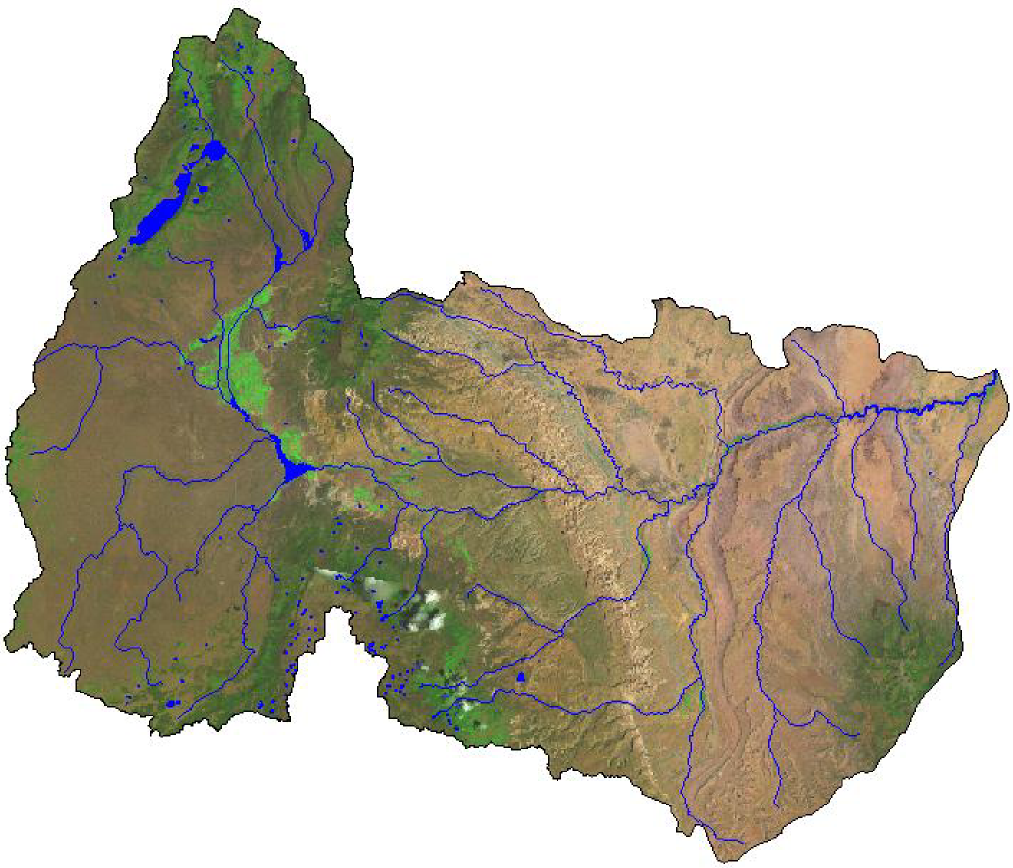
# Fremont River Watershed

Water Quality Management Plan



**September 27, 2002**

Includes TMDLs for:

- Johnson Valley Reservoir
- Forsyth Reservoir
- Mill Meadow Reservoir
- UM Creek
- Upper Fremont River
- Lower Fremont River

**FREMONT RIVER WATERSHED**
**WATER QUALITY MANAGEMENT PLAN**

## TABLE OF CONTENTS

**FREMONT RIVER WATERSHED**
**WATER QUALITY MANAGEMENT PLAN**

## TABLE OF CONTENTS
**(Continued)**

**FREMONT RIVER WATERSHED**
**WATER QUALITY MANAGEMENT PLAN**

## LIST OF TABLES

## LIST OF TABLES

## (Continued)

# LIST OF APPENDICES

# 1.0 INTRODUCTION

This document presents a Water Quality Management Plan for the Fremont River watershed located in south-central Utah. The Fremont River Watershed Steering Committee developed this Water Quality Management Plan with assistance from Millennium Science & Engineering (MSE), and their subcontractors. The Utah Division of Water Quality (DWQ) contracted MSE to assess water quality impairments of the Fremont River watershed, quantify loadings for limiting water quality parameters, develop Total Maximum Daily Loads, and assist the Fremont River Watershed Steering Committee to develop this Water Quality Management Plan. Many private individuals, agencies, and consultants contributed to these efforts. A list of contributors is provided in **Appendix A**.

The Fremont River watershed is subdivided into two parts in this plan, the upper and lower, to help distinguish the unique water quality issues of each sub-watershed. The upper Fremont River begins at the headwaters in Fishlake National Forest and extends to the eastern boundary of Capitol Reef National Park. The lower Fremont River begins at the eastern boundary of Capitol Reef National Park and ends at the confluence with the Dirty Devil River.

**Section 1** of the Water Quality Management Plan introduces the Total Maximum Daily Load (TMDL) process, the water quality impairments of the Fremont River watershed, and Utah's Watershed Approach. **Section 2** contains a description of the Fremont River watershed, including specifics about the history of the watershed, climate, geology, soils, land use, land cover, and hydrology. **Section 3** describes the current water quality-monitoring program for the Fremont River watershed. An assessment of the water quality of the Fremont River watershed is discussed in detail in **Section 4** and includes an explanation of the applicable water quality standards. **Section 4** also describes the significant sources of point and nonpoint pollution, loading calculations for each source, water quality goals and targets, and best management practices (BMPs) and best available technologies (BATs) to attain the water quality goals and targets. **Section 5** contains the TMDL portion of the Water Quality Management Plan. **Section 5** is designed to be a stand-alone document that details the technical analysis, water quality goals and endpoints, and TMDLs for the parameters of concern. Project Implementation Plans (PIPs) are presented in **Section 6**. These PIPs set forth potential projects, waterbody prioritization, and the estimated costs for implementing management measures. **Section 7** addresses the implications of future land use on water quality and the implementation of management practices. A water quality-monitoring plan is recommended in **Section 8** to measure the effectiveness of watershed management modifications. Conclusions and recommendations are presented in **Section 9**. **Section 10** is a comprehensive list of references cited in this document.

## 1.1 The TMDL Process

Water quality standards are set by States, Territories, and Tribes. They identify the scientific criteria to support a waterbody's beneficial uses such as for drinking water supply, contact recreation (swimming), and aquatic life support (fishing). A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards (USEPA, 1999a). As part of the TMDL process, the maximum amount of the pollutant of concern is allocated to its contributing sources. Therefore, a TMDL is the sum of the allowable loads of the pollutant of concern from all contributing point and nonpoint sources. The calculation must include a margin of safety to account for future growth, changes in land use and uncertainties in data collection, analysis and interpretation. The Clean Water Act, Section 303(d), establishes the TMDL program.

Section 303(d) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130), requires that States report waterbodies (i.e., lakes, reservoirs, rivers, and streams) that currently do not meet water quality standards for their designated beneficial use(s). EPA regulations require that each State submit a prioritized list of waterbodies to be targeted for improvement to EPA every two years. These regulations also require States to develop TMDLs for those targeted waterbodies. Thus, those waterbodies that are not currently achieving, or are not expected to achieve, applicable water quality standards are identified as water quality limited. Waterbodies can be water quality limited due to point sources of pollution, nonpoint sources of pollution, or both. Examples of pollutants that can cause use impairment include chemicals and pathogens for which there are numeric standards. In addition to pollutants, impairments may originate from sources such as habitat alteration or hydrologic modification that have associated narrative standards (UDEQ-DWQ, 2000a). Section 303(d)(1)(A) and the implementing regulations (40 CFR 130.7(b)) provide States with latitude to determine their own priorities for developing and implementing TMDLs.

Once a waterbody is identified as water quality limited, the State, Tribe or EPA is required to determine the source(s) of the water quality problem and to allocate the responsibility for controlling the pollution. The goal of the TMDL is reduction in pollutant loading necessary for a waterbody to meet water quality standards and support its beneficial uses. The result of this process determines: 1) the amount of a specific pollutant that a waterbody can receive without exceeding its water quality standard or impair a beneficial use; 2) the allocation of the load to point and nonpoint sources; and 3) a margin of safety. While the term TMDL implies that loading capacity is determined on a daily time scale, TMDLs can range from meeting an instantaneous concentration (e.g., an acute standard) to computing an acceptable annual load to a waterbody (UDEQ-DWQ, 2000a).

> *"The primary mission of the TMDL program is to protect public health and the health of impaired aquatic ecosystems by ensuring attainment of water quality standards, including beneficial uses."* (USEPA, 1998a).
>
> *The objective...is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.* (Clean Water Act).

Several waterbodies within the Fremont River watershed including; Johnson Valley Reservoir, Forsyth Reservoir, Mill Meadow Reservoir, Lower UM Creek, Fremont River near Bicknell to U.S.F.S. boundary, and Fremont River and tributaries from the confluence with the Dirty Devil River to the east boundary of Capitol Reef National Park were identified as a high priority for TMDL development in the State of Utah’s 2000 303d list. The listing was based on an intensive water quality study that was completed in 1997-1998 by DWQ. This survey found numerical criteria exceedences for three water quality parameters of concern – total phosphorus (TP), dissolved oxygen (DO), and total dissolved solids (TDS) (UDEQ-DWQ, 2000b). Therefore, DWQ prompted this TMDL to identify and quantify point source and nonpoint source pollution in the Fremont River watershed.

### 1.2 Utah’s Watershed Approach

Utah’s watershed approach is aimed at improving the protection of the State’s surface and groundwater resources. Characteristics of the approach include a high level of stakeholder involvement, water quality monitoring and information gathering, problem targeting and prioritization, and integrated solutions that make use of multiple agencies and groups. Federal and state regulations appoint DWQ with the task of preventing, controlling, and abating water pollution. Other state and local agencies have associated responsibilities. Utah's watershed approach is to form partnerships with accountable government agencies and interested groups to combine resources and increase the effectiveness of existing programs.

Throughout the State of Utah a series of ten nested management units provide spatial focus to watershed management activities, thereby improving coordination. Watershed management units in the State may contain more than one stream system, or watershed, defined as the entire area drained by a stream and its tributaries. Delineated watershed units are consistent with the hydrologic basins defined by Division of Water Resources for the State Water Plan project (UDNR-DWR, 1990). The watershed management units provide boundaries for evaluating the impact of various stressors on commonly shared resources, provide boundaries for better understanding the impacts of management actions, and provide a better perspective for DWQ and stakeholders to determine environmental objectives and to develop management strategies that account for local and regional considerations.

Each watershed plan will address management actions at several spatial scales ranging from the watershed scale to specific sites that are influenced by unique environmental conditions. Watershed plans consider a holistic approach to watershed management in which groundwater hydrologic basins and eco-regions encompassed within the units are considered. The goal of Utah's watershed approach is better coordination and integration of the State's existing resources and water quality management programs to improve protection for surface and groundwater resources. Better coordination and integration extends beyond the tiers of government agencies to include all stakeholders in the watershed.

Utah’s watershed approach is based on hydrologically defined watershed boundaries and aims to de-emphasize jurisdictional delineations in watershed management efforts. This approach is expected to accelerate improvements in water quality as a result of increased coordination and sharing of resources. Statewide watershed management is not a new regulatory program, it is a means of operating within existing regulatory and non-regulatory programs to more efficiently and effectively protect, enhance, and restore aquatic resources. The Statewide watershed management approach has been introduced to establish a framework to integrate existing programs and coordinate management activities geographically (UDEQ-DWQ, 2000c).

In addition to the technical components, Utah’s watershed approach is dependant on the critical role stakeholders play in watershed water quality management. The success of the implementation plan and ultimately the restoration of water quality depends on the voluntary involvement of the stakeholders in Utah's watersheds. Therefore, to be successful, the TMDL development approach must ensure public participation and input at critical points throughout the process.

A successful water quality management plan and TMDL relies as much on voluntary stakeholder involvement and buy-in as on the rigor of technical analysis. The advantages of involving stakeholders throughout the TMDL development and implementation process are numerous. Through their voluntary participation, the dischargers can become more comfortable that the monitoring and modeling programs generate reliable data that are scientifically defensible. Further, effluent limits and Best Management Plans developed by the Stakeholders are less prone to credibility challenges and litigation. Stakeholders are more apt to agree to pollutant reduction or habitat improvement schemes that they helped to formulate.

The boundaries of watershed management units in Utah were drawn so that stakeholders would be aggregated or grouped into areas sharing common environmental characteristics. Defining watershed management units in this way is intended to encourage a sense of ownership in the resident stakeholders and to encourage involvement in stewardship activities. Based on a model successfully used by other states, the program draws on the expertise of those involved in or affected by water quality management decisions. These stakeholders help gather information and design Best Management Plans, then become involved in stewardship activities.

In the Fremont River watershed, both governmental and non-governmental entities worked to achieve a skillful and honest presentation of technical information to the Fremont River Watershed Technical Advisory Committee (TAC) and Watershed Steering Committee (WSC) throughout this TMDL study. These efforts have resulted in a Water Quality Management Plan and TMDL that insure that controls of point and nonpoint pollution, needed to meet water quality standards, are acceptable by those living and working in the watershed.

## 2.0 WATERSHED DESCRIPTION

The Fremont River watershed boundaries are defined by the USGS Hydrologic Accounting Unit (HUC) # 14070003 (**Map 1**).

### 2.1 Historic Perspective

Evidence indicates that prehistoric man inhabited the Fremont River watershed area, as well as several other regions of Utah. Petroglyphs and pictographs carved and painted on the cliff walls in Capitol Reef National Park are thought to be the work of the prehistoric Basketmaker and Pueblo peoples, some of whom were the ancient ancestors of the Hopi Indians. The first white man to enter the area was probably Dennis Julian. By the time he arrived, Ute Indians inhabited the area. Julian’s name and the date 1836 can be found scratched on local rocks. There is no indication of further visits to the area until John C. Fremont and a company of twenty men, half who were Delaware Indians, camped in the area during the Fall and Winter of 1853 and 1854, on his last expedition to the West. The town of Fremont and the river were named in his honor. In 1856, General William B. Pace and his men passed through the western portion of the watershed and named it Rabbit Valley, the present day location of Loa, Bicknell, and Torrey (Wayne County Commission, 1978).

The first home in the area was built east of the present day town of Fremont, by a man named Tidwell. The Tidwell Canyons north and northeast of Forsyth Reservoir were named in his honor. Between 1876 and 1880, the first permanent homesteaders came to the region. A Mormon missionary named Franklin Wheeler Young settled and named Loa, the present day county seat, after the Hawaiian Volcano, Mauna Loa in 1876. Fremont was settled at roughly the same time (Wayne County Commission, 1978).

The upper portion of the watershed was settled because of its lush grasslands for cattle and sheep and the lower portion was settled as a result of mining interests. Farming was concentrated in the western portion of the watershed including: Rabbit Valley and Fishlake Plateau Regions. The remainder of the watershed has historically been considered suitable for Spring and Fall grazing (Wayne County Commission, 1978).

Raising livestock is the oldest and still the primary industry in the watershed. Beef cattle have had the most economic impact in the past; however, dairy cows, sheep, and poultry have also contributed to the local economy. Historically, getting cattle to market was difficult. Until good roads were built in the 1930’s, livestock were driven 100 miles north to Nephi or to a Denver and Rio Grande railroad branch line in Sevier County. The development of the National Forests in the early 1900s and the Taylor Grazing Act reduced the number of sheep grazing in the area.

The majority of the Fremont River watershed is located in Wayne County, Utah. This includes the central portion of the watershed, the course of the Fremont River, and all of the major settlements within the Fremont basin. However, the headwaters (located in the northwestern portion of the watershed) are within Sevier County. In addition, a small portion of the watershed on the western extreme is located in Piute County and the southeast portion of the basin, including the southern extent of Capitol Reef National Park, is within Garfield County **(Map 1)**.

The municipalities within the watershed are all within the boundaries of Wayne County including Loa, Lyman, Bicknell, Torrey, and Hanksville. Various unincorporated areas including Fremont, Grover, Teasdale, Fruita, and Caineville are also located within the watershed boundaries. According to the U.S. Census Bureau, the estimated 1999 population of Wayne County was 2,387 persons, and the majority work in farm related industries (Governor's Office of Planning and Budget, 1994).

The Fremont River watershed was the first hydrologic area in Utah to be studied in depth for State water planning purposes by the Utah Division of Water Resources (UDNR-DWR, 1975). The intent of the preliminary study was to examine the resources of the river basin, formulate alternative plans for management and development of these resources, and determine the environmental, economic, and social impacts. The concepts are similar to those proposed by the Water Resources Council in “Proposed Principles and Standards for Planning Water and Related Land Resources” (UDNR-DWR, 1975). Since then, Federal, State, local, and non-governmental entities have all contributed to the planning and management of the water resources and water quality within the watershed to sustain historic farm related land uses well into the future.

