Middle Boulder Creek.

12.10 Impacts on Safety and Emergency Resources

Illegal camping on or around Boulder Canyon Hydroelectric Project facilities and along the Middle Boulder Creek corridor below Barker Dam principally affects fire potential and law enforcement. Campfires associated with unauthorized camping increase the potential for wildland fire. The Middle Boulder Creek Canyon consists of steep, rugged terrain that makes rapid attack and containment of a fire difficult[3] and which can intensify the fire as it spreads. This is one of the reasons that camping is not currently allowed in Boulder Canyon.

Notwithstanding, camping does occur along Middle Boulder Creek. Area residents report campers each summer, and some of these campers are especially persistent. This area is patrolled by a single Sheriff’s Deputy, whose large territory prevents constant monitoring of the canyon. Usually, campers are discovered in the morning and are asked to move on.

In the past, there have been questions concerning jurisdiction over the highway right-of-way in Boulder and Middle Boulder Creek Canyons. While camping in the highway right-of-way is not permitted by the Colorado Department of Transportation, Boulder County has not had the

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[3] The 1989 Black Tiger Fire started in Boulder Canyon and rapidly grew as it proceeded up a steep drainage (“Chimney”) fueled by the wind. When it reached the top of the canyon, the fire was so intense that little could be done to stop its spread across Sugar Loaf Mountain.

authority to remove trespassers from the right-of-way. It would be beneficial if the Boulder County Sheriff and Colorado Department of Transportation could reach an agreement that would allow Boulder County to enforce restrictions on camping in Middle Boulder Creek Canyon.

USFS lands are open for camping, as long as the campsite is not continuously used for more than a few weeks. However, during most summers, Boulder County bans open burning (excluding fire contained within liquid-fueled stoves, fireplaces within buildings, charcoal grill fires at private residences and permanent fire pits or fire grates located in developed picnic or campgrounds). Therefore, campfires outside developed campgrounds may be controlled on USFS land.

12.11 Conclusions

Middle Boulder Creek currently provides limited recreation. The creek is not very accessible via SH 119 due to a lack of parking and steep terrain. Private property also limits access at several locations. The continuation of ice climbing is an unresolved issue. Neither the USFS nor Boulder County Parks and Open Space desire to see the activity expand. There are environmental resource concerns about present ice climbing use near Castle Rock and Boulder Falls. The city's commitment to maintaining minimum instream flows is a very positive action and may result in substantial enhancement of the of the creek's aquatic habitat and recreational fishery. The expansion of existing trails near Barker Reservoir or the pipeline is a concern of the city of Boulder, the Town of Nederland, Boulder County Parks and Open Space, and the USFS.

12.12 Recommendations

Recommendations pertaining to recreation along the Middle Boulder Creek and Barker Gravity Pipeline Corridors can be broadly summarized as follows:

- Prepare a comprehensive series of recreation management plans including an Ice Climbing Plan, a Trail Management Plan, and a Recreational Fishing and Aquatic Habitat Enhancement Plan for Middle Boulder Creek. The city of Boulder should cooperate with Boulder County, the U.S. Forest Service, and the Town of Nederland regarding present and future trails planning.
- Evaluate means to minimize use of project undesired recreational access.
- Maintain documentation of recreation decision-making, including public involvement, to facilitate the FERC relicensing process.

Additional recommendations and more detailed recommendations are presented in Section 19.

12.13 Existing Source Material of Special Relevance to Recreation: Middle Boulder Creek and Barker Gravity Pipeline Corridor

BASIN.org. 2001. Boulder Area Sustainability Information Network.

Boulder County Parks and Open Space. 1999. *Platte Rogers Memorial Park, Reynolds Ranch and Rogers Property Evaluation*, Boulder County, Colorado.

Boulder County Parks and Open Space. 1999. *Platte Rogers Memorial Park, Reynolds Ranch and Rogers Property Management Plan*, Boulder County, Colorado.

City of Boulder. 1999. *City of Boulder Open Space and Mountain Parks Lands Trails Map,* city of Boulder, Colorado.

Hallock, Dave. 2001. Boulder County Parks and Open Space Department, Boulder County, Colorado, personal communication.

Miller Ecological Consultants, Inc. 2000. *Review of Minimum Instream Flows for Middle Boulder Creek*, prepared for the city of Boulder.

Miller, William. 2001. Miller Ecological Consultants, personal communication.

Moran, Martha. 2001. U.S. Forest Service, personal communication.

13 Recreation: Main Boulder Creek

13.1 Existing Opportunities

Main Boulder Creek provides an array of recreation activities, including fishing, kayaking, wading, tubing, nature study, trail use, picnicking and socializing or general day use. The city of Boulder's Eben G. Fine Park provides an excellent urban river park like setting. Quality visitor amenities are available for people recreating around this reach of Main Boulder Creek.

The Main Boulder Creek fishery is healthy and self-sustaining (CDOW, 2001). There has been some augmentation stocking including some funded by the city of Boulder. Brown and rainbow trout that were stocked are now gone and replaced by a reproducing fishery. The Colorado Division of Wildlife is considering augmentation stocking of catchable size rainbow trout.

Winter evening kayaking also historically occurred when Xcel would discharge surge flows for hydropower generation. The Colorado White Water Association (Hazleton, 2001) express support for winter kayaking flows. These surge flows will not occur, as the city of Boulder will give water storage priority over power generation.

13.2 Visual Resources

Some of the upper reaches of Main Boulder Creek are not visible due to steep terrain and land features. Vegetative screening of creek side view also occurs. The Boulder Creek Path and nearby parking areas along the lower reaches afford excellent views of the creek. The creek is highly visible from Boulder's premiere creek side park, Eben G. Fine Park, located near the mouth of Boulder Canyon. The park is a major amenity to the city and its visual quality greatly enhances the park's many recreation opportunities. Generally, greater flows increase the visual attraction and diversity, but not always. Some lower flows create more white water, a strong visual attraction.

13.3 Issues

Main Boulder Creek is a valued community amenity and quality-of-life benefit. Many people recreate in the vicinity of the creek. The creek also is highly visible from SH 119 and Eben G. Fine Park. The park enhances the visual quality of the Main Boulder Creek corridor.

People are concerned that operational changes may adversely impact any recreation activities and settings.

13.4 Impacts on Water Quantity

Recreation activities on Main Boulder Creek should have no significant impact on water quantity. However, changes in Barker System operations to specifically accommodate or enhance recreation on Main Boulder may adversely affect the reliability and cost of Boulder's water supply and hydropower generation potential. For example, a program designed to provide instream flows to Middle Boulder Creek <u>and</u> to simultaneously increase flows in Main Boulder

Creek would be more costly to Boulder in terms of yield than a program designed to benefit only Middle Boulder Creek. Any proposed changes to water supply operations for recreational purposes should be evaluated and weighed against their impacts on Boulder's water supply and hydropower generation potential.

13.5 Conclusions

There will be no project-induced effects on Main Boulder Creek recreation with the exception of the elimination of the evening peak flows that have historically supported kayaking during the winter. Minimum instream flows in Middle Boulder Creek will provide beneficial additional flows in Main Boulder Creek that are especially important during winter months and low flow years.

13.6 Recommendations

Recommendations pertaining to recreation in and along Main Boulder Creek can be broadly summarized as follows:

- Fabricate and install an interpretive sign at Eben G. Fine Park that explains the Barker system and its influence on Main Boulder Creek.
- Prepare a Recreational Fishing and Aquatic Habitat Enhancement Plan for Main Boulder Creek. Monitor changes in aquatic habitat and fisheries in Main Boulder Creek resulting from winter-season instream flows in Middle Boulder Creek.
- Maintain documentation of recreation decision-making, including public involvement, to facilitate the FERC relicensing process.

Additional recommendations and more detailed recommendations are presented in Section 19.

13.7 Existing Source Material of Special Relevance to Recreation: Main Boulder Creek

Arnold, Landis. 2001. American Whitewater Association, personal communication.

Hazelton, Craig. 2001. Colorado Whitewater Association, Trout Unlimited, Colorado Chapter, Boulder Flycasters, personal communication.

Reynolds, Peter. 2001. City of Boulder Parks and Recreation Department, personal communication.

14 Recreation: Kossler Reservoir

14.1 Existing Opportunities

Kossler Reservoir is closed to public access and recreation. The reservoir, when mostly full (12.25 surface acres), provides a scenic resource from several vantage points. However, the reservoir fluctuates rapidly and makes for unsafe recreation. There also is little ground to develop for recreational purposes.

14.2 Visual Resources

Kossler Reservoir lies within a depression largely surrounded by forested hilly terrain with some undergrowth. The reservoir is fenced with barbed wire. There are limited views of the reservoir from close-by Flagstaff Road. A few residences also view the reservoir. The visual attraction of Kossler also is highly dependent on how full it is. The reservoir is subject to radical fluctuations with the operation of the Boulder Canyon Hydroelectric Plant. The visual attraction of the reservoir radically declines as it drains. The dam and inlet structure are visually obvious.

14.3 Issues

People have inquired about allowing public recreation at Kossler. Kossler neighbors express concerns about the provision of public recreation in such close proximity to private property.

14.4 Impacts on Water Quality

The reservoir is fenced with restricted access and no recreation occurs within the immediate watershed. As a result, no potential recreational impacts on water quality have been identified.

14.5 Impacts on Water Quantity

There will be no recreation-related impacts on water quantity.

14.6 Impacts on Safety and Emergency Resources

Kossler Reservoir is fenced, closed to public access, and patrolled by Utilities Division Staff. The Cherryvale Fire Protection District Station No. 4 is located adjacent to Kossler Reservoir. Assuming there is no change to its current status, there will be no effects to safety or emergency resources.

14.7 Conclusions

Kossler Reservoir will remain closed to public use. There will be no project-induced recreation impacts to the reservoir.

The city of Boulder owns the penstock right-of-way between Kossler Reservoir and the Boulder Canyon Hydro Plant. The penstock is closed to recreation use due largely to its 40 to 80 percent slopes of unconsolidated material. There also are sensitive plant species in the right-of-way (city of Boulder, 2001).

14.8 Recommendations

It is recommended that Kossler Reservoir remain closed to public recreation. Additional recommendations and more detailed recommendations are presented in Section 19.

15 Historical and Cultural Resources

15.1 Boulder Canyon Hydroelectric Project

On November 13, 1906, Myron T. Herrick and five others formed the executive committee of the new Central Colorado Power Company with visions of an extensive network of hydroelectric power plants and transmission lines throughout the Rocky Mountains. The ambitious plan was based upon two simple factors – supply and demand. Hydroelectric Power Resources appeared abundant in the Rocky Mountains, and the doubling of population in Denver between 1890 and 1905 indicated that the demand for electricity would continue to grow through the foreseeable future. Central Colorado Power Company's first project, the Shoshone Plant in Glenwood Canyon, began a month after the company was formed (PSCo, undated*)*.

The Eastern Colorado Power Company first purchased two tracts of land in the Sulphide Flats area from W. Hollingsworth McCleod to explore the possibility of dam and reservoir construction. In the summer of 1907, test pits sunk at the proposed dam site revealed gravel deposits too thick for a suitable dam. With the onset of the 1907 depression, further work was halted (Weiss, 1980).

In 1909, Eastern Colorado Power Company had combined assets with Central Colorado Power Company and the search for a suitable dam site on Middle Boulder Creek began in earnest again. Principal financial backing of the Central Colorado Power Company was obtained from the Electric and Hydraulic Company of Colorado Springs, whose investors included Thomas F. Walsh and David H. Moffat. Moffat is associated with such noteworthy endeavors in Boulder County as the Caribou Mine, the Denver, Northwestern & Pacific Railroad (also known as the Moffat Road), and the Moffat Tunnel. Walsh was an architect of Denver's Union Station, the Cathedral of the Immaculate Conception in Denver, and the Holy Family Catholic Church in Meeker (Noel, 1989). Herrick, in later years, became the Governor of Ohio and later, the U.S. Ambassador to France (Weiss, 1980; Public Service Company of Colorado, undated).

Barker Dam, measuring 175 feet in height and 720 feet long along its crest, was completed in August 1910, 18 months after construction began. The dam and reservoir were named for landowner Hannah Barker, who had refused to sell her ranch holdings to the Central Colorado Power Company, necessitating condemnation proceedings to acquire the dam and reservoir site (Weiss, 1980).

> "This dam was built across Boulder Creek, a few miles from the town of Nederland, in Boulder County, Colorado. It is the property of the Central Colorado Power Company and was designed by that company's engineers under the direction of Mr. A.S. Crane, of New York, as consulting engineer . . . In addition to the State supervision, the Central Colorado Power Company maintained a constant and careful engineering inspection and the contractors seemed also to have a pride in doing good work. The result is a structure which is not only safe and substantial in every way, but a credit to everyone connected with it as well." (Comstock, 1911).

The other principal components of the project included:

- The 36-inch, concrete Barker Gravity Pipeline, which carries water released from one of the dam's 10 gates through seven siphons and four tunnels to Kossler Reservoir, located 11.7 miles away.
- Kossler Reservoir, the hydroelectric project forebay, which is a crater type reservoir created with three earthen dams at the apex of Hawkin Gulch and Wood Gulch holding approximately 165 acre-feet of water. Kossler Reservoir was named for the landowner, one of Boulder County's historic ranching and farming families with a long history of landownership in the Flagstaff Mountain and Walker Ranch areas.
- The steel penstock, which varies in diameter from 56 inches at the top to 44 inches at the plant entrance, was constructed to carry the water from Kossler Reservoir to the hydroelectric plant at the bottom of the canyon. The penstock's 1828-foot drop between Kossler and the hydroelectric plant, created the highest head of any plant in the United States at the time and is still regarded as one of the highest head hydroelectric plants in the United States.
- The Boulder Hydroelectric Plant, with two I.P. Morris Company turbines and General Electric AC generators capable of producing 10,00 kilowatts of power at the time of project completion.

Construction of the gravity pipeline and penstock far exceeded dam construction in terms of difficulty and technological challenge. To construct the gravity pipeline, workers faced dense forest, rough terrain, and the need to construct four tunnels and seven siphons. Due to the distance between the facilities, work camps were established at several locations along the pipeline, which provided tent housing for workers, as well as intermediate staging areas for construction supplies and equipment.

Upon completion of the penstock, it was found that the riveted butt joints in the steel penstock could not withstand the 800 pounds per square inch water pressure that developed in the pipeline, and it leaked significantly. Using the then-new acetylene welding process, construction workers discovered that hammering the weld while it was still warm prevented the joints from cracking as they cooled. Discovery of the ball-peen welding method is the most famous engineering innovation credited to the project (Public Service Company of Colorado, undated).

Construction of the power plant was accomplished by sending construction materials by train to Orodell, where they were off-loaded onto specially constructed wagons that followed a track to the plant site. Teams of up to 16 horses were used to pull the wagons (Weiss, 1980). The plant went into operation on August 4, 1910.

The water rights needed to operate the Boulder Hydroelectric Project were appropriated on December 18, 1906 and adjudicated on October 18, 1920 (District Court of the County of Boulder, State of Colorado, Case No 5563). Decree adjudicated rights were:

1. The right to store 509,068,800 cubic feet of water once annually from waters of Middle Boulder Creek in Barker Meadow Reservoir for power, manufacturing or other beneficial purposes other than irrigation.
2. Fifty cubic feet of water per second of time to flow through the Boulder Power Pipeline (formerly known as Omega Ditch and Pipeline) for power, manufacturing or other beneficial purposes other than irrigation.
3. The right to fill and refill Kossler Reservoir to its capacity of 5,616,000 cubic feet of water as often as necessary from waters to which priority of storage right has been awarded as set forth by virtue of construction and use of Barker Meadow Reservoir and Boulder Power Pipeline for diversion and use of waters of Middle Boulder Creek for power, manufacturing and other beneficial purposes other than irrigation.

In 1913, the Colorado Power Company acquired the Central Colorado Power Company. By 1924, the Colorado Power Company had merged with the Public Service Company of Colorado. Under this new ownership, modifications were made to the hydroelectric plant that by 1936 had increased its capacity to 20,000 kilowatts (Public Service Company of Colorado, undated.)

The Boulder Hydroelectric Project was never a major contributor to PSCo's power generation system. Even running at full capacity, the plant contributed less than one half of one percent of PSCo's power generation. However, PSCo kept the plant operating for two important reasons: Boulder Hydro provided very economical power, since no fuel costs were involved. In addition, PSCo's hydroelectric power plants, Boulder, Shoshone and Cabin Creek, could begin production from a standstill in the event of a system-wide blackout, thereby providing the power needed to restart PSCo's steam plants in an emergency situation (Public Service Company of Colorado, undated).

In addition to its historic importance as a hydroelectric facility, Barker Reservoir and the Boulder Hydroelectric Project have played an important role in the development of Boulder's water supply system. By the 1950s, Boulder was approaching the limits of its water yields from the Silver Lake Watershed. The city's supplies at the time consisted of transferred Farmers and Anderson Ditch rights, its relatively junior direct flow decrees, and storage in the Silver Lake Watershed. The city's direct flow rights were routinely called out by downstream users with more senior rights, and the city was forced to bypass direct flows and use mainly releases from storage reservoirs. During a major drought in 1954, when stream flows fell to below 50 percent of normal, this system broke down (Boulder City Council Study Session Packet, November 30, 1999).

In response to the crisis, Water Superintendent E.B. Debler proposed that the city obtain water from PSCo and the city of Denver by exchange. The city's exchange right which has been in use since 1954 allows the city to divert water out of priority at upstream diversions and replace it at downstream locations. This was first accomplished with water from PSCo and the city of Denver, and later with Colorado-Big Thompson water and releases from Baseline Reservoir. Today, most of the water the city stores in Barker Reservoir is replaced with Colorado Big-Thompson water released from Boulder Reservoir.

The city had a series of agreements with PSCo regarding use of Baker Reservoir storage and its associated water transmission facilities. A 1959 agreement allowed the city to use any excess storage in Barker Reservoir which PSCo was unable to use. In 1961, the city was granted the right to use up to 4,000 acre-feet of storage in Barker Reservoir, transport this water in the PSCo transmission facilities and construct the city of Boulder Pipeline No. 3 from the penstock to the planned Betasso Water Treatment Plant. In 1970, an agreement allowed for gradual increase in the city's storage at Barker to 8,000 acre-feet by 1978.

When the Federal Energy Regulatory Commission relicensed PSCo's Boulder Hydroelectric Project in 1981, it also issued requirements that would increase the safety of Barker Dam. In exchange for partial funding of these required improvements, the 1986 Barker Agreement granted the city perpetual use of 8,000 acre-feet of storage in Barker Reservoir and allowed for city use in excess of 8,000 acre-feet. In return, Boulder paid a proportionate cost for maintenance, repair, overhead expenses and license and permit fees for the facilities. This agreement also allowed the city the first right to acquire PSCo's interests in the Boulder Hydroelectric Project.

The Boulder Hydroelectric Project was recorded with the Colorado State Historic Preservation Officer (Weiss, 1980). The site has been recommended as eligible for nomination to the National Register of Historic Places (see Section 15.2.1). The city completed a cultural resource inventory of the gravity pipeline and dam area during the summer of 2001 (Gleichman, under development). No additional significant historic resources, aside from the Boulder Hydroelectric Project facilities themselves, were identified.

There is extensive historic documentation of the Boulder Canyon Hydroelectric Project, including photograph archives at the Denver and Boulder Public Libraries, and drawings and technical information that were transferred to the Utilities Division by PSCo at the time of purchase.

15.2 Potential Historic Designations for the Boulder Hydroelectric Project

15.2.1 National Register of Historic Places

The National Register of Historic Places (NRHP) is a list of cultural properties maintained by the National Park Service which have been determined significant in accordance with the following criteria:

"The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or
B. That are associated with the lives of persons significant in our past; or
C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic

values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. That have yielded or may be likely to yield, information important in prehistory or history."

Properties are nominated to the National Register by the State Historic Preservation Officer (SHPO) of the State in which the property is located. Ordinarily, State nomination forms are prepared by private individuals or the staff of the SHPO. These nomination forms are then submitted to a State review board, which makes a recommendation to the SHPO either to approve the nomination if, in the board's opinion, it meets the National Register criteria, or to disapprove the nomination if it does not.

During the time the proposed nomination is reviewed by the SHPO, property owners and local officials are notified of the intent to nominate. Local officials and property owners are given the opportunity to comment on the nomination and owners of private property are given an opportunity to object to or concur with the nomination. If the owner, or majority of owners in situations of multiple ownership, object to the nomination, the SHPO may forward the nomination to the National Park Service for a formal determination of eligibility. Without formally listing the property, the National Park Service then determines if the property is eligible for listing. Determinations of eligibility are important even when listing is not sought for historic sites which could be affected by projects involving federal action. Section 106 of the National Historic Preservation Act of 1966 (see Section 7.2.6) requires that Federal agencies allow the Advisory Council on Historic Preservation an opportunity to comment on all projects affecting historic properties either listed in or determined eligible for listing in the National Register. The Advisory Council oversees and ensures the consideration of historic properties in the Federal planning process.

Examples of National Register sites and districts which are familiar to residents of Boulder County include the Walker Ranch Historic District (5BL235, roughly coincident with the Boulder County Parks and Open Space Walker Ranch boundaries); the Eldora Historic District (5BL758, including Huron, Washington, Klondyke and Eldora Streets); the Switzerland Trail of America (5BL358, Denver, Boulder & Western Railway from Ward to Eldora); the Ryssby Church (Swedish Evangelical Lutheran Church of Ryssby, 5BL434); and the Wall Street Assay Office (5BL2674, 6352 Four Mile Canyon Drive).

Under federal law, owners of private property listed in the National Register are free to maintain, manage, or dispose of their property as they choose provided that no federal monies are involved. Modifications which result in loss of historic significance could result in the property being removed from the National Register. If land under federal ownership is involved, as is the case for the Boulder Hydroelectric Project (the project is subject to Federal Energy Regulatory Commission licensing and the Federal Energy Regulatory Commission project boundaries include 36.49 acres of Arapaho and Roosevelt National Forests lands), the Advisory Council on Historic Preservation will comment on any federal action that may adversely affect a site or district that is listed or eligible for listing on the National Register.

There are additional benefits that may accrue to owners of private properties listed on the National Register of Historic Places, including tax credits for certified rehabilitation of historic structures. Historic preservation grant programs may require National Register listing for eligibility.

15.2.2 Colorado State Register of Historic Properties

The Colorado State Register of Historic Properties is a listing of the state's significant cultural resources worthy of preservation for the future education and enjoyment of Colorado's residents and visitors. Properties listed in the Colorado State Register include individual buildings, structures, objects, districts and historic and archaeological sites. The Colorado State Register program is administered by the Office of Archaeology and Historic Preservation within the Colorado Historical Society. The Society maintains an official list of all properties included in the Colorado State Register. Properties listed in the National Register of Historic Places are automatically placed in the Colorado State Register. They may also be nominated separately to the Colorado State Register without inclusion in the National Register.

Criteria for consideration of properties for nomination and inclusion in the Colorado State Register include the following (Office of Archaeology and Historic Preservation, Colorado Historic Society, 2001):

1. The association of the property with events that have made a significant contribution to history;
2. The connection of the property with persons significant in history;
3. The apparent distinctive characteristics of a type, period, method of construction, or artisan;
4. The geographic importance of the property;
5. The possibility of important discoveries related to prehistory or history.

Properties may be nominated to the Colorado State Register by the owner, a local government, an agency or by the Colorado Historical Society. However, all nominations must contain the owner's signed and notarized approval of the nomination.