## 2.2 Climate

The climate of the Fremont River watershed can be defined according to the Modified Koppen System, which delimits various climate types according to vegetation response and precipitation patterns. On a large scale the Fremont River watershed is located within the Middle-Latitude Desert region and can be described by two climate types: Steppe (Semiarid) and Desert (Arid). The Fishlake National Forest portion of the watershed (headwaters) is classified as Steppe and the remainder of the watershed is classified as Desert. Steppelands occur between the desert margins and higher mountain regions. The average annual precipitation is slightly less than the potential evapotranspiration, creating a semi-arid climate sufficient for the growth of short and medium grasses, sagebrush, and other woody plants. Much of this grassland region forms the basis for Utah’s livestock ranching industry (Pope et al., 1994). The remainder of the watershed is located on the Colorado Plateau desert. Deserts occur where the annual precipitation is less than potential evapotranspiration.

The wide local variations in climate within the watershed are primarily due to topography, but also depend on general air circulation, the relative position of the continental landmass, and latitude. The highlands of this area have different temperature and precipitation characteristics due to their elevations. They give rise to characteristic “humid islands”, wherever mountain masses project to a substantial height above the desert valleys (UDNR-DWR, 1975). Temperatures in the watershed range from between -20° F in the mountains during the Winter to over 100° F in the lower portions of the basin during the summer. Table 2.1 includes annual average temperatures for Fishlake National Forest, Capitol Reef National Park, and Hanksville.

**Table 2.1**
**Annual Average Temperature**

| Location | Annual Average Temperature |
|---|---|
| Fishlake National Forest | Fewer than 8 months above 50˚ F[1] |
| Capitol Reef National Park | 66.9˚ F[2] |
| Hanksville | 70.3˚ F[2] |

1. UDNR-DWR, 1975; 2. Pope et al., 1994

Precipitation in the Fremont River watershed varies with topography. Weather Bureau records from 1931 to 1960 indicate that the average annual precipitation ranges from less than six inches in the low-lying desert area near Hanksville to more than 40 inches in the high plateaus surrounding the Upper Fremont Valley. Approximately two-thirds of annual precipitation falls between the months of October – April, and the remainder occurs during the months of May – September. In general, Winter precipitation falls in the form of rain or snow, while summer precipitation is characterized by random convective thunderstorm activity, resulting from the northward flow of warm, moist air from the Gulf of Mexico. Two major storm paths affect the Fremont River watershed. During the Winter and Spring months, frontal storm systems for the Pacific Northwest predominate. These Winter storms affect mostly the northern half of the watershed. During the late summer and early Fall, thunderstorms move in from the south and southwest. These thunderstorms occur in isolated areas, are of great intensity, and have the potential to produce flood events. Precipitation varies from 8-10 inches at the U.S. Forest Service (USFS) boundary to 40 inches at the highest elevations (USFS, 1986a). In contrast, annual precipitation in the lower desert portion of the watershed is usually about five to eight inches (Pope et al., 1994). The extremely dry desert condition east of Caineville is attributed to the rain shadow effect of high plateaus to the west (UDNR-DWR, 1975). Mean annual precipitation for the upper, middle, and lower Fremont River watershed is summarized in Table 2.2.

**Table 2.2**
**Mean Annual Precipitation**

| Location | Mean Annual Precipitation |
|---|---|
| Fishlake National Forest | 16-30 inches[1] |
| Capitol Reef National Park | 7.40 inches[2] |
| Hanksville | 5.69 inches[2] |

1. Judd, 1997; 2. Pope et al., 1994.

The frost-free season within the basin varies from less than 20 days in the high mountain areas surrounding the headwaters to more than 200 days in the vicinity of Hanksville. The growing season in Rabbit Valley, based on temperature observations in Loa, is 108 days. During a ten-year period 1957-66, consecutive days with minimum temperatures above 32°F ranged from 57 days in 1960 to 103 days in 1958, and averaged 84 days during that period (UDNR-DWR, 1975).

The Fremont River watershed lies within the Eastern Utah Air Shed. An air shed is a layer of air with homogenous wind, temperature, and humidity characteristics where movement across land surface is restricted by topographic barriers. The irregular topographic features within the greater Colorado River watershed, of which the Eastern Utah Air Shed is a part, produces a complex arrangement of separate air sheds. Relatively high velocities of wind are needed to move these air sheds through the passages in topography. This type of wind is absent in the Fremont River basin. Therefore, typical wind movement is restricted to the daily exchange of down-slope and up-slope motion (UDNR-DWR, 1975).

## 2.3 Geology / Soils

Geology

The geology of the Fremont River drainage is the foundation of all its other features. The structural position and erosional products of the rock formations determine the topography that in turn affects the climate, precipitation, water supply, and types of soils for agricultural development. The combined geologic features also determine the types of vegetation, wildlife, and raw materials such as coal and petroleum that are available for industrial development (UDNR-DWR, 1975).

This unique area displays a wide variety of geologic features. The Fremont River flows eastward from approximately 11,000 feet, where land surfaces have been formerly glaciated, through a transition zone of intermediate elevations and erosional features, to a desolate desert area of elevations below 5,000 feet (UDNR-DWR, 1975).

The watershed lies entirely within the Colorado Plateau physiographic region. The western part of the basin is commonly included in the High Plateau district of Utah. The northern geologic boundary is the San Rafael Swell, a dome trending northeast from the basin approximately 70 miles. The Henry Mountains, a classic laccolithic structure, form a part of the southern boundary. The eastern part of the basin is defined by a low plateau deeply dissected by erosion (UDNR-DWR, 1975).

The headwaters of the watershed are located in the High Plateaus Section of the Colorado Plateaus Physiographic Province. There is considerable evidence of volcanic activity in this part of the basin, predominantly of Tertiary and Quaternary age. Most of the Awapa Plateau, Aquarius Plateau, and Thousand Lake Mountain are covered with volcanic rock derived from lava flows. In addition, Basin and Range type block faulting, present along the edges of several of the mountains, is responsible for much of the local topography. Plateau glaciation and land sliding around Fish Lake have also helped to form the present landscape (USFS, 1986a). Nonetheless, much of the geology here is hidden by soil and sagebrush. Thousand Lake Mountain is located in the southeastern portion of Fishlake National Forest. It is composed of Miocene volcanic rock capped by Pliocene lava flows; although its slopes are almost entirely formed by landslides that conceal most of the geology. To the south, in Dixie National Forest, Boulder Mountain is a Miocene shield volcano. Rabbit Valley lies on broad gravel-covered slopes below these mountains. Most of the gravel was deposited during the Pleistocene epoch when the mountains streams were heavily loaded with coarse glacial debris (Chronic, 1990). Groundwater reservoirs of both artesian and water table conditions have been proven and developed to a limited extent in the alluvium of Rabbit Valley. This alluvium of sands, gravels, silts, and clays is known to be as much as 500 feet thick, and is recharged with abundant precipitation on the adjacent lava-capped plateaus, through fractured lava flows which project beneath the valley fill (UDNR-DWR, 1975). The geology of the Fremont River watershed is shown on **Map 2**.

At Bicknell the geology begins to change from volcanic rocks to sedimentary rocks. Between Bicknell and Teasdale a north-south fault brings Mesozoic sedimentary strata, the rocks that characterize the Plateau country of southeastern Utah, to the surface. Wingate cliffs and massive cross-bedded Navajo sandstone rocks east of Bicknell are a Jurassic dune deposit, tilted steeply along the fault. Triassic rocks, comprised of the Moenkopi formation and Shinarump conglomerate, appear in the canyon along the Fremont River. Torrey lies on a pediment cut in rocks of Moenkopi formation (Chronic, 1990).

Capitol Reef National Park is located east of Torrey. Sedimentary rocks exposed in the Capitol Reef area range from the Coconino sandstone of Permian age to the Flagstaff limestone of early Tertiary age (Smith et al., 1963; in UDNR-DWR, 1975). The dominant feature of the park is the Waterpocket Fold, a single large monocline formed in late Cretaceous time. The Capitol Reef is a predominant part of the fold and is formed of steeply tilted Jurassic rocks including: dune formed Wingate sandstone, floodplain deposits of the Kayenta formation, and massive dune-formed Navajo sandstone. West of the reef crest, Triassic and Permian strata appear. Waterpockets in the Navajo sandstone form along joints that serve as natural channels for flowing water. These waterpockets begin as wind-etched depressions and eventually deepen to become large enough to hold water for a considerable amount of time (Chronic, 1990).

East of Capitol Reef National Park the geology changes again as drab gray hills of Mancos Shale appear around Caineville. Dakota sandstone appears below valley forming Mancos Shale, in the area surrounding the town of Hanksville. High concentrations of salts within the units of the Mancos Shale of Cretaceous age and the Carmel formation of Jurassic age affect the quality of any water with which these sediments come in contact. In the lower portion of the watershed the river is overloaded with rock debris that block shallow channels with gravel and sand causing it to form a braided channel (Chronic, 1990).

The geology of the watershed also influences the occurrence, distribution and availability of the groundwater resources. A study of the Navajo sandstone shows it to be a favorable groundwater aquifer, both in receiving and storage. Preliminary but unconfirmed measurements show that the Navajo sandstone is capturing considerable water from the Fremont River where the river passes over it east of Fruita. The Navajo sandstone probably holds a large and extensive groundwater reservoir in the synclinal area between Caineville and Hanksville, which is being recharged from surface drainage into the exposed outcrops of Navajo. The capability of the formation to give up water has yet to be further tested. Oil and gas test wells drilled in the area indicate that the Navajo sandstone will produce water, especially east of the waterpocket fold (UDNR-DWR, 1975).

The river bottom in the area between Caineville and Hanksville flourishes with phreatophyte growth rooted in sand clay, and possibly gravels at depth. This material is saturated from high flows of the Fremont River during times of high runoff, and from mainstream seepage through the river banks and bed as the stream wanders.

In the vicinity of Hanksville, the Entrada sandstone of Jurassic age is exposed at or near the surface and wells that have been drilled into it have produced artesian flows of good quality water at a depth between 300-400 feet. The largest flow known is approximately 45 gallons per minute (gpm), although most are less than 10 gpm (UDNR-DWR, 1975).

There have been three major mineral developments in the watershed. In recent times, copper was mined in the Capitol Reef area, but the tonnage produced was less than 1,000 tons. Throughout the area, numerous uranium deposits have been located, and claims have been filed on Sandy Creek, North Salt Wash, and the Fremont River. Coal development near Factory Butte was still active in the 1970’s. However, a larger but remote field occurs in the Henry Mountains. Other potential mineral resources of the watershed include vanadium, manganese, gypsum, building stone, sand and gravel, oil and gas.  A manganese deposit is located on the east side of Boulder Mountain and two wells drilled in the Moenkopi sandstone at the Last Chance field in Emery County encountered natural gas (UDNR-DWR, 1975).

Soils

The arable lands of the Fremont River watershed are generally scattered in flat areas along the Fremont River.  In addition, large arable areas exist on higher benches several miles from the river.  Most of the arable lands in the upper Fremont River valley are already under cultivation.  This valley is no more than 3 miles wide and 12 miles long, and contains about 10,200 acres of cropland (Fremont Irrigation Company, 2001).  Most of the bottomlands near Torrey are also irrigated.  The Caineville and Hanksville areas include about 10,000 acres of arable land of which 1,500 acres is presently irrigated.  A lack of sufficient quantities of water during the critical growth period has limited development in the lower portion of the watershed.  Potential areas of future irrigation development include the lands between Caineville and Hanksville, and tracts of land both north and south of the river near Hanksville, however these lands would require moderate pumplifts.  Additionally, the Burr desert, southeast of Hanksville, has very good soils, but the area has not yet been developed.  Bureau of Reclamation studies indicate about 8,400 acres could be irrigated, although development would require several hundred feet of pumplift (UDNR-DWR, 1975).

The soils of the Fremont River watershed are described here from the headwaters to Hanksville and are shown on **Map 3**.  The soils of the Fish Lake and Johnson Valley Reservoir subwatersheds are described the same.  DWR has categorized the soils as 100% Lithic Cryoborolls-Mollic Cryoboralfs-Rock Outcrop Association (soil type 3).  This soil type contains mildly to strongly acidic, loams to cobbly loams that have low to moderately high erodibility (K = 0.17 - 0.28) and well to excessive drainage.  Permeability above the bedrock is slow to moderate.  Runoff is medium and sediment production is low.  The hydrologic groups are mainly C and D (Judd, 1997).

The soils of the Forsyth Reservoir subwatershed are categorized as 98% Argic Cryoboborolls-Pachic Cryoborolls-Cryic Paleborolls Association (soil type 1) and 2% Aridic Argiustolls-Typid Agriustolls Association (soil type 5).  Argic Cryoboborolls-Pachic Cryoborolls-Cryic Paleborolls Association contains mildly alkaline to strongly acidic, silt loams to clay loams that have low to moderately erodibility (K = 0.17 - 0.28) and moderate to somewhat excessive drainage.  Permeability is slow to rapid.  Runoff is medium to slow and sediment production is moderately low – the hydrologic groups are mainly B and C (Judd, 1997).

Aridic Argiustolls-Typid Agriustolls Association contains neutral to moderately alkaline soils.  The surface areas are dark reddish-brown very fine sandy loams.  The subsoils are reddish-brown fine silt.  The soils in this association are well drained and permeability is moderate.  Runoff is medium to rapid and sediment production is moderate.  The hydrologic groups are mainly B and C.  Wind erosion is a problem on these soils when vegetation is removed (K value = 0.43) (Judd, 1997).

The soils of the Mill Meadow Reservoir subwatershed is comprised of Soil types 1, 5, and 3, relative percent 65%, 25%, and 10%, respectively.  The three soil types present in the Mill Meadow subwatershed are described above.

## 2.4 Land Use / Land Cover

Major political boundaries (city and county), roads, and highways are shown on **Map 1**. **Map 4** shows land uses and land ownership.

<u>Cultural Characteristics/Land Use</u>

The number of people residing within the boundaries of the watershed is estimated to be less than 3,000 (Governor's Office of Planning and Budget, 1994). The area is primarily rural with numerous farms in the Rabbit Valley area.

Within 30 years, from 2000 to 2030, the population of Wayne County is projected to grow to over 5,000 with an average annual rate of change of 2.14 percent. The average annual growth rate for the State of Utah is projected to be less than 2 percent for the same period (Governor's Office of Planning and Budget, 1994).

The primary land uses in the watershed are associated with livestock production, including grazing on rangelands and alfalfa and grass hay production on croplands. Approximately 5% of the watershed is in private ownership, while only 2.3% of the land in Wayne County is privately owned. The basin contains approximately 16,000 acres of irrigated land and approximately 70,000 acres of private and state rangelands. The remaining acres are federally administered public lands. There are two distinct physiographic units within the basin that affect land use. The first is the upper Fremont River basin, which is defined by high mountain valleys, volcanic rocks, wet meadows, irrigated agriculture, and coldwater fisheries. The second unit is the lower Fremont River basin, which is characterized by desert landscapes, Mancos Shale, sandstone, significant sedimentation, and warm water fisheries. Both areas attract a visiting population from outside the basin that comes for the fishing, hunting, camping, and sightseeing that both of these physiographic regions offer.

The State's Division of Wildlife Resources and Trust Lands Administration manage a significant proportion of the watershed for multiple purposes including wildlife, grazing and mineral extraction. The Division of Wildlife Resources maintains a fish hatchery between Loa and Fremont (Loa Fish Hatchery), and one south of Bicknell (JP Egan Fish Hatchery). In addition, they administer approximately 700 acres of land in the Bicknell Bottoms, which provides important waterfowl habitat. They also manage the lake and stream fisheries as well as many game species in the area. The Trust Lands Administration manages approximately 142,000 acres within the river basin (UDNR-DWR, 1975).

Five federal agencies are actively involved within the watershed. The Natural Resources Conservation Service (NRCS) provides financial and technical assistance to agricultural producers. The Farm Service Agency (FSA) administers programs including crop insurance, farm loans and the Conservation Reserve Program. The US Forest Service (USFS) manages the Fishlake and Dixie National Forests, which include most of the headwaters within the watershed. The Bureau of Land Management (BLM) administers the majority of land within the watershed, which consists primarily of mid and low elevation desert rangelands. The National Park Service administers Capitol Reef National Park located in the middle of the watershed (**Map 1**).

Land Cover

**Map 5** shows general vegetation in the watershed. **Map 6** shows general topography in the watershed. Like all areas in the mountainous west, the Fremont River watershed shows a vertical succession, or belt, of plant associations from its lowest elevations to the highest summits. The elevations at which various plant associations occur depends on characteristics such as latitude, exposure, soil, and moisture, while the width of the belts depends on steepness of the slope (UDNR-DWR, 1975). Generalized vegetation communities in order from high elevation to low include coniferous forests, sagebrush grasslands, Pinyon-Juniper woodlands, shadscale deserts and greasewood flats.

Streamside vegetation provides a very important wildlife habitat, as it generally exhibits richer growth of plants than the surrounding areas. At the lower elevations within the watershed vegetation includes cottonwood trees, salt cedar and numerous shrubs such as sagebrush, greasewood, willows, and wild rose. Wetlands and marshes found in Rabbit Valley offer good conditions for waterfowl. Bicknell Bottoms, a 1200-acre marsh area, is especially important to ducks and geese. Higher in the mountain canyons, the streams are lined with willow, alder, and thickets of rose. Cropland and irrigated pastures, if adjacent to rangeland, forest, or marsh, provide habitat for a number of animals such as pheasants, quail, doves, and rabbits. They may also provide feed for resident and migrating waterfowl. Fish Lake, Johnson Valley Reservoir, Mill Meadow Reservoir, Forsyth Reservoir, and numerous lakes on Boulder Mountain provide excellent fishing at various times of the year.

## 2.5 Hydrology

The general hydrology of the Fremont River watershed is described from the headwaters in Fishlake National Forest to the confluence with the Dirty Devil River near Hanksville. **Map 7** shows the general hydrology of the watershed including streams, lakes, canals, ditches, and significant wetlands. Reservoir hydrology is described in Section 2.5.1. The hydrology of sub-basins and the irrigation canal systems in the watershed are discussed in Sections 2.5.2 and 2.5.3, respectively. The hydrology of the Fremont River is very complex and is described with respect to nutrient loading in Sections 4.2.3 and 4.3.3 for the upper and lower Fremont River.

### 2.5.1 Reservoirs

Fish Lake

Fish Lake, located at the headwaters of the Fremont River watershed, is the highest impoundment in the watershed system. It is the largest natural mountain lake in the State of Utah. Fish Lake Plateau, on which the lake is situated, is the sixth highest mountain in the state and the highest of the high plateaus in Southern Utah. The lake is located in a deep, wide graben valley. It is easily reached by a paved state highway and has many recreational developments on the north shore. The state beneficial use classifications include boating and similar recreation (2B), coldwater game fish and organisms in their food chain (3A), and agricultural uses (4) (Judd, 1997). A summary of the characteristics and morphometry of Fish Lake is presented in Table 2.3.

**Table 2.3**
**Fish Lake**
**Characteristics and Morphometry**

| | |
|---|---|
| Lake elevation (feet) | 8,843 |
| Surface area (acres) | 2,500 |
| Watershed area (acres) | 11,500 |
| Volume (acre-feet) | 212,500 |
| Annual inflow (acre-feet) | Not available |
| Retention time (years) | 58.5 |
| Mean annual vertical fluctuation (feet) | 3 |
| Depth (feet) | |
| Maximum | 174.8 |
| Mean | 84.9 |
| Length (miles) | 5.3 |
| Width (miles) | 1.1 |
| Shoreline (miles) | 12.3 |

Source: Judd, 1997

In 1935, a dam was constructed to regulate the release of water from the lake. Since that time the storage rights have been continually decreased until now the lake remains essentially in its natural state. The reservoir shoreline is publicly owned and administered by the Fishlake National Forest with unrestricted public access. Recreational facilities are provided to accommodate heavy usage, including: public and private campgrounds, housekeeping cottages, improved boat ramps, boat rental, and picnic grounds.

Aspen and coniferous forests extend across the mountains around the reservoir. The forests remain largely intact; however some clearing has occurred for land development and road construction. At the higher elevations, alpine vegetation exists. Other vegetation communities consist of pine, aspen, spruce-fir, and oak brush. The watershed receives approximately 16-30 inches of precipitation annually with a frost-free season at the reservoir of 60-80 days (Judd, 1997).

The watershed highpoint, 11,633 ft, is located on the south shoulder of Fish Lake Hightop Plateau, directly north of the lake. Inflow sources include Jorgenson Creek, Bowery Creek, Twin Creek, and Doctor Creek. The outlet is Lake Creek, a headwater stream of the Fremont River. The soil is largely volcanic in origin with moderate permeability and moderately slow erosion and runoff qualities (Judd, 1997).

Fish Lake's water quality is very good. Historically, there have been some exceedences for phosphorus but water quality has improved since all the cabins along the lake have connected to a centralized sewer system. . All other parameters evaluated are within the state standards. The trophic status for the lake is essentially oligotrophic. According to DWR stocking records the following fish have been introduced to the lake: subcatchable or advanced rainbow trout, lake trout, splake – a cross of brook and lake trout, and fingerling brook trout. Typically, all of the brook trout are stocked annually. Since the lake has not been treated for control of rough fish species, native fish can still exist in the lake or its tributaries. Therefore, the following species of fish may also be present in the lake: yellow perch, Utah sucker, brown trout, and possible kokanee salmon, and mottled sculpin (Judd, 1997).

Even though the water quality in Fish Lake is very good at present, potential pollution sources should be mentioned. They include livestock and wildlife grazing in the vicinity of Fish Lake, concentrated recreation, construction, and summer home resort activities. Concentrated recreation disturbs the shoreline and other areas around the lake, accelerating erosion. Litter can also be a problem. There are no point sources in the Fish Lake subwatershed (Judd, 1997).

Johnson Valley Reservoir

Johnson Valley Reservoir is located northeast of Fish Lake, on Fish Lake Plateau. It is a shallow, intermediate sized impoundment of a mountain meadow. The dam at Johnson Valley was completed in 1899 (Fremont Irrigation Company, 2001). The shoreline is publicly owned and administered by the Fishlake National Forest with unrestricted public access. The state beneficial use classifications include boating and similar recreation, coldwater game fish, and organisms in their food chain, and agricultural uses. The water quality of Johnson Valley Reservoir is poor. Johnson Valley Reservoir is listed for total phosphorus. DWQ calculations from the most recent DO profiles (June 1999) show a 25% exceedence for the entire water column of Johnson Valley Reservoir (see Section 4.1.2).

Recreational facilities exist to accommodate heavy usage. There is an improved public boat ramp and picnic facilities at Johnson Reservoir Park. The forest service maintains a free and improved campground (Judd, 1997). A summary of the characteristics and morphometry of Johnson Valley Reservoir is presented in Table 2.4.

**Table 2.4**
**Johnson Valley Reservoir**
**Characteristics and Morphometry**

| | |
|---|---|
| Lake elevation (feet) | 8,819 |
| Surface area (acres) | 704 |
| Watershed area (acres) | 34,634 |
| Capacity (acre-feet) | 9,997 |
| Conservation Pool (acre-feet) | 2,500 |
| Annual inflow (acre-feet) | not available |
| Retention time (years) | not available |
| Mean annual vertical fluctuation (feet) | 12.5 ft. |
| Depth (feet) | |
| Maximum | 21 |
| Mean | 14.2 |
| Length (miles) | 1.7 |
| Width (miles) | 1.2 |
| Shoreline (miles) | 4.9 |

Source: Judd, 1997

Johnson Valley reservoir is located in an area of high, rolling ridges that are characteristic of the top of Fish Lake Plateau. The watershed high point (the Fish Lake Hightop Plateau) is 11,633 ft above sea level, thereby creating a slope of 12.5% to the reservoir. The average stream gradient above the reservoir is 7.3% (386 feet per mile). The soil is largely volcanic in origin with moderate permeability and moderately slow erosion and runoff (Judd, 1997).

The vegetation communities consist of pine, aspen, and spruce-fir. The watershed receives approximately 16-30 inches of precipitation annually with a frost-free season averaging between 60-80 days at the reservoir.

Currently, DWR stocks the reservoir with fingerling rainbow and cutthroat trout. The reservoir was treated in 1979 for rough fish control and later restocked with rainbow trout, cutthroat trout, and brook trout. In 1979 DWR reported an abundant invertebrates population including snails, Chironomids midges, and mayfly larvae; plankton was evident, but not abundant; only submergent macrophytes were found and these were abundant. The two most common types were *Scirpus* and *Potamageton*. DWR recorded the stocking of catchable rainbow trout for 1980 (Judd, 1997).

Nonpoint pollution sources include natural background, animal waste, and recreation. About 1,144 cattle graze in the reservoir's watershed for approximately 4 to 6 months each year (see Section 4.1.3). There are no point sources of pollution to Johnson Valley Reservoir (Judd, 1997).

<u>Forsyth Reservoir</u>

Forsyth Reservoir is located at the base of the Fish Lake Mountains. It is an intermediate-sized impoundment of a stream valley. The reservoir was created in 1922 by the construction of an earth-fill dam. The Fishlake National Forest has administrative ownership of sixty percent of the shoreline with the remaining forty percent in private ownership (at the north end). Public assess is unrestricted. The state beneficial use classifications include boating and similar recreation, coldwater game fish, and organisms in their food chain, and agricultural uses. The water quality of Forsyth Reservoir is poor. It is listed on the State's 303d list for total phosphorus and dissolved oxygen. DWQ calculations from the most recent DO profiles (July 1998) show a 37.5% exceedence for the entire water column of Forsyth Reservoir (see Section 4.1.2).

Forsyth offers fishing, boating, and primitive camping. Recreational facilities include a public boat ramp, campsites, and bathrooms. The nearest campground is located seven miles east of the reservoir, on the north slope of Thousand Lake Mountain. Water use is not expected to change in the foreseeable future (Judd, 1997). A summary of the characteristics and morphometry of Forsyth Reservoir is presented in Table 2.5.

**Table 2.5**
**Forsyth Reservoir**
**Characteristics and Morphometry**

| | |
|---|---|
| Lake elevation (feet) | 7,989 |
| Surface area (acres) | 158 |
| Watershed area (acres) | 47,872 |
| Capacity (acre-feet) | 5,765 |
| Conservation Pool | none |
| Annual inflow (acre-feet) | not available |
| Retention time (years) | not available |
| Mean annual vertical fluctuation (feet) | 40 |
| Depth (feet) | |
| Maximum | 80 |
| Mean | 26 |
| Length (miles) | 1.3 |
| Width (miles) | 0.3 |
| Shoreline (miles) | 3.4 |

Source: Judd, 1997

Forsyth Reservoirs subwatershed has been characterized as follows. Forsyth Reservoir is in an area of rolling ridges and valleys. UM Creek extends up a long and forested valley to the northwest. The Tidwell Canyons are located to the northeast of UM Creek. The area immediately around the reservoir is forested with relatively shallow slopes. The watershed high point is Mount Marvine, which rises 11,610 ft. above sea level, thereby developing a slope of 6.4% to the reservoir. Inflows of Forsyth include UM Creek and Short Creek. The average stream gradient above the reservoir is 2.3% (120 feet per mile). The outflow is UM Creek.

The Forsyth subwatershed is composed of high mountains and valleys. The soil is largely volcanic in origin with moderate permeability and moderately slow erosion and runoff. The vegetation communities are pine, aspen, mountain mahogany, pinyon-juniper, sagebrush and grass. Approximately 16-30 inches of precipitation falls annually in the vicinity of the reservoir and the frost-free season averages 80 – 100 days (Judd, 1997).

Fishlake National Forest administers 95% of the land surrounding the reservoir. The main land uses on forest service lands include livestock grazing, recreation, and timber harvesting. The remaining 5% of the land is administered as State holdings and private land within the Fishlake National Forest. These lands are primarily used for grazing (Judd, 1997).

Historically, DWR has stocked the reservoir annually with 7,000 fingerling trout and 3,000 fingerling brook trout. In 1991, the trout became infected with whirling disease, and the reservoir was treated with rotenone in 1992. It has been stocked with wipers, a cross between white bass and striped bass rather than trout until the late 1990's. This was an effort to eradicate the disease before the trout were returned. In addition to being treated in 1992, the reservoir was treated in 1959 by DWR to control rough fish competition (Judd, 1997). The phytoplankton community is dominated primarily by blue-green algae, indicative of eutrophic or nutrient enriched water.

Nonpoint pollution sources include natural background, animal waste, and recreation. During the summer, 670 head of cattle graze in the watershed and around the reservoir. In 1992 there were several active timber sales in the Sheep Valley area, with 1,000,000 board feet of aspen being removed from a windstorm area and timber sales ceased in 1992. There are no point sources of pollution in Forsyth's subwatershed (Judd, 1997).

Mill Meadow Reservoir

Mill Meadow is an intermediate impoundment of a stream valley just below the confluence of the Fremont River and UM Creek. The Fishlake National Forest and some private owners administer the shoreline. Public access is unrestricted. The shore within a quarter mile of the earth-filled dam is BLM land. The earth-filled dam was built in 1954. The shore near the center of the reservoir is privately owned. The state beneficial use classifications include boating and similar recreation, coldwater game fish, and organisms in their food chain, and agricultural uses. The water quality of Mill Meadow Reservoir is fair. It is listed on the State's 303d list for total phosphorus. In addition, the DO levels have occasionally been below the State criterion. However, DWQ calculations from the most recent DO profiles (June 1999) show no DO exceedences for Mill Meadow Reservoir (see Section 4.1.2).

Facilities are limited and include restrooms and campsites (Judd, 1997). A boat ramp is planned for Mill Meadow (WSC, 2000). A summary of the characteristics and morphometry of Mill Meadow Reservoir is presented in Table 2.6.

**Table 2.6**
**Mill Meadow Reservoir**
**Characteristics and Morphometry**

| | |
|---|---|
| Lake elevation (feet) | 7,681 |
| Surface area (acres) | 156 |
| Capacity (acre-feet) | 5,232 |
| Conservation Pool | none |
| Annual inflow (acre-feet) | not available |
| Retention time (years) | not available |
| Mean annual vertical fluctuation (feet) | 40 |
| Depth (feet) | |
| Maximum | 66 |
| Mean | 33.5 |
| Length (miles) | 1.6 |
| Width (miles) | 0.28 |
| Shoreline (miles) | 4.73 |

Source: Judd, 1997

Mill Meadow Reservoir is in an area of rolling ridges and valleys. The watershed high point (the Fish Lake Hightop Plateau) is 11,633 ft above sea level, thereby creating a slope of 6.9% to the reservoir. Inflows are the Fremont River and UM Creek. The average stream gradient above the reservoir is 4.0% (209 feet per mile). Upstream impoundments include Forsyth Reservoir (3 miles up UM Creek) and Johnson Valley Reservoir (approximately 13 miles up the Fremont River). The outflow is the Fremont River.

The soil is of limestone origin with rapid permeability and erosion is rapid. The vegetation communities are comprised of pine, aspen, bitterbrush, mountain mahogany, pinyon-juniper, sagebrush and grass. The watershed for Mill Meadow receives approximately 20-40 inches of precipitation annually with an average frost-free season of 80-100 days.

Land use is classified as 98% multiple use and recreation. The majority of Mill Meadow's watershed is used for livestock grazing and timber harvesting. The remaining 2% is private land used for livestock grazing.

According to DWR, no fish kills have been reported in recent years. The reservoir supports populations of brook trout, rainbow trout, and sculpins. The reservoir is stocked annually with rainbow and cutthroat trout. Gill net surveys show that the Utah chub, the redside shiner, and the Utah sucker are also present. Invertebrates, primarily midges, were found in addition to plankton including Copepods, Cladocerins, rotifers, and algae. Historically, DWR has stocked the reservoir annually with 10,000 –20,000 fingerling trout. In 1991, the reservoir became infected with whirling disease and consequently it was treated with rotenone in 1992. It was stocked with centrachids rather than trout until the disease was eradicated (Judd, 1997).

The reservoir was chemically treated by DWR to control rough fish competition in 1966, 1978, 1986, and 1992. In a phytoplankton study conducted during August 1991 the cellular biomass of *Aphanizomenon*, a blue-green alga, was an indicator of poor water quality (Judd, 1997).

Nonpoint pollution sources include natural background, animal waste, and recreation. During the summer 670 head of cattle graze the Mill Meadow Reservoir sub-watershed and the area immediately around the reservoir. In 1992, there were several active timber sales in the Sheep Valley area of the UM Creek drainage, with 1,000,000 board feet of aspen removed from a windstorm area. In the summer of 1992, FS-036 was widened and paved. There are no point sources of pollution in the Mill Meadow subwatershed (Judd, 1997).