In addition to examples of historic resources in Boulder County which are listed on the State Register of Historic Properties without also being listed on the National Register include the Ewing Family Farm House (5BL1995, 1915 N. 95th Street); the Marshall School (5BL397, 1595 S. Cherryvale Road); and the Meadow Park Shelter House (5BL383.1, 600 Park Drive, Lyons).

Similar to the National Register, inclusion on the State Register is voluntary, and there are not restrictions upon property modification or maintenance. Modifications that result in loss of historic significance may result in the property being removed from the Register. There are state tax credits similar to federal tax credits for restoration, rehabilitation, or preservation of State Register properties. In addition, properties listed on the State Register are eligible to compete for grants from the State Historical Fund for acquisition, development, education and survey and planning projects.

15.2.3 Historic American Engineering Record (HAER)

The Historic American Engineering Record (HAER) is a cooperative effort among the National Park Service, Library of Congress, American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronic Engineers (IEEE), American Institute of Chemical Engineers (AIChE) and American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) to preserve information concerning historic American industry, engineering and technology. Rather than a designation, HAER is a recording procedure that includes measured and interpretive drawings, large-format photography and written history. Documentation is archivally preserved in the Library of Congress where it is readily available to the public.

The HAER program employs teams of student architects, engineers, photographers and student and professional historians each summer to complete HAER documentation for previously selected properties. The HAER program tends to concentrate on the most endangered of the significant historic properties brought to its attention. Funding comes from a variety of sources, including the property owner. The program receives significant financial support from the participating engineering associations due to the outstanding educational opportunities offered to the summer interns.

The average recording project administered by HAER runs for twelve weeks during a summer and employs from three to a dozen students per recording team, depending on a site's complexity and available funding. Some sites require two or more successive summers to document, usually due to funding limitations and optimum team management.

HAER records pertain to the site as it exists at the time of documentation. One of the main reasons the recording is done is to document technical engineering data for historic engineering sites imminently threatened with destruction or significant modification. Since this is not a designation, there are no restrictions concerning modification of sites for which HAER documentation has been completed. The purpose of the program is to preserve data that could be lost as a site is modified over time.

Examples of HAER projects undertaken during the summer of 2000 include:

- Los Angeles Bridges, Los Angeles, CA.: HAER documented both the historic and contemporary engineering of bridges linking East Los Angeles with the central city, in preparation for on-going seismic upgrading of all bridges in California to withstand earthquakes up to 8.7 on the Richter scale.
- Bodie Gold Stamp Mill, Bodie, CA.: HAER documented a ca. 1900 timber-frame mill containing much of its original equipment.
- Broughton Cant Flume, Columbia River Gorge, WA: Emergency documentation was completed on one of the last remaining log flumes in the Northwest.
- Pittsburgh Wool Company, Pittsburgh, PA.: This was an emergency documentation project for one of the last remaining wool pulleries in the country and one of the last remnants of the Pittsburgh meat packing industry. Demolition was imminent.

Since the Boulder Hydroelectric Project is not endangered at the present time, and since the facilities are largely historically intact with no plans for major modification of system components, it is doubtful that the project would receive priority in terms of consideration by the National Park Service, unless a thematic study of hydroelectric facilities is undertaken. However, HAER standards are published and the documentation can be completed by private consultants outside of the National Park Service program. Completion of HAER documentation for the Boulder Hydroelectric Project would preserve historic details of project operation as a hydroelectric facility prior to implementation of new management strategies to facilitate its operation as a municipal water supply. In addition, it would allow for collection, review and organization of the abundant historic documentation concerning this project.

15.2.4 Boulder County Historic Landmark Designation

Article 15 of the Boulder County Land Use Code contains Boulder County's historic preservation regulations. Among the objectives of the regulations are the identification of historically significant resources; review of building permits for structures greater than 50 years in age to determine the historical appropriateness of proposed exterior modifications to historically significant structures; review of demolition permit applications for historic structures; nomination and designation of historic landmarks; and review of proposed modifications to historic landmarks to determine their appropriateness. Building code variances may be requested to preserve the historic significance of a landmarked structure. During 2001, Boulder County also began developing a loan program to provide matching funds to property owners for rehabilitation and restoration of designated landmarks. This program is expected to begin in 2002.

The Boulder County Board of County Commissioners (BOCC) is advised in historic preservation matters by the Boulder County Historic Preservation Advisory Board (HPAB). The HPAB is comprised of up to nine Boulder County residents appointed by the BOCC. The Land Use Code requires that the HPAB include at least one member knowledgeable in the mining practices and history of Boulder County, at least one member knowledgeable in the agricultural practices and history of Boulder County, at least one architect, at least one member of the historic preservation community of Boulder County, and at least one member who is not affiliated with the historic preservation community of Boulder County.

While landmarking is voluntary and similar to the National and State Registers in terms of tax credits, pursuit of grant money and eligibility for variances from the Building Code to preserve historic significance, County landmarking differs from the National and State Register programs in one important way. Listing on the National or State Registers provides no protection from inappropriate alteration or demolition. Proposed exterior changes to or demolition of a National or State Register properties and Boulder County Historic Landmarks are all reviewed by the HPAB. In the case of a National or State Register property, the County can delay alteration or demolition up to 120 days, but inappropriate alteration or demolition of County Historic Landmarks can be prevented. As a matter of practice, alterations are generally approved and granted a Certificate of Appropriateness, but in some cases, the county has required redesign of proposed modifications to be more in keeping with the historic character of the structure or property prior to granting approval.

In determining whether a structure, site or district is appropriate for designation as an historic landmark, HPAB and the BOCC consider whether the landmark proposed for designation meets one or more of the following criteria (Boulder County Land Use Code, 15-501):

1. The character, interest, or value of the proposed landmark as part of the development, heritage, or cultural characteristics of the county;
2. The proposed landmark as a location of significant local, county state, or national event;
3. The identification of the proposed landmark with a person or persons significantly contributing to the local, county, state or national history;
4. The proposed landmark as an embodiment of the distinguishing characteristics of an architectural style valuable for the study of a period, type, method of construction, or the use of indigenous materials;
5. The proposed landmark as identification of the work of an architect, landscape architect, or master builder whose work has influenced development in the county, state, or nation;
6. The proposed landmark's archaeological significance;
7. The proposed landmark as an example of either architectural or structural innovation; and
8. The relationship of the proposed landmark to other distinctive structures, districts, or sites which would also be determined to be of historic significance.

Landmark applications are reviewed by the HPAB at regularly scheduled public hearings. The HPAB forwards a recommendation for approval or denial of landmark designation to the BOCC, who also hold a public hearing prior to reaching a decision.

Once landmarked, properties must be issued a Certificate of Appropriateness (CA) in order to complete any proposed work which requires a building permit from the County and which affects the exterior appearance, structural stability, or other characteristics as may be listed in the BOCC Resolution of Approval for the landmark designation. Prior to submission of an application for a CA, the applicant may request a consultation with an HPAB subcommittee to discuss the proposed design. Certificates of Appropriateness may be approved in subcommittee if there is unanimous agreement by subcommittee members. A CA approved in subcommittee is not heard in a regularly scheduled HPAB meeting.

Examples of Boulder County Historic Landmarks include the Orodell Site (5BL7178); the Nederland Old Stone Garage (5BL7184); St. Catherine's Chapel on the Rock at Camp St. Malo; the Snowbound Mine (5BL448); and the Betasso Ranch Complex and Site (roughly coincident with Boulder County's Betasso Preserve.

Frequently, landmark designations apply to just a structure, and in those cases, a CA is required only for proposed exterior modifications. However, landmarks may include provisions to protect interior features and equipment associated with the site, or may include provisions to limit the types of disturbance and activities which may occur within the landmark boundaries. In the case of the Snowbound Mine (BOCC Resolution 97-181 and the Cardinal Mill interior fixtures, machinery and equipment are protected under the Landmark designation. The Rock Creek Farm Cultural Landscape designation (BOCC Resolution 98-113) includes limitations on the locations and types of landscape disturbance which may occur. Depending upon the definition of landmark boundaries, proposals to build new structures within a landmarked area are reviewed by the HPAB as a part of the building permit review process.

The city provided the Boulder County HPAB with a field visit to the Boulder Hydroelectric Project in May 2001. City staff presented its plans for Barker Gravity Pipeline repairs to the HPAB in June 2001, and presented a preliminary overview of alternatives for modification of the dam outlet works. Additional County permitting may be required prior to the proposed dam outlet works modifications, and this permitting may or may not include a separate hearing before the HPAB.

The Boulder Hydroelectric Project appears to qualify for Historic Landmark designation by Boulder County under eligibility criteria 1, 2, 3 and possibly 7 (if technological innovation can be considered) and would be especially appropriate considering the prominence of Barker Reservoir in the County landscape. It would be appropriate to nominate the Boulder Hydroelectric Project for designation as a Boulder County Historic Landmark, provided the following requirements can be met:

1. Landmark designation of the entire Boulder Hydroelectric Project will require consent of the owners of at least 67% of the parcels of land included within the boundaries. If this consent cannot be attained, a less desirable alternative may be to landmark just the power plant and/or reservoir.
2. Landmark designation of any or all Boulder Hydroelectric Project facilities must contain provisions to allow the city to operate, maintain, repair and/or replace project components as needed to ensure its continued reliability as a municipal water supply as well as its safe and efficient operation. An Intergovernmental Agreement may be an appropriate method of addressing the types of provisions the city would need to allow designation as a Boulder County Historic Landmark.

15.2.5 American Society of Civil Engineers/American Society of Mechanical Engineers Historic Engineering Landmarks Designations

Both the ASCE and the ASME designate Historic Engineering Landmarks. ASCE nominations are generally coordinated through the appropriate ASCE Section and Zone. ASCE's Committee on History and Heritage of American Civil Engineering reviews all nominations, and the review process can take up to one year to complete. The specific merits of each nominated project are weighed, and the project is also compared to similar projects, including those that have and have not been previously nominated or designated as Historic Civil Engineering Landmarks. Designation involves the placement of a plaque and a dedication ceremony. ASCE has designated several dams and power generation projects as well as water supply and transport facilities, as Historic Civil Engineering Landmarks. Cheesman Dam is an Historic Civil Engineering Landmark, so designated as it was the world's tallest dam, at 221 feet above the streambed, when completed in 1905. Because of its role in the early development of high-head hydroelectric power design, the Boulder Hydroelectric Project would probably qualify for designation as an Historic Civil Engineering Landmark[4].

ASME has designated 215 Historic Mechanical Engineering Landmarks. Landmarks, sites and collections of historic importance to mechanical engineering are considered eligible for nomination. In Colorado, the Manitou & Pike's Peak Railway (commonly referred to as the Cog Railway) has been designated as an Historic Mechanical Engineering Landmark because it is the highest railway in the United States, the highest rack railway in the world, and it has been in continuous seasonal operation since 1891. ASME has designated a total of nine hydroelectric power facilities as Historic Mechanical Engineering Landmarks[5].

15.3 Conclusions and Recommendations

The Boulder Hydroelectric Project is considered eligible for nomination to the National Register of Historic Places, and as such, is treated by federal agencies the same as if it were listed. Tax incentives associated with listing are of limited value to a tax-exempt municipality. Unless there is a need to pursue grant monies available only for listed properties, there would be little advantage to listing the Boulder Hydroelectric Project on the National Register at the present time. The same conclusions apply to listing on the State Register of Historic Properties. If the Boulder Hydroelectric Project is listed on the National Register at some point in the future, it will also be listed on the State Register.

Completion of HAER documentation for the Boulder Hydroelectric Project would preserve a detailed record of the history and current condition of the project facilities. Archiving the documentation at the Library of Congress ensures that these data will be available to students and engineers far into the future. This is an attractive option, since the project's principal purposes as a hydroelectric generation facility has drawn to a close with the city's purchase of the system for municipal water supply objectives. With the shift in primary purpose, it is likely that the hydroelectric component of the project, which is now largely historically intact, will be modified. HAER documentation provides an opportunity to preserve the historic data and records without limiting the city's ability to modify the facilities to best suit its future purposes.

It is recommended that the city consult with the National Park Service concerning the possibility and timing of completion of HAER documentation for the Boulder Hydroelectric Project. If the National Park Service is not interested in completing the HAER study for the facilities, it is recommended that the city request cost information from private individuals and firms providing HAER documentation services to evaluate the feasibility of completing HAER documentation. A possible constraint to the completion of HAER documentation would be the cost of completing the detailed records.

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[4] The Colorado Section Office of ASCE has recommended contacting ASCE headquarters in Reston, VA. at 1-800-548-ASCE for additional information on the Historic Civil Engineering Landmarks program. Local contacts include Scott Tucker and Art Greengard, who have both chaired the Colorado Section History and Heritage Committee.

[5] The ASME contact for additional information concerning Historic Mechanical Engineering Landmarks is the History and Heritage Committee, c/o ASME Public Information, 23S2, Three Park Avenue, New York, NY 10016-5990, (212) 591-7740.

Historic Landmarking through Boulder County is a very appropriate means of recognizing the historic significance of the Boulder Hydroelectric Project. To put it most simply, Barker Reservoir is a prominent local landmark. The feasibility of County landmarking of the entire system depends, however, on the consent of a majority of landowners and the ability of the city and Boulder County to agree in terms of future maintenance and modification needs of the system. Less desirable in terms of historic significance and context, but also an option, would be the nomination of one or more of the system components.

It is recommended that the city initiate discussions with Boulder County to determine the feasibility of Historic Landmark designation for the Boulder Hydroelectric Project.

Designation of the Boulder Canyon Hydroelectric Project as either an Historic Civil Engineering Landmark or an Historic Mechanical Engineering Landmark are appropriate options for the city to consider. It is recommended that an ASCE and ASME member from the Utilities Division staff contact these organizations for additional information concerning their landmark programs and consider nominating the Boulder Hydroelectric Project for the designation that seems most appropriate and pertinent.

Of all the potential historic designations available for the Boulder Canyon Hydroelectric Project, two provide for historic preservation. HAER documentation preserves historic design and details without restricting future modifications of project facilities. Boulder County Historic Landmarking focuses on physical preservation through restricting future modifications to those that are deemed architecturally and historically appropriate to the facility.

15.4 Existing Source Material of Special Relevance to Historic and Cultural Resources

American Society of Civil Engineers, *National Historic Civil Engineering Landmarks,* www.asce.org/history.

American Society of Mechanical Engineers, *Landmarks, Heritage Sites, and Heritage Collections,* www.asme.org/history.

Boulder County. *Land Use Code, Article 15, Historic Preservation.*

Boulder Public Library, Carnegie Branch for Local History. Historic photograph archives.

Colorado State Archives, *"Barker Meadow Dam Photograph Album 1906-1910."* A collection of 65 photographic prints donated to the Colorado State Archives.

Commstock, Charles W. 1911. *"Fifteenth Biennial Report of the State Engineer to the Governor of Colorado for the Years 1909-1910.* Denver: Smith-Brooks Printing Company.

Gleichman, Peter. *Cultural Resource Inventory of the Boulder Canyon Hydroelectric Project,* currently under prepared for the city of Boulder, Department of Public Works, Utilities Division.

National Park Service, *Historic American Engineering Record.* www.cr.nps.gov .

National Park Service, *National Historic Landmarks*, www.cr.nps.gov.

National Park Service, *National Register of Historic Places,* www.cr.nps.gov.

Noel, Thomas J. 1989. *Colorado Catholicism, The Archdiocese of Denver 1857-1989.* The Archdiocese of Denver.

Norman, Cathleen. 2001. *Nederland Design Standards and Guidelines*, Town of Nederland. January 2.

Office of Archaeology and Historic Preservation. Undated. Colorado Historical Society.

Office of Archaeology and Historic Preservation, Colorado Historical Society. 2001. *Colorado Preservation 2005,* Colorado Historical Society.

Office of Archaeology and Historic Preservation, Colorado Historic Society. 2001. *Directory of Colorado State Register Properties*, February 28.

Pettem, Silvia. 2000. *Barker Dam, Boulder Hydroplant, Kossler Lake and pipeline Preliminary inventory of information sources to date*, prepared for the city of Boulder, March 10.

Public Service Company of Colorado. Undated. *Shoshone*.

Public Service Company of Colorado. Undated. *A Diamond Jubilee, Boulder Hydroelectric Plant, 1910-1985*.

Weiss, Manuel. 1980. *Inventory Record Form, Barker Dam and Reservoir,* Colorado Historical Society, Office of Archaeology and Historic Preservation, October.

16 Safety and Security

16.1 Introduction

Utilities Division staff routinely engages in project safety and emergency response planning for its major facilities and construction projects. Partnership with emergency response agencies together with advanced planning is necessary to ensure maximum public, staff, construction contractor, and infrastructure safety and security. To address safety and security issues in the context of Boulder Canyon Hydroelectric Project management planning, the city established a work group from the emergency response agencies with jurisdiction in the project area, as shown in Table 16.1.

TABLE 16.1
EMERGENCY RESPONSE AGENCIES WORK GROUP

Name	Representing
Dave Buchanan	U.S. Forest Service
June Busse	City of Boulder, Public Works Department, Utilities Division
Jim Creek	City of Boulder, Public Works Department, Utilities Division
Brian Dillman	Boulder Emergency Squad
Rick Dirr	Nederland Fire Department
Justin Dombrowski	Boulder Fire & Rescue, Wildland Fire Division
Carol Ellinghouse	City of Boulder, Public Works Department, Utilities Divison
Brett Gibson	Fourmile Fire Protection District
Kris Kranzush	Consultant to city of Boulder, Public Works Dept., Utilities Division
Marc Mullenix	Boulder Fire & Rescue, Wildland Fire Division
Craig Skeie	City of Boulder, Public Works Department, Utilities Division
Joanna Stansbury	City of Boulder, Public Works Department, Utilities Division
Larry Stern	Boulder County Sheriff's Dept./Office of Emergency Management
Sally Stoffel	Sugar Loaf Fire Department
Steve Stolz	Boulder Fire & Rescue
Mike Tombolato	Cherryvale Fire Department

Emergency response planning for the Boulder Canyon Hydroelectric Project has had several distinct focuses, including:

- Preparation of an Emergency Action Plan, as required by the Federal Energy Regulatory Commission, to provide planned, coordinated and practiced response in the event of dam failure or significant flood events.
- Identification of public safety hazards associated with facilities, ways to reduce hazards, and emergency responder needs and requirements.
- Analysis of potential threats to the city's water supplies from significant wildland fires, analysis of fire hazards on Utilities Division managed lands, and initiation of a fire hazard mitigation program for these properties.

- Identification of worker safety hazards, ways to reduce hazards, and emergency responder needs and requirements.
- Identifying threats to the water supply and appropriate precautionary and protective actions, and coordinating/linking response to emergency procedures identified in other plans.
- Identifying threats to infrastructure and identifying appropriate levels of security.

Planning for infrastructure and water supply safety and security was redefined in the days and weeks following September 11, 2001.

16.2 FERC Requirements

The Federal Energy Regulatory Commission (FERC) is charged with statutory responsibility for the safety of nonfederal hydroelectric projects. Through inspections and studies, FERC ensures that dams are kept in good shape and monitors them to help prevent unanticipated dam safety incidents. As a second line of defense, emergency action plans make sure that the dam owner and community know how to deal with potential emergencies. Elements of the dam safety program are annual project inspections by FERC inspectors, engineering and environmental analyses, Part 12-D safety reviews, and emergency action plan tests.

16.2.1 Project Inspections

Inspections verify the structural integrity of dams and compliance with engineering, environmental, and public safety conditions and regulations. They also identify necessary maintenance and remedial modifications. FERC is responsible for inspecting more than 2,600 dams and related water retention structures. The agency conducts periodic inspections starting from the receipt of an application for a proposed jurisdictional project, throughout the life of a project license. Types of inspections include pre-license, construction, operation, instrumentation, exemption, environmental and public use, safety, and special. The city of Boulder's hydroelectric projects, including the Boulder Canyon Hydroelectric facilities, are inspected by personnel from the FERC regional office in San Francisco.

For the Boulder Canyon Hydroelectric Project, FERC inspections focus on ensuring safe operation and maintenance of the dam. Annual on-site operation inspections by FERC inspectors ensure that dams are maintained for long-term structural integrity of the project works, with remediation implemented as necessary. They also ensure that the licensee complies with license provisions.

FERC inspectors have historically required that the outlet works of Barker Dam, including the condition of the gate seals on the upstream face outlet gates, be visually inspected and fully operated every five to seven years. Due to the configuration of the Barker Dam outlet works, this visual inspection is most readily accomplished by emptying the reservoir. The previous project owner, Public Service Company of Colorado, coordinated the occurrences of these complete reservoir drawdowns with the city and scheduled these inspections in the spring. This scheduling corresponded with periods of relatively low municipal water demand and occurred prior to late spring snowmelt to facilitate the refilling of the reservoir to the maximum extent. This inspection requirement and methodology wasted stored municipal water, reduced the reliability of the municipal water supply by restricting carryover storage, and does not align well with principles of municipal water supply management, Neither did it allow for development of the reservoir fishery beyond support of annually stocked game fish. In the past, the city has experienced serious water shortages during the time Barker Reservoir was drained for inspection[6]. The city of Boulder is currently finalizing the design of outlet works modifications that will eliminate the need to drain the reservoir every five to seven years for outlet works inspection. Modification of the dam outlet works is scheduled to begin in 2002.

16.2.2 Engineering and Environmental Analyses

FERC provides guidance to its engineering staff, dam owners, their consultants and the entire dam safety community by publishing Engineering Guidelines for the Evaluation of Hydropower Projects. These guidelines specify the criteria, analytical methods, engineering parameters, and other engineering aspects related to the design, construction, monitoring, and operation of safe dams. Those responsible for dam safety rely on these guidelines. FERC updates and expands the guidelines as necessary to ensure consistency with state-of-the-art technology.

As dams age and undergo various stress conditions, such as floods or earthquakes, FERC may increase its monitoring and use of instrumentation data to decide whether the condition of the dam and appurtenant facilities is changing. FERC requires that licensees and their consultants evaluate the condition and performance of dams on a continual basis.

16.2.3 Part 12-D Safety Reviews

FERC's dam safety program must ensure consistently high safety standards at high and significant hazard potential dams to maintain the lowest probability of failure. In addition to its own periodic visual inspections and evaluations, FERC requires periodic independent consultant inspections of dams with high hazard potential. These inspections include a complete engineering assessment and inspection of the project works, with a detailed review of the project design and a thorough inspection of project structures. For quality control, FERC dam safety experts approve qualifications of independent consultants. They also thoroughly review all independent consultant inspection reports for validity of the analysis and conclusions and the need for additional studies or remedial measures.

16.2.4 Structural Condition of Barker Dam

FERC classifies Barker Dam as a Class 1 Dam based on the probable loss of human life should the dam fail. The dam and reservoir are considered to have a high hazard potential based on the size of the reservoir, its location in a mountain canyon discharging into a populated area, and the number of people living and working in the floodplain below the dam. The hazard rating relates

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[6] In May 1996, during a period when Barker Reservoir was drained for FERC inspection, the city experienced a water shortage that barely avoided becoming a crisis. Unexpected warm weather and resulting high water demand occurred while the Barker system was out of operation. The city was barely able to supply its municipal water needs by running both Boulder Reservoir Water Treatment Plant and Lakewood Pipeline at or beyond capacity, and through imposition of aggressive water use restrictions. Despite these efforts, treated water storage levels dropped to a low of 3 million gallons and water pressure began dropping throughout the distribution system before recovering.

only to the potential for damage and loss of life should the dam fail and is not an indicator of the structural condition or maintenance level of the dam.