### 2.5.2 Subbasins

DWQ has identified numerous subbasins within the watershed system. These subbasins are shown on **Map 7.**

### 2.5.3 Irrigation Canal System

The major irrigation pathways in the Rabbit Valley portion of the watershed are Highline Canal, Fremont/Loa Ditch, Spring Ditch (south of Bicknell), and Spring Creek north of Road Creek. In the Caineville and Hanksville portion of the watershed irrigation ditches run along the perimeter of the irrigation tracts to divert water onto the irrigated tracts. In addition, irrigation canals exist on the north side of State Highway #24 in the Caineville area. The Caineville total ditch length is approximately 30 miles and the Hanksville total ditch length is approximately 20 miles. Irrigation ditches and canals are shown on **Map 7**. Irrigation canal systems in the watershed are discussed in detail in Section 4.2.3 under “Flow Routing Descriptions and Water Budget”.

## 3.0 CURRENT MONITORING PROGRAM

The most complete water quality monitoring station summaries and water quality observation data for the Fremont River watershed exist in the DWQ STORET database. STORET, short for STOrage and RETrieval, is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. Each data entry in the STORET database is accompanied by information on where the sample was taken (latitude, longitude, state, county, Hydrologic Unit Code, and a brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring.

### 3.1 Locations

There are 139 documented STORET sampling sites within the Fremont River watershed. All of these STORET water quality sampling sites are shown on **Map 8**. The raw data from all the STORET sites in the watershed is provided in **Appendix C**.

After all of the data were compiled, the STORET water quality sites were screened based on the following criteria: 1) the availability of water quality data; 2) the data collection time period (the data collected from 1997 forward were retained); and 3) the site proximity or subwatershed relationship to impaired waters. According to this screening, 24 sites were retained for TMDL analysis. Twenty-one of these retained STORET sites are located in the upper portion of the watershed. These sites are listed below, arranged from the headwaters to eastern boundary of Capitol Reef National Park.

| STORET No. | Site Name |
|---|---|
| 495492 | Lake Creek below Fish Lake |
| 595615 | Sevenmile Creek above Johnson Valley Reservoir |
| 595610 | Johnson Valley Reservoir above Dam |
| 495455 | Fremont River above Mill Meadow Reservoir |
| 595601 | Right Fork of UM Creek at Black Flat |
| 595600 | UM Creek at Forest Service Road 015 |
| 595599 | UM Creek above Forsyth Reservoir |
| 595595 | Forsyth Reservoir above Dam |
| 595592 | UM Creek above Mill Meadow Reservoir |
| 595589 | Mill Meadow Reservoir – Midlake |
| 595588 | Mill Meadow Reservoir above Dam |
| 495451 | Loa Fish Hatchery – Inflow |
| 495450 | Loa Fish Hatchery – Outfall |
| 495511 | Road Creek Trout Farm – Inflow |
| 495510 | Road Creek Trout Farm – Outfall |
| 495442 | JP Egan Fish Hatchery – Inflow |
| 495443 | JP Egan Fish Hatchery – Outfall Hatchery Building |
| 495441 | JP Egan Fish Hatchery – Outfall No. 2 below Pond |
| 495438 | Fremont River near Bicknell |
| 495439 | Fremont River at State Highway 12 Crossing |
| 495436 | Fremont River at Hickman Bridge Trailhead |

Three retained STORET sites are located in the lower section of the watershed. These sites are listed below, arranged from the west boundary of Capitol Reef National Park to Hanksville.

| STORET No. | Site Name |
|---|---|
| 495483 | Pleasant Creek at State Highway 24 Crossing |
| 495506 | Caineville Wash at State Highway 24 Crossing |
| 495433 | Fremont River at Old Highway 24 Crossing |

One hundred and fifteen of the documented sites were not retained because: 63 were outside of the water quality impaired sections; 17 had very limited data; and 35 had no data. The results of this screening, and the STORET sites that were retained for TMDL analysis in the watershed are shown in red on **Map 8.** Statistics performed on the retained STORET data points are provided in **Appendix D**. The statistics include the number of samples, mean, median, variance, 1$^{st}$ quartile, 2$^{nd}$ quartile, 3$^{rd}$ quartile, 4$^{th}$ quartile, and percent exceedence for each retained STORET site.

The DO data provided in the STORET database could not be used to evaluate potential DO exceedences in the reservoirs because the data are averaged from specific depth intervals. Therefore, DWQ provided DO profiles for the reservoirs of concern. These DO profiles are in **Appendix E**.

In addition, a spreadsheet of Hach kit water quality and macroinvertebrate data was provided by the BLM. However, these data were collected prior to 1993. Data collected before 1997 were screened out to better reflect current conditions, and therefore, these data were not incorporated into the TMDL analysis. In addition, the State Division of Natural Resources provided macroinvertebrate data for UM Creek, Sevenmile Creek, and the upper portion of the Fremont River. Although these biological data are not used directly in the TMDL analysis they were useful for establishing baseline conditions on which to evaluate progress towards meeting water quality goals.

## 3.2 Frequency

Stream Monitoring

The DWQ stream monitoring program consists of intensive and long-term ambient water quality monitoring stations. The focus of intensive monitoring surveys is to determine if the rivers and streams, or segments of them, are meeting their designated beneficial uses. Samples collected for intensive monitoring are collected every 5 years with the last sampling event completed in 1997-1998. The long-term, fixed-station, ambient monitoring network is used to evaluate long-term water quality trends. Samples collected from long-term monitoring stations are collected every six weeks (eight times per year). The data are stored on Utah's water quality data storage and retrieval system. These data are periodically uploaded to the EPA's STORET system.

River/stream STORET sites in the Fremont River watershed considered intensive monitoring stations are listed as:

| STORET No. | Site Name |
|---|---|
| 495492 | Lake Creek below Fish Lake |
| 595600 | UM Creek at Forest Service Road 015 |
| 595601 | Right Fork of UM Creek at Blacks Flat |
| 595615 | Sevenmile Creek above Johnson Valley Reservoir |

River/stream STORET sites considered long-term ambient monitoring stations are listed as:

| STORET No. | Site Name |
|---|---|
| 495436 | Fremont River at Hickman Bridge Trailhead |
| 495438 | Fremont River near Bicknell |
| 495439 | Fremont River at State Highway 12 Crossing |
| 595592 | UM Creek above Mill Meadow Reservoir |
| 495455 | Fremont River above Mill Meadow Reservoir |

The remaining river/stream STORET locations in the upper Fremont River watershed are located at the inflow and outflows of fish hatcheries in the Fremont basin. These hatchery sites are used to monitor compliance with the general statewide discharge permit for hatcheries over 40,000 lbs/year. Total phosphorus measurements at these stations are only made during intensive water sampling monitoring (every 5 years).

Lake Monitoring

Every lake within the DWQ's lake assessment program is sampled twice during May/June and August/September every other year. The objectives of the State's lake monitoring plan are to determine existing water quality conditions, evaluate lake water quality trends, protect and enhance lake water quality, and to determine beneficial use support. Lake/reservoir STORET sites in the Fremont River watershed are listed as:

| STORET No. | Site Name |
|---|---|
| 595588 | Mill Meadow Reservoir above Dam |
| 595589 | Mill Meadow Reservoir – Midlake |
| 595595 | Forsyth Reservoir above Dam |
| 595599 | UM Creek above Forsyth Reservoir |
| 595610 | Johnson Valley Reservoir above Dam |

### 3.3 Parameters

The water quality and associated parameters included in the STORET database include the following.

- Sample date & time
- Sample type
- Depth (lakes and reservoirs)
- Flow (streams)
- Field temperature (Celsius)
- Field pH (std units)
- Field DO (mg/L)
- Chlorophyll A (ug/L)
- Sulfate (mg/L)
- Ammonia (mg/L)
- $NO_2$+$NO_3$, N (mg/L)
- Total Phosphorus (mg/L)
- Dissolved Total Phosphorus (mg/L)
- Total Dissolved Solids @ 180 Celsius (mg/L)
- Total Suspended Solids (mg/L)

However, select parameters are included for each site depending on the focus of the sampling event. The parameters for each sample are included in **Appendix C**.

## 4.0 WATER QUALITY

The DWQ has subdivided the Fremont River watershed into two sections based on beneficial use classifications (See **Map 8**).

The upper section is from the headwaters to the eastern boundary of Capitol Reef National Park and is also referred to as the upper Fremont River watershed. The beneficial uses for the upper Fremont River watershed are:

- 1C – Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water;
- 2B – Secondary contact recreation (boating, wading, or similar uses);
- 3A – Cold water species of game fish and other cold water aquatic life; and
- 4 – Agricultural uses including irrigation of crops and stock watering.

The lower section is from the eastern boundary of Capitol Reef National Park to the confluence with the Dirty Devil River and is also referred to as the lower Fremont River watershed. The beneficial uses for the lower Fremont River watershed are:

- 2B – Secondary contact recreation (boating, wading, or similar uses);
- 3C – Nongame fish and other aquatic life; and
- 4 – Agricultural uses including irrigation of crops and stock watering.

The following is a brief discussion of the impaired stream segments/waterbodies in the upper and lower Fremont River watershed. A detailed discussion of the applicable water quality standards, listing criteria, assessment of water quality, identification of nonpoint and point sources, and water quality goals and targets for the upper and lower Fremont River watershed are discussed in Sections 4.1 and 4.2, respectively.

Upper Fremont River Watershed

Two river segments of the upper Fremont River watershed are impaired for designated beneficial use 3A. These segments include UM Creek from Mill Meadow to Forsyth Reservoir, and the Fremont River from the US Forest Service boundary (at the outflow of Mill Meadow Reservoir) to Bicknell (STORET 495438). UM Creek is listed only for depressed dissolved oxygen concentrations (DO) while the Fremont River is listed both for low DO and elevated total phosphorus (TP) concentrations. In addition, three reservoirs located near the headwaters of the Fremont River are listed as impaired. Johnson Valley Reservoir and Mill Meadow Reservoir are listed for TP. Forsyth Reservoir is listed for TP and DO. The listings are based on an intensive water quality study that was completed in 1997-1998 by DWQ. This survey found numerical criteria exceedences for these water quality constituents (UDEQ-DWQ, 2000b). The upper Fremont River watershed from Bicknell to the eastern boundary of Capitol Reef National Park is not included on the 303(d) list. Listed waterbodies in the upper Fremont River watershed are summarized in Table 4.1.

**Table 4.1**
**303(d) Listed Segments and Waterbodies in the Upper Fremont River Watershed**

| Upper Fremont River Watershed Stream Segment or Waterbody | Waterbody ID | Waterbody Size | Listed Parameter of Concern | Impaired Beneficial Use | Date First 303(d) Listed |
|---|---|---|---|---|---|
| Mill Meadow Reservoir | not available | 156 Acres | Total Phosphorus | 3A | 1998 |
| Lower UM Creek from Mill Meadow to Forsyth Reservoir | UT14070003-003 | 0.8 Miles | Dissolved Oxygen | 3A | 1998 |
| Forsyth Reservoir | not available | 158 Acres | Dissolved Oxygen & Total Phosphorus | 3A | 1998 |
| Johnson Valley Reservoir | not available | 285 Acres | Total Phosphorus | 3A | 1998 |
| Fremont River near Bicknell to the USFS Boundary | UT14070003-005 | 24 Miles | Dissolved Oxygen & Total Phosphorus | 3A | 1998 |

Source: UDEQ-DWQ, 2000b

The following is a brief discussion of phosphorus in the environment and how it is related to dissolved oxygen concentrations and fishery habitat.

Phosphorus

As indicated above, impairments in the upper watershed are due to depressed levels of DO and elevated levels of TP, for fisheries beneficial use. Under normal conditions, phosphorus is scarce in aquatic environments. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus and releases of these deposits occur through weathering, leaching, erosion, and mining. Phosphorus can be transported to aquatic systems via water, wind or terrestrial cycling (terrestrial phosphorus cycling includes immobilizing inorganic phosphorus into calcium or iron phosphates, incorporating inorganic phosphorus into plants and microorganisms, and breaking down organic phosphorus to inorganic forms by bacteria [USEPA, 1999a]). The measurement of all phosphorus forms in a water sample, including all inorganic and organic particulate and soluble forms, is known as total phosphorus.

Anthropogenic (human caused) activities have resulted in excess loading of phosphorus into many freshwater systems. Excess loading results in an imbalance of the natural nutrient cycling processes. Excess available phosphorus in freshwater systems can result in accelerated plant growth if other nutrients are available and other potentially limiting factors are absent (e.g. light availability, temperature, water velocity, substrate, and algae consuming grazers) (USEPA, 1999a).

Excess nutrients in a waterbody can have many detrimental effects on existing designated beneficial uses. With respect to aquatic life and fisheries, a variety of impairments can result from the excessive plant growth associated with nutrient loadings. These impairments primarily occur when dead plant matter settles to the bottom of a waterbody, stimulating microbial decomposition that requires oxygen. Eventually, oxygen in the hypolimnion of lakes and reservoirs can be depleted, due to consumption of oxygen in the decomposition process, creating an environment for the re-introduction of phosphorus from underlying sediments. Oxygen depletion also might occur nightly throughout the waterbody because of plant respiration. Extreme oxygen depletion can stress or eliminate desirable aquatic life (USEPA, 1999a).

Lower Fremont River Watershed

The lower Fremont River watershed is impaired for designated beneficial use 4, due to high levels of total dissolved solids (TDS). The listings are based on an intensive water quality study that was completed in 1997-1998 by DWQ. This survey found numerical criteria exceedences for these water quality constituents (UDEQ-DWQ, 2000b). Listed waterbodies in the lower Fremont River watershed are summarized in Table 4.2.

**Table 4.2**
**303(d) Listed Segments in the Lower Fremont River Watershed**

| Lower Fremont River Watershed Stream Segment | Waterbody ID | Waterbody Size | Listed Parameter of Concern | Impaired Beneficial Use | Date First 303(d) Listed |
|---|---|---|---|---|---|
| Fremont River from the Confluence with the Dirty Devil River to the Eastern Boundary of Capital Reef National Park | UT1407000 3-014 | 100 Miles | Total Dissolved Solids | 4 | 1998 |

Source: UDEQ-DWQ, 2000b

The following is a brief discussion of TDS in the environment.

TDS

TDS is listed as a criterion for protection of agricultural uses because of the negative effect of high salinity on crop production. The Agricultural Salinity Assessment and Management Manual (Tanji, 1990) provides guidance on assessment of water used for irrigation. The following material is paraphrased from the manual (Tanji, 1990).

> Measurements of water samples should include salinity, soluble salts, toxic elements, and pH. Salinity is defined as the total sum of inorganic ions and molecules. The major components of salinity are the cations calcium, magnesium, and sodium, and the anions chlorine, sulfate, and bicarbonate. The potassium and nitrate ions are usually minor components of the salinity. Salinity reduces crop growth by reducing the ability of plant roots to absorb water, and is evaluated by the relationship to salt tolerance of crops.
>
> Unlike the salinity hazard, excessive sodium does not impair the uptake of water by plants, but does impair the infiltration of water into the soil. The growth of plants is, thus, affected by an unavailability of water. The reduction in infiltration of water can usually be attributed to surface crusting, the dispersion and migration of clay into the soil pores, and the swelling of expandable clays. The hazard from

sodium is evaluated using the Sodium Absorption Ratio (SAR), a ratio of sodium to calcium and magnesium in the irrigation water, in relationship to the TDS.

Boron is the primary toxic element of concern in irrigation waters. Boron is an essential trace element at low concentrations, but becomes toxic to crops at higher concentrations. Other trace elements, (boron, arsenic, cadmium, chromium, copper, lead, selenium) are potentially toxic to plants and animals. High pH (pH > 9.0) directly and adversely affects infiltration as well as limiting calcium concentrations and high SAR.

Therefore, in addition to evaluating TDS, the listed TMDL parameter of concern, a water quality assessment for protecting the agricultural beneficial use may also consider assessment of sodium, SAR, Boron, pH, and other toxic metals. This additional assessment may be of special interest if the source of TDS is primarily a natural source and does not impair agricultural uses. As identified in the Utah Water Quality Standards (Utah WQS), the 1,200 mg/L limit “may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water”.

## 4.1 Upper Fremont River Watershed – Reservoirs and Tributaries

Mill Meadow, Forsyth, and Johnson Valley Reservoirs are located within Fishlake National Forest at the Fremont River watershed headwaters. These reservoirs are currently listed as impaired for Class 3A (protected for cold water species of game fish and other cold water aquatic life, including necessary organisms in their food chain). Forsyth Reservoir is currently not meeting beneficial use 3A because of low DO in the water column and high concentrations of TP (>0.025 mg/L) leading to excessive algal production. Mill Meadow and Johnson Valley Reservoirs are not meeting this beneficial use due to high concentrations of TP. Excess nutrient concentrations in reservoirs over a prolonged period of time usually lead to increased productivity of macrophytes and algae, which results in decreased DO levels and elevated ammonia during decomposition. This succession of events has been shown to lead to periodic fish kills in other waterbodies. These eutrophic to hypereutrophic reservoirs exhibit blue-green algae species dominance and/or high (>50) Trophic State Index (TSI) values. Because of these impaired conditions the development of a TMDL is required for these reservoirs. An evaluation of all source pollution (point and nonpoint) inputs into these reservoirs, the establishment of endpoint targets or water quality goals, and a plan to meet these goals are required as part of this assessment.

UM Creek between Forsyth and Mill Meadow Reservoirs is listed as impaired for low levels of DO. The primary factors causing the DO impairment are twofold. First, UM Creek is fed from a bottom outlet structure on Forsyth reservoir that typically has an anoxic hypolimnion. The second factor is nutrient loading. The cause-effect relationship between low DO and elevated nutrient concentrations indicated a need to establish endpoints/targets associated with a reduction of TP. Often, excess nutrient levels will lead to depressed DO concentrations due to increased biomass of periphyton (organisms, such as some algae, that live attached to underwater surfaces) in streams. This DO decline is associated with the respiration cycle of periphyton and may result in fish kills or the death of organisms necessary for fish survival (invertebrates) (UDEQ-DWQ, 2000d).

In a review of scientific literature, Carpenter et al. (1998), have shown that non-point sources of phosphorus has lead to eutrophic conditions for many lakes and reservoirs across the country. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of the designated beneficial uses; although the rates of recovery are variable among lakes and reservoirs. This supports the Division of Water Quality's viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels; however, that this process takes a significant amount of time (5-15 years) is of concern.

In Lake Erie, heavy loadings of phosphorus have impacted the lake severely. Monitoring and research from the 1960's has shown that depressed DO levels were responsible for large fish kills and large mats of decaying algae. Programs to reduce nutrients into the lake have resulted in a downward trend of oxygen depletion rates since monitoring began in the 1970's. The trend of oxygen depletion has lagged behind that of P reduction, but this was expected (See http://www.epa.gov/glnpo/lakeeerie/dostory).

Nurnberg (1995, 1995a, 1996, 1997) developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual total phosphorus concentrations (TP). The AF may also be used to quantify response to watershed restoration measures that makes it very useful for TMDL development. Nurnberg (1996) developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes and reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. The DWQ has calculated morphometric parameters such as surface area ($A_o$), mean depth (z), and the ratio of mean depth to surface area ($z/A_o^{0.5}$) for the concerned reservoirs in the upper Fremont River Watershed (Table 4.3). The results show that these parameters are within the range of lakes used by Nurnberg. Because of this we feel confident that Nurnberg's empirical nutrient-oxygen relationship holds true for these reservoirs. We are also convinced that prescribed BMPs will reduce external loading of nutrients to the reservoirs; resulting in reduced algae blooms and an increase in dissolved oxygen levels over time. In addition, Nurnberg rejects absolute $DO_{min}$ as a trophic state metric (e.g. see pp 442, Nurnberg (1996)) in particular for an observation that there are many oligotrophic lakes with zero DO). Nurnberg presents other variables and metrics that would predict trophic status that we are relying on besides DO alone. It is the compilation of all these indicators that will allow for complete evaluation of the lake health and achievement of water quality standards.

Utah's approach to treat the sources of nutrients and reduce or eliminate nutrient loads to impaired water bodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low DO). However, if after treatment of sources and a sufficient period for recovery (10+ years), if dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. However, in-lake treatments should not be implemented without control of nutrient sources within the watershed. This approach is also supported by Carpenter et al. (1998).

**Table 4.3**
**Morphometry Data for Fremont River Watershed Reservoirs**

| Lake | Nurnberg Range | Johnson Valley | Forsyth | Mill Meadow |
|---|---|---|---|---|
| z (m) | 1.8 - 200 | 4.3 | 8 | 10.2 |
| $A_o$ (ha) | 5 – 8.2 x $10^6$ | 285 | 64 | 63 |
| z / $A_o^{0.5}$ | 0.14 – 48.1 | 2.55 | 10 | 1.28 |

### 4.1.1 Applicable Water Quality Standards

DWQ lists any waterbody assessed as ‘partially supporting’ or ‘not supporting’ its beneficial uses on the 303(d) list with the exception of those waterbodies for which a TMDL study has already been completed and approved by the EPA. As indicated in Section 4.0 of this document, the designated beneficial uses for Johnson Valley, Forsyth, and Mill Meadow Reservoirs includes 1C, 2B, 3A, and 4. According to DWQ's assessment of these waterbodies, all three reservoirs are not meeting the water quality standards to support beneficial use 3A. Therefore, this explanation of the applicable water quality standards will focus on the standards for beneficial use 3A.

Throughout the State of Utah, essentially the same criteria are used to assess lakes and reservoirs, and rivers/streams for beneficial uses 3A (cold water game fish), 3B (warm water game fish), and 3C (warm water nongame fish). The applicable numeric and narrative criteria for assessing beneficial use support for fisheries in all of the above mentioned waterbody types is presented in the following tables. In addition, supplementary criteria are applied to assess conventional parameters in lakes and reservoirs including pH, DO, and temperature. These additional criteria are described in the narrative following the tables.

The total phosphorus method for identifying waterbodies as “needing further study” is not applied to lakes and reservoirs. The State of Utah exercises discretion in using data or information that go beyond the criteria listed in the following tables and/or narrative for listing waterbodies and can include other types of information and best professional judgment. Table 4.4 and Table 4.5 include the criteria used for determining beneficial use support of waterbodies.

**Table 4.4**
**Numeric Criteria for Aquatic Life**

| Parameter | Aquatic Wildlife 3A |
|---|---|
| Minimum Dissolved Oxygen (mg/L) [1] | |
| 30 Day Average | 6.5 |
| 7 Day Average | 9.5 / 5.0 |
| 1 Day Average | 8.0 / 4.0 |
| Maximum Temperature (C) | 20 |
| Maximum Temperature Change (C) | 2 |
| pH (range) | 6.5 - 9.0 |
| Turbidity Increase (NTU) | 10 |
| Nitrate as N (mg/L) | 4 |
| Total Phosphorus as P (mg/L) [2] [3] | 0.05 |
| Total Suspended Solids (mg/L) [3] | 35 |

[1] These limits are not applicable to lower water levels in deep impoundments. First number in column is for when early life stages are present, second number is for when all other life stages are present. [2] Total Phosphorus as P (mg/l) limit for lakes and reservoirs shall be 0.025. [3] Indicators of pollution.

**Table 4.5**
**Narrative Criteria for Assessing Aquatic Life Beneficial Support Classes 3A, 3B, 3C, 3D in Streams**

| Degree of Use Support | Conventional Parameters (pH, DO, temperature) | Toxic Parameters (priority pollutants, chlorine, and ammonia) |
|---|---|---|
| Full | For any one pollutant, no more than one violation of criterion or criterion was not exceeded in < 10% of the samples if there were two or more Exceedences | For any one pollutant, no more than one violation of acute criteria |
| Partial | For any one pollutant, criterion was exceeded two times, and criterion was exceeded in more than 10%, but not more than 25% of the samples | For any one pollutant, two or more violations of the acute criterion, but violations occurred in ≤ 10% of the Samples |
| Non | For any one pollutant, criterion was exceeded two times, and criterion was exceeded in more than 25 % of the Samples | For any one pollutant, two or more violations of the acute criterion, and violations occurred in more than 10% of the samples |

(Source: UDEQ-DWQ, 2000b)

For total phosphorus, the following criteria were used to identify waters as "needing further evaluation". If the pollution indicator value for TP (0.05 mg/L) was exceeded in more than 10% of the samples, and the mean of all samples was > 0.06 mg/L the waterbody was identified as "needing further evaluation or study" before a decision was made to list a stream waterbody on the 303(d) list. Additional evaluations including benthic macroinvertabrate data, diurnal DO data, and habitat quality evaluations can be used to determine beneficial use support (UDEQ-DWQ, 2000b).

Initial evaluation targets were developed to conduct a preliminary assessment of impaired waters. These initial evaluation targets were collected from the following sources:

- Utah Administrative Code (UAC) Rule R317-2 - Standards of Quality for Waters of the State (State of Utah, 2000, UAC R317-2);
- Utah's Year 2000 303(d) List of Waters (UDEQ-DWQ, 2000b);
- Utah Water Quality Assessment Report to Congress 2000 (305(b) Report) (UDEQ-DWQ, 2000e); or
- An interpretation of the standards where no numeric criteria are provided.

The evaluation targets include numeric criteria for DO, TP, Trophic State Index (TSI), TDS, temperature, and pH as indicated in Table 4.6.

**Table 4.6**
**Initial Evaluation Criteria**

| Parameter | Lakes/Reservoirs | Rivers/Streams |
|---|---|---|
| DO | 4.0 mg/L[1] | 6.5 mg/L[2] |
| TP [1] | 0.025 mg/L | 0.05 mg/L |
| TSI[3] | >50 | not applicable |
| TDS[2] | not applicable | 1,200 mg/L |
| Temperature[2] | 20 C | 20 C |
| pH[2] | 6.5 - 9.0 | 6.5 - 9.0 |

1. Utah's Year 2000 303(d) List of Waters (UDEQ-DWQ, 2000b)
2. UAC R317-2. Standards of Quality for Waters of the State
3. Utah Water Quality Assessment Report to Congress 2000 (305(b) Report) (UDEQ-DWQ, 2000e)

The interpretation of full, partial, and non-support are discussed in Section II of the " Methodology for Developing the 303(d) List". Part B of Section II describes the "Criteria for Listing Waterbodies on the 303(d) List" and Part C discusses "Additional Criteria for Listing Lakes and Reservoirs". These criteria are summarized below to develop a rule set that were applied to the evaluation of support status for the Fremont River watershed.

<u>Lakes and Reservoirs Listing Criteria</u>

The 303(d) listing criteria for reservoirs include the evaluation of DO, TP, TSI, pH, temperature, fish kills and algal dominance. The Fremont basin reservoirs are not listed for pH or temperature, and the data summaries (**Appendix D**) support that decision. Therefore, this summary focuses only on the listing criteria as it applies to DO, TP, TSI, and other biological evidence of impairment.

To determine the beneficial use support for aquatic life (Class 3A) in listing lakes and reservoirs, DWQ applies the following additional criteria. An initial support status is determined for three conventional parameters (DO, temperature, and pH) according to the national 303(b) criteria. The data for these three parameters are analyzed for the entire water column and a percent of the readings in violation of State standard is determined. However, State standards account for the fact that anoxic or low DO conditions may exist in the bottom of deep reservoirs and therefore, an exceedence of the lower 25% of the water column is allowed for DO concentrations against the State standard. Current 303(d) guidelines indicate that for any one pollutant or stressor, when the criteria were exceeded in less than or equal to 10 percent of the measurements, a designation of fully supporting was assigned. When the criteria were exceeded in greater than 10, but less than 25 percent of the measurements, a designation of partially supporting was assigned. When the criteria were exceeded in greater than 25 percent of the measurements, a designation of non-supporting was assigned. Exceedence percentages used to assess support status are those identified in the 303(d) guidelines with the exception of DO.

Exceedence criteria for DO in lakes and reservoirs are defined using the 1-day minimum DO concentration of 4.0 mg/L (UDEQ-DWQ, 2000a). Evaluation of profile data is specific to each sampling period and is not averaged over a seasonal or annual basis. When DO is greater than 4.0 mg/L for greater than 50% of the water column depth, a fully supporting status is assigned; partial support when 25-50% is greater than 4.0 mg/L, and non-support when less than 25% of the water column is greater than 4.0 mg/L. Unless a reservoir is classified as fully supporting (50% of total water column is above the 4.0 mg/L DO standard) it meets the criteria for listing. Reservoir DO profiles provided by DWQ (**Appendix E**) were used to evaluate the support status according to the criteria described above.

For Class 3 (aquatic life) lakes and reservoirs the TP pollution indicator is 0.025 mg/L. The general listing rule in the current 303(d) guidelines indicate that less than 10% exceedance is fully supporting, 10% to 25% partially supporting, and greater than 25% is non-supporting. It should be noted that the process for listing lakes for TP is based upon TSI rankings. Other evidence of impairment includes an evaluation of Winter DO with reported fish kills, and presence of blue green algae in the phytoplankton community. Additionally, trends in the data are evaluated to account for hydrology and seasonality in reservoirs.

A final determination to list the waterbody is made through an evaluation of the historical beneficial use support trends since 1989. It is necessary to incorporate such an evaluation to incorporate the hydrology and seasonality associated with lakes and reservoirs. In general, if a waterbody exhibits a beneficial use that is consistently partially supporting or not supporting, DWQ will place it on the 303(d) list. However, if a waterbody exhibits a mixture of partially and fully supporting conditions over a period of time, DWQ will not list the waterbody, but continue its evaluation (UDEQ-DWQ, 2000b).

Rivers and Streams 303(d) Listing Criteria

The listing criteria applicable to the Fremont River Watershed streams and rivers are included in Tables 3 and 4 of the 303(d) list of waters document (UDEQ-DWQ, 2000b). We applied the 30 day average DO criteria for Class 3A waters (6.5 mg/L) to the rivers/streams data for this screening exercise.

For DO in streams and rivers, the general listing rule applies: less than 10% exceedence is interpreted as full support, 10% to 25% partial support, and greater than 25% exceedence is interpreted as non-support. This was applied to the 6.5 mg/L criterion.

For TP, the following criteria were used to identify waters as "needing further evaluation": if the TP exceeded 0.05 mg/L in more than 10% of the samples, and the mean of all samples was greater than 0.06 mg/L the waterbody was identified as 'needing further evaluation or study'. Additional information that were considered includes: benthic macroinvertebrate data, diurnal DO, habitat quality evaluations, and fisheries data.

### 4.1.2 Reservoir Water Quality Assessment

The initial data evaluation targets and listing criteria presented in Section 4.1.1 were applied to the water quality data for the Fremont River watershed. An evaluation of the water quality data for the reservoirs of concern (and UM Creek) in the Fremont River watershed is presented in this section. An evaluation of the water quality data for the upper and lower Fremont River is presented in Sections 4.2 and 4.3, respectively.

Three reservoirs of concern (Johnson Valley, Mill Meadow, and Forsyth) are all located in the upper reaches of the Fremont River drainage. Johnson Valley receives inflow from Lake Creek, outflow of Fish Lake, and Sevenmile Creek. Forsyth Reservoir receives inflow from UM and Tidwell Creeks. Mill Meadow Reservoir receives the outflows from both Forsyth and Johnson Valley Reservoir. **Map 9** identifies the locations of potential point and nonpoint sources for the parameters of concern in the three impaired reservoirs and UM Creek, with livestock grazing contributing areas delineated.

STORET water quality data from all reservoirs begins in the late 1970s and early 1980s and has continued to be collected through the present time. For the purposes of developing the TMDLs, the 1997 and forward data were used to evaluate reservoir quality. Data from this period were collected primarily during a DWQ intensive survey. Samples collected during the DWQ intensive survey were collected every five years and last completed in 1998. The majority of the reservoir data were collected between late May and early September. During this part of the year, the water column is generally thermally and chemically stratified. As with all temperate latitude lakes and reservoirs, nutrients are relatively low in the surface waters due to fixation by biological activity while the bottom waters become enriched in nutrients due to sinking and remineralization of the biological material. For this reason, caution must be exercised when applying uniform numeric water quality standards to a non-homogenous water column.

Eutrophic reservoirs tend to accumulate large amounts of organic matter at the bottom where DO is consumed by bacteria that decompose the organic matter. Many lakes and reservoirs with otherwise very good water quality have low to non-existent DO near the bottom. For this reason, the Utah water quality standards specifically state that DO limits are not applicable to lower water levels in deep impoundments. Therefore, an allowance for depletions in the lower 25% of a reservoir is acceptable.

The listing as a 303(d) water for these reservoirs therefore should be based on the biological effect of nutrients in producing excessive phytoplankton (or aquatic macrophytes), and their effect on DO. The Trophic State Index (TSI) is also used by the State of Utah. The trophic status for lake and reservoirs is determined using Carlson's TSI values (secchi depth, chlorophyll-a and TP). If the TSI is greater than 50, the State of Utah considers the lake or reservoir to be eutrophic, and hypereutrophic if the TSI is greater than 70.