When the Boulder Canyon Hydroelectric Project was last relicensed in 1981, FERC inspected the project works and found the dam and powerhouse to be in good operating condition. Although severe spalling was noted on the downstream face of Barker Dam, FERC concluded that the condition was unsightly but did not affect the dam's structural integrity. No other areas of concern or deficiencies were noted which would affect the safety and adequacy of the project.

FERC required Public Service Company of Colorado to perform several additional studies and analyses following issuance of the project license to support this finding. A previous study had analyzed the factor of safety against sliding and overturning under various loading combinations of normal reservoir levels, earthquake, and ice conditions. Results showed that, with full uplift, tension would develop for all loading conditions. Because the tensile strength of the concrete, the strength of the bond between the foundation and the dam, the effectiveness of the drain, and the uplift forces were not known, special terms were included in the 1981 license requiring PSCo to make these determinations. If the stability analysis of the dam showed that it was unsafe, the license required PSCo to take remedial measures.

The subsequent stability analysis did indeed show that the factor of safety against uplift and overturning was too low. PSCo negotiated an agreement with the city of Boulder (the "1984 Agreement") whereby the city paid the costs of a project to anchor the dam into the bedrock and attain a sufficient factor of safety. In return for Boulder completing this project, the city received use of two-thirds of the reservoir storage space and use of the delivery pipelines in perpetuity. FERC has routinely inspected the facilities throughout the current license period and has found Barker Dam to be structurally sound.

16.2.5 Emergency Action Plans

Recognizing that its inspection, monitoring, evaluation and remediation programs cannot guarantee the emergencies will not occur, FERC requires all licensees to develop, implement, maintain and test a project-specific Emergency Action Plan for each of its licensed dams. These plans specify actions that owners must take, in coordination with federal, state and local preparedness agencies, to protect life, property and the environment in case of flood, earthquake or project facility failure.

The city began preparing its draft interim Emergency Action Plan (EAP) in consultation with local emergency responders and FERC for the Boulder Canyon Hydroelectric Project upon assuming ownership of the project. This plan has been accepted on an interim basis by FERC. The city has tentatively scheduled its first EAP tests for the spring of 2002. The first test will be an exercise in combination with the annual city and county flood drill in which notification and evacuation will be implemented in response to a hypothetical flood event resulting from a significant storm over the Middle Boulder Creek watershed. This exercise will test both the city's emergency action planning and the responses of participating agencies. Following the flood drill, the city will conduct a review of plans, procedures and policies to evaluate emergency preparedness and responsibilities.

The city will conduct an in-house drill on an annual basis. This drill will test city staff familiarity with and the use of the EAP and will provide hands-on training concerning EAP implementation.

16.2.6 Guidelines for Public Safety and Hydropower Projects

FERC, through its Division of Dam Safety and Inspections, evaluates the requirements for specific public safety measures on a case-by-case basis, depending upon such things as the level of public use and recreation development. While recognizing that the implementation of safety measures to minimize accidents that are not associated with project structures or operations is usually the responsibility of local entities and law enforcement agencies, FERC nonetheless has the authority to require the installation of safety devices or other measures deemed necessary.

Recognizing its responsibilities to provide for public safety at its facilities, the city of Boulder is preparing an "all-risk" emergency response plan for the Boulder Canyon Hydroelectric Project in consultation with local emergency response agencies. In this collaborative effort, the city and local emergency services providers have identified the types of public safety risks associated with the Boulder Canyon Hydroelectric Facilities and evaluated the adequacy of the current emergency response protocols and procedures in addressing public safety risks. The city is currently examining alternatives for the enhancement of emergency response to the Boulder Canyon Hydroelectric Project facilities.

16.2.7 FERC Response to the Events of September 11, 2001

On September 14, 2001, FERC issued a statement that acknowledged the safety and reliability of the nation's energy supply infrastructure as being critical to the nation's economic well-being. In addition, FERC announced its intention to approve applications proposing the recovery of prudently incurred costs necessary to further safeguard the nation's energy and infrastructure in response to the county's heightened state of alert.

FERC has also assisted in informing its licensees via email of warnings and alerts issued by the U.S. Government.

Since then, FERC has contacted hydroelectric power project owners and operators to review security measures at hydropower facilities and to share the actions being taken at many of the nation's hydroelectric facilities. Examples of these measures are:

- Immediately inspecting projects to identify any unusual activity, personnel or containers on site;
- Restricting access to important project works for increased knowledge and control over activities within those project areas;
- Tightening of security through increased monitoring of facilities, personnel and deliveries;
- Briefing staff on heightened security and surveillance;
- Increasing staff in number and duration;
- Requesting local law enforcement assistance;

- Curtailing non-emergency activities to allow projects to remain in full operation and to minimize the number of non-security personnel on site;
- Establishing and/or reconfirming contact notification lists for local, state and federal law enforcement agencies;
- Determining which initial security measures to keep in place and which to terminate or modify, focusing on project facilities where modest effort would result in maximum damage or impact to life or essential services, including the nation's power supply, and;
- Recommending that all facility owners/operators review availability of sensitive project information to the public and confirming that FERC has taken steps to limit Internet access to sensitive project information.

In addition to sharing recommendations and typical measures taken in response to heightened security, FERC required confirmation that the city had evaluated its specific needs for increased security and a general description of measures being taken by the city to safeguard its power facilities and sensitive information related thereto.

16.3 Other Safety Requirements and Procedure

16.3.1 State of Colorado

The Colorado Division of Water Resources, Dam Safety Branch administers the Dam Safety Program for the state of Colorado. The Dam Safety Branch carries out two principal duties of the State Engineer: to determine the safe storage level of the reservoir dams in the state; and to approve the plans and specifications for the construction and repair of dams greater than 10 feet in vertical height to the bottom of the spillway, or greater than 20 surface acres or 100 acre-feet in capacity at the high-water-pipeline. The Dam Safety Branch issues guidelines for dam safety emergency preparedness, and requires dam owners to have an approved Emergency Preparedness Plan. The Emergency Action Plan for the Boulder Canyon Hydroelectric Project meets the State of Colorado requirements for an Emergency Preparedness Plan.

The State Engineer's Office and the Dam Safety Branch participate in advising dam owners and operators of potential threats to facilities.

16.3.2 Local Law Enforcement Agencies

Pursuant to C.R.S. 29-22-102(3)(b) and County Resolution 84-9, the Boulder County Sheriff is the "Designated Emergency Response Authority" for the unincorporated portions of Boulder County. The Boulder Canyon Hydroelectric Project is located within the jurisdiction of the Boulder County Sheriff. The city has coordinated with the Sheriff's Department concerning all aspects of emergency preparedness and emergency response, including potential threats to system components.

The initial response to emergency incidents within the Boulder Canyon Hydroelectric Project boundaries is provided by several Fire Protection Districts, as defined and supplemented by a variety of interagency agreements. All emergency dispatch within Boulder County is provided by the Boulder Regional Communications Center. Therefore, to report an emergency of any type, callers need only to dial 911. The Boulder Regional Communications Center is equipped with 911 call-back capabilities, allowing all telephones within map-defined boundaries to be contacted with a recorded message at the rate of 2000 calls per minute.

The following all risk mode system is utilized in Boulder County:

- Mode 1: Jurisdiction(s) having authority responds and handles event without requesting outside resources.
- Mode 2: Jurisdiction(s) having authority requests outside resources including mutual aid, however, retains incident command authority.
- Mode 3: Jurisdiction(s) having authority requests that the incident management authority be transferred to a County agency. Incident command may be transferred or a joint command may be established.
- Mode 4: County agency or joint command requests that the incident management authority be transferred to a state or federal agency.

16.4 Middle Boulder Creek Watershed/Boulder Canyon Hydroelectric Project – Hazards and Risks

16.4.1 Introduction

This section provides an overview of the types of emergencies that could occur within the Middle Boulder Creek watershed and the Boulder Canyon Hydroelectric Project boundaries.

16.4.2 Flood

16.4.2.1 Potential Hazards

The city recognizes four emergency scenarios with respect to Barker Dam and Reservoir, Middle Boulder Creek below the dam, Kossler Reservoir dams and Hawkin and Woods Gulches, which could be affected by failure of the Kossler dams:

1. Slow failure of a dam, classified as “potential failure situation is developing.”
2. Rapid failure of a dam, classified as “failure is imminent or has occurred.”
3. Instantaneous failure of a dam, classified as “failure is imminent or has occurred.”
4. Abnormally high natural stream flow in Middle Boulder and Boulder Creeks causing high rates of flow over the emergency spillway and possibly the crest of Barker Dam, classified as “non-failure emergency condition.[7]”

16.4.2.2 Emergency Response

The city will activate its Emergency Action Plan if any of the four emergency scenarios pertaining to flooding develop. When activated, the appropriate emergency management officials are notified. Warning and evacuation planning are the responsibilities of the city of

[7] A non-failure emergency condition is unlikely at Kossler Reservoir, since flows into and out of the reservoir are regulated. Kossler Reservoir is a forebay and regulating reservoir, rather than an on-channel reservoir subject to flooding from abnormally high stream flow.

Boulder and Boulder County, who are the local authorities with the statutory obligation. The city and County have a Flood Emergency Plan in place, including procedures for the notification and evacuation of flood prone areas, notification of emergency service providers upstream of the dam and reservoir, and notification of a flood emergency via pager to all city and Boulder County employees.

16.4.2.3 Precautions

The city regularly inspects the dam, abutments, spillway, gravity pipeline and downstream toe of the dam to monitor for unusual conditions or activity that could forewarn of a potential dam failure.

FERC inspects the Boulder Canyon Hydroelectric Project, including Barker Dam, at the following intervals:

FERC requires that licensees review, update and internally exercise the project's Emergency Action Plan on an annual basis. Additional exercises are required approximately every five years. The city will conduct its first two of these exercises in the spring of 2002.

The city has installed a SCADA system which monitors and reports information from the Barker system to the Betasso Water Treatment Plant, which is staffed 24 hours per day and 7 days per week:

Barker Reservoir inflow is recorded at the inlet weir on a chart recorder. There is a separate radio transmitter system that transmits the level in the weir as measured by a level float to the State of Colorado Division of Water Resources. There is also a chart recorder at Barker Dam which records stream level at the 800-foot weir (below Barker Dam.)

In addition to the city-operated surveillance equipment, the Boulder County Sheriff's Department is notified when stream flow reaches 1200 cfs (10-year flood event) at the following gauges:

- Boulder Falls on North Boulder Creek, just upstream from its confluence with Middle Boulder Creek;
- The tunnel on Colorado Highway 119 in the vicinity of the Boulder Canyon hydroelectric plant.
- Orodell, located approximately one mile downstream from the hydroelectric plant.

These gauges are located considerably farther downstream than the Barker Dam monitoring equipment. An alarm from the Orodell gage provides approximately 15 minutes of warning before high flows enter the city limits. The city has increased security measures in response to the September 11, 2001 terrorist attacks.

16.4.3 Fire

The potential for contamination of Boulder's water supplies due to a wildland fire in the watershed above the city's water intakes exists and is of great concern to city staff. The Barker

Reservoir/Middle Boulder Creek watershed includes 11,687 acre-feet of storage in Barker Reservoir which, in conjunction with Middle Boulder Creek direct flow and exchange rights have historically supplied 40 percent of the city's annual municipal water supply, and the city recognizes the potential for increasing reliance on these water supplies with the acquisition of Barker Reservoir and the Boulder Canyon Hydroelectric Project in 2001.

16.4.3.1 Forest Conditions in the Middle Boulder Creek Watershed

Throughout the west, natural fire patterns were disrupted on a large scale with widespread vegetation modification associated with 19th century settlement activity. Decades of aggressive fire suppression have drastically changed the appearance of Western forests and rangelands - and fire behavior in those ecosystems (U.S. Departments of Interior and Agriculture, 2000):

- Forests a century ago were less dense and had larger, more fire-resistant trees.
- Species of trees that ordinarily would have been eliminated from forests by periodic, low-intensity fires became a dominant part of the forest canopy. Over time, these trees became susceptible to insects and disease, resulting in the accumulation of standing dead and dying trees, along with other brush and downed material on the forest floor.
- When dried by short-term or extended periods of drought, these fuels promote uncharacteristically intense wildfires, which are typically hotter, faster, larger and more devastating than those of the past.
- In Boulder County, 80 years of fire suppression preceded by European settlement and grazing have left the forest with vegetation densities 10 to 100 times their historic levels.
- Combined with increased residential development and high recreation demands in the mountains, the potential for catastrophic wildfire has reached crisis levels. A significant management problem has arisen from the fact that wildland fuels are partially dependent upon fire as part of their ecology, yet structures are not compatible with a fire environment (Hay, C.M. and J.H. Korte, 2000).

In 1990, following the Black Tiger Gulch Fire which consumed 44 homes and blackened 2,000 acres of land in western Boulder County, the Boulder County Wildfire Mitigation Group (BCWMG) was formed to determine and coordinate actions that could help minimize the loss of life and property from wildfires. This led to the Wildfire Hazard Identification and Mitigation System (WHIMS) to identify wildfire hazards, educate homeowners, assist land managers, and assess the risks involved due to wildfires. Broad level analysis consisting of topographic (elevation, slope and aspect) and fuels data considered through a hazard rating model has been completed for the entire county, including the Middle Boulder Creek Watershed (Boulder County, 2000). The Middle Boulder Creek Watershed below timberline consists of a mixture of areas of low, moderate and high wildfire hazard ratings. When considered in terms of both wildfire hazard rating and structural density, the Middle Boulder Creek watershed contains areas of extreme and very high concern due to concentrations of structures in and around Nederland and Eldora.

The Colorado State Forest Service has examined the Front Range in terms of potential for a catastrophic event, such as a significant wildland fire. High hazard areas, delineated as “red zones”? encircle the city. In the past decade, the city has experienced dozens of fires within this red zone, ranging from easily controlled, inconsequential events to major catastrophes such as the Black Tiger Gulch Fire of 1989. The September 2000 Walker Fire also occurred within this high hazard zone. The 1996 Buffalo Creek fire, which burned more than 11,000 acres occurred in area with only a moderate hazard rating.

Annually, Boulder County averages 100 wildland fire starts per year. Of these, from one to three, on an average, develop into ”large” fires affecting an area greater than 100 acres in size. Wildland fires are commonly ignited by lightning (the Left Hand Canyon area fire during 2000) and careless handling of fire by people (1989 Black Tiger Gulch fire; 2000 Bobcat Fire in Larimer County), but structural fires may also be responsible for igniting significant wildland fires (1990 Old Stage Fire, which resulted in the loss of 10 structures).

16.4.3.2 Effects of Fires on Water Supplies

Fires consume ground litter and vegetation and promote the formation of water-repellent (hydrophobic) soils, all of which may decrease rainfall infiltration into the soil and significantly increase overland flow and runoff in channels. Removal of obstructions to overland flow can enhance its erosive power, resulting in accelerated erosion from hill slopes. Increased runoff may also erode significant volumes of material from channels. All factors contribute to the transport and deposition of large volumes of sediment both within and downstream from a burned area. Post-fire floods and debris flows can occur with little warning, exert great force on objects in their paths, strip vegetation, block drainage ways, damage structures, and endanger human life (Cannon et al, 2000). Water quality, and fish and wildlife can be severely affected. Impacts from erosion and flooding occur within and far downstream of the burned area. Strontia Springs Reservoir, which received the majority of the debris carried downstream by severe flooding following the 1996 Buffalo Creek fire, is approximately 2 miles downstream from the burn area.

A burn area of significant size can actually modify local weather patterns in the months and years following a fire. Removal of vegetation and charring of the land surface increases heat absorption, causes changes in wind patterns and creates atmospheric instability which may actually contribute to the formation of severe storms in and around the burn area. Topography, slope and aspect of the burn area contribute to this phenomenon. Under the right circumstances, a major wildland fire may not only affect the land’s ability to absorb and retain precipitation, but also contribute to the frequency and intensity of storm events, which may cause flooding, erosion and debris flows. An example of this phenomenon is the occurrence of 13 separate 100-year flood events in and around the Buffalo Creek fire area in the four years following the fire (Denver Water Department, 2001). Stratigraphic studies in the Buffalo Creek Watershed suggest that there may have been about seven similar fire-flood cycles in the last 2,000 years (USGS, 2001).

In the western states, long dry summers, hot dry winds, and low relative humidity directly impact fire behavior. Dry lightning storms start thousands of fire each year. Steep mountainous terrain and difficult access affect fire behavior and resistance to control. Along the Colorado Front Range, the wildland fire season coincides with the severe thunderstorm season, increasing the immediate threat of post-fire floods and debris flows resulting from extreme storm events.

In May 1996, the Buffalo Creek Fire burned 11,900 acres of mostly USFS land in the Denver Water Department's (DWD) North Fork of the South Platte watershed. Fire suppression costs were approximately $2.6 million. Property losses from the fire exceeded $1.0 million. In July 1996, torrential rains caused flash flooding which swept ash, debris, uprooted trees, buildings, propane gas tanks, 55-gallon drums and other items down the mountainsides into the river, which carried the debris to Strontia Springs Reservoir. There were two fatalities from the floods and over $2.6 million in property losses. Follow-on effects to Denver's water supply include (Denver Water Department, 2001):

- Sediment - DWD estimated a minimum of 200,000 cubic yards of sediment (equivalent to about 16,000 dump truck loads) were deposited in Strontia Springs Reservoir during the first (July 12, 1996) flood event. At least an additional 170,000 cubic yards of sediment were deposited in the reservoir during 1997. During these two years, more sediment was deposited in the reservoir than during the previous 13 years of its existence.[8] The sedimentation rate has been estimated at 5 times faster than engineering estimates at the time of project planning. Topsoil from the burn area was washed away in 1996 and is most likely at the bottom of the reservoir. It is estimated that sediment removal will cost $12 million.

- Turbidity - Normal turbidity levels in the watershed are 30-40 ntu or below. Turbidity levels in the South Platte River following the flood exceeded 2000 ntu. The water was untreatable for human consumption.

- Debris - Debris temporarily lodged in the upper end of the reservoir but quickly migrated toward the dam. More than 15 surface acres of floating debris came into the reservoir. DWD engineers and crews rigged a boom to protect the water intake towers and floated or hauled debris onto a shelf of land next to the auxiliary spillway for drying and burning. The reservoir water level was intentionally raised and lowered 12 times to facilitate burning of 3,600 cubic yards of debris.

- Dam Safety - Valves had to be cleared of debris to operate the dam safely.

- Hydroelectric Power Generation - DWD was unable to operate the hydroelectric plant at Strontia Springs Reservoir for about 90 days following the flood. The outage cost DWD about $1,000 per day. In the following two years (1997 and 1998) debris from the flood caused numerous interruptions in power both at Strontia Springs Reservoir and Foothills Treatment Plant.

[8] The design capacity of Strontia Springs Reservoir is 7,700 acre feet (9,500,000 cubic meters)- or approximately two-thirds that of Barker Reservoir.

- Water Quality - DWD experienced a serious water quality crisis following the flood due to floating burned debris and high levels of manganese. Two years after the flood, phosphate levels remained high, and DWD considered water quality to be impaired. Initial costs associated with reservoir clean up and losses due to poor water quality were approximately $1 million. DWD estimates that future water quality and clean-up costs will be approximately $8 million.

- Watershed Assessment - The 1996 flood and fire resulted in loss of life, and loss of properties and forest cover on 11,900 acres. Soils continue to erode because of thirteen 100-year flood events which occurred in the three years following the fire. In 1998, DWD proposed the Upper South Platte Watershed Protection and Restoration Project as a cooperative effort among DWD, the Colorado State Forest Service, the Environmental Protection Agency, Colorado State University, the Rocky Mountain Region of the USFS, Rocky Mountain Research Station and the Pike and San Isabel National Forests. Much like the Winiger Ridge Project, the Upper South Platte Watershed Project will involve a landscape assessment of 600,000 acres and development and implementation of a menu of landscape-scale forest management opportunities to maintain or restore management opportunities. Monitoring requirements will be determined following completion of the landscape assessment.

Following the 1061-acre Walker Fire in 2000, Boulder County acted rapidly to assess burned area condition and implement a burned area mitigation effort through the Natural Resources Conservation Service Emergency Watershed Protection Program. Boulder County received a $169,000 grant (for which the County is 25% responsible for funding). As of January 1, 2001, Boulder County had implemented one phase of the grant, involving contour tree felling for erosion control on 151 acres of the burn and was in the process of implementing erosion control, including straw wattles, seeding and mulching, on an additional 186 acres of severely or moderately burned areas (Glowacki, personal communication).

The September 2000 Walker Fire required substantial application of fire retardant to protect life and property. A fish kill in South Boulder Creek occurred on September 18, 2000, and was attributed to the use of the fire retardant. The retardant is ammonia-based commercial fertilizer. The fish most likely were affected by the ammonia in the slurry or by chemical uptake of oxygen in the stream. If a cyanide additive was present in the fire retardant (unclear at the current time), the Colorado Department of Health and Environment has stated that it would not have been either a drinking water concern or human health risk.

The city is monitoring South Boulder Creek water quality following the Walker Ranch fire. Potential water quality impacts involve a major tributary to Boulder Creek and a drinking water supply reservoir. It is estimated that 500,000 people receive their drinking water from water resources affected by this fire. These include South Boulder Creek, which is a drinking water source for the cities of Louisville and Lafayette and the town of Superior; and Gross Reservoir, a DWD water supply which serves the city of Arvada. Several small drainage ways which cross the burned area are tributary to South Boulder Creek and upstream of Louisville's and Lafayette's diversion structures. The northern corner of Gross Reservoir is within a few hundred feet of the fire area, and South Boulder Creek forms most of the eastern boundary of the fire.

Long-term water quality concerns include the impacts of runoff from the burned area (Scott, 2001). The sediment load potentially has severe detrimental effects on water quality and aquatic habitat, particularly over the next two years. Water Quality and Environmental Services staff will continue to monitor water quality of South Boulder Creek to help evaluate fire mitigation measures and assess drinking water concerns.

16.4.3.3 Emergency Response

The Middle Boulder Creek watershed and the Boulder Canyon Hydroelectric Project fall within the jurisdictions of multiple fire protection districts. Boulder Canyon Hydroelectric Project facilities fall within the Nederland, High Country, Cherryvale and Fourmile Fire Protection Districts.

The city currently has cooperative agreements with 11 rural fire protection districts[9] to provide initial response to wildland fires affecting city lands and facilities. These agreements help to ensure attention to fires which threaten city land and facilities and assist rural fire protection districts in obtaining needed training and equipment.

Initial response to a fire at the Boulder Canyon Hydroelectric Facility would be provided by the Fourmile Fire Department (FD). The Fourmile FD has neither the equipment nor the training to provide a full-scale response to a fire involving the significant electrical components or hazards that would occur in the event of a hydro plant fire. It is recommended that Utilities Division staff develop a specific plan for dealing with a hydroelectric plant fire in consultation with the Fourmile Fire Protection District. The objectives of this planning exercise would be to ensure the safety of the responders, minimize damage to the facility, and to prevent or minimize damage to surrounding lands and properties.

The Boulder County Annual Operating Plan sets forth the standard operating procedures, mutual policies, and responsibilities to implement cooperative wildland fire suppression on all lands within Boulder County. The Boulder County Sheriff is responsible for all wildland fire suppression activities on private and state lands within Boulder County. By virtue of the resources of Fire Protection Districts to make initial attack, Fire Departments and Fire Protection Districts are dispatched and respond to wildland fires without regard to land jurisdiction.