The identification as an impaired water depends on a weight of evidence approach, namely: 1) the evidence of DO sags; 2) the nutrient concentrations; and 3) the production of excessive algal growth. Additional anecdotal information such as evidence of fish kills, odor, appearance, or interference with recreational activities would support the identification.

DWQ calculations of DO concentrations in the entire reservoir water column less than 4.0 mg/L are listed in Table 4.7A. These calculations show that the DO in reservoir waters was less than 4.0 mg/L between 0 and 40% of the time (4.7A). TP exceeds the pollution indicator of 0.025 mg/L in the Fremont reservoirs 50 - 100% of the time (Table 4.7B), and TSI trends indicate that all Fremont reservoirs are eutrophic to hypertrophic (Table 4.7C).

Johnson Valley, Mill Meadow, and Forsyth Reservoirs are listed for TP (UDEQ-DWQ, 2000b) and the summary statistics (Table 4.7B) support that decision. In addition, Forsyth Reservoir is listed for DO. DWQ calculations from the most recent DO profiles show a 25% exceedence for the entire water column of Johnson Valley Reservoir, a 37.5% exceedence for the entire water column of Forsyth Reservoir, and no DO exceedence for Mill Meadow Reservoir. These exceedence calculations are based on DO results for the entire water, and indicate a fully supportive status. However, impairment of downstream waters in UM Creek supports the listing for dissolved oxygen in Forsyth Reservoir.

**Table 4.7**
**Summary Statistics for Listed Reservoirs in the Fremont River Watershed**

**A. Dissolved Oxygen – Percent Exceedence of Criteria**

| Date | Johnson Valley Reservoir | Forsyth Reservoir | Mill Meadow Reservoir |
|---|---|---|---|
| 06/24/97 | 0% | N/A | 9.5% |
| 08/19/97 | 40% | N/A | 24% |
| 07/08/98 | N/A | 37.5% | N/A |
| 06/29/99 | 25% | N/A | 0% |

Note: DWQ Calculations for DO less than 4.0 mg/L for the entire water column.

**B. Total Phosphorus (mg/L)**

| Statistic | Johnson Valley Reservoir (595610) | Forsyth Reservoir (595595) | Mill Meadow Reservoir Midlake (595589) | Mill Meadow Reservoir Above Dam (595588) |
|---|---|---|---|---|
| Number | 6 | 4 | 4 | 8 |
| Mean | 0.050 | 0.052 | 0.030 | 0.039 |
| Median | 0.041 | 0.052 | 0.034 | 0.034 |
| Min | 0.025 | 0.039 | 0.010 | 0.024 |
| 1st Quartile | 0.033 | 0.039 | 0.021 | 0.027 |
| 3rd Quartile | 0.060 | 0.065 | 0.043 | 0.047 |
| % Exceedence | 83 % | 100 % | 50% | 75% |

**C. TSI Evaluation**

| Date | Johnson Valley Reservoir | Forsyth Reservoir | Mill Meadow Reservoir |
|---|---|---|---|
| 1989-90 | 63.77 | 61.88 | 67.06 |
| 1991-92 | 68.04 | 52.76 | 69.15 |
| 1993-94 | 65.18 | 56.87 | 55.75 |
| 1995-96 | 63.63 | 49.00 | 59.74 |
| 1998-99 | 58.38 | 55.33 | 50.48 |

The three reservoirs in the watershed are considered eutrophic, with TSI values greater than 50. In the State of Utah trophic status for lakes and reservoirs is determined utilizing Carlson's TSI values. Trophic status has been determined using this methodology since the initial classification and inventory project in 1981-82. To establish trends, these TSI values are used in comparison (UDEQ-DWQ, 2000c).

The water quality assessment for UM Creek was based on water quality data collected at STORET Site 595592. UM Creek is listed on Utah's Year 2000 303(d) list for DO. Descriptive statistics for this station are listed in **Appendix D** for total phosphorus, dissolved nitrites plus nitrates, and DO. Summary statistics are listed in Table 4.8 below. Nutrients are within the range of concentrations generally considered eutrophic at this station. Total phosphorus exceeds the 0.05 mg/L criteria 63% of the time, with median concentration of 0.069 mg/L. Nitrates are below the screening criteria of 0.3 mg/L in the UM Creek station. So, at this level of analysis it appears that nutrients are sufficiently high to stimulate algal growth and cause possible negative problems associated with eutrophication.

Instantaneous DO as contained in the STORET database is not decisive for interpreting water quality criteria exceedences. Diurnal DO data are necessary to determine impairment in streams. Two of the 13 samples collected for DO are below the criteria of 6.5 mg/L, indicating the potential for depressed DO, and therefore, the need for diurnal DO monitoring.

**Table 4.8**
**Summary Statistics for UM Creek above Mill Meadow Reservoir**
**STORET ID #595592**

| Statistic | Total Phosphorus (mg/L) | Dissolved Oxygen (mg/L) |
|---|---|---|
| Number | 8 | 13 |
| Mean | 0.104 | 8.3 |
| Median | 0.069 | 8.1 |
| Min | 0.044 | 5.6 |
| 1st Quartile | 0.047 | 7.4 |
| 3rd Quartile | 0.164 | 9.2 |
| % Exceedence | 63% | 15% |

### 4.1.3 Nonpoint Sources

Nonpoint sources include sources that reach a waterbody by way of surface runoff or subsurface flow to groundwater. Land uses in the upper watershed that may contribute to water quality degradation include grazing, logging, and recreation. In this section, nonpoint sources of nutrients and nutrient loading potential are described.

Livestock Grazing Allotments

Livestock grazing allotments are designated within Fishlake National Forest by the U.S. Forest Service (USFS). Grazing patterns have the potential to accelerate erosion rates and nutrient loads to surface water. When surface water runoff occurs in grazing areas, contaminates, such as nutrients and bacteria, can wash directly into receiving waters or these contaminates can sorb to sediments and then be transported to surface waters during storm or snowmelt events (USEPA, 1999c; Doran et al, 1981). A transport mechanism for nutrients and bacteria to enter a waterbody is not necessary if grazing occurs directly in the waterbody. Nutrient loading from grazing in the watershed was estimated from available data and literature values (see Source Load Calculations below).

Table 4.9 lists the allotments for grazing in the Fishlake National Forest portion of the basin. These allotments are located within the USFS area shown on **Map 9.** Only fractions of the Daniels, Last Chance, Solomon, and Thousand Lake allotments are within the Fremont River watershed boundaries.

**Table 4.9**
**Grazing Allotments – USFS Fishlake National Forest**

| Allotment | # of Permitted Animals | Acreage | Permitted Dates |
|---|---|---|---|
| Daniels | 400 Cow/Calf Pair | 14,157 | 7/1 – 9/30 |
| Hancock | 1300 Sheep | 20,728 | 7/15 – 10/15 |
| Sevenmile | 1129 Cow/Calf Pair | 32,114 | 5/11 – 10/16 |
| UM | 819 Cow/Calf Pair | 39,500 | 6/1 – 10/16 |
| Tidwell | 670 Cow/Calf Pair | 13,873 | 6/1 – 10/31 |
| Last Chance | 483 Cow/Calf Pair | 36,091 | 6/1 – 10/20 |
| Solomon | 408 Cow/Calf Pair | 35,299 | 6/1 – 10/31 |
| Thousand Lake | 406 Cow/Calf Pair | 70,982 | 6/1 – 10/15 |

Source: USFS Fishlake National Forest

Logging

Historic logging has been identified as a potential source of nonpoint source pollution to Forsyth Reservoir (Judd, 1997). Depending upon the logging practices employed and the magnitude of associated road building, there is a potential for accelerating runoff and erosion rates and therefore transporting sediments to receiving waters. The logging sales listed in Table 4.10 have occurred during the past five years (USFS – Fishlake National Forest). Several other sales have occurred in the area during the 1980s and early 1990s and are not listed, as it was assumed that new growth has reduced the runoff rates and potential for loading from these sources.

**Table 4.10**
**Logging Sales – USFS Fishlake National Forest**

| Year | Volume | Slope | Location | Acres | Type |
|---|---|---|---|---|---|
| 1995-Current | 615 MBF | $\leq$ 15% | 1000 Lake Mountain | 40 | Spruce |
| 1997-1998 | 500,000 MBF | $\leq$ 20% | Hens Peak - burn area | 200 | Spruce |
| 1998 | 2,069 CCF | $\leq$ 15% | Sevenmile Drainage | 197 | Spruce |
| 1999 | 1,231 CCF | $\leq$ 15% | Briggs Hollow | 72 | Aspen |

MBF = Thousand Board Feet
CCF = Hundred Cubic Feet
Source: USFS correspondence 10/12/00

All of the 1000 Lake Mountain areas drain to the east and away from impaired waterbodies, and the other logging sales listed in Table 4.10 are located a significant distance from the Fremont River. Therefore, logging is not considered a significant nonpoint source of pollution.

Prescribed fires on the Tidwell slopes have the potential to increase runoff and soil erosion. The goals of these burns are to rejuvenate decadent sagebrush, increase forage for livestock and wildlife and reduce conifer encroachment into aspen stands. The burns are conducted either in late Fall or early Spring to minimize damage to grass root crowns. Depending upon the timing and intensity of rainfall there is potential for increased runoff and soil erosion originating from treated areas; however, in the long-term prescribed fire has been shown to decrease runoff and erosion through the rejuvenation of native vegetation. The potential short-term impacts of prescribed burns can be minimized by limiting their extent away from steep slopes and riparian areas.

### Recreation

Litter and wastes from recreation have been identified as a potential source of nonpoint pollution to all three of the impaired reservoirs within the watershed (Judd, 1997). Johnson Valley Reservoir is used heavily for fishing and boating, and offers limited facilities for persons who utilize the reservoir for recreational activities. Forsyth and Mill Meadow Reservoirs offer fishing, boating, and camping. Limited recreation facilities are provided at Mill Meadow including vault toilets and campsites. Vault toilets are also provided at Forsyth Reservoir.

Another recreational activity that is increasing within the upper watershed and has the potential to cause significant resource damage is the use of All Terrain Vehicles (ATVs). The majority of ATV users ride responsibly by staying on the trails and primitive roads provided for their use, however some take advantage of the unprecedented access these vehicles provide. Areas where ATV use has caused problems include sensitive areas such as steep slopes that are prone to erosion and wet meadow and riparian areas where the tracks left behind can remain indefinitely providing a conduit for runoff that often leads to the formation of gullies.

### Loading Calculations

Limited data exist for the Fremont River watershed and therefore the suite of modeling approaches applicable to the watershed is limited. MSE evaluated a variety of methods for estimating nutrient and TDS loads to waterbodies and river segments within the watershed and determined that a simple spreadsheet approach, described below, requiring minimal input data would be the most appropriate. This approach is technically sound in using scientifically based principles and is in line with State/EPA expectations for a phased approach to a TMDL. However, it should be kept in mind that any modeling approach provides an estimate, useful for relative ranking of pollution sources and evaluation of pollution control alternatives. This simple modeling approach should not be expected to be a substitute for quantitatively measured loading from watershed sources.

Nutrient loads from nonpoint sources were estimated using adjusted Unit Area Loads (UALs) x area. UALs represent the average amount of a specific land use related pollutant that enters receiving waters. For a first approximation, MSE used UALs to estimate TP loading to the reservoirs from rangeland in the upper portion of the watershed. Similarly, in Rabbit Valley, MSE used UALs to estimate TP loading to the Fremont River from pastures, croplands, dairies, and feedlots in Rabbit Valley.

Loading to Tributaries and Reservoirs in the Upper Portion of the Watershed

A spreadsheet was used to estimate the phosphorus loading from grazing to Johnson Valley, Forsyth, and Mill Meadow Reservoirs. To estimate a UAL that represents phosphorus inputs from grazing, several variables were considered including the:

- The boundaries of the grazing allotments;
- Land area of the allotments, the type of livestock, and the number of grazing days on the allotment;
- Number of animals per allotment;
- Amount of manure produced by each type of animal while present on the allotment;
- Amount of phosphorus contained in the manure produced during the grazing season on the allotment; and
- Contributing source areas.

The methods used to estimate each of these variables are discussed below.

The USFS Fishlake National Forest - Loa Ranger District provided the information summarized in Table 4.11 for the grazing allotments through which the reservoir tributaries flow and/or in which the reservoirs are located. These areas exclude surface areas of lakes and reservoirs.

**Table 4.11**
**Summary of the Grazing Allotments - Reservoirs**

| Allotment | Land Area | Cow/Calf Pairs | Sheep | Days on Allotment |
|---|---|---|---|---|
| Sevenmile | 53 sq mi. | 1,129 | 0 | 158 days<br>(May 11 – October 16) |
| Hancock | 33 sq mi. | 0 | 1,300 | 90 days<br>(July 15 – October 15) |
| UM | 67 sq mi. | 819 | 0 | 108 days<br>(June 1 – October 16) |
| Tidwell | 31 sq mi. | 670 | 0 | 123 days<br>(June 1 – October 31) |

Table 4.12 lists the tributaries and the reservoirs (nonpoint source receiving waters) in the upper portion of the watershed, the name of the allotment where the waterbodies are located, the type of livestock present on each allotment during the grazing season, and the area adjacent to each waterbody that is assumed to contribute nonpoint source loads to the tributaries and reservoirs. These contributing source areas were assumed to only include the land areas directly adjacent to reservoirs and tributaries. More specifically, contributing areas were assumed to include only 0.4 km (0.25 mi) on either side of receiving waters. Others have used this distance in calculating nutrient loads (Walker et al., 1989). In the Fremont River watershed model, the size of the contributing area can be adjusted as appropriate.

**Table 4.12**
**Receiving Waters, Allotments, Animal Types, and Contributing Areas**

| Receiving Waters | Allotment | Animal Type | Contributing Area (sq mi.) |
|---|---|---|---|
| Tasha Creek | Hancock | Sheep | 2.1 |
| Sevenmile Creek* | Sevenmile | Cow/Calf Pairs | 2.9 |
| Johnson Valley Reservoir | Sevenmile | Cow/Calf Pairs | 1.3 |
| Upper UM Creek | UM | Cow/Calf Pairs | 8.6 |
| East Tidwell Canyon | Tidwell | Cow/Calf Pairs | 3.3 |
| Fremont River between Johnson Valley Reservoir & Mill Meadow Reservoir | UM | Cow/Calf Pairs | 3.2 |
| Lower UM Creek between Forsyth & Mill Meadow Reservoir | UM | Cow/Calf Pairs | 0.7 |
| Forsyth Reservoir | UM | Cow/Calf Pairs | 1.0 |
| Mill Meadow Reservoir | UM | Cow/Calf Pairs | 1.1 |

*Has riparian exclosures on approximately 2.5 miles that have been incorporated.

To estimate the number of livestock per sq mi., it was assumed that the livestock are evenly distributed across the land within each allotment. Using the information provided in Table 4.11 the distribution of animals was estimated (Table 4.13). However, the animals usually spend a higher percentage of their time along streams, and this assumption may be refined via the literature.

**Table 4.13**
**Livestock Distribution**

| Allotment | Land Area | Cow/Calf Pairs per sq mi. | Sheep per sq mi. |
|---|---|---|---|
| Sevenmile | 53 sq mi. | 21.3 | 0 |
| Hancock | 33 sq mi. | 0 | 39.4 |
| UM | 67 sq mi. | 12.2 | 0 |
| Tidwell | 31 sq mi. | 21.6 | 0 |

To estimate the amount of manure produced by the livestock, and the resulting phosphorus produced by each animal, phosphorus loading coefficients for animal waste were derived from the Natural Resources Conservation Service (NRCS) Animal Waste Management Field Handbook, Ch. 4 (USDA - NRCS, 1992). Table 4.14 provides a summary of the total of manure produced by each type of animal and the corresponding amount of phosphorus produced.

**Table 4.14**
**Animal Phosphorus Production**

| Animal Type | Equivalent Animal Unit | Average Weight per Animal (lbs) | lbs of Phosphorus Produced (per day/1000#) |
|---|---|---|---|
| Cow | 1 | 1000 | 0.11 |
| Calf | 0.6 | 600 | 0.09 |
| Sheep | 0.2 | 200 | 0.07 |

* Values derived from NRCS, 1992.

The information provided in Table 4.11, Table 4.12, Table 4.13, and Table 4.14 were used to estimate the phosphorus UAL to the tributaries and reservoirs due to grazing.

The basic UAL equation is expressed as:

UAL = total phosphorus (P) produced by each animal x number of animals per area.

For example:

UAL for Sheep within the Hancock Allotment is:

0.07 lbs P / 5 sheep per day x 39.4 sheep per sq mi.

= 0.55 lb P / sq mi. per day.

Similarly,

The UAL for Cattle within the Sevenmile Allotment is:

(0.11 lbs P/1 cow per day + 0.09 lbs P/1.67 calf per day)
x 21.3 cow/calf pairs per sq mi.

= 3.49 lbs P / sq mi. per day.

Once the UAL was determined for each allotment, the estimates were adjusted to consider P remaining after mineralization. Mineralization is the sequestration of bioavailable P into unavailable mineral form. To account for mineralization, the USDA – NRCS Animal Manure Nutrient Balance spreadsheet was consulted (Goodrich, 2000 manure24.xls). Accordingly, the estimated UALs were multiplied by 79% (the fraction of P available after mineralization) to arrive at the amount of P available for delivery to surface waters. This adjusted UAL was then used to determine the loads from each delineated source area. Table 4.15 includes the estimated UALs and adjusted UALs for each grazing allotment.

**Table 4.15**
**UAL and Adjusted UAL Calculations**

| Allotment | Cow/Calf Pairs per sq mi. | Sheep per sq mi. | lb of P Produced (per day) | UAL (lb P/ sq mi. /day) | Adjusted UAL for P Remaining after Mineralization (lb P/ sq mi./day) |
|---|---|---|---|---|---|
| Sevenmile | 21.3 | 0 | Cow = 0.11/1 cow<br>Calf = 0.09/1.67 calf | 3.5 | **2.8** |
| Hancock | 0 | 39.4 | Sheep = 0.07/5 sheep | 0.6 | **0.4** |
| UM | 12.2 | 0 | Cow = 0.11/1 cow<br>Calf = 0.09/1.67 calf | 2.0 | **1.6** |
| Tidwell | 21.6 | 0 | Cow = 0.11/1 cow<br>Calf = 0.09/1.67 calf | 3.5 | **2.8** |

The phosphorus load was then calculated by multiplying the contributing area x adjusted UAL x the number of days on the allotment per year. Table 4.16 summarizes the estimated animal manure nutrient production for source areas assumed to be contributing phosphorus loads to receiving waters.

**Table 4.16**
**Loads from Delineated Source Areas to Receiving Waters**

| Allotment | Receiving Water | Contributing Area (sq mi.) | Adjusted UAL (lbs P/ sq mi./day) | Days on Allotment (per year) | P Load (lb/yr) |
|---|---|---|---|---|---|
| UM | Upper UM Creek | 8.56 | 1.6 | 108 | 1,460 |
| UM | Fremont River between Johnson Valley & Mill Meadow Reservoir | 3.19 | 1.6 | 108 | 544 |
| UM | Lower UM Creek between Forsyth & Mill Meadow Reservoirs | 0.69 | 1.6 | 108 | 118 |
| UM | Forsyth Reservoir | 0.95 | 1.6 | 108 | 162 |
| UM | Mill Meadow Reservoir | 1.10 | 1.6 | 108 | 188 |
| Hancock | Tasha Creek | 2.07 | 0.4 | 90 | 81 |
| Sevenmile | Sevenmile Creek | 2.9 | 2.8 | 158 | 1,264 |
| Sevenmile | Johnson Valley Reservoir | 1.31 | 2.8 | 158 | 571 |
| Tidwell | East Tidwell Canyon | 3.27 | 2.8 | 123 | 1,125 |

Next, the hydrology of the watershed was considered to estimate the total phosphorus load entering each of the three impaired reservoirs in the upper Fremont River watershed. Johnson Valley Reservoir receives inflow and/or runoff from the following nonpoint source impacted sources: Tasha Creek, Sevenmile Creek, and the land area adjacent to the reservoir. Forsyth Reservoir receives inflow and/or runoff from the upper segment of UM Creek, East Tidwell Canyon, and the land area adjacent to the reservoir. Mill Meadow is the lowest reservoir in the system and receives inflow from Johnson Valley and Forsyth Reservoirs via a segment of the Fremont River and the lower portion of UM Creek, respectively. The estimated total phosphorus loads entering each of the impaired reservoirs annually are included in Table 4.17.

**Table 4.17**
**Unit Area Loads to Impaired Reservoirs**

| Receiving Water | P Load (lb/yr) |
|---|---|
| **Johnson Valley Reservoir** | |
| Tasha Creek | 81 |
| Sevenmile Creek | 1264 |
| Johnson Valley Reservoir | 571 |
| **Total Load to Johnson Valley Reservoir** | **1,916** |
| **Forsyth Reservoir** | |
| Upper UM Creek | 1,460 |
| East Tidwell Canyon | 1,125 |
| Forsyth Reservoir | 162 |
| **Total Load to Forsyth Reservoir** | **2,747** |
| **Mill Meadow Reservoir** | |
| Fremont River between Johnson Valley and Mill Meadow Reservoirs | 544 |
| Lower UM Creek between Forsyth & Mill Meadow Reservoirs | 118 |
| Mill Meadow Reservoir | 188 |
| **Total Load to Mill Meadow Reservoir** | **850** |

Assumptions and Uncertainties in Estimating Phosphorus Loading to Reservoirs:

1. Potential background TP contributions from local soils and geology were not considered in this first estimation. The primary factor in determining the potential for local soils to contribute TP into the system is riparian condition. Riparian areas in poor condition contribute higher sediment and nutrient loads downstream than properly functioning areas. Evidence of poor riparian condition includes broken down streambanks, bank shearing and the absence of willows that hold streambanks together. There are several riparian areas, particularly within the flat meadow areas at the headwaters of UM Creek that have been identified as at risk (Whelan, 2002). A more comprehensive Integrated Riparian Evaluation – Level 2 is scheduled for completion in the summer of 2002. We anticipate that identified problem areas will be restored as additional efforts and funding are put in place to address them.
2. Due to the limited data sets, the bioavailable fraction of total phosphorus was not considered.

Tributary Phosphorus Loading

In addition to the Unit Area Load (UAL) analysis, the in-stream concentrations of P tributary to the reservoirs were analyzed. There are seven water quality monitoring stations located on these tributaries to the upper Fremont River Watershed reservoirs. Phosphorus loading calculations for each reservoir are presented in Table 4.18.

**Table 4.18**
**Phosphorus Loading To Reservoirs From Tributaries**

| STORET | Description | Tributary To: | Year | No. Flow Samples | No. TP Samples | Average Flow (cfs) | Average TP (mg/L) | P Load (lbs/yr) | Average Annual Load in Tributary (lbs/yr) | Average Annual Load to Reservoir (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 595615 | Sevenmile Creek above Johnson Valley Reservoir | Johnson Valley Reservoir | 1999 | 2 | 2 | 9 | 0.036 | 639 | 639 | |
| 495492 | Lake Creek below Fish Lake 1.4 Mile S. Frying Pan Campground | Johnson Valley Reservoir | 1999 | 2 | 2 | 1.1 | 0.041 | 89 | 89 | **728** |
| 595599 | UM Creek above Forsyth Reservoir | Forsyth Reservoir | | 0 | 1 | | | | | |
| 595600 | UM Creek at Forest service Road 015 | Forsyth Reservoir | 1999 | 2 | 2 | 6.7 | 0.058 | 766 | 766 | |
| 595601 | Right Fork UM Creek at Blacks Flat | Forsyth Reservoir | 1999 | 2 | 2 | 4.9 | 0.061 | 589 | 589 | **766** |
| 495455 | Fremont River above Mill Meadow Reservoir | Mill Meadow Reservoir | 1997 | 13 | 4 | 24.3 | 0.041 | 1,964 | | |
| " | " | " | 1998 | 8 | 8 | 31.5 | 0.072 | 4,470 | | |
| " | " | " | 1999 | 5 | 6 | 49.6 | 0.045 | 4,399 | 3,618 | |
| 595592 | UM Creek above Mill Meadow Reservoir | Mill Meadow Reservoir | 1997 | 5 | 2 | 22.2 | 0.139 | 6,082 | | |
| " | " | " | 1998 | 4 | 4 | 29.1 | 0.076 | 4,359 | | |
| " | " | " | 1999 | 2 | 2 | 18 | 0.123 | 4,364 | 4,946 | **8,564** |

The load estimated for Johnson Valley using UALs totaled 1,916 lbs/yr while the phosphorus loading from its tributaries, Sevenmile and Lake Creeks, totaled only 728 lbs/yr. The load for Forsyth Reservoir using UALs totaled 2,747 lbs/yr while the loading from its primary tributary, UM Creek, totaled only 766 lbs/yr. It must be noted that the phosphorus data for these tributary creeks consists of only two site visits in 1999. There is considerably more data on the Fremont River and UM Creek above Mill Meadow Reservoir from 1997 – 1999. Phosphorus loading from tributary inflows into Mill Meadow Reservoir totaled 8,564 lbs/yr, versus the 850 lbs/yr estimate from the UAL analysis.

Given the lack of sufficient data on inflows to Johnson Valley and Forsyth Reservoirs, loading estimates of P based on the UAL analyses is most conservative. However there is a good set of data on tributary inflows into Mill Meadow Reservoir. Therefore loading estimates for Mill Meadow Reservoir will be based upon inflow concentrations of Phosphorus.

## Best Management Practices

Potential Best Management Practices within the upper watershed will be discussed in reference to the major land uses of the area including recreation, agriculture and silviculture (timber). This discussion is not meant to include all of the possible practices that may be used to improve water quality but rather provide an introduction to the types of activities that have proven effective in other watersheds to manage water quality. The implementation of these recommended BMPs are completely voluntary and will be accomplished through an incentive-based approach in which cost-share funding and volunteer labor will be solicited.

Some of the more popular recreational uses of the upper watershed include hunting, fishing, camping and sightseeing via horseback or all terrain vehicles. The primary means of reducing the potential impacts of recreational activities on water quality is through changing the public’s behavior through education. Increased signage at road turnouts explaining the water quality goals of the watershed and how the public can assist in meeting these goals will be helpful. Another effective educational tool is working with local schools in educating students of the linkage between watershed health and water quality along with their role in maintaining and improving water quality.

Aside from education, public recreational facilities must be maintained (and added where needed) to encourage their use. The Forest Service, BLM, Park Service, and the local stakeholders all have a responsibility for maintaining and improving public facilities. There are numerous opportunities for volunteer assistance that would also encourage local stewardship.

Activities associated with hunting and fishing also have the potential to impact water quality. Specifically, cleaning fish and disposing of entrails back into the reservoir or stream should be discouraged through signage and other educational programs. Fish entrails provide a relatively small but concentrated source of nutrient loading into reservoirs and streams. Management of deer and elk for sport hunting must take into consideration the potential impacts these large animals have on water quality. Current management guidelines typically do not include water quality considerations such as the duration and concentration of animals in critical or sensitive areas such as wetlands and riparian areas. It is recommended that the Division of Wildlife Resources work together with the Watershed Steering Committee to respond in earnest to water quality concerns associated with big game management.

Road and trail management will be included here with recreational uses although they are utilized for agricultural and silvicultural purposes as well. Roads and trails can be a significant source of excess sediment depending on many factors including slope, type of construction and bed material. A particular feature of roads design that justifies re-consideration is the draining of ditchlines directly into adjacent stream channels. A comprehensive roads survey will be completed which identifies problem areas including the location of ditchline drainages along with suggestions on how to disconnect them from the stream channel. Best management practices for road construction and maintenance are contained in the manuals of the Forest Service and Utah Department of Transportation. The Uniform Building Code, Chapter 70, contains provisions for grading (UDEQ, 2000).

Livestock grazing is the only agricultural land use that occurs within the upper watershed. Best management practices for grazing generally entail modifying the foraging behavior of livestock through the use of fence and strategic placement of stock water. Cattle in particular prefer to graze in close proximity to water sources including streams and reservoirs. The key principle in grazing management for water quality is to distribute use evenly between upland and bottom areas. There are many practices and management strategies that are effective in relieving pressure on bottom areas including improvement of upland range conditions and forage availability, development of alternative watering sources and limiting access to bottom areas through fencing or herding. A key area where these practices could be applied is in the Fishlake basin above Johnson Valley Reservoir that serves as a staging area for rounding up livestock in the Fall. Presently, the equivalent of approximately 200 cows graze in the vicinity of Johnson Valley Reservoir for 2 weeks in the late summer (Hamilton, 2002). The water level of the reservoir during this time of year is typically low requiring the animals to trail below the high water line to drink. During the Winter and Spring, as water levels in the reservoir rise, animal waste deposited on the shoreline is inundated contributing nutrients into the reservoir. The potential phosphorus loading from livestock watering below the high water line during this short period of time is estimated to total approximately 308 lbs or 16% of the total P loading into Johnson Valley Reservoir during the entire grazing season.

It must be stressed that present water quality concerns regarding livestock grazing in the upper watershed are related to the location of livestock during critical periods of time such as when the reservoirs are drawn down and not the total number of livestock. The Watershed Steering Committee has expressed concerns that this Watershed Plan and TMDL could be used as justification for reducing livestock numbers. It is not the intention of this Water Quality Management Plan and TMDL to recommend stocking rates but rather to recommend best management practices that will improve their distribution. Grazing management practices, with special relevance to water quality in the upper Fremont watershed include; Fence (382), Heavy Use Area Protection (561), Prescribed Grazing (556 & 528A), Proper Woodland Grazing (530), Spring

Development (574), Trough's or Tank (614) and Use Exclusion (412). Numeric codes following practices coincide with NRCS standards and specification numbers from the NRCS Field Office Technical Guide.

Many of these same practices also apply to riparian area management, which deserves special attention due to these areas critical role in trapping sediment and nutrients providing fish and wildlife habitat. In riparian areas, where over-utilization has occurred, it is usually warranted to try and re-establish functionality through plantings of native vegetation such as willows and sedges along with changes in management to protect the plantings until they become well established. Relevant practices include Riparian Herbaceous Cover (390), Riparian Forest Buffer (391A), and Tree/Shrub Establishment (612).

Best management practices for silvicultural activities (timber harvest) are well documented in Forest Service manuals and in the Nonpoint Source Management Plan Silviculture Activities July 1, 1998 addendum. The primary water quality concerns surrounding silvicultural activities include proper road construction and maintenance and erosion control measures such as minimizing skid trails and reseeding surface disturbances.

#### 4.1.4 Point Sources

There are no point sources that affect the water quality of the reservoirs or tributaries in Fishlake National Forest of the upper Fremont River watershed.

#### 4.1.5 Water Quality Goals and Targets

The water quality goals for Johnson Valley, Forsyth and Mill Meadow Reservoirs are to reduce nutrient loading into the reservoirs (less than 0.05 mg/L total phosphorus in tributary inflows and 0.025 mg/L in-lake concentrations), shift algal dominance away from blue-green algae and increase dissolved oxygen concentrations (greater than 4 mg/L in the upper 75% of the water column). The primary means of reducing nutrient loading into the reservoirs are to improve riparian and upland range conditions and restrict livestock access below the high water line. The water quality goals for the upper Fremont River and tributaries including Sevenmile Creek and UM Creek are to meet water quality standards for total phosphorus (less than 0.05 mg/L), reduce sediment loading, improve riparian habitat, and increase dissolved oxygen concentrations in the lower reaches of UM Creek (greater than 6.5 mg/L). Because the impaired section of UM Creek is between Forsyth and Mill Meadow Reservoirs, it is expected that in meeting the water quality goals for Forsyth Reservoir, UM Creek will meet its water quality standards for dissolved oxygen.

It must be stressed that since this is primarily a nonpoint source TMDL load reductions may not be evident for quite some time until the system has had the opportunity to flush out the excess nutrients.

The estimated target phosphorus load for the TMDL was calculated by substituting the water quality standard of 0.025 mg/L into Table 4.18 and recalculating the P mass balance to determine the percent reduction needed to meet water quality standards. This percent reduction was then applied to the estimated P load coming from grazing allotments to obtain the necessary load reductions. The in-lake mass reductions are summarized in Table 4.19.