In the case of federal land, excluding Rocky Mountain National Park, the responsibility of the fire protection district is to respond with the jurisdictional agency, initiate initial attack, control the fire if possible, and to call for assistance as necessary. Fires on federal lands are normally managed by the federal agency with jurisdiction.

Boulder Emergency Squad (BES) provides extensive support for fire departments and fire districts during fires. BES can respond with needed equipment for refilling self-contained

[9] The city currently has contractual agreements with Boulder Mountain, Boulder Rural, Cherryvale, Coal Creek, Eldorado Springs, Fourmile, Indian Peaks, Left Hand, Mountain View, Nederland and Sugar Loaf Fire Protection Districts.

breathing apparatus used by firefighters, lighting equipments, and also assist with traffic control, firefighter rehabilitation and emergency medicine and other services.

16.4.3.4 Precautions

The city has to date taken the following precautions against significant wildland fire effects to its Middle Boulder Creek water supplies:

- During 2001, the Utilities Division participated in a pilot program for a dedicated local air support resource for use in wildland fire fighting throughout Boulder County and the Front Range of Colorado and is participating in an expanded program for 2002. This program, when fully developed and operational, will provide a helicopter for rapid response to fires in rugged terrain and remote locations, thus reducing response time and increasing the likelihood that fires can be controlled before they grow to potentially catastrophic size.

- During 2001, the Utilities Division requested that the Boulder Fire and Rescue Wildland Fire Division assess all its properties and facilities in terms of wildland fire hazards and make specific recommendations concerning hazard reduction programs. This assessment is currently in progress.

- During 2001 and 2002, the Boulder Wildland Fire Division and Cherryvale Fire Department are assisting the Utilities Division in fire hazard mitigation efforts on city lands surround Barker Dam and Reservoir.

- The Utilities Division has initiated discussions concerning service agreements for protection of its land and infrastructure with the appropriate fire protection districts.

- The Boulder Wildland Fire Division conducts an annual visit to the Municipal Watershed for fire hazard mitigation and seasonal crew training.

In addition to precautions currently in place, the following additional precautionary measures are recommended:

- Continued cooperation and support for Fire Protection Districts in which city facilities are located and other organizations involved in wildland fire management efforts, as appropriate[10].

- Designation of individuals who will represent the water utility on fire management teams during wildland fires in the water supply watersheds. Active participation in the management of suppression efforts would help maintain water supply protection as a priority in strategy development. Water utility equipment and resources could potentially be made available to the suppression effort.

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[10] For example, the air support program to which the Utilities Division contributed support during 2001 is administered by an association of wildland fire fighters and fire departments in Boulder County.

- Update the existing "Draft Emergency Response Plan for the city of Boulder Water Supply System" to specifically address water supply emergencies caused by wildland fires.

- Carefully consider all management decisions for the Boulder Canyon Hydroelectric Project in terms of their impact on fire danger, and consult with jurisdictional agencies to determine how to best contain and manage associated risks. For example, expansion of the existing authorized recreational uses of project facilities will increase fire danger in those areas.

16.4.4 Injuries and Medical Emergencies

16.4.4.1 Importance

Medical emergencies comprise the majority of requests for emergency response in Boulder County. This category includes vehicle accidents and all varieties of injuries and illnesses. Hiking, biking, rock climbing, ice climbing and other outdoor recreation activities may result in injuries that require emergency response.

16.4.4.2 Potential Hazards

Currently, there is no public access or use allowed to the top of Barker Dam and the spillway, the Gravity Pipeline corridor, Kossler Reservoir, the penstock corridor, or the hydroelectric plant, in part because of the safety hazards associated with these facilities (however, see Law Enforcement Incidents, below).

Boating, swimming and other water-based recreation is currently not allowed on Barker Reservoir, in part due to safety concerns. The safety of boating on Barker Reservoir has been the subject of much debate in the past. One of the issues has been the risk of serious injury if high winds should blow a watercraft into the upstream face of the dam or over the spillway. During the boating trials conducted during the summer of 1999, a cable was strung across the reservoir above the dam as an additional safety measure for boaters who approached the dam too closely. While providing some additional protection against boating accidents involving Barker Dam, this is considered an inadequate safety program.

Limited access and difficult terrain can complicate response to injury incidents whether they involve recreationalists, project staff, or contractors. These factors apply to both the Barker Gravity Pipeline and penstock corridor. Personnel involved in the on-going Barker Gravity Pipeline repairs have adopted policies of requiring at least two people whenever accessing these areas, as added protection in the event someone should fall or be otherwise injured. The city has provided maps with key features associated with the gravity pipeline to emergency responders to aid in the location of anyone requiring medical assistance. The city also updates emergency responders weekly concerning work site locations during periods of project maintenance.

FERC's *"Guidelines for Public Safety at Hydropower Projects"* include as hazardous features: spillways, powerhouse intakes, powerhouse tailrace areas; spillway tailraces; canals; pipeline and canal intakes; boat ramps, substations and power lines, project structures, natural topography, and; winter conditions. FERC includes the following safety devices and measures, implemented to an appropriate degree depending upon the types, intensity and hazards associated with public use of project facilities, as guidelines for hydroelectric project operators: education and information; warning devices (signs, audible warnings, light, illumination, beacons and strobes, buoys, etc.); restraining devices (boat restraining barriers, fences, guardrails, natural barriers, trash racks, debris deflector booms, etc.), and; escape devices (life preservers, escape ladders, safety nets, etc.).

16.4.4.3 Emergency Response

Response to medical incidents in Boulder County is provided by the fire department/fire protection district in whose jurisdiction the incident occurs and by medical transport/paramedic agencies under contract with Boulder County (Pridemark Paramedic Services, Inc. in western Boulder County). As needed, air transport may be ordered from either Flight for Life (Denver) or Air Life (Greeley). Boulder Emergency Squad frequently assists responders if vehicle extrication, emergency evacuation, traffic or crowd control is needed. Rocky Mountain Rescue Group may assist if the injured party cannot be located, is in a remote location or requires transportation out of areas with difficult or dangerous terrain.

16.4.4.4 Precautions

At the current time, public access to most of the potentially dangerous facilities associated with the Boulder Canyon Hydroelectric Project is not allowed. However, enforcement has until recently been sporadic. In developing long-term management strategies for the Boulder Canyon Hydroelectric Project facilities, the city should plan for adequate warnings, barriers and restrictions, following the FERC guidelines, to prevent public access to those areas deemed a safety hazard.

Facilities that are open to public access, such as trails, as well as warning signs, will require maintenance to ensure that safety hazards are eliminated as they develop.

Any proposed new uses of the Boulder Canyon Hydroelectric Project facilities should be carefully reviewed in terms of safety hazards and appropriate hazard mitigation programs should be developed. Safety programs should be developed in consultation with the Boulder County Sheriff's Office and emergency responders. In addition, FERC will review public safety programs as a function of its project inspections and may require additional safety measures to be implemented.

16.4.5 Rescue

Rescue incidents include Search-and-Rescue, water rescue, and confined space rescue. Search-and-Rescue and water rescue, under current management of Boulder Canyon Hydroelectric Project facilities, would be needed in limited instances since the more remote project components - the Gravity Pipeline and penstock corridors- are closed to public use and since boating and other forms of water-based recreation are prohibited. Nonetheless, the pipeline corridors are subject to some use (see Law Enforcement, below), and city staff and consultants periodically use boats to collect water samples and conduct technical investigations. Since the Boulder Canyon highway is adjacent to Barker Reservoir, there could be accident situations requiring water rescue as well. Confined space incidents would presumably be limited to situations where city staff, consultants or contractors enter the dam or pipelines.

16.4.5.1 Potential Hazards

Water temperature is considered to be a major complicating factor in terms of water accidents involving Barker Reservoir and many of the lakes and streams of Boulder County. The U.S. Coast Guard provides guidelines shown in Table 16.4.5.1 concerning cold-water exposure (U.S. Coast Guard, 2001).

Cold water can kill rapidly. The U.S. Coast Guard Auxiliary reports that on Memorial Day 1996, an 18-year-old canoeist capsized into 50ºF lake water. He sank to the bottom before a rescuer in a boat towing the canoe could reach him (U.S. Coast Guard Auxiliary, 1997). BASIN water quality data indicate that water temperatures for Middle Boulder Creek at the Nederland Water Treatment Plant vary from 32 to 54ºF. City of Boulder data indicate the average summer water temperature in Barker Reservoir is 53^{o} F at an average depth of approximately five feet (Stansbury, 2001).

TABLE 16.4.5.1
EXPECTED COLD WATER SURVIVAL

Water Temperature (^{O}F)	Exhaustion/Unconsciousness	Expected Survival
32.5 º	< 15 minutes	10-45 minutes
32.5-40º	15-30 minutes	39-90 minutes
40-50º	30-60 minutes	1-3 hours
50-60º	1-2 hours	1-6 hours
60-70º	2-7 hours	2-40 hours
70-80º	3-12 hours	3-indefinitely
Over 80º	Indefinitely	Indefinitely

More than half of fatal boating accidents occur in cold (less than 60ºF) water. Water removes heat from the body 25 times faster than cold air. Physical activity such as swimming or struggling in the water increases heat loss. Wet or dry suits, and personal flotation devices which maintain an unconscious person in a face-up position can greatly improve chances of survival.

Miraculous recovery of cold water, near-drowning victims occurs. Therefore, the Boulder County Sheriff's Office considers all rescue attempts within reasonable time as valid efforts.

Boating and other water-based recreation is currently not allowed on Barker Reservoir

The city restricts public access to facilities for which confined space rescue could be needed (Barker Dam, gravity pipeline intake, gravity pipeline). Therefore, it is assumed that confined space rescue would only be required if an emergency arose when city staff, consultants or contractors are conducting maintenance on these facilities. The city routinely advises emergency responders when personnel will be in a confined space situation.

16.4.5.2 Emergency Response

Water and ice rescue is provided in this area of Boulder County by Boulder Emergency Squad. BES is the primary in-water response agency for Boulder Creek, which has a formidable period of high water each Spring. BES would also be responsible for dive rescue/recovery from Barker or Kossler Reservoirs. In addition, Boulder Fire & Rescue has a dive rescue team.

Initial response to confined space or search-and-rescue incidents is provided by the fire department/fire protection district with jurisdiction. Additional resources are summoned if the incident is beyond responder capabilities.

16.4.5.3 Precautions

The current no-boating policy on Barker and no-access policy for Kossler confine the need for water rescue to limited accidental occurrences or situations of trespass. Before considering changing the current no-boating policy, a comprehensive evaluation of current levels of service for water rescue/recovery should be undertaken in consultation with the appropriate emergency response organizations.

16.5 Physical Threats to Facilities and Water Contamination Incidents

The majority of the information in this section has been taken from "Early Warning Monitoring to Detect Hazardous Events in Water Supplies" (Brosnan, ed., 1999). Contrary to common knowledge, identification and planning for threats to public water supplies has been the subject of on-going analysis long before September 11, 2001. Therefore, the structure for identifying threats, vulnerabilities and strategies for defending public water supplies was in place to facilitate rapid response to events occurring in the aftermath of September 11, 2001.

The Utilities Division has formed a security evaluation group since September 11. 2001. The group meets weekly to assess current conditions and security needs for the entire municipal water system and licensed and exempt hydropower facilities.

The city of Boulder has taken what city staff believes to be the necessary activities to provide heightened security and to ensure the safety of the municipal water supply system and the hydroelectric power projects. For security reasons, responses are not described in detail here.

16.5.1 Potential Hazards

Threats to water supplies include natural, recurring events such as floods, droughts, earthquakes, landslides, high winds, storm surges, and volcanic eruptions, and anthropogenic-related events such as spills, accidents, point and nonpoint pollution sources, vandalism and terrorism.
Prior to September 11, 2001, the perceived greatest threats to water supplies were (1) oil and petroleum products from spills: (2) insecticides and herbicides from agricultural run-off, and; (3)

bacteria from untreated sewage discharges. In the absence of direct attacks on water supplies since September 11, 2001, these are still perceived to be the greatest threats to water supplies.

Intentional threats against water supplies have been recorded since the earliest archaeological and biblical reports of well poisonings. Most studies indicate that the numbers of threats and acts of sabotage against water supply systems are relatively small and that hoaxes are much more likely (Carus, 1999)

There are two major types of intentional threats to the water supply: (1) destruction of parts of a system, either by physical destruction or by computer hacking, and; (2) contamination of the system with chemicals, microbes, toxins, or radioactive compounds.

No water treatment or distribution system will survive direct hits by missiles, but explosives of a more limited nature could interrupt electric power, gravity supply, or pumping or cause large leaks in reservoirs or dam failures. The city's Emergency Action Plan deals with the latter situations. Cyber attacks against the SCADA are also possible. The city of Boulder experienced direct vandalism of its SCADA system for the Boulder Canyon Hydroelectric Project during the summer of 2001, when vandals entered the plant and physically incapacitated the SCADA system.

Any water supply system may be intentionally contaminated by chemical or radioactive compounds, infectious agents or toxins. The most likely points of attack for intentional contamination include post-treatment storage reservoirs, distribution reservoirs and water mains.

The list of bioweapons of greatest concern is relatively small and includes (in decreasing order of concern) anthrax, smallpox, plague, tularemia, botulism toxin and viral hemorrhagic givers such as Ebola. Most of these agents would be most readily released as an aerosolized weapon and are therefore considered as less likely attacks on water supplies, due to the effects of dilution and treatment.

However, the U.S. Army has concluded that on the basis of exiting weaponalization, stability in water, and known or potential resistance to chlorine, some of the bacterial agents (anthrax, plague) and all of the biotoxins (e.g., botulinum, aflatoxin, ricin) are potential waterborne threats (Burrows and Renner, 1998). However, the dose required to cause a health effect is so high that that contamination would have to be targeted close to the consumer.

16.5.2 Emergency Response

The specific response to accidental contamination of the water system is based upon the location, type and severity of contamination. Possible responses include closing intakes, hazardous materials unit response, and reliance on other water supplies until the problem can be eliminated. Voluntary or mandatory water conservation measures could be necessary until the water supply returns to normal. Loss of a specific component of the city's raw water supply system is addressed in the *Draft Emergency Response Plan, City of Boulder Water Supply System.*

Additional measures have been developed to detect, report, evaluate, monitor and respond to the threat of terrorist attack of water systems since September 11, 2001. These measures will not be discussed in detail for obvious security reasons.

Standard reporting requirements exist for all contamination incidents, regardless of whether they are accidental or intentional. These include:

- Notification of the local emergency planning committee and response agency for all hazardous substance incidents (911 and (303) 441-3637)
- Notification of the National Response Center (1-800-424-8802) and the Colorado Department of Public Health and Environment (CDPHE) (303 756-4455) for releases from fixed facilities which exceed reportable quantities.
- Notification of the National Response Center for transportation accidents that result in spill or release of hazardous substances.
- Notification of CDPHE for releases from fuel storage tanks to the ground surface which exceed 25 gallons.
- Notification of CDPHE of any release from fuel storage facilities to surface water, ground water, dry drainages or storm sewers regardless of quantity.

In addition to standard notification procedures, threats against water supplies are to be reported to the local office of the FBI.

16.5.3 Precautions

Strategies for improving security and strengthening water supply defenses against threats of all kinds can be found in *Strategic Security Planning for Public Drinking Water Systems* (University of Michigan, 1989) and in Haimes et al. (1998).

Since September 11, 2001, the Utilities Division has taken steps to reduce public availability to water system design and construction details and increase security at its water facilities. Concrete Jersey barriers have been installed to prevent vehicles from approaching the top of Barker Dam from State Highway 119. Fencing of the Boulder Canyon hydroelectric plant has been upgraded. On-going Barker Gravity Pipeline repairs include the installation of locking access covers.

The most effective defenses against physical and cyber acts of destruction or contamination include redundancy in water treatment and distribution systems and denial of access to critical or vulnerable facilities. Redundancy ensures that in the event of failure of multiple system components, the system will still be able to function at some level. Boulder has intentionally designed redundancy into its raw water supply and water treatment systems. Since September 11, 2001, these facilities have practiced heightened security and greater restriction of public access.

Storage reservoirs in distribution systems should be secured to prevent access by unauthorized individuals. Treated water reservoirs should have locked and secured vents, hatches, etc. Intakes, pumping stations, treatment plants and reservoirs can be fenced and equipped with intrusion alarms to notify operators that an unauthorized person has entered a restricted area. Immediate response might include shutting down the breeched part of the system until authorities can determine whether the system has been threatened or compromised.

If physical barriers are overcome, the second line of defense, at least for microbial contaminants, is chemical. Maintaining a chlorine residual of about 0.5 mg. per liter free chlorine in the distribution system will protect against most bacterial pathogens. Depending upon the gravity of a threat, chlorine residuals may be increased. However, many nonbacterial pathogens are resistant to chlorine and the effectiveness of disinfectants on some microbes is not know. The use of chlorine must also be evaluated against the risks associated with the formation of chlorinated by-products.

Back flow prevention programs and attention to possible cross-connection situations are needed to prevent accidental contamination of the water system. The Utilities Division conducts on-going evaluations of these factors in the construction and maintenance of its facilities.

Continued monitoring of national, regional and local security advisories and evaluation of real or perceived threats will be on-going for all city water facilities. Threat detection may be enhanced through staff and public education concerning awareness of suspicious individuals or activities near water facilities. The public should be encouraged to call 911 if any suspicious occurrences are witnessed.

On-going evaluation of water facilities in terms of vulnerability to specific types of accidental and intentional incidents and alternatives for increasing water facility security is required. Staff will continue to develop detailed emergency response plans for prevention and detection of water system contamination and provision of alternate water supplies in the event the city's water system is compromised.

All proposed changes in the current management of Boulder Canyon Hydroelectric Project facilities should be carefully evaluated in terms of potential risks to the water supply.

16.6 Law Enforcement Incidents

16.6.1 Overview

Law enforcement incidents of concern to the city include trespass, illegal camping, violation of burn bans which are routinely enacted by Boulder County during high fire danger seasons, and vandalism. All unincorporated areas of Boulder County, including the majority of the Middle Boulder Creek watershed, are under the jurisdiction of the Boulder County Sheriff. In addition, Open Space and Mountain Parks rangers patrol city open space, and the Colorado State Patrol provides enforcement on State Highway 119. City water facilities, including the Boulder Canyon Hydroelectric Project, are monitored by Utilities Division staff.

Illegal camping in Middle Boulder Creek and Boulder Creek canyons was the subject of numerous public comments during the preparation of this plan. While the city does not own significant property in the canyons, illegal camping is a concern due to potential water quality effects and increased fire danger associated with campfires.

Enforcement of camping restrictions in the canyons is complicated by land ownership and jurisdictional concerns. Camping is allowed on U.S. Forest Service land, as long as no single campsite is continuously occupied for more than two weeks. Camping is not allowed on State Highway rights-of-way, although enforcement of this policy has been problematic. As a result of concerns raised during the preparation of this management plan, the Colorado Department of Transportation and Boulder County Sheriff's Office are resolving jurisdictional issues.

Trespass on private property for which the city hold easements for the Barker Gravity Pipeline was also a frequently voiced concern. The linear pipeline corridor is attractive to hikers and bicyclists who may not be aware that the majority of this pipeline is located on private property. City easements in these areas are for the operation and maintenance of the pipeline and do not allow for recreational use.

Law enforcement issues are generally reported to the Boulder County Sheriff by members of the public.

16.6.2 Emergency Response

The Boulder County Sheriff responds to reports of law enforcement issues as they are reported. Trespass citations may be issued.

B.R.C. Chapter 11-1-11 (*Trespass, Interference with Water Utility Prohibited)* prohibits trespass upon the property of the water utility and other interference with water supply and distribution facilities. City citations for trespass may also be issued.

16.6.3 Precautions

The precautions addressed in section 16.5.3 apply to this section.

A public education program concerning the location of the majority of the Barker Gravity Pipeline on private property would help landowners in this area with on-going trespass problems.

16.7 Conclusions

Purchase of the Boulder Canyon Hydroelectric Project has introduced new security and safety concerns for the city of Boulder. These concerns include regulatory compliance related to Barker Dam and Reservoir and public safety around project facilities. The events of September 11, 2001, have resulted in the need to monitor and assess security of public water supply facilities on an on-going basis.

16.8 Recommendations

Recommendations pertaining to safety and security can be broadly summarized as follows:

- Support fire protection districts and wildland fire management efforts.

- Track security advisories and follow the recommendations of law enforcement agencies regarding heightened security during the current national action against terrorism.
- Continue emergency response planning.
- Improve security measures through training, adding personnel, and constructing security barriers.

Additional recommendations and more detailed recommendations are presented in Section 19.

16.9 Existing Source Material of Special Relevance to Safety and Security

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17 Natural Resources

17.1 Barker Reservoir and Watershed

17.1.1 Vegetation

Barker Reservoir lies within the montane life zone of the eastern flank of the Rocky Mountain Front Range. Its watershed grades upward into the subalpine life zone toward the Continental Divide to the west, and is characterized by coniferous forests, aspen forests, meadows, wetlands and riparian communities, and alpine tundra.

17.1.1.1 Coniferous Forests

The pattern of coniferous forest found around Barker Reservoir and in its watershed is influenced by elevation, slope, aspect and soil type. Shoreline vegetation around Barker Reservoir is limited due the steep terrain and fluctuations in reservoir elevations. Ponderosa pine (*Pinus ponderosa*) woodlands and Douglas-fir (*Pseudotsuga menziesii*) forests dominate the slopes above the Reservoir and the lower elevations of the watershed. All ages of ponderosa pine and Douglas-fir are present, indicating that the species are reproducing and that the species composition will remain relatively similar in the future. The upper elevations of the watershed are covered with dense stands of lodgepole pine (*Pinus contorta*) with a sparse understory due to the dense nature of the stands. Engelmann spruce-subalpine fir (*Picea engelmannii-Abies lasiocarpa*) forests occupy the highest forested environments in the watershed and some small tributaries to Middle Boulder Creek.

17.1.1.1.1 Ponderosa Pine Woodlands

This community is most dominant on south- and southwest-facing slopes. Ponderosa pine is the dominant tree, although Douglas-fir and Rocky Mountain juniper (*Sabina scopulorum*) are present. Forest structure is highly variable, ranging from areas dominated by saplings to mature stands. Many large individual ponderosa pines persist on the rocky crags above the north shore of the reservoir.

The well-developed shrub layer in the forest understory consists of common juniper (*Juniperus communis*), kinnikinnick (*Arctostaphylos uva-ursi*), mountain maple (*Acer glabrum*), wax currant (*Ribes cereum*), and Wood's rose (*Rosa woodsii*). Other common understory plants include yellow stonecrop (*Sedum lanceolatum*), sulphur flower (*Eriogonum umbellatum*), cinquefoil (*Potentilla fissa*), hairy goldenaster (*Heterotheca villosa*), mountain muhly (*Muhlenbergia montana*), and needle-and-thread (*Stipa comata*).

17.1.1.1.2 Douglas-fir Forests

Steep, north-facing slopes below 8,500 feet within the watershed are typically dominated by Douglas-fir forests. The forest structure can range from closed canopies on north-facing slopes to more open stands on exposed, rocky slopes. Aspen (*Populus tremuloides*), lodgepole pine, and ponderosa pine also may be present in this community. Numerous snags, probably killed by insects such as the western spruce budworm, provide nesting sites for cavity-nesting birds. The understory includes aspen, mountain maple, waxflower (*Jamesia americana*), common juniper, kinnikinnick, wax currant, and wallflower (*Erysimum capitatum*).

17.1.1.1.3 Lodgepole Pine Forests

This community is primarily found on forested uplands above 8,500 feet. Lodgepole pine (*Pinus contorta*) forests are usually very dense, with a closed canopy. Regeneration of these forests may be low to non-existent except in the cases of catastrophic fires, insect infestations, and logging operations. In these cases, lodgepole pine will regenerate vigorously. There is very low species diversity and understory cover within the closed canopy. The main vegetation association is lodgepole pine/kinnikinnick. Common juniper, ninebark (*Physocarpus monogynus*), and buffaloberry (*Shepherdia canadensis*) also may be common.

17.1.1.1.4 Engelmann Spruce-Subalpine Fir Forests

Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are the dominant forest species in subalpine habitats of the watershed. These species can form large, homogeneous forest between 9,000 feet and timberline. In the understory of this community, subalpine fir seedlings usually outnumber Engelmann spruce seedlings because they are more shade tolerant and readily establish on duff seedbeds. Other species in the understory may include bog birch (*Betula glandulosa*), buffaloberry (*Shepherdia canadensis*), common juniper (*Juniperus communis*), and willow (*Salix* spp.). Exposed, rocky, windy ridges are often dominated by limber pine (*Pinus flexilis*) in this forest community. Some small tributaries to Middle Boulder Creek are deeply shaded with Englemann spruce and subalpine fir and have moist banks that are covered with plants such as swamp wintergreen (*Pyrola rotundifolia*), one-sided winter green (*Orthilia secunda*), chiming bells (*Mertensia ciliata*), bittercress (*Cardamine cordifolia*), and sedge (*Carex disperma*).

17.1.1.2 Aspen Forests

Aspen forest communities occur on upland sites at the edges of meadows, in swales with seasonal water saturation, and in relatively dry drainages in the watershed. In this community type, aspen dominates the overstory, with conifers often present. In most stands, conifers are invading and eventually will replace aspen in the absence of natural disturbances such as fire.

The understory of aspen forest communities is often lush and includes mountain bluebells (*Mertensia ciliata*), iris (*Iris missouriensis*), Canada violet (*Viola canadensis*), cow parsnip (*Heracleum sphondylium*), yarrow (*Achillea millefolium* var. *occidentalis*), Indian paintbrush (*Castilleja sulphurea*), Richardson’s geranium (*Geranium richardsonii*), false Solomon’s seal (*Maianthemum racemosum*), and bracken fern (*Pteridium aquilinum*).

17.1.1.3 Alpine Tundra

The upper headwaters of Barker Reservoir watershed along the Continental Divide support alpine tundra. Tundra vegetation includes low growing grasses, forbs, and shrubs at elevations too high for trees. Snowfields in the alpine tundra are a principal source of runoff and stream flow for Middle Boulder Creek.

17.1.1.4 Meadows, Wetlands and Riparian Communities

The watershed supports abundant wetland and riparian habitat along streams, ponds, and lakes. Principal areas of wetland and riparian development are located along the South and North Forks of Middle Boulder Creek and large tributaries such as Caribou Creek, Jasper Creek and Coon Track Creek. Barker Reservoir supports wetland meadows near the inlet, but shoreline riparian habitat is lacking due to steep terrain and fluctuations in reservoir elevations.

Within the watershed there are several areas of beaver ponds with associated wetland vegetation such as willow shrublands dominated by various willows (*Salix planifolia, S. drummondiana, S. bebbiana,* and *S. monticola*). Other shrubs include swamp honeysuckle (*Distegia involucrata*) and thinleaf alder (*Alnus incana* ssp. *tenuifolia*). The vegetation communities associated with beaver change over time due to successional processes. New dams create ponds that flood previously vegetated areas. When dams are breached, the drained ponds create conditions for plant colonization. These areas often become colonized by sedges and willows. This type of pattern may lead to the development of montane willow carrs or a mosaic of dense tall shrubs mixed with stream channels, beaver ponds, and wet meadows. Willow carrs are areas of important habitat for a number of avian species.

17.1.1.5 Significant Plant Communities

The Colorado Natural Heritage Program has identified Middle Boulder Creek at Eldora as a potential conservation area of High Significance (B3). The 102-hectare site contains a good (B-ranked) occurrence of sedge (*Carex oreocharis*), which is a state critically imperiled species. The occurrence is surrounded by the encompassing wetland, which buffers the sedge and protects it against disturbance. The hydrology of the site should be maintained and the occurrence should be considered during any modifications within the watershed.

17.1.2 Wildlife

The habitats in the Barker Reservoir watershed are home to a wide variety of wildlife, both resident and migratory. Large mammals of particular interest in the watershed include elk, mule deer, and black bear.

17.1.2.1 Mule Deer (Odocoileus hemionus)

Mule deer are common in the watershed, occupying habitats that provide adequate browse. Mule deer prefer “edge” habitat, thus allowing them to benefit from human-related disturbance such as forest clearing. The entire watershed is considered mule deer overall range. Lower elevations near Barker Reservoir are considered winter range (NDIS 2001a). Mountain lions, coyotes, and packs of domestic dogs prey upon mule deer in the watershed.

17.1.2.2 Elk (Cervus elaphus)

Elk in the Middle Boulder Creek area were studied in response to planned expansion at the Eldora Ski Area (Hallock 1991). General findings of the study indicated there were two major herds of elk that summered in different locations in the watershed. The larger herd, which numbered about 300 animals, summered in the Indian Peaks Wilderness from the Fourth of July Valley southwest to Rollins Pass. This herd used the Arapaho Ranch area west of Nederland for important transitional range in the spring (Hallock 1991). The smaller herd of about 100 animals summered near East Portal and used the area around Tolland for spring transitional range.

17.1.2.3 Black Bear (Ursus americanus)

Although the east slope of the Front Range is not considered prime bear habitat in Colorado due to poor food resources, the entire watershed is considered suitable habitat and overall range for black bear (NDIS 2001b). Black bears are wide-ranging and relatively secretive forest mammals. They probably use habitat blocks of the watershed with little human presence as primary habitat.

17.1.2.4 Other Wildlife Species

The variety of habitats present in the Barker Reservoir watershed provide for porcupines (*Erethizon dorsatus*), striped skunk (*Mephitis mephitis*), weasels (*Mustela erminea* and *M. frenata*), and a number of small mammals. Numerous songbirds, water birds, and raptors are seasonal migrants and residents in the watershed. Riparian areas provide particularly valuable habitat for wildlife. Species common to riparian areas include beavers (*Castor canadensis*), muskrat (*Ondatra zibethicus*), Nuttall's cottontail (*Sylvilagus nuttallii*), American dipper (*Cinclus mexicanus*), belted kingfisher (*Ceryle alcyon*), white-crowned sparrows (*Zonotrichia albicollis*), and warbling vireo (*Vireo gilvus*). A one-season breeding bird inventory for the 200-acre Mud Lake Open Space property north of Nederland indicated that the riparian area along Sherwood Creek is a rich habitat for breeding birds and was home to two species of special concern, golden-crowned kinglet (*Regulus satrapa*) and MacGillivray's warbler (*Oporornis tolmiei*) (Hallock 2000). A similar study on Caribou Ranch Open Space identified 11 Boulder County Avian Species of Special Concern including ring-necked duck (*Aythya collaris*), northern goshawk (*Accipiter gentilis*), three-toed woodpecker (*Picoides tridactylus*), olive-sided flycatcher (*Contopus borealis*), pygmy nuthatch (*Sitta pygmaea*), golden-crowned kinglet (*Regulus satrapa*), veery (*Catharus fuscescens*), MacGillivray's warbler (*Oporornis tolmiei*), western tanager (*Piranga ludoviciana*), savannah sparrow (*Passerculus sandwichensis*), and fox sparrow (*Passerella iliaca*) (Hallock 1999). Although the Mud Lake and Caribou Ranch Open Space areas are located in the North Boulder Creek watershed, similar habitats are present in the Middle Boulder Creek watershed.

Amphibians and reptiles, such as tiger salamanders (*Ambystoma tigrinum*), striped chorus frogs (*Psuedacris triseriata*), and northern leopard frogs (*Rana pipiens*), also are present in riparian habitats. A summary report (BCPOS 2000a) of research activities at Mud Lake, a four-acre lake one mile north of Nederland, provides some indication of amphibians and reptiles in the watershed. Found in small ponds and lakes up to 12,000 feet elevation, tiger salamanders were recorded in 1939 in Mud Lake, and have been observed in the lake in recent years. Striped chorus frogs are found in wet meadows and marshy ponds up to 12,000 feet and are found at Mud Lake. Northern leopard frogs are found in shallow permanent water up to 10,000 feet. They were last recorded at Mud Lake in 1959 and have not been found in recent surveys (BCPOS 2000a).

17.1.3 Aquatic Resources

17.1.3.1 Fisheries

Fish population sampling summaries from the Colorado Division of Wildlife (CDOW) indicate brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), splake (*Salvelinus fontinacis x S. namaycush*), longnose sucker (*Catostomus catostomus*) and white sucker (*Catostomus commersoni*) in Barker Reservoir (CDOW 1995). Streams above Barker Reservoir support brook trout, rainbow trout, brown trout, and native suckers and minnows. CDOW sampling in 1993 about 3 miles above the inlet to Barker Reservoir resulted in a minimum population estimate of about 90 rainbow trout and 110 brook trout per acre (CDOW 1993). Middle Boulder Creek and its tributaries are historical habitat for native greenback cutthroat trout (*Oncorhynchus clarki stomias*), and one individual was captured during CDOW sampling in 1993.

17.1.3.2 Macroinvertebrates

Construction of Barker Reservoir altered the natural stream processes along Middle Boulder Creek. Benthic macroinvertebrate habitat above the reservoir remains in a near natural condition; however, habitat quality is affected by human activities in the upper watershed including water quality influences from the community of Eldora, Eldora Ski area, previous and ongoing mining, roads, and recreational activity. Sampling of benthic macroinvertebrate populations at a site on Middle Boulder Creek above the Town of Nederland indicates higher species richness than sites below Barker Reservoir (Wicken et al. 1998). Benthic macroinvertebrates are secondary producers that require flowing, highly aerated water and nutrients for growth and reproduction.

17.1.4 Threatened, Endangered, and Rare Species

Federally threatened and endangered species are protected under the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 et seq.). Significant adverse effects to a federally listed species or its habitat require consultation with the U.S. Fish and Wildlife Service (FWS) under Section 7 or 10 of the Endangered Species Act (ESA). Federal and state listed threatened and endangered species with suitable habitat in the Barker Reservoir watershed include lynx (*Felis canadensis*), wolverine (*Gulo gulo*), boreal toad (*Bufo boreas boreas*), and greenback cutthroat trout (*Oncorhynchus clarki stomias*) as described below.

17.1.4.1 Lynx (Felis canadensis) and Wolverine (Gulo gulo)

Both the state and the USFS consider Boulder County to be potential, but unoccupied habitat for lynx and wolverine. Lynx, listed as federally threatened and state endangered, may use suitable subalpine forest in the watershed for foraging or denning. Snowshoe hare, the principal prey species of lynx, is found west of Barker Reservoir in the Eldora area (LREP, Inc., 1994). Wolverine, listed as state endangered, have been reported in the watershed through unconfirmed reports (PUMA 2000).

17.1.4.2 Boreal Toad (Bufo boreas boreas)

The boreal toad is a candidate species for federal listing, and also is a state endangered and USFS sensitive species. It occupies forest habitats between approximately 7,000 and 12,000 feet in Colorado. Boreal toads occupy three different types of habitat during the course of the year including breeding ponds, summer range, and overwinter refugia (Loeffler 2001). All of these specific habitats occur within lodgepole pine or spruce/fir forests found within the Barker Reservoir watershed. Records for boreal toad include Lost Lake, North Fork of Middle Boulder Creek, and at several small ponds. They were documented in Mud Lake in 1931, but have not been found in recent surveys (BCPOS 2000a). There are historical records of boreal toad at Barker Reservoir, but the reservoir site does not provide habitat typically used by boreal toads.

*17.1.4.3 Greenback Cutthroat Trout (*Oncorhynchus clarki stomias*)*

The greenback cutthroat trout, listed as federally threatened, is the only trout endemic to the headwaters of the Arkansas and South Platte River drainages and was once abundant within Colorado. The subspecies declined in the late 1800s due to over-harvest and the introduction of non-native trout species. The native habitat of the greenback cutthroat trout includes all of the clearwater streams of the Barker Reservoir watershed, downstream to the western edge of the plains. The nearest known population of greenback cutthroat trout is in Como Creek in the North Boulder Creek watershed. According to the Colorado Natural Heritage Program (CNHP), the water quality and flow of Como Creek is important to the survival of the population of greenback cutthroat trout in this location. The greenback is highly vulnerable to displacement by other species of trout. Reproducing genetically pure strains of greenback cutthroat trout are not known to be present in Middle Boulder Creek or other drainages in the watershed although a single specimen was identified by the CDOW in 1993.

17.2 Near Barker Gravity Pipeline

17.2.1 Vegetation

The pipeline starts at an elevation of about 8,000 feet and follows a bench on the south side of Boulder Canyon terminating at an elevation of about 7,700 feet at Kossler Reservoir. The pipeline traverses three properties held by Boulder County Open Space and Parks including the lower portion of Reynolds Ranch, the southeast corner of Rogers Property, and the entire length of Platt Rogers about 300 feet above the valley floor.

The pipeline crosses several intermittent drainages, in which seven inverted siphons and related drain valves are located. Vegetation near the pipeline includes many species typical of the foothills and montane life zones of the Front Range. The area is mainly forested with Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*Pinus contorta*). In the drainages, species such as Engelmann spruce (*Picea engelmannii*), alder (*Alnus* *tenuifolia*), aspen (*Populus tremuloides*), and redosier dogwood (*Cornus stolonifera*) are common. Descriptions of the various community types can be found in Section 17.1.

17.2.1.1 Wetlands

Wetlands occur at each of the siphons along the pipeline, with the exception of siphon 3, where wetlands occur in the drainage swale up and down gradient of the siphon and valve box. Generally, wetlands are confined to the narrow valley bottom along intermittent and ephemeral creek channels, although some wetlands have formed at leaks along the pipeline. The wetlands that have formed at leaks along the pipeline are considered to be non-jurisdictional because they are wholly supplied by water from the pipeline (ERO 2001a).

All of the wetlands at the siphons and valve boxes are considered to be jurisdictional wetlands under Section 404 of the Clean Water Act because they occur along intermittent and ephemeral creeks. Wetland vegetation generally is dominated by alder (*Alnus incana*), red osier dogwood (*Cornus stolonifera*), redtop (*Agrostis gigantea*), bluejoint reedgrass (*Calamagrostis canadensis),* and cow parsnip (*Heracleum lanatum*). Other common species include mannagrass (*Glyceria striata*), large-leaved avens (*Geum macrophyllum*), Bebb's willow (*Salix bebbiana*), Baltic rush, and Engelmann spruce.

Additional wetlands include three large wet meadows found on Reynolds Ranch, which are considered to be significant plant communities by Boulder County (BCPOS 1999). These wetlands received high ratings in the County-wide wetland inventory (Wright Water Engineers 1993). The three wetlands on Reynolds Ranch are significant for their large size, relatively undisturbed condition, and plant communities uncommon for Boulder County Parks and Open Space properties (Gage 1999). One of the wetlands, associated with Giggy Lake, has a floating sedge mat along the north margin of the lake. The location of the Reynolds Ranch wetlands is unusual because of their position on top of a high plateau far above the local principal drainages about 1 mile south of the pipeline. Common plants in these wetlands include arctic rush (*Juncus arcticus*), spikerush (*Eleocharis palustris*), water sedge (*Carex aquatilis*), beaked sedge (*Carex utriculata*), tufted hairgrass (*Deschampsia caespitosa*), and Rocky Mountain iris (*Iris missouriensis*).

17.2.1.2 Old Growth Forest

Boulder County Parks and Open Space has identified two small stands of old growth ponderosa pine (*Pinus ponderosa*) on the Platt Rogers property (BCPOS 1999). The stands are 6 and 12 acres in size with the largest trees averaging over 200 years of age.

17.2.1.3 Significant Plant Communities

A population of pictureleaf wintergreen (*Pyrola picta*), an imperiled plant in Colorado, was found on Platt Rogers Memorial Park Open Space about 0.25 miles upslope from Castle Rock, a popular climbing area located within the State Highway 119 right-of-way. Pictureleaf wintergreen is found on moist, cool, north-facing slopes under confers between 7,100 and 9,800 feet.

A rare plant study conducted in Lost Gulch for the city of Boulder Open Space and Mountain Parks indicated that the riparian corridors contain much of the rare flora of the area and many other species of interest (Nelson 1998). Lost Gulch is located about .5 mile east of the pipeline as it travels north from Kossler Reservoir and returns to Middle Boulder Creek. Riparian areas in general are considered by Hogan (1993) to be the richest vegetation type in the city of Boulder Mountain Parks both floristically and ecologically. Specific species found in Lost Gulch are discussed in Section 17.2.3.

17.2.2 Wildlife

The montane lifezone through which the pipeline passes contains important wildlife habitat. The mixture of forest types provides good habitat diversity. Common carnivores include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and long-tailed weasel (*Mustela frenata*). Black bear (*Ursus americanus*), mountain lion (*Felis concolor*), and bobcat (*Felis rufus*) may occasionally be seen. Elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) are fairly common. The pipeline traverses habitat considered by the Colorado Division of Wildlife to be elk overall range, winter range, severe winter range, and winter concentration area. The Winiger Ridge area is considered a key winter range for two herds of elk discussed in Section 17.1.2.2. Based on the Magnolia Area Breeding Bird Survey (PUMA 2000), the list of potential breeding birds near the pipeline includes several Boulder County Avian Species of Special such as sharp-shinned hawk, Cooper's hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentilis*), golden eagle (*Aquila chrysaetos*), three-toed woodpecker (*Picoides tridactylus*), olive-sided flycatcher (*Contopus borealis*), pygmy nuthatch (*Sitta pygmaea*), golden-crowned kinglet (*Regulus satrapa*), veery (*Catharus fuscescens*), fox sparrow (*Passerella iliaca*), and evening grosbeak (*Coccothraustes vespertinus*) (PUMA 2000).

17.2.3 Threatened, Endangered, and Rare Species

The northern goshawk (*Accipiter gentilis*) is a USFS sensitive species with suitable habitat in the area of the pipeline. In Colorado, goshawks occur in mature stands of aspen, lodgepole pine, and spruce-fir forests at elevations ranging 7,500 to 11,000 feet (USFS 1997). Nests are usually in dense coniferous forest, often on north- or east-facing slopes (Shuster 1980). Northern goshawks show a high fidelity to a specific nesting territory, although alternate nest sites within a nesting territory may be used from year to year (Herron et al. 1985). Nesting goshawks were observed in mixed coniferous forest in Boulder Canyon near Castle Rock during summer 1996 (Hallock, pers. comm.)

According to Nelson (1998), Lost Gulch, an area just east of the pipeline as it descends back into Middle Boulder Creek, contains an exceptionally high species richness, representing over half of the flora known from the city of Boulder Mountain Parks. Four of the species documented in Lost Gulch are listed as rare or imperiled species by the Colorado Natural Heritage Program. These species include grass fern (*Asplenium septentrionale*) (G3G4/S3S4), broadlipped twayblade (*Listera convallarioides*)(G5/S2), pictureleaf wintergreen (*Pyrola picta*) (G4G5/S2), and Weatherby's spikemoss (*Selaginella weatherbiana*) (G3G4/S3S4). These rare species were found most commonly along streams in the Lost Gulch area. Weatherby's spikemoss and grass fern were documented in upland areas typically on steep north-facing rock outcrops and cliffs.

17.3 Kossler Reservoir

17.3.1 Vegetation

Ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) interspersed with open meadows and aspen groves characterize the vegetation of Kossler Reservoir and its watershed. Small streams dissect the hills before joining South Boulder Creek. Upland areas in the watershed are dominated by ponderosa pine woodlands on south-facing slopes, lower montane coniferous forest on north-facing slopes, aspen forests in moist intermittent drainages. Mixed grassland, riparian and wetland communities also are present.

Ponderosa pine and Rocky Mountain juniper (*Juniperus scopulorum*) are the dominant woodland trees; commonly associated species include mountain mahogany (*Cercocarpus montanus*), currant (*Ribes cereum*), kinnikinnick (*Arctostaphylos uva-ursi*), western wheatgrass (*Agropyron smithii*), pine dropseed (*Blepharoneuron tricholepis*), blue grama (*Bouteloua gracilis*), and prairie Junegrass (*Koeleria cristata*). Douglas-fir is the common tree on north-facing slopes supporting a very sparse understory.

Grasslands present are an association of montane grassland and introduced species. Dominant grass species include little bluestem (*Andropogon scoparius*), blue grama, side-oats grama (*Bouteloua curtipendula*), needle-and-thread grass (*Stipa comata*), pine dropseed, prairie Junegrass, western wheatgrass, purple three-awn (*Aristida longiseta*), and smooth brome (*Bromus inermis*). Riparian and wetland communities are limited but are found along tributary drainages to South and Middle Boulder Creeks.

17.3.2 Wildlife

A diversity of animals and birds including coyote, deer, black bear, mountain lion, and wild turkey frequent the area around Kossler Reservoir. Elk herds, described in Section 17.1.2.2, migrate to the area from higher elevations in the winter. Common bird species in the area include tree swallow, violet-green swallow, barn swallow, Steller's jay, black-billed magpie, American crow, common raven, black-capped chickadee, gray-headed junco, mountain chickadee, red-breasted nuthatch, and white-breasted nuthatch.

17.3.3 Threatened, Endangered Species, and Rare Species

Lost Gulch, an area about 1 mile northeast of Kossler Reservoir, contains four plant species listed as rare or imperiled species by the Colorado Natural Heritage Program. Grass fern (*Asplenium septentrionale*), broadlipped twayblade (*Listera convallarioides*) pictureleaf wintergreen (*Pyrola picta*), and Weatherby's spikemoss (*Selaginella weatherbiana)* are discussed in Section 17.2.3.

17.4 Riparian Corridor Downstream from Barker Dam

17.4.1 Vegetation

Most of the area at the base of Barker Dam is dominated by smooth brome (*Bromus inermis*) and other pasture grasses, with scattered lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa),* narrowleaf cottonwood (*Populus angustifolia*), and aspen (*Populus tremuloides)*. Along the river corridor, Douglas-fir (*Pseudotsuga menziesii*) is the common tree on north-facing slopes supporting a very sparse understory. Typically, riparian communities downstream from Barker Dam are dominated by plains and narrowleaf cottonwood, mountain maple (*Acer glabrum*), chokecherry (*Prunus virginiana*), American plum and currant (*Ribes cereum*). Wetland communities are characterized by a number of shrubby willow species (*Salix* spp.), Baltic rush (*Juncus arcticus*), and beaked sedge (*Carex utriculata*).

17.4.1.1 Riparian Communities

The riparian communities along Middle Boulder Creek include montane riparian shrublands and forests. Montane riparian shrublands are found along Middle Boulder Creek on Reynolds Ranch and Platt Rogers Memorial Park, both Boulder County open space properties. Common species generally include alder (*Alnus incana*), river birch (*Betula fontinalis*), and willow (*Salix* spp.). Other species present are narrowleaf cottonwood, aspen, Engelmann spruce, and blue spruce. The montane riparian forest along Middle Boulder Creek is a community dominated by narrowleaf cottonwood, aspen, Engelmann spruce, and blue spruce (*Picea pungens*). Douglas-fir, lodgepole pine, and ponderosa pine are also present throughout this community along the river corridor. The shrub layer of this community includes willow species (*Salix* spp.), mountain maple, chokecherry, ninebark, and waxflower. The riparian communities along Middle Boulder Creek are considered significant by Boulder County, which also notes the importance of these communities for flood control, shoreline anchoring, sediment trapping, nutrient retention and removal, ground water recharge and discharge, food chain support, and wildlife habitat (BCPOS 1999). Much of the forested riparian community below Barker Reservoir is absent along the north side of Middle Boulder Creek due to the presence of Highway 119.

17.4.1.2 Wetlands

Wetlands occur along the Middle Boulder Creek channel and are supported by the creek and its alluvial aquifer. These wetlands occur as narrow fringes along the bank of the creek and are dominated by mountain willow (*Salix monticola*) with some scattered narrow-leaved cottonwood. In the understory, species such as redtop (*Agrostis gigantea*), Baltic rush (*Juncus arcticus*), and beaked sedge (*Carex utriculata*) are dominant.

An isolated wetland supported by a ground water seep is located on a rocky slope between the Barker Reservoir Dam and the spillway channel. This wetland is dominated by Drummond's willow (*Salix drummondiana*), alder (*Alnus incana*), birch (*Betula occidentalis*), redtop, beaked sedge, and Baltic rush.

Wetlands in the Boulder Creek floodplain have been mapped in the portion of the floodplain below siphon 6 (ERO 2001b). These wetlands are supplied by surface water from Boulder Creek and two small tributaries, and by ground water associated with Boulder Creek. Wetlands on the Boulder Creek floodplain below siphon 6 are dominated by alder (*Alnus tenuifolia*), cow parsnip (*Heracleum lanatum*), bluejoint reedgrass (*Calamagrostis canadensis*), Booth's willow (*Salix boothii*), plains cottonwood (*Populus deltoides*), and clustered field sedge (*Carex praegracilis*).

17.4.2 Wildlife Resources

The riparian and wetland habitats along Middle Boulder Creek are important areas for wildlife. Common carnivores along Middle Boulder Creek include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and long-tailed weasel (*Mustela frenata*). Mountain lion (*Felis concolor*), bobcat (*Felis rufus*), and black bear (*Ursus americanus*) may occasionally be seen along the creek below Barker Reservoir. Several common ground dwelling rodents include least chipmunk (*Eutamias minimus*), golden-mantled ground squirrel (*Spermophilus lateralis*), and deer mouse (*Peromuscus maniculatus*). Chickarees (*Tamiasciurus hudsonicus*) are often seen and Aberts squirrel (*Sciurus aberti*) may be present in habitat containing mature stands of ponderosa pine. Some of the more common species of birds along Middle Boulder Creek are generalists that use the resources of several habitat types. These species include American robin (*Turdus migratorius*), mountain chickadee (*Parus gambeli*), common flicker (*Colaptes auratus*), gray-headed junco (*Junco hyemalis*), and pine siskin (*Carduelis pinus*). The riparian areas along Middle Boulder Creek provide habitat for a number of neo-tropical migrants such as veery (*Catharus fuscescens*), fox sparrow (*Passerella iliaca*), song sparrow (*Melospiza melodia*), and Wilson's warbler (*Wilsonia citrina*).

17.4.3 Aquatic Resources

17.4.3.1 Fisheries

Middle Boulder Creek provides habitat for rainbow, brown, and book trout. Although diversion of water into the Barker pipeline reduces streamflow in Middle Boulder Creek below Barker Reservoir, healthy trout populations are present. In 1998, CDOW sampling on Middle Boulder Creek below Barker Reservoir resulted in population estimates of about 365 rainbow trout, 580 brook trout, and 25 brown trout per acre (CDOW 1998). CDOW sampling on Middle Boulder Creek about 2.5 miles above the confluence with North Boulder Creek indicated rainbow trout densities of 90 per acre and brook trout densities of about 135 per acre. Trout production in Boulder Creek within the city limits in January to March 2000 indicates trout densities of 1,000 per acre (Hazelton and McGrath 2000).

17.4.3.2 Macroinvertebrates

Benthic macroinvertebrate habitat and populations in lower Middle Boulder Creek and Main Boulder Creek are influenced by the presence and operation of Barker Reservoir. Research suggests a lack of macroinvertebrate diversity just below Barker Dam due to an increase in temperature and low levels of dissolved oxygen in the water. Benthic macroinvertebrate species richness was highest at a site above the Town of Nederland, lowest just below Barker Dam, and showed signs of recovery downstream (Wicken et al. 1998). The historical pattern of peak power releases (up to 125 cfs) in the winter could potentially affect downstream macroinvertebrate populations in Boulder Creek, but quantitative analysis is needed to evaluate possible impacts.

17.4.4 Threatened, Endangered, and Rare Species

As discussed in section 17.2.3 northern goshawks a USFS sensitive species may forage in riparian habitat along Middle and Main Boulder Creek. There are no known federally listed species of concern in riparian habitat below Barker Reservoir.

17.5 Conclusions, Key Ecological Issues, and Recommendations

17.5.1 Vegetation

The three most common conifer communities are ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). Lodgepole pine is most common in the western half of the Barker Reservoir watershed; ponderosa pine and Douglas-fir are most common in the eastern half below Barker Dam. All of these forested communities have been significantly altered by human activities including logging, residential and recreational development, and especially fire suppression.

Lodgepole pine is a fire-dependent species that is subject to infrequent, high intensity fires. Lodgepole pine at higher elevations in the watershed generally replaces itself after fires and can form stable, persistent communities. Ponderosa pine forests are both fire-adapted and fire-dependent. This community type requires fire to maintain optimum stand structure, especially for regeneration. In the absence of fire, Douglas-fir, which is shade tolerant, is slowly invading areas that were ponderosa pine woodlands. Fire suppression has resulted in dense forest stands with an abundance of ladder fuels or multiple canopy layers.
In the ponderosa pine and Douglas-fir communities, forest conditions are conducive to larger and more intense wildfires than typical under natural processes. These wildfires have the potential of becoming catastrophic, and substantially impacting the vegetation cover, forest soils, and subsequently water quality.

Middle Boulder Creek has a perennial flow augmented by its main tributaries, seeps, springs, and ephemeral side tributaries. This mosaic of riparian and wetland habitats creates a botanically rich area throughout the watershed. The watershed contains several populations of Colorado Natural Heritage Program rare and imperiled species and other species uncommon to the region that should be protected. In an arid setting like the Front Range, these riparian areas and wetlands naturally attract a multitude of animal species, many of which are dependent upon these habitats for all or part of their life cycles. Riparian areas, even naturally patchy ones, can form corridors that link many different habitat types and wildlife populations along the drainage gradient they occupy. As productive as they may be, riparian areas make up only a small part of the total land area (less than 3 percent) in Colorado, yet they house 40 percent of all the known plant species in the State and provide habitat for nearly 80 percent of the wildlife species that live in and migrate through Colorado (Kittel et al. 1999).

The factors that allow riparian areas to be so productive and attractive to wildlife have contributed to their undoing in the watershed. Diversion or water control structures generally change the timing of wet and dry periods, degrade stream systems and, in some cases, eliminate riparian vegetation. Development of buildings, roads, railbeds, recreation trails, and cultivated fields in the floodplain usually results in the complete site-specific loss of riparian vegetation and the modification of stream channels and banks.

17.5.2 Wildlife Resources

Wildlife with large ranges have been adversely affected by disruption and fragmentation of hunting/feeding areas, migration routes, and movement corridors by human activities, roads, and development. Human use in the watershed has fragmented desirable habitat, further reducing the likelihood that wide ranging species sensitive to human use will use the available habitat within the watershed.

Recognition of wildlife habitats of special interest such as severe winter range for elk (*Cervus elaphus*), riparian areas for neo-tropical migrants, or montane willow carrs for breeding birds should not diminish the value of wildlife throughout the watershed. Habitats of special interest and the species that depend on them only highlight some of the unique characteristics found in the Middle Boulder Creek watershed. Maintaining large areas of unfragmented effective habitat for species (e.g., mountain lion, black bear, elk, northern goshawk) with large territories or that may be sensitive to humans is important for overall ecosystem function and condition.

17.5.3 Aquatic Resources

Barker Reservoir and Middle Boulder Creek below the dam are altered environments that affect macroinvertebrate diversity and populations of native and introduced fish species. Stream flow releases below Barker Dam and hydropower operations are operational parameters that, if modified, may affect habitat for aquatic resources. Designated flows for fish typically fall somewhere between "bare survival" and "optimum" flows (Gillilan and Brown 1997). "Bare survival" flows are those that are thought to allow short-term survival of a small population, whereas "optimum" flows include occasional habitat-maintenance flows. Natural hydrologic variability, particularly the existence of occasional high flows, is important to maintain fish habitat.

17.5.4 Threatened, Endangered and Rare Species

Federal and state listed threatened and endangered species with suitable habitat in the Barker Reservoir watershed include lynx, wolverine, boreal toad, and greenback cutthroat trout. In addition, several state rare plant species are present in the watershed.

17.5.5 Habitat Preservation and Maintenance

It is recommended that a Habitat Preservation and Maintenance Plan be developed that includes the following considerations for the preservation and maintenance of habitat for wildlife, aquatic resources, and vegetation communities in the Middle Boulder Creek watershed:

- Large blocks of habitat should be maintained, fragmentation limited, and recreational use managed to benefit wildlife species with large territories (e.g., northern goshawk, mountain lion, and black bear).
- Wetlands and riparian areas are significant habitat that should be maintained and enhanced when appropriate.
- Recreational use should be directed away from significant resources such as wetlands, riparian areas, ravine forests, old growth forests, and areas containing sensitive plant species.
- Land closures to protect wildlife should be used where and when appropriate.
- Restoration of damaged habitat, particularly near streams, should be considered to protect natural resources including water quality.
- Prescribed fire should be applied judiciously to reduce the potential for catastrophic wildlife.
- Activities in or near significant natural resources should be carried out using best management practices.
- Research and monitoring should focus on the status of known northern goshawk nests in the watershed, along Middle Boulder Creek and near the pipeline.
- Forest management should perpetuate large-diameter trees and snags throughout the forests.
- Aquatic ecosystems, fisheries, and associated wetlands and riparian areas should be managed for the protection of their natural integrity.
- Minimum instream flows below Barker Dam should be established and maintained to provide adequate habitat for aquatic species.
- Establishment of minimum instream flows should include natural hydrologic variability, particularly the existence of occasional high flows.

17.6 Summary Recommendations

Recommendations pertaining to natural resources can be broadly summarized as follows:

- Protect healthy ecosystems.
- Restore degraded ecosystems as reasonable.
- Provide minimum instream flows in Middle Boulder Creek below Barker Dam in cooperation with the Colorado Water Conservation Board.

Additional recommendations and more detailed recommendations are presented in Section 17.5 and Section 19.

17.7 Existing Source Material of Special Relevance to Natural Resources

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18 Operational Issues

18.1 Introduction

This section covers operational issues related to the Barker system as a part of Boulder's water supply system and as a hydropower generation facility. Boulder's purchase of the Barker system can enhance the reliability and water quality of the city's water supply. It has also created opportunities to address instream flow and recreational issues. These opportunities must be considered in light of operating constraints and potentially conflicting goals.

In discussing the operational issues for each component of the Barker system, it is important to understand the interdependencies of the facilities on each other, and on operational choices made at other facilities in Boulder's water supply system. For example, modifications to the timing of Barker deliveries to Betasso cannot be proposed without considering Betasso operating requirements and treatment capacity, North Boulder Creek system operating requirements and capacities, Boulder Reservoir WTP capacity, and the city's total demand.

Some operating goals may conflict with each other. For example, operating the additional 3,300 AF of Barker capacity as a drought reserve pool would require the city to continue its winter operation of the Boulder Reservoir WTP, with its increased operating costs and water quality considerations.

18.2 Historical Operations

The historical operations of the Barker system are well documented in a variety of reports and data sources. Of particular value is PSCo's entire collection of Barker Reservoir-related documents, which is currently being inventoried by Hydrosphere.

From the time of its construction until the mid-1950's, the Barker System was used exclusively to generate hydropower. The system operated under two water rights: a 1905 priority 50 cfs direct flow right for the Barker Gravity Pipeline (the Boulder Power Pipeline) and a 1906 priority 11,687 AF storage right for Barker Reservoir. PSCo's operating rules were relatively straightforward: (1) divert inflow into the Gravity Pipeline up to its 50 cfs capacity, (2) store excess inflow in Barker Reservoir when its storage rights were in priority, and (3) release stored water to fill the Gravity Pipeline when inflows fell below 50 cfs. Barker Reservoir typically stored water during April and May. During June through August, Barker Reservoir usually remained full, as inflows were typically sufficient to fill the Gravity Pipeline. During September through March, Barker Reservoir released stored water to supplement inflows and keep the Gravity Pipeline as full as possible.

PSCo had the ability to run the Boulder Canyon Hydro Plant either on a constant low-level generation basis or as a peaking facility by generating at higher levels for a portion of each day when power demands peak. The project has options to operate in either manner because Kossler reservoir can store water coming in from the Barker Gravity Pipeline for a portion of the day to provide sufficient peaking flow to the power plant's penstock, which has a larger flow capacity than the Barker Gravity Pipeline.

During April through October, PSCo generated hydropower on a continuous run-of-river basis only. The State Engineer prohibited peaking operations during this period because resulting stream flow fluctuations interfered with administration of downstream senior water rights. During the non-irrigation season (November through March), PSCo fluctuated the volume of Kossler Reservoir in order to produce flows of up to 150 cfs through the Boulder Canyon Hydro Plant for peak hydropower generation, typically during evening hours.

Under agreements with PSCo, Boulder began using Middle Boulder Creek and the Barker system as a municipal water source during the drought of 1954 – 1957, when the city had trouble meeting its water demands. Boulder obtained its own water rights for storing water in Barker and diverting water through the Gravity Pipeline for municipal purposes. Boulder began leasing space in Barker and using municipal water from the system in 1955. In 1963, Boulder completed a pipeline from the Boulder Canyon Hydro plant to Boulder's newly constructed Betasso WTP. By the mid-1970's, Boulder controlled 8,000 af of storage space in Barker Reservoir and had the right to use the Gravity Pipeline for municipal water supply in preference to PSCo's ability to generate hydropower. These improvements provided the city with needed additional water as well as some redundancy to the North Boulder Creek system.

Boulder attempts to maximize its use of direct flow and direct exchange rights through the Gravity Pipeline, taking water out of storage only when the yields of Boulder's direct flow rights are insufficient to meet demands. During May and June, as water became available under Boulder's storage and exchange rights, Boulder typically filled its upper portion of Barker Reservoir after PSCo had finished filling its lower portion. Following Boulder's purchase of the Barker system, the city no longer has to wait for PSCo to finish filling its storage space before the city can store water. Boulder can simultaneously divert water directly into the Gravity Pipeline using its direct flow and exchange rights. After filling as much of Barker Reservoir storage space as possible, the city continues to divert water directly to Betasso via direct flow and exchange as far into the summer as possible. By late July, the city's exchange right is usually called out and Boulder begins releasing water from storage in Barker Reservoir to supplement direct flow diversions under senior rights as needed to meet the city's water demands. Typically in August and September, municipal storage releases only occur from Barker Reservoir, and not the Silver Lake watershed, because the Lakewood Pipeline is usually running at capacity delivering water from the city's direct flow rights on North Boulder Creek.

18.3 Operation of Barker Reservoir

18.3.1 Introduction

There are physical, legal, and institutional considerations that guide and limit choices for operating Barker Reservoir. The sections that follow delineate factors that constrain operations at Barker Reservoir, Barker Gravity Pipeline, and Kossler Reservoir; that permit operational flexibility; and that have primary or secondary impacts to recreation or the environment.

18.3.2 Operational Restrictions

18.3.2.1 Overview

The primary factors that will constrain Barker Reservoir's future operation include:

- Stream flows, particularly spring runoff patterns
- Water rights and water right administration practices
- Boulder's municipal water demands
- Interactions with other water supply system components
- Extent of storage releases needed during the summer
- Daily adjustments to optimize water reliability
- Minimum flows required to prevent pipe freezing
- Barker spillway and outlet works characteristics
- Instream flow requirements

Each of these factors is discussed in the sections below.

18.3.2.2 Runoff Patterns

Most of the stream flow in the Boulder Creek watershed, including Middle Boulder Creek, occurs during May through July. The rate and volume of stream flows determine whether Barker Reservoir can fill in a given year. Barker's storage rights are relatively junior, and are normally in priority only during high flow periods when there is sufficient water to satisfy downstream senior water rights.

Just as important as total runoff volume is the duration and magnitude of runoff, which is influenced by temperature conditions during the snowmelt. Runoff occurring at high rates over a short period more easily eliminates downstream calls, and makes it easier for Boulder to fill Barker under it's junior municipal storage rights. An equal volume of runoff occurring at lower flow rates over a longer period may not satisfy downstream calls. Under this scenario, Boulder may not be able to exercise its municipal storage rights, but may instead be able to exchange water into storage in Barker (see Section 18.3.2.3 for an explanation of the exchange process).

Stream flows into Barker vary considerably, both seasonally and annually. In winter, flows into Barker Reservoir may range from 3 – 5 cfs, and in springtime, 300 – 500 cfs. In very dry years stream flows may not be sufficient to allow Barker to fill completely, even with Boulder's exchange rights.

Because of the unpredictable and highly variable nature of stream flows, exercising Boulder's exchange rights to fill Barker often becomes a game of chance and timing. In years with average to slightly above average snow pack, the odds of Barker filling under its own storage rights are uncertain, so Boulder usually begins exchanging water into Barker during the early part of runoff. On more than one occasion, the ensuing runoff turned out to be sufficient to have allowed Barker to fill under Boulder's junior storage rights. However, since the system cannot be operated using hindsight, it must be operated based on conservative assumptions about how much water may eventually become available.

18.3.2.3 Water Rights

Water rights define how much water can be stored in Barker and for what purposes. Water rights in conjunction with stream flows determine when Barker can fill and when releases from Barker will be needed for municipal water supply purposes or to meet downstream calls.

With its purchase of the Barker system, Boulder owns all of the water rights associated with the Barker system that are listed in Table 8.2. Boulder owns both hydropower and municipal storage rights for Barker Reservoir. Boulder is free to store water in Barker under either set of storage rights, but water stored under Barker's hydropower storage rights can only be used to generate hydropower at the Boulder Canyon Hydro Plant. Conversely, water stored under Barker's municipal storage rights can only be used for municipal purposes within Boulder's water supply service area and hydropower generation within the municipal water delivery system.

Barker's municipal storage rights are junior to nearly all downstream rights and are normally in priority only during May and June of above-average runoff years. In dry years, downstream senior water rights may call for water year round, preventing Boulder from storing any water in Barker under Boulder's municipal storage rights. If possible in such situations, Boulder uses its exchange rights to store water in Barker.

Barker's hydropower storage rights are relatively more senior than Boulder's municipal rights, and are normally in priority during April through June and frequently during the winter.

Because the South Platte basin is administered on a unified basis according to the prior appropriation doctrine, all downstream senior water rights exert a combined effect on Barker Reservoir. Generally, speaking, there is usually an irrigation call in effect that is senior to all of Barker's storage rights from July through October, and a storage call in effect that is senior to Barker's municipal storage rights during November, March and April. While there is often no call on Barker Reservoir during December through February, PSCo's historical use of the Barker Gravity Pipeline has prevented Barker from filling during these months. While Boulder's ownership of Barker Reservoir and Boulder Canyon Hydroelectric Powerplant will result in municipal water supply having precedence over hydropower, it is unlikely that Barker Reservoir will store much water in the winter because any inflows divertible under Boulder's municipal rights will most often be diverted to meet immediate demands, unless the Barker Gravity Pipeline is out of service.

Boulder's exchange rights allow Boulder to store water in Barker or divert water directly into the Barker Gravity Pipeline even when there is a senior call in effect. Boulder exercises these exchange rights by making releases of water it controls from Boulder Reservoir or Baseline Reservoir and simultaneously diverting water into Barker Reservoir or the Barker Gravity Pipeline at the same rate. This operation results in no change in stream flow below Boulder's downstream release point. However, there are limits to Boulder's operation of its exchange rights. All intervening senior water rights between Barker Reservoir and Boulder's downstream release point must not be injured as a result of the exchange. It is also possible for Boulder to exchange against calls by the Boulder and White Ditch and Boulder and Left Hand ditches, which can be supplied from points where they cross the Boulder Creek Supply Canal.

18.3.2.4 Boulder's Municipal Water Demand

Boulder's municipal water demand represents another operational constraint on Barker: it defines when reservoir releases occur. The avenue of reservoir storage is essential to meeting Boulder's water demands. Boulder's water demand usually exceeds the combined yield of Boulder's direct diversions during mid-July through April. Therefore, during the majority of the year, direct diversions are supplemented with releases of stored water in order to satisfy municipal water needs. The city is able to meet all of its water needs using direct flow diversions during what is referred to as the direct flow season, typically from May to mid-July.

18.3.2.5 Interactions with Other Water Supply System Components

Barker's operation will be constrained by its interactions with other components of Boulder's water supply system. These interactions result in three constraints of particular importance:

- required storage releases during July through September,
- daily adjustments to storage releases, and
- continuous winter season draw-downs.

18.3.2.5.1 Required Storage Releases from July to September

While storage water can usually be released from any of Boulder's water supply reservoirs to help meet demands, during July through mid-September all storage releases almost always come from Barker Reservoir because of capacity limitations at the Lakewood Pipeline and the Boulder Reservoir WTP. During these months, Boulder's water demand usually runs between 25 and 45 MGD. At the same time, Boulder's senior direct flow rights can usually fill the Lakewood Pipeline to its current 15 MGD capacity and its soon to be restored 20 MGD capacity during this period. Boulder Reservoir WTP is normally operating at its normal 8.5 MGD or maximum 10.5 MGD capacity. The remaining water must come from the Barker Gravity Pipeline because there is no other raw water delivery capacity available. While Boulder's exchange right can sometimes be used to divert water into the Barker Gravity Pipeline in early July, the exchange usually goes out of priority after that time. From mid-July through mid-September the remaining water must usually come from Barker storage. By late September, Boulder's water demands have usually dropped enough to be met through the combined capacity of the Lakewood Pipeline and the Boulder Reservoir WTP.

18.3.2.5.2 Daily Adjustments to Storage Releases

In order to optimize the reliability of its water supply system, Boulder should maximize the use of its direct flow water rights and direct-use exchange rights. This requires that releases from Boulder's reservoirs be adjusted daily to compensate for fluctuations in direct flow yields and municipal water demands.

In the past, Boulder was unable to adjust its Barker releases in response to changes in direct-flow availability because of contractual limits with PSCo on the frequency of adjustments, advance notification requirements to PSCo operations staff, and delayed response times following notification. As a result, Boulder sometimes had to bypass water available to its senior direct flow water rights on North Boulder Creek at times when storage releases were being made from Barker. As the owner of the Barker system, Boulder will be able to improve the responsiveness of Barker storage release adjustments.

18.3.2.5.3 Continuous Winter Season Draw-Downs

The Barker Gravity Pipeline represents another constraint upon Barker operations. The Barker Gravity Pipeline may be susceptible to freezing problems in its siphons if the pipeline is operated in an intermittent fashion during the winter. Historically, the pipeline was operated continuously throughout the fall and winter season as part of PSCo's hydropower peaking operations. With the elimination of peaking operations, the Gravity Pipeline will be used during winter to divert inflows (either for delivery to Betasso or release to downstream senior water rights) and to deliver municipal water from Barker storage to Betasso. In order to avoid freezing problems, it may be necessary to maintain some level of continuous flow in the pipeline. Barker inflows may not provide a sufficient flow through the pipeline during the winter, given instream flow needs below Barker. Therefore, Barker may have to be continuously drawn down at some rate during the winter. The extent of the freezing problem and the flow rate needed to prevent it can be established as the city gains experience operating the Barker system.

18.3.2.6 Barker Spillway and Outlet Works Characteristics

The condition and adequacy of Barker's spillway and outlet works could present potential constraints to storage in the reservoir. Fortunately, Barker currently has no PMP/PMF storage constraints because of spillway/outlet works inadequacies. It is important that these facilities be maintained, and improved if needed, in order to maintain this desirable condition.

Barker's existing outlet gates require that the reservoir be completely drained every five years for inspection and maintenance. This condition represents a potentially severe constraint to the reliability of Barker Reservoir as a municipal water supply, particularly with respect to maintaining a drought reserve pool in Barker. A planned alternative to the existing outlet works is under development.

18.3.2.7 Instream Flow Requirements

Instream flow requirements on Middle Boulder Creek below Barker represent a future constraint on Barker's operations. Under PSCo's operation of the Barker system, there was basically no flow in Middle Boulder Creek below Barker from September through April of each year. Boulder has committed to providing year-round instream flows sufficient to adequately protect aquatic species in Middle Boulder Creek. Potential trade-offs exist between the amounts of instream flows provided and the water supply benefit Boulder derives from its purchase of the Barker system. Instream flow issues are discussed more fully in Section 18.4.

18.3.3 Operational Choices

18.3.3.1 Overview

Within the framework of constraints discussed above, there are several choices that can be made regarding Barker Reservoir storage and releases.

The Barker system is an integral part of Boulder's raw water delivery system. As such, the city needs to consider Barker operations within the system as a whole, taking into account factors such as water quantity and quality, hydrology, system reliability, and cost effectiveness. In addition, the city will need to determine how secondary objectives (for example, hydropower, instream flow, and recreation) will be considered when developing operating plans for Middle Boulder Creek. The city should probably do extensive cost-benefit and public values analyses when considering other uses.

18.3.3.2 Setting a Storage Accounting Year

Colorado's water rights administration rules require that every storage right operate on a fixed calendar year that is specific to that storage right. The purpose of a storage calendar year is to limit the storage right to one fill per year, after deducting for water already in storage under that right at the beginning of the calendar year. Ideally, the storage year begins when the water in storage reaches the minimum level for the year.

The existing storage years for Barker's hydropower and municipal storage rights begin on April 1st and May 23rd, respectively. Because Boulder's primary purpose for Barker Reservoir is municipal water supply, Boulder may want to advance the storage year for its municipal storage rights to an earlier date in the spring. This would allow Boulder to begin storing municipal water in Barker earlier in the spring, during the time when PSCo historically stored water for hydropower production. However, setting a starting date too early in the spring could reduce Barker's ability to fill.

Selection of the proper starting date will require additional analysis of historical hydrology, call conditions, Boulder's storage operations and municipal demand patterns. It may be beneficial to stagger the start dates, with the senior municipal storage right starting first. Because the senior water is pulled from storage first according to the state engineer's practices, it is unlikely that storage space would be filled with the previous year's senior diversion and therefore unavailable early in the year.

18.3.3.3 Storage under Hydropower vs. Municipal Rights

Boulder anticipates using Barker Reservoir primarily for municipal water supply purposes. However, there will be opportunities for synergistically storing water for hydropower production. There is usually space available in Barker from August through April as a result of Boulder's normal municipal water supply operations. During this period Boulder's ability to store municipal water in Barker is constrained by the demands of downstream senior water rights. However, there are often occasions during this period when Barker's hydropower storage right would be in priority, even when Barker's municipal rights would not be. In such situations, Boulder could store water in Barker for hydropower, so long as that stored water was subsequently used for hydropower generation through Boulder Canyon Hydro and was evacuated from Barker before the beginning of the ensuing municipal storage season.

Specific operating and accounting criteria will be needed to guide the city in the best use of the multiple storage rights associated with Barker Reservoir.

18.3.3.4 Reservoir Drawdown

18.3.3.4.1 Typical Operational Pattern

At present, the city keeps Barker as full as possible following capture of spring snowmelt runoff, preferring to maximize the use of its direct flow and exchange rights as late into summer as possible. Storage releases to the Betasso facility occur only when the Middle Boulder Creek direct diversions and exchanges are out of priority and the water supplies available at the Lakewood Pipeline and Boulder Reservoir WTP are insufficient to meet the city's total demand. This pattern of management provides security against future drought, as the water diverted under junior storage rights for Barker is used last (i.e., saved until last because it is the hardest space to fill). The water stored under the senior right is used first and so does not count against the next year's fill under the senior right. This general pattern of use by the city is not likely to change.

18.3.3.4.2 Requirements

As discussed previously, there are two conditions that would normally require storage releases from Barker at specific times. One condition usually occurs during July through mid-September when combined capacities of the Lakewood Pipeline and the Boulder Reservoir WTP are not enough to meet the city's municipal demand, and Middle Boulder Creek direct flows and exchanges are called out. The other condition occurs in the winter, when some small amount of storage release may be continuously required in order to maintain sufficient flow in the Barker Gravity Pipeline to prevent freezing.

There is also the system-wide need for storage drawdowns to help meet Boulder's municipal demand during low stream flow periods of the year. This function can be shared between Barker, Boulder's Silver Lake Watershed reservoirs and Boulder Reservoir during mid-September through April.

18.3.3.4.3 Potential Benefits of Maintaining a Minimum Reservoir Pool Elevation

From a water supply perspective, the primary benefit of a minimum pool in Barker would be as a drought reserve, to be accessed only under specified drought response conditions. However, the drought reserve function should be distributed among Boulder's three storage locations (Barker, the Silver Lake Watershed, and Boulder Reservoir), so that Boulder's combined raw water delivery capacity to its treatment plants is maximized during droughts. Major emphasis should be given to drought reserves in Barker and Boulder Reservoirs, however, because Boulder Reservoir has a long-term storage account and the Silver Lake watershed reservoirs have more senior storage rights than Barker.

A minimum pool in Barker could also facilitate treatment of water at Betasso during the early spring months when Barker is normally at its minimum contents. Historically, water delivered from Barker to Betasso during April and early May was often relatively high in turbidity due to the onset of runoff and the relative lack of dilution volume in Barker following PSCo's winter releases.

A minimum pool could also help sustain or enhance the reservoir fishery, and seasonal pool elevation targets would benefit potential late summer and fall recreation opportunities. However, any operating policies designed to support fishing or recreation on Barker must be carefully designed so as not to impair the operation of Boulder's water supply system.

18.3.3.5 Criteria for a Sustainable Fishery

The city of Boulder has previously conducted instream flow studies to quantify stream flow requirements downstream from Barker Dam. One study (Miller, 2000) indicates that a winter flow of 2 cfs and a summer flow of 4 cfs in Middle Boulder Creek are adequate to maintain a fishery. One criterion not met by these lower minimum flows is a velocity criterion recommended to keep trout streams well aerated for benthic invertebrate production and high oxygen levels required by trout (Miller, 2000); however, the Miller (2000) review suggests that the steep gradient and natural drops of Middle Boulder Creek provide additional aeration not accounted for by the velocity criterion as the water flows over and around rocks and cobbles.

18.3.3.6 Impacts on Drought Preparedness

Direct control over Barker Reservoir operations should significantly enhance the reliability of the city's supply system as a whole. Ownership of the entire reservoir provides the city with an additional 3,300 af of storage. Elimination of the competitive exercise of PSCo's hydropower rights will enable the city to more reliably fill Barker under its municipal rights and to divert Middle Boulder Creek water for municipal use during the winter season.

Ownership of Barker Reservoir has provided significant benefits during the drought of 2002. Since Boulder was able to fill the reservoir with water decreed for municipal use in 2001, the city entered 2002 with 3,300 acre-ft more than it would otherwise have had available. However, this fortuitous timing on reservoir fills can't be guaranteed prior to future severe drought years.

While Boulder's purchase of Barker will clearly increase the city's level of drought protection, realizing this benefit will require development of a system-wide drought plan that includes clearly defined drought recognition and response triggers, operating rules for all of Boulder's raw water facilities and associated demand management responses. As noted previously, operation of Boulder's water supply system to address non-water supply purposes (e.g., recreation, instream flow) may impact Boulder's drought protection, and should be formally evaluated in that context. Hydrosphere is currently developing a drought recognition and response plan for the city.

18.3.3.7 Impacts on Water Quality

Operational choices at Barker Reservoir can affect drinking water quality both at Betasso and system-wide. Delivery of more water from Barker during the winter could reduce the amount of lower-quality water delivered from the Boulder Reservoir WTP, although this practice would negate the increase in drought protection gained by the purchase. On the other hand, an increased drought protection pool in Barker would help with seasonal turbidity problems at Betasso.

In either case, there is increasing concern about water quality impacts of the Nederland wastewater treatment plant upon Barker Reservoir. The Nederland WWTP is by far the largest nutrient loading into Barker Reservoir and is a potential source of pathogens. Recent water quality studies indicate that water near the bottom of Barker Reservoir is nearly anoxic at times, due primarily to impacts of the WWTP. Potential solutions to this problem could include enhanced treatment processes at the WWTP, an increased minimum storage pool in Barker and routing the wastewater discharge into Middle Boulder Creek below Barker. This last option could help address instream flow issues below Barker Reservoir but could also create water quality problems due to increased nutrient loading on Middle Boulder Creek.

18.3.3.8 Impacts on Recreational Fishery

There are two potential changes in the operation of Barker Reservoir that will probably improve the recreational fishery in the reservoir. First, Boulder is planning to rebuild the reservoir's outlet works. This will probably eliminate the current requirement that the reservoir be completely drained every five years for outlet works inspection and maintenance purposes.

Second, if Boulder decides to maintain an increased minimum pool level in Barker for drought protection purposes, this would also provide a greater fishery conservation pool and would reduce the amount of seasonal storage fluctuation in the reservoir.

18.4 Instream Flows

18.4.1 Introduction

Boulder has committed to establishing a year-round instream flow regime in Middle Boulder Creek below Barker Reservoir. While there are several options for developing such a program, certain operational restrictions must be addressed.

18.4.2 Operational Restrictions

18.4.2.1 Applicable Colorado Water Law

An instream flow program for Middle Boulder Creek must be enacted in a manner consistent with Colorado water law. Under Colorado's water laws, water flowing in a stream cannot be legally protected against diversion unless an instream flow right exists for that stream segment and the right is in priority. The Colorado Water Conservation Board (CWCB) is the only entity that can file for or own an instream flow water right. Currently there are no competing water rights on Middle Boulder Creek that could divert water that Boulder bypasses or releases from Barker Reservoir. However, without an instream flow right in place on Middle Boulder Creek it is possible that water rights filings or changes in the future could allow diversion to occur from Middle Boulder Creek. Therefore, it is recommended that Boulder develop an instream flow plan with the involvement of the CWCB.

18.4.2.2 Protection of Boulder's Water Rights

Boulder's overriding interest in acquiring Barker Reservoir is to enhance the reliability of its municipal water supply and its raw water facilities. Boulder should balance its commitment to provide an instream flow for Middle Boulder Creek below Barker with its water supply system reliability criteria. Any instream flow program should be implemented in such a way that does not expose Boulder's municipal water rights to diminishment or jeopardize the city's ability to meet municipal water needs, including in times of drought or emergency.

18.4.2.3 CWCB

Under Colorado law, the Colorado Water Conservation Board (CWCB) is the only entity that can file for or own an instream flow water right for the purpose of protecting or enhancing the natural environment. The CWCB can also acquire water rights or interests in water to help meet the purposes of instream flow. The CWCB can enter into agency relationships with other entities, such as the city of Boulder, for administration of instream flow rights.

Boulder should therefore develop a plan with the CWCB to legally protect instream flows provided to Middle Boulder Creek. Under this plan the CWCB could appropriate a new instream flow right for Middle Boulder Creek below Barker Reservoir. Because the CWCB's instream flow right would be very junior, it would have water available for appropriation only during periods in May through August of most years, based on previous Hydrosphere studies. Boulder should therefore agree to donate additional water as needed to support a year round instream flow program with the majority of donated water to be made available during September through April.

18.4.2.4 Project Purpose

Instream flow is an important secondary project purpose, but during an extreme drought it may be necessary to curtail or discontinue instream flows in order to meet the primary project purpose of a reliable municipal water supply. Operational models and any agreement between CWCB and the city of Boulder should specify instream-flow release patterns during droughts.

18.4.3 Operational Choices

Under existing conditions, Middle Boulder Creek below Barker Reservoir usually has adequate stream flows from May through August. During the rest of the year, flows in this stream segment have historically been near zero. Boulder has operational choices regarding the amount of instream flow water to provide and the mechanism of delivery - either bypassing inflows or releasing water from Barker storage.

As discussed in the fishery studies mentioned above, the amount of instream flow water needed to protect aquatic habitat has been determined to be in the range of 2 to 4 cfs during November through March and from 4 to 9 cfs during April through October based on both R2Cross and IFIM habitat modeling.

Under the inflow bypass option, Boulder could enter into an agreement with the CWCB under which Boulder would agree to not divert water otherwise available to its 50 cfs 1905 priority direct flow hydropower right for the Boulder Canyon Hydro. This is the most senior direct flow right associated with the Barker system and it is always in priority whenever the Boulder Canyon Hydro is operational. Such an agreement not to divert would add water to the stream below Barker, where it could be protected from future diverters by a new CWCB instream flow right. However, the bypassed water would be available for diversion by other water rights below Orodell as it was historically. Such an agreement would require that Boulder continue operating the Boulder Canyon Hydro Plant.

Boulder's other choice would be to release water from Barker Reservoir that had been stored under Boulder's 1956 and 1966 Barker Reservoir municipal storage rights. Boulder has previously entered into an agreement with the CWCB allowing Boulder to make releases of this water at the city's discretion for use by the CWCB for instream flows in Boulder Creek below Orodell. These rights have previously been changed to include instream flow in Boulder Creek between Orodell and 75th Street as an alternate use. Water could be released from Barker Reservoir to be delivered through Middle Boulder Creek for instream flow in Boulder Creek. However, this alternative would not be as reliable as bypassing inflows because Boulder's municipal storage rights are not always in priority for storage every spring. Releasing municipal storage water for instream flow could also reduce the reliability of Boulder's water supply.

Irrespective of the method used to provide instream flows, Boulder should include a drought and emergency reservation clause in its instream flow agreement with the CWCB in order to protect Boulder's water supply reliability.

18.4.3.1 Status of Dedicated Instream Flows

The city of Boulder is currently working with the Colorado Water Conservation Board to donate water rights for instream flow purposes below Barker Dam. The city wants to ensure that these flows will be protected and adequate without neglecting the obligation to meet customer demand for a reliable water supply. The city anticipates protected releases for instream flows might be in place by 2003.

18.4.3.2 Operational Priorities

Boulder's first priority is to provide municipal water supply consistent with the city's reliability criteria, with instream flow provision as a second priority. This can be enacted through a drought reservation clause in the instream flow agreement. Boulder has included suitable drought reservation clauses in its previous instream flow donation agreements. The need for a drought reservation clause in any instream flow agreement has been demonstrated during the 2002 drought when Boulder found it necessary to partially curtail instream flows on North and Main Boulder Creeks in order to assure availability of sufficient municipal supplies. The instream flow curtailments were necessary even with implementation of mandatory water restrictions.

18.5 Barker Gravity Pipeline

18.5.1 Function

The Barker Gravity Pipeline delivers water from Barker Reservoir to Kossler Reservoir, where it is staged for delivery either to the Betasso WTP or through the penstocks of the Boulder Canyon Hydro plant.

18.5.2 Capacity

While the Barker Gravity Pipeline's original capacity was 50 cfs, leakage and obstructions have reduced its current delivery capacity to 43 cfs. Based on a comparison of diversion data at the head of the Barker Gravity Pipeline to deliveries at Betasso (Hydrosphere, 2001), the pipeline appears to leak at varying rates based on its flow rate. On average, losses are about 10% of the flow at the headgate (see Section 18.3).

18.5.3 Water Rights

The Gravity Pipeline has two water rights that were originally decreed for diversion at the pipeline intake: a 50 cfs year-round hydropower right appropriated in 1905 and a 50 cfs year-round municipal right appropriated in 1956. The Gravity Pipeline is also an alternate point of diversion or exchange destination for 12 other municipal rights and two conditional municipal rights. The water rights associated with the Gravity Pipeline are listed in Table 8.2.

18.5.4 Winter Operations

Historically the Gravity Pipeline flowed continuously throughout the winter as part of PSCo's hydropower peaking operations. Boulder's municipal use of the Gravity Pipeline has been sporadic during the winter because Boulder usually used its North Boulder Creek supplies more extensively in the winter. Boulder no longer has PSCo's hydropower "baseflows" upon which to piggy-back its municipal deliveries, and so Boulder must carefully evaluate the freezing hazards in the Pipeline. Low or zero flows may result in freezing of the Pipeline, particularly across the numerous siphons, where the pipeline is above ground. Boulder should plan on continuous operation of the Pipeline at a flow sufficient to prevent freezing. This will require some drawdown of Barker during the winter.

18.5.4.1 Peaking

Historically, PSCo ran peaking power through the Boulder Canyon Hydro plant from November through early April, primarily using water released from its portion of Barker storage, along with Barker inflows, to supply the peaking operations. PSCo ran a steady flow through the Gravity Pipeline and fluctuated the volume of Kossler Reservoir in order to produce flows of up to 150 cfs through the Boulder Canyon Hydro Plant for peak hydropower generation, typically during evening hours in the winter. While these peaking flows produced valuable hydropower, they also caused significant impacts to aquatic ecosystems in Boulder Creek.

One of Boulder's main reasons for purchasing the Barker system was to use PSCo's portion of Barker storage for municipal water supply purposes. Therefore, most of the supply for peaking operations at Boulder Canyon Hydro will no longer be available. The remaining supply - winter season Barker inflows - will now be subject to instream flow bypass requirements and municipal diversion by Boulder. As a result there will no longer be water supply for any significant level of peaking operation.

18.5.4.2 Run-of-River

Any remaining inflow over and above instream flow requirements and Boulder's municipal diversions can be used for run-of-river hydropower operations, provided the remaining inflows are sufficient to operate the turbines, which require a minimum flow of 3 cfs. If remaining inflows fall below this level, they could either be bypassed or stored in Barker or Kossler for future hydropower releases.

18.5.4.3 Freezing

As discussed above, the Gravity Pipeline may be prone to freezing damage if it is not operated continuously at some minimum flow rate during the winter. Boulder should devise its operating plans for Barker to take this requirement into account. Such a requirement should be evaluated for its impact on Barker drought protection and Boulder's water supply reliability in general. A ruptured pipeline resulting from a freezing episode could seriously restrict the city's ability to meet demand.

18.5.4.4 Ice Climbing

With the city's ongoing repairs to the Gravity pipeline to eliminate leaks, it is possible that the ice climbing opportunities in Boulder Canyon will be diminished or disappear altogether. In addition to the loss of yield resulting from gravity pipeline leakage, there is the issue of liability that may result if the city were to actively endorse the ice climbing resource (see Section 12.3).

18.5.5 Summer Operations

There are no significant impediments to summer operation of the Gravity Pipeline, and run-of-river hydropower production should continue, subject to Boulder's use of the Gravity Pipeline to supply Betasso. The city will enjoy more efficient operations of their Middle Boulder Creek rights and facilities since it will now directly control Barker operations. The previous protocol for releasing Barker water or changing direct flow diversions required advance notice to PSCo and were contractually limited to two flow rate changes per day.

18.6 Kossler Reservoir

18.6.1 Capacity

The active capacity of Kossler Reservoir is approximately 120 acre-feet. At full capacity (150 cfs), the Boulder Canyon Hydro penstocks can empty Kossler Reservoir in about 9.7 hours. At full capacity (currently estimated to be 43 cfs), the Barker Gravity Pipeline can fill Kossler Reservoir in about 34 hours (see Section 18.5). There is not presently a way to discharge water from Kossler through the penstock to Boulder Creek when Boulder Canyon Hydro is not running. There may be occasions when flows out of Kossler are needed to prevent Kossler Reservoir from spilling when Boulder Canyon Hydro is not operational and no Barker deliveries are needed to Betasso WTP. Installation of a pressure release valve and possibly a second small hydro at Boulder Canyon would provide a means to reduce pressure and allow discharges to the creek from Kossler when the existing hydro is out of service.

18.6.2 Winter Operations

There are no known operational issues associated with running Kossler in winter. The inlet and outlet works are deep in the lake, so icing should not be an issue if the lake is kept at normal (historic) storage levels.

18.6.2.1 Peaking

Since the city will be eliminating peaking power production at the Hydro plant, Kossler Reservoir surface elevations will stabilize during the winter.

18.6.2.2 Run-of-River

Run-of-river hydropower operations during the winter will occur at very low flow rates and are not expected to significantly affect Kossler Reservoir water levels.

18.6.3 Summer Operations

We do not anticipate any significant changes that will impact summer operation of Kossler Reservoir.

18.6.4 Impacts on water quality

PSCo's historical operations resulted in very short residence times in Kossler. Boulder's future operation of the Barker system may significantly increase the residence time in Kossler during the fall and winter. This could negatively impact water quality and aquatic life in the reservoir by reducing dissolved oxygen levels. This is another reason why a winter season minimum flow through the Gravity Pipeline would be desirable.

18.7 Recommendations

Recommendations pertaining to operational issues and operational decision support can be broadly summarized as follows:

- Maximize use of direct flow water rights and direct use exchange rights.
- Develop a system based operations plan based on water quality, system reliability, cost, risk, and secondary project objectives like instream flow and recreation.
- Develop a multi-system based operations plan for drought management.
- Legally protect instream flows through agreements with the CWCB.
- Develop short-term and long-term decision support models.
- Develop and test a Betasso Water Treatment Plant Notification Plan.

Additional recommendations and more detailed recommendations are presented in Section 19.

19 Recommendations

19.1 Introduction

The Management Work Plan recommendations are organized under eight topics: Operations, Operational Decision Support, Water Quality, Recreation, Environment and Land Management, History and Culture, Safety and Security, and Community Education and Facilities Enhancement. Several recommendations overlap across topics. Those recommendations have been categorized according to their primary focus.

The recommendations are <u>not</u> listed in order of priority. Factors that should be considered when developing a schedule for implementing the recommendations include required interaction with other agencies, available budgets, and water supply priorities.

Many of the recommendations, particularly those related to the environment, require Boulder to actively work with other agencies. It is recommended that an overriding goal for those recommendations should be the identification and implementation of "win-win" solutions for all stakeholders.

19.2 Operations

1. <u>Operate the Barker system as part of the broader Boulder water supply system</u>: The Barker system is becoming an integral part of Boulder's treated water delivery system. As such, the city needs to consider Barker operations within the system as a whole, taking into account factors such as water quantity and quality, system reliability, hydrologic reliability, cost effectiveness, and other factors. In addition, the city will need to determine how secondary objectives, such as hydropower, instream flow, and recreation, will be approached when developing plans for the Middle Boulder Creek watershed. The city should do extensive cost-benefit and public values analyses when considering secondary uses.

2. <u>Maximize the use of direct flow water rights and direct-use exchange rights</u>: These two priorities are important steps for optimizing the reliability of Boulder's water supply system. Water storage releases from Boulder's reservoirs to Betasso Water Treatment Plant should be adjusted daily or more often to compensate for fluctuations in direct flow yields and municipal water demands. The city's newfound ability to make frequent adjustments in Barker Reservoir storage releases should be developed and managed to maximize direct flow yield.

3. <u>Monitor Barker Reservoir water surface elevation and area</u>: In order to enhance predictive modeling and to facilitate the use of direct-flow water rights and direct-use exchange rights, the city of Boulder should monitor and record Barker Reservoir pool elevations and surface acreage and relate these to average, wet and dry years.

4. <u>Maintain continuous flow in the Barker Gravity Pipeline when temperatures drop below freezing</u>: Continuous flow is intended to prevent internal freezing when the Barker Gravity

Pipeline is not completely drained. Boulder should devise its operating plans accordingly. A continuous-flow requirement should be evaluated for its impact on Barker Reservoir drought protection, Boulder's water supply reliability, and minimum required flow rates.

5. Develop a plan with the CWCB to legally protect instream flows provided to Middle Boulder Creek downstream of Barker Dam: The plan should account for at least four objectives: (1) Boulder should balance its commitment to provide an instream flow for Middle Boulder Creek below the dam with its water supply system reliability criteria, (2) any instream flow program should be implemented in such a way that does not expose Boulder's municipal water rights to diminishment or jeopardize the city's ability to meet municipal water needs, (3) the instream flow program should have provisions to modify operations in times of drought or emergency, and (4) the instream flow program for Middle Boulder Creek should be coordinated with similar programs on Main Boulder and North Boulder Creeks.

6. Develop a comprehensive Drought Management Plan: The Drought Management Plan should include an assessment of all Boulder water supplies and distribute a drought reserve function among Boulder's three storage locations (Barker Reservoir, the North Boulder Creek Watershed, and Boulder Reservoir). The Plan should provide recommendations for maximizing Boulder's combined raw water delivery capacity to its treatment plants during droughts. Hydrosphere is currently developing a drought recognition and response plan for the city.

7. Optimize hydropower generation as a secondary objective after optimizing the system for water supply and accommodating competing commitments like instream flow releases: Hydropower is a clean, renewable energy that reduces our reliance on nonrenewable fossil fuels. Hydropower generation should be maximized to the extent reasonably possible.

19.3 Operational Decision Support Tools

8. Develop short-term and long-term decision support models: Figure 19.2 shows a Decision Issues Diagram to summarize the key issues that should be considered when developing decision support tools, including various operational decision models. The Work Plan is intended to provide a framework from which both long-term and short-term decision support models can be developed.

9. Develop and test a Betasso Water Treatment Plant Notification Plan: As part of a Source Water Emergency Response Plan, it is desirable to have a Betasso Water Treatment Plant Notification Plan. The purpose of the Notification Plan is to provide timely warnings to water treatment plant operators in the event of a water quality emergency or an uncommon water quality event.

10. Explore the uses, benefits, reliability, and costs of remote sensing capabilities associated with water quality, dam safety, and safety and operation of various components of the Barker System.

19.4 Water Quality

11. Initiate an expanded water quality monitoring program: The water quality monitoring program should include the following elements and considerations:

    - Include Middle Boulder Creek upstream of Barker Reservoir, Barker Reservoir, and Middle Boulder Creek and Boulder Creek downstream of Barker Reservoir.
    - Establish a baseline against which the effects of future changes, such as recreation expansion or watershed development, can be measured.
    - Include constituents that have been historically measured.
    - Treat Barker Reservoir and the creek segments upstream and downstream of the reservoir as separate, but interrelated, features.
    - Evaluate the use of a continuous, remote monitoring system upstream of Barker Reservoir. A continuous monitoring system would potentially provide an early warning system and more accurate information for identifying and tracking potential contaminant sources.
    - Ensure that the water quality monitoring program and data analysis protocols are directly linked to decision-making processes and management goals.
    - Evaluate the need for targeted water quality monitoring or special studies to evaluate the relationship between watershed use/recreation and water quality.

12. Initiate an expanded water quality modeling program: The water quality modeling program should include the following elements and considerations:

    - Develop water quality goals for source waters to assist in water supply decisions. There are city staff groups currently meeting to create water quality and quantity goals.
    - Develop and apply a watershed model to quantify potential contaminant loads.
    - Develop a process to regularly update the assessment of water quality threats and the vulnerability of the Middle Boulder Creek and Barker Reservoir system.
    - Coordinate additional studies, water quality monitoring, and water quality modeling to integrate the three and target them toward water quality goals.
    - Evaluate potential water quality changes with projected development and transportation.

13. Complete a joint study on options for mitigating the impacts of the Nederland Wastewater Treatment Plant: The study should be conducted cooperatively with the Town of Nederland. At a minimum, evaluate the feasibility of relocating the treatment plant and developing a natural area or gateway park and/or wetlands at the west end of Barker Reservoir, as well as improving wastewater treatment at the existing location. The city of Boulder and the Town of Nederland have been meeting to discuss alternatives for the Wastewater Treatment Plant and a joint study is in progress.

14. Collaborate with the Town of Nederland and other stakeholders to implement water quality maintenance actions: A list of water quality maintenance activities that benefit from cooperative actions is described in Table 9.11 (repeated below).

TABLE 9.11
RECOMMENDED ACTIONS FOR MAINTAINING WATER QUALITY IN MIDDLE BOULDER CREEK WATERSHED

Description	Anticipated Benefits Via Control of Constituents in the Column Headings			
	Nutrients	Toxins	Pathogens	Sediments
Work with the town of Nederland to achieve diversion of the Nederland effluent from the Barker Reservoir watershed.	X	X	X	
Work with the town of Nederland and Boulder County Health Department to assure quality in installation, maintenance, and monitoring of ISDS.	X		X	
Work with the town of Nederland and the County Health Department and sanitation authorities toward a plan for discouraging excessive additional installation of ISDS.	X		X	
Work with the town of Nederland and other authorities as necessary to achieve best management practices for urban and residential runoff control in the Barker Reservoir water shed.	X	X	X	X
Develop a water quality improvement plan for Beaver Creek watershed.		X		X
Consider destratification of Barker Reservoir if deep water oxygen conditions cannot be improved in Barker Reservoir in the future.	X			
Continue monitoring reservoir and tributary waters.	X	X	X	X
Establish a program of special studies of one- to two-year duration designed to answer specific questions related to water quality.	X	X	X	X

15. Map contaminant source locations that have not previously been located: Not all contaminant sources are identified in existing databases, nor are all the databases that identify potential contaminant sources GIS based. Work with local stakeholders, land use mangers, watershed visitors, and residents to identify and confirm locations of point and nonpoint contaminant sources. Develop, update, or refine the following GIS data:

- Survey, using GPS, point contaminant sources based on a priority system.
- Update land use information with satellite imagery.
- Update slope analysis using contours from Computer Terrain Mapping. This would include constructing contours for the entire watershed down to the water treatment plant.
- Monitore USGS status on making available 1:24,000 scale streams data made available in digital form (probably available in the next year).
- Obtaine a GIS layer of domestic/household wells from the State Engineer to estimate septic system distribution and integrate with County septic information.

16. Track and influence watershed development: Coordinate with local land use agencies to identify and review plans for new development or changes in land use within the watersheds.

17. Evaluate the integration of a GIS with water quality data: The goal is improved understanding of sources and locations of contaminants in the watershed. The integration

process could include linking available water quality data to the Middle Boulder Creek watershed GIS and performing simple spatial analyses (including graphs of hot spots, water quality contour plots, and others) to try and develop an understanding of potential contaminant issues and sources. This city could use this type of tool in annual water quality analyses and watershed assessments.

18. Evaluate how the use of water quality threshold levels can be used to trigger mitigation activities: Examples of mitigation activities include best management practices.

19. Identify and prioritize contaminant sources that may require specific study or mitigation: Examples of priority contaminant sources include the Nederland WWTP and unstable mine tailing deposits.

20. Conduct a special study to identify any correlation between high watershed use periods, such as weekends and holidays, with contaminants, particularly pathogens.

21. Coordinate with watershed stakeholders to identify sensitive areas or zones that need more stringent regulation: Examples of more stringent regulations might include limitations to development or access.

22. Investigate grant opportunities: Grant funding may be available for special monitoring studies or education programs.

23. Coordinate with local emergency response entities to develop a coordinated emergency notification and response plan.

24. Develop a risk-based assessment of existing and potential contaminant sources, which would assist in prioritizing management efforts.

25. Develop water quality data analysis protocols to evaluate temporal and spatial changes in water quality: If a water quality trend is detected (e.g., increasing organic carbon over time), determine the possible causes and evaluate potential protection strategies.

26. Prepare for response monitoring and special studies: Once a potential water quality issue is identified, response monitoring may determine the source and location impacting water quality. The response monitoring should be based on the constituent, upstream land use, potential sources, and other factors. Special studies should include source tracking to identify whether a pathogen source is human or animal and targeted monitoring to determine impacts solely from humans (e.g., indicators such as ibuprofen or triclosan, a component in soap).

27. Monitor implementation of the Roosevelt National Forest Land and Resource Management Plan: Cooperation with the U.S. Forest Service to identify recreation activities that may adversely impact water quality now or in the future.

19.5 Recreation

28. Prepare a Barker Reservoir Recreation Resource Management Plan for existing recreational uses: The Plan should address, as a minimum, the following topics:

    - Administration
    - Operations and Maintenance
    - Facilities and Parking
    - Trails
    - Levels of Use
    - Recreation Leasing Opportunities
    - Fees/Concession Management
    - User Satisfaction Surveys
    - Ongoing Public Involvement Process
    - Safety and Law Enforcement
    - Water Facility Security
    - Water Quality Monitoring and Protection
    - Fishery Management
    - Other Natural Resource Protection and Monitoring
    - Primary Function of Facilities as Water Supply

29. Do not open Barker Reservoir to recreational boating at this time: Maintaining the current closure on Barker Reservoir boating appears warranted due to security, safety and water quality concerns, as well as a lack of consensus among area residents as to the desirability of boating on Barker Reservoir. The city should maintain the current policy of closure to recreational boating and continue to gather information regarding water quality and safety during the period in which security concerns remain heightened.

30. Initiate a Barker Reservoir Boating Feasibility Assessment: The assessment should address, as a minimum, the following topics:

    - Boating Demand, Availability and Comparable Facilities
    - Physical Improvement Needs
    - Operations and Maintenance Requirements
    - Safety/Emergency Response/ Law Enforcement
    - Water Facility Security
    - Revenue Generating Potential/Willingness to Pay
    - Visual Resource Impacts
    - Lake Boating Carrying Capacity
    - Community Sentiment Regarding Potential Boating Effects
    - Fishery Management
    - Water Quality Protection
    - Primary Function of Facilities as Water Supply
    - Traffic Impacts

Specific areas of data collection for this assessment would include a number of considerations, including weather, wind speed and direction, water temperature, water quality, and traffic counts on SH 119. Boulder should coordinate with CDOT for traffic count data on SH 119.

31. Consider installation and monitoring of wind gauges and water temperature recorders on or near the dam. Wind and temperature gages would provide important information (along with a number of other considerations) for the Barker Reservoir Boating Feasibility Assessment.

32. Evaluate recreation plans at comparable reservoirs: Assess operations, maintenance and other relevant recreation planning issues at facilities comparable to Barker Reservoir, including other terminal drinking water reservoirs.

33. Prepare Fishery Enhancement Plans for Middle Boulder Creek, Barker Reservoir, and Main Boulder Creek: Coordinate plan development with the Colorado Division of Wildlife and meet the following guidelines:

    - The Plan for Barker Reservoir should identify and quantify the impacts of establishing a minimum pool elevation for fishery maintenance or enhancements during average and wet years, and it should be conducted independent of boating issues.
    - The Plan for Middle Boulder Creek below Barker Dam should include continued coordination with the Colorado Water Conservation Board, the U.S. Forest Service, Trout Unlimited, the Colorado Division of Wildlife and others in establishing instream flow water rights.

34. Maintain a document of all aspects of recreation decision-making, including public involvement, for use in the FERC relicensing process: Boulder should ascertain the level of detail necessary for FERC recreation assessments for Barker Reservoir. Primary re-licensing issues or concerns should be identified at this point.

35. Develop an Ice Climbing Plan for Boulder Canyon: Coordinate with Boulder County, the U.S. Forest Service and CDOT. The plan should address, as a minimum, the following issues:

    - Parking along SH 119 and Middle Boulder Creek (Boulder Canyon).
    - The progress of ice climbing groups on obtaining permission to ice climb on U.S. Forest Service land and Boulder County land.

36. Repair leaks in the Barker Gravity Pipeline and prepare designs for a secure water tap to provide water for ice falls: Although leaks may contribute to the formation of ice falls, leaks jeopardize the structural integrity of the pipeline and compromise the city's water supply. A secure water tap should not be installed until ice climbing groups obtain authorization to climb from the U.S. Forest Service and Boulder County and enter into a water lease agreement with the city of Boulder.

37. Develop a trail plan for trails near Barker Reservoir: Review current trail planning near Barker Reservoir in conjunction with Boulder County, Nederland and the U.S. Forest Service. The trail plan should incorporate the following:

- Do not formalize or encourage the use of a trail along the south shore.
- Mitigate safety concerns along the trail on the north side.
- Address erosion control problems (site-specific) along the trail on the north side.
- Conduct a visitor count survey (windshield survey) to measure levels of use for different types of use days, for example peak weekend days and weekdays.
- Photograph and monitor informal or social trail use, such as shoreline fishing access points. The city should take corrective actions should these sites become degraded.

38. Assess trail use issues near Middle Boulder Creek and the Barker Gravity Pipeline: Cooperate with Boulder County Parks and Open Space and the U.S. Forest Service on trail-related issues. Implement a site-monitoring program to ascertain whether trail segments are being degraded by excessive or inappropriate use.

39. Continue to promote stream habitat enhancement or restoration as a public and private sector goal.

40. Cooperate with Boulder County efforts to direct and restrict trail use and formation: Be cognizant that project roads and trails may provide access for undesired recreation even if posted as closed to recreation activity.

41. Proceed cautiously, conducting all appropriate studies and hearings, before opening up any part of the Barker System to new secondary uses: Potential impacts to the primary water-supply objectives, safety, security, liability and other considerations should be evaluated carefully, systematically, and professionally.

19.6 Environment and Land Management

42. Work with stakeholders to develop environmentally friendly watershed development plans: Monitor land use practices within the upper watershed. Key plan objectives should include the following:

- Large blocks of habitat should be maintained, fragmentation limited, and recreational use managed to benefit wildlife species with large territories (e.g., northern goshawk, mountain lion, and black bear).
- Wetlands and riparian areas are significant habitat that should be maintained and enhanced when appropriate.
- Recreational use should be directed away from significant resources such as wetlands, riparian areas, old growth forests and areas containing sensitive plant species.
- Area closures to protect wildlife should be used where and when appropriate.
- Restoration of degraded habitat, particularly near streams, should be considered to protect natural resources including water quality.

- Activities in or near significant natural resources should be carried out using best management practices.
- Aquatic ecosystems, fisheries, and associated wetlands and riparian areas should be managed for the protection of their natural integrity.

43. Support research and monitoring efforts that quantify the status of known northern goshawk nests in the watershed, along Middle Boulder Creek and near the Barker Gravity Pipeline.

44. Encourage the perpetuation of large-diameter trees and snags throughout the watershed.

45. Establish a coordinated land management effort between Utilities, Open Space Mountain Parks, Boulder County and the US Forest Service in the Tram Hill / Lost Gulch area[11]: Land management efforts should include fire management, improve forest health, preserve historic resources, protect water system infrastructure and limit illegal access.

46. Establish a coordination group comprised of Utilities staff, Open Space Mountain Parks staff and others as necessary to develop joint land management policies and best management practices (BMPs) for integrating land management activities. These policies and BMPs will address activities such as:

- accommodating necessary environmental impacts of water and power infrastructure and its operation and maintenance and providing reasonable mitigation of environmental impacts due to repair, replacement, reconstruction, or expansion of water and power facilities
- reducing the probability or effects of stand-level, high-intensity fire
- contributing to the improvement of the area's forest health
- protecting the area's rare and sensitive plant communities and diverse forest conditions
- protecting and maintaining wildlife habitat values
- coordinating integrated weed treatments and preventing the spread of weeds
- managing recreational access and use
- providing adequate security and emergency response
- preparing for post-fire ecological restoration activities
- effectively operating and maintaining water system infrastructure
- protecting historic resources
- protecting water quality and riparian habitat in Boulder Creek
- managing impacts of power utility easements and corridors

19.7 History and Culture

47. Consider designating the Boulder Canyon Hydroelectric Project as either an Historic Civil Engineering Landmark or an Historic Mechanical Engineering Landmark: A member of the American Society of Civil Engineers (ASCE) and American Society of Mechanical Engineers (ASME) from the city's Utilities Division should contact the organization for

[11] Vegetation mapping, including forest stands, for the Tram Hill / Lost Gulch area is available from Open Space Mountain Parks and Utilities. The maps were created using aerial photos and field checks (see Appendix A).

additional information concerning their landmark programs. The city should consider nominating the Boulder Hydroelectric Project for the designation that seems most appropriate.

48. Carefully consider the pros and cons of a historical listing on the National Register: Listing on the National Register is a special honor and distinction that the city of Boulder may want to pursue. The Boulder Canyon Project appears to be eligible for listing on the National Register. However, the Boulder Canyon Project is federally licensed (FERC) and involves federal lands (USFS), so alterations to the project that may affect its historic significance will be considered under Section 106 of the National Historic Preservation Act regardless of National Register listing. Since federal protection mechanisms are in place due to federal licensing and land ownership, efforts might be better directed elsewhere than pursuing nomination to the National Register. Listing would be beneficial if the city intends to pursue any preservation grant funding requiring National Register listing.

49. No specific action is needed regarding the State Register of Historic Properties: If the city decides to list the Boulder Hydroelectric Project on the National Register of Historic Places, the project will also be included on the State Register.

50. Consult with the National Park Service concerning the possibility and timing of completion of the Historic American Engineering Record (HAER) documentation for the Boulder Hydroelectric Project: If the National Park Service is not interested in completing the HAER study for the facilities, it is recommended that the city request cost information from private individuals and firms providing HAER documentation services to evaluate the feasibility of completing HAER documentation.

51. Initiate discussions with Boulder County to determine the feasibility of Historic Landmark designation for the Boulder Hydroelectric Project: Historic landmarking through Boulder County is a very appropriate means of recognizing the historic significance of the Boulder Hydroelectric Project since Barker Reservoir is a prominent local landmark. The feasibility of County landmarking of the entire system depends on the consent of a majority of landowners and the ability of the city and Boulder County to agree on future maintenance and modification needs of the system. Less desirable in terms of historic significance and context, but also an option, would be the nomination of one or more of the system components.

52. Maintain operation of the Boulder Canyon Hydro Plant for historic reasons: Boulder Canyon Hydro Plant is one of the oldest operable hydro plants in Colorado. As such, Boulder Canyon Hydro should be kept in operation to the extent feasible based on economics, water availability and operational factors.

19.8 Safety and Security

53. Follow the recommendations of law enforcement agencies and water industry groups and the practice of the majority of local water providers regarding heightened security during the current national action against terrorism.

54. Take steps to reduce risks to Boulder's water supply associated with wildland fires: Steps should include the following:

- Continue cooperation and support for Fire Protection Districts in which city facilities are located and other organizations involved in wildland fire management efforts, as appropriate. The city of Boulder, Boulder County, the Town of Nederland, the U.S. Forest Service and local fire districts should coordinate on public education pertaining to wildfires. Prescribed fire should be coordinated between all stakeholders and applied judiciously to reduce the potential for catastrophic wildfire.

- Designate individuals who will represent the water utility on fire management teams during wildland fires in the water supply watersheds. Active participation in the management of suppression efforts would help maintain water supply protection as a priority in strategy development. Water utility equipment and resources could potentially be made available to the suppression effort.

- Carefully consider all management decisions for the Boulder Canyon Hydroelectric Project in terms of their impact on fire danger, and consult with jurisdictional agencies to determine how to best contain and manage associated risks. For example, expansion of the existing authorized recreational uses of project facilities will increase fire danger in those areas.

- Update the existing "Draft Emergency Response Plan for the city of Boulder Water Supply System" to specifically address water supply emergencies caused by wildland fires.

55. Take steps to prevent public access to hazardous areas: In developing long-term management strategies for the Boulder Canyon Hydroelectric Project facilities, the city should plan for adequate warnings, barriers and restrictions, following the FERC guidelines.

56. Carefully review any proposed new uses of the Boulder Canyon Hydroelectric Project facilities in terms of safety hazards and develop appropriate hazard mitigation programs: Safety programs should be developed in consultation with the Boulder County Sheriff's Office and emergency responders. In addition, FERC will review public safety programs as a function of its project inspections and may require additional safety measures to be implemented.

57. Maintain a current, dynamic Emergency Response Plan: The need for emergency preparedness—both to prevent and respond to emergencies—has come to the forefront of American public policy. A comprehensive source water emergency response plans should be maintained and rehearsed. Adequate planning will entail careful review of the existing emergency response plan, coordination with local emergency response agencies, and implementation of a variety of structural and non-structural safety and security measures.

58. Install additional fencing at Boulder Canyon Hydro, increased surveillance and security patrols.

59. Provide on-site supervision at specific facilities.

60. Take steps to minimize staff response times for emergencies at water facilities.

19.9 Community Education and Facilities Enhancement

61. Design and install an interpretive panel at the west end of Barker Reservoir: The panel should interpret Barker Reservoir as a water supply facility, its context within the Boulder Canyon Hydro system, and the importance of water quality both for drinking water and lake aesthetics. The panel should also address permitted uses, restrictions and visitor ethics.

62. Coordinate with the Town of Nederland to integrate any improvements to Barker Reservoir recreational facilities with the Town's park improvements.

63. Develop a short, educational brochure: The brochure should educate about the reservoir and explain reservoir recreation resources, permitted uses, and restrictions, and emphasize the importance of water quality protection.

64. Install and maintain bag dispensers for use by visitors in picking up after their pets: Include information on the effects of animal excrement on drinking water supplies at these stations along with information on leashed and unleashed areas.

65. Post signs near private property to educate visitors about inadvertently trespassing on private property near the reservoir.

66. Improve the aesthetics of Barker Reservoir's public facilities: Improvements should include landscape screening to hide the garbage dumpster at the west end of the reservoir and rehabilitation of the public restrooms.

67. Ensure sufficient restroom facilities and trash receptacles at designated recreation sites.

68. Design and install an interpretive panel near Main Boulder Creek: The panel would serve to interpret the creek as part of the larger watershed in terms of water supply and water quality. It would also address permitted uses, restrictions and visitor ethics.

69. Enhance public education efforts to raise awareness of watershed activity impacts on water quality.

70. Educate residents and staff to be the eyes and ears of safety to report law enforcement violations and suspicious activities anywhere in the Barker system.

19.10 Conclusions

Conclusions that follow from the Work Plan are summarized in the recommendations, the Executive Summary and various conclusion subsections under the major sections of the Work Plan.

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FIGURES

Appendix A: Integrated GIS Maps of the Barker Watershed

Appendix B: List of Existing Documents Supplementary to Report References (Barker Reservoir and Dam)

Appendix C: Conceptual Breakdown Structure

Appendix D: Project Scope of Work Statement (Feb. 2001)

Appendix E: Questions and Answers from Public Meetings