**Table 4.19**
**Upper Fremont River Watershed Reservoirs – In-lake Mass Reduction**

| Reservoir | Volume (L) | Water Quality Criteria (mg/L) | Mass Allocation (mg) | Mass Allocation (lbs) | Current Mass (lbs) | Mass Reduction (lbs) | Mass Reduction (%) |
|---|---|---|---|---|---|---|---|
| Johnson Valley | 1.2E+10 | 0.025 | 3.1E+08 | 680 | 1,359 | 679 | 50% |
| Forsyth | 7.1E+09 | 0.025 | 1.8E+08 | 392 | 815 | 423 | 52% |
| Mill Meadow | 6.4E+09 | 0.025 | 1.6E+08 | 356 | 555 | 199 | 36% |

**Table 4.20**
**Upper Fremont River Watershed Reservoirs - Load Allocations**

| Reservoir | Mass Reduction (%) | Current Loading (lbs) | Load Capacity (lbs) | 5% Margin of Safety (lbs) | Wasteload Allocation (lbs) | Load Allocation (lbs) |
|---|---|---|---|---|---|---|
| Johnson Valley[1] | 50 | 1,916 | 958 | 48 | 0 | 910 |
| Forsyth[1] | 52 | 2,747 | 1,319 | 66 | 0 | 1,253 |
| Mill Meadow[2] | 36 | 8,564 | 5,481 | 274 | 0 | 5,207 |

[1] Loading derived from Unit Area Load Analysis

[2] Loading derived from tributary inflow data

## 4.2 Upper Fremont River – Fremont River near Bicknell to USFS Boundary

The applicable water quality standards for this section of the Fremont River are presented in Section 4.1.1. This section discusses the available water quality data compared to those water quality standards.

### 4.2.1 Water Quality Assessment

There is one sampling location for the upper Fremont River (STORET 495438 - Fremont River Near Bicknell). Descriptive statistics for this station are listed in **Appendix D** for total phosphorus, dissolved nitrites plus nitrates, and DO. Summary statistics are included in Table 4.21 A and B. Fremont River stations downstream from the 303(d) listed water are included, for comparison to conditions measured at Bicknell. Nutrients are within the range of concentrations generally considered eutrophic at these stations. Total phosphorus concentration exceeds the 0.05 mg/L criteria in 68 to 73 % of the samples, with median concentrations ranging from 0.06 to 0.09 mg/L. DO is less than 6.5 mg/l in 13% of the samples. Nitrates exceed the screening criteria of 0.3 mg/L in 39 - 61% of the samples at the Fremont River stations. So, at this level of analysis it appears that nutrients are sufficiently high to stimulate algal growth and cause problems such as nuisance algae growth, low DO and odors associated with eutrophication.

**Table 4.21**
**Summary Statistics for Listed Steam/River Segments in the Upper Fremont River Watershed**

**A. Dissolved Oxygen (mg/L)**

| Statistic | Fremont River near Bicknell (495438 - listed segment) | Fremont River at U12 Crossing (495439) | Fremont River at Hickman Bridge (495436) |
|---|---|---|---|
| Number | 24 | 12 | 22 |
| Mean | 8.8 | 9.1 | 9.2 |
| Median | 9.3 | 9.1 | 9.1 |
| Min | 3.3 | 7.0 | 6.1 |
| 1st Quartile | 8.2 | 7.8 | 8.1 |
| 3rd Quartile | 9.9 | 9.9 | 10.2 |
| % below criteria | 13 % | 0 % | 5 % |

**B. Total Phosphorus (mg/L)**

| Statistic | Fremont River near Bicknell (495438 - listed segment) | Fremont River at U12 Crossing (495439) | Fremont River at Hickman Bridge (495436) |
|---|---|---|---|
| Number | 19 | 7 | 15 |
| Mean | 0.068 | 0.077 | 0.210 |
| Median | 0.060 | 0.073 | 0.092 |
| Min | 0.034 | 0.010 | 0.031 |
| 1st Quartile | 0.047 | 0.052 | 0.045 |
| 3rd Quartile | 0.072 | 0.100 | 0.116 |
| % Exceedence | 68 % | 71 % | 73 % |

The DO data presented in Table 4.21 were derived from instantaneous one-time readings. In the future it will be useful to obtain diurnal DO readings to better characterize the existing situation and assess progress toward meeting water quality goals. Other information such as benthic macroinvertebrates, habitat quality and fisheries data will also be helpful in assessing improvement in water quality.

### 4.2.2 Nonpoint Sources, Identification and Loading

Cropland

The majority of irrigated lands in Rabbit Valley are serviced by pressurized sprinkler systems. Sprinkler systems are much more efficient than traditional flood irrigation techniques in terms of applying just the amount of water needed by the crop while minimizing the potential for runoff of return irrigation flows entering the Fremont River. Therefore, sprinkler irrigated croplands are not considered a significant source of nonpoint pollution.

Flood irrigation methods are used on approximately 345 acres of pasturelands in the Bicknell Bottoms area, south of the town of Fremont, and along Spring Creek. The predominant soils are calcareous clay loam with particle sizes ranging from fine to coarse. The slope of the landscape ranges from 0 to 5 percent. The location of the flood-irrigated pastures is shown in **Map 9** as a small area south and adjacent to the Fremont River in the vicinity of Bicknell Bottoms. Because the area is small, flood irrigated croplands are not considered a significant source of nonpoint pollution. However, pastures directly adjacent to the Fremont River, and its tributaries, should employ Best Management Practices such as buffer strips and off-stream watering to minimize the potential for nutrient loading.

### Livestock Grazing Allotments

In the Teasdale Ranger district there is one grazing allotment that partially drains into the Fremont River. The Dark Valley Common Use allotment includes 67,800 total acres of land. The southwestern portion of the allotment drains to the Sevier River Basin and is therefore not considered for the Fremont River watershed. The portion of the allotment that drains to the Fremont River basin includes approximately 44,748 acres. The soils in this area vary with the topography and are comprised primarily of sandy loams. The slope ranges from 0 to 20 percent. The numbers of permitted animals for various date ranges throughout the year are listed in Table 4.22.

**Table 4.22**
**Grazing Allotments – USFS Teasdale Ranger District**

| Allotment | Acreage (approximate) | # of Permitted Animals | Permitted Dates |
|---|---|---|---|
| Dark Valley Common Use | 44,748 | 1,105 Cattle | 6/16 – 10/15 |
| Dark Valley Common Use | 44,748 | 1,312 Sheep | 7/1 – 7/14 & 9/1 – 9/15 |
| Dark Valley Common Use | 44,748 | 1,487 Sheep | 6/21 – 7/14 & 9/1 – 9/15 |
| Dark Valley Common Use | 44,748 | 1,393 Sheep | 6/26 – 7/14 & 9/1 – 9/3 |

Source: USFS, 2000

There are also several BLM cattle grazing allotments to the south of Rabbit Valley including Loa Winter, Bicknell Winter and Bicknell Spring. Each of these cattle allotments also contain several sheep allotments as follows: Loa Winter -Terza Flat, Long Hollow, and Deleeuw; Bicknell Winter - Flat Top and King Sheep; and Bicknell Spring - Cedar Peak, Smooth Knoll, and Hare Lake. The soils and slopes are similar to the Dark Valley Common Use allotment. The numbers of permitted animals for various date ranges are summarized in **Appendix G**.

Upon evaluation of the nutrient loading potential from these grazing allotments it was determined that they do not contribute a significant amount of nutrients to the Fremont River due to the aridity of the area (less than 8 inches per year), distance to perennial water, plant uptake potential and soil mineralization.

### Dairies

There are three dairy operations within Rabbit Valley. Two of the three dairies are currently implementing solid and liquid waste containment measures and will be developing Comprehensive Nutrient Management Plans in the near future. Due to the waste management practices in place, dairies are not considered to be a significant source of nutrient loading to the Fremont River, although it is expected that all dairy operations will participate in developing Comprehensive Nutrient Management Plans in the near future.

### Feedlots

There are approximately seventeen feedlots located in Rabbit Valley. A feedlot is defined as an area where livestock are held and vegetation is absent. Several feedlots are located immediately adjacent to the Fremont River or its tributaries. These sites were investigated and supplementary data were acquired to assess their potential for nutrient loading (see Loading Calculations below).

### Urban (stormwater and septic systems)

All of the homes in Rabbit Valley have individual septic tanks with private leach lines (WSC, 2000). Due to their low density, septic tanks are not considered a significant source of nutrient loading relative to other sources.

### Loading Calculations

The upper Fremont River segment includes the approximately 19 river miles of the Fremont River between the Mill Meadow Reservoir dam and the Fremont River monitoring station near Bicknell. Developing the TMDL for this segment entails: 1) calculating the current phosphorus load at the end of the river segment, 2) calculating the target load based on the State water quality standards, and 3) estimating the current source loads. A brief overview of the methods used to make these calculations is described below. The details of the analysis are contained in the sections that follow. In this section, “phosphorus” refers to total phosphorus in mg/L.

The current phosphorus load for the lower Fremont River segment is measured at the water quality station, Fremont River near Bicknell (STORET # 495438). USGS operates a gaging station at this site and reports daily stream flows. Average monthly flow data were combined with average seasonal P concentrations to calculate average annual loading. This method smoothes the data based on a longer time period and decreases the effect of short-term variability on the calculated load. The five-year monthly average flows at the gaging station were used to calculate current and target P loads. An average concentration of P was calculated for the irrigation season and non-irrigation season from the DWQ database. The target P load was based on the P concentration of 0.05 mg/L identified in the State water quality standards.

Calculating the P loads from sources within this reach required estimating both flows and phosphorus loads. Flows were estimated for sub-reaches of the river segment by developing a water budget based on known spring flows and local knowledge of the irrigation company. There are some water quality and flow data for the larger hatcheries and these data were used to calculate loadings from the larger hatcheries. The P load from animal feeding areas and pastures was estimated by calculating the potential P contribution from manure within an estimated 1/4 mile contributing area on each side of the Fremont River and tributaries.

Current and Target P Loads at Fremont River near Bicknell

The USGS Gage, 09330000, Fremont River near Bicknell, Utah, covers a discontinuous, but long-term period of 50 water years dating back to June 1909. Monthly stream flows for the most recent five-year period, October 1994 to September 1999, are summarized in Table 4.23.

**Table 4.23**
**Average Flow - Fremont River near Bicknell**
**USGS Gage 09330000 (cfs)**

| | Water Year | | | | | | |
|---|---|---|---|---|---|---|---|
| **Month** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **Average** |
| Jan | | 85.1 | 88.3 | 92.0 | 83.2 | 89.0 | 85.5 |
| Feb | | 95.8 | 89.8 | 84.2 | 92.2 | 93.5 | 91.1 |
| Mar | | 91.0 | 85.8 | 243.5 | 100.3 | 90.5 | 122.2 |
| Apr | | 80.8 | 70.1 | 93.5 | 136.5 | 119.2 | 100.0 |
| May | | 77.8 | 59.6 | 65.3 | 91.2 | 93.9 | 77.5 |
| Jun | | 63.2 | 53.5 | 58.5 | 60.7 | 64.9 | 60.2 |
| Jul | | 54.4 | 54.8 | 51.9 | 61.5 | 71.1 | 58.7 |
| Aug | | 65.5 | 58.6 | 73.3 | 61.7 | 79.3 | 67.7 |
| Sept | | 77.9 | 73.9 | 96.4 | 99.1 | 77.5 | 84.9 |
| Oct | 92.0 | 92.3 | 82.5 | 84.7 | 90.3 | | 88.4 |
| Nov | 96.6 | 97.1 | 87.5 | 85.9 | 90.1 | | 91.4 |
| Dec | 88.7 | 91.3 | 79.5 | 79.5 | 79.6 | | 83.7 |
| **Average** | **92.4** | **80.9** | **73.6** | **91.7** | **87.1** | **86.5** | **84.2** |

Flows are fairly stable over the course of the water year due to the capture of runoff in the upper watershed in irrigation reservoirs and the dependability of flows from springs in the valley. Flows increase noticeably only briefly from surface runoff in the early Spring during March and April, and are lowest during the summer from June through August.

There are 19 measurements of P, from January 1997 to October 1999, in the DWQ database for the Fremont River near Bicknell monitoring station (STORET 495438). Because the data are not continuous for any annual water year period, the data were averaged for periods sampled during the irrigation (April 16 – Oct 30) and the non-irrigation (Nov 1 – April 15) season (Table 4.24). As can be noted in the table, the irrigation season P averages 0.073 mg/L compared to the average of 0.063 mg/L during the non-irrigation season.

**Table 4.24**
**Total Phosphorus at Fremont River near Bicknell**
**1997 – Oct. 1999**

| | Total Phosphorus (mg/L) | |
|---|---|---|
| Season | Irrigation | Non-irrigation |
| Number | 10 | 9 |
| Mean | 0.073 | 0.063 |
| Median | 0.068 | 0.060 |
| Max | 0.137 | 0.122 |
| Min | 0.034 | 0.037 |
| **Overall Mean** | **0.068** | |

The current P load was estimated by multiplying average monthly flow times the average seasonal P concentration, the number of days, and a factor to convert to pounds/month (Table 4.25). By summing the pounds per month, the current annual load was estimated at 11,263 pounds of P per year (see Table 4.25).

**Table 4.25**
**Calculated Current Total Phosphorus Load at Fremont River near Bicknell**

| | Five Year Average Flow (cfs) | Total Phosphorus (mg/L) | Days | Conversion Factor | Load (lbs/month) |
|---|---|---|---|---|---|
| Nov | 91.4 | 0.063 | 30 | 5.4 | 932.8 |
| Dec | 83.7 | 0.063 | 31 | 5.4 | 882.7 |
| Jan | 85.5 | 0.063 | 31 | 5.4 | 901.7 |
| Feb | 91.1 | 0.063 | 28 | 5.4 | 867.8 |
| Mar | 122.2 | 0.063 | 31 | 5.4 | 1288.7 |
| Apr 1-15 | 100 | 0.063 | 15 | 5.4 | 510.3 |
| Apr 16-30 | 100 | 0.073 | 15 | 5.4 | 591.3 |
| May | 77.5 | 0.073 | 31 | 5.4 | 947.1 |
| Jun | 60.2 | 0.073 | 30 | 5.4 | 711.3 |
| July | 58.7 | 0.073 | 31 | 5.4 | 717.3 |
| Aug | 67.7 | 0.073 | 31 | 5.4 | 827.3 |
| Sep | 84.9 | 0.073 | 30 | 5.4 | 1004.0 |
| Oct | 88.4 | 0.073 | 31 | 5.4 | 1080.3 |
| **Total Annual Load** | | | | | **11,263 lbs/year** |

Notes: Based on monthly average flows and average seasonal phosphorus concentrations. Load (lbs) = Flow (cfs) x T.P. (mg/L) x Number of Days x 5.4 (A factor to convert to pollutant load to lbs/day.

The estimated target phosphorus load for the TMDL was calculated by substituting the water quality target of 0.05 mg/L into the third column of Table 4.25 and recalculating the P load. The target load totals 8,300 pounds of P. Including a 5% margin of safety (415 lbs), the remaining load is 7,885 pounds of P. The required load reduction is estimated as 3,378 pounds or 30% of the current load.

<u>Source Loads</u>

Estimating loading from source areas in the watershed is much more complex because of the highly managed water resource and the number of different operations in the watershed. Man-caused phosphorus sources in the watershed are primarily associated with livestock grazing and fish hatcheries. There are always other possible sources in the watershed to consider (such as septic systems, storm water runoff, fertilizer application, recreational activities, and wildlife), however, these sources were not considered to be sufficiently significant. Controlling the major sources of P will be an important first step in reducing P loadings before other sources become of more than academic importance. Two processes were initiated to assist in estimation of source loads: 1) Estimating the contribution of flows within the reach; and 2) estimating the P contributed from individual sources.

Flow Routing Description and Water Budget

The Fremont Irrigation Company, provided information on inputs and diversions for this segment of the river based on both measured and estimated flows. This detailed information is listed in Table F-1, in **Appendix F**. This information was combined with measured flows at the Fremont River near Bicknell gage to develop a water budget for this reach.

The flow of the Fremont River from Mill Meadow Reservoir to the Fremont River at Bicknell is managed to maximize the use of a limited supply of water for irrigation, stock water, fish hatcheries, and communities. Inputs of flow to the river and residual flows left in the river result from an intensive water management system combined with numerous spring sources. The following description of a water budget is intended to characterize the major inputs, withdrawals and the residual flows left in the river during a "typical" year. This description provides the water quantity component needed to calculate nutrient loading when combined with the potential sources of phosphorus along this segment of the river.

A "typical" year description is feasible because flows in this section of the Fremont River are so closely managed. All surface runoff from the upper watershed is captured by the reservoir system ending at Mill Meadow Reservoir. Other contributing sources of water to the river below Mill Meadow Reservoir are predominately springs and a few major tributaries. The springs provide consistent discharge rates; their flows enter the river during the non-irrigation season, and are diverted to sprinkler systems during the irrigation season. Although the major tributaries drain some large watersheds, the runoff from these streams only enters the river during limited periods (on the order of days and weeks) associated with snowmelt in the Spring (typically March/April) or during flash flooding related to storms during the rainy season in August and September. Therefore, although this description of flow rates does not capture the natural variability associated with surface runoff, it does adequately characterize water quantity that may be associated with important nutrient sources.

The major locations of inputs and withdrawals to this section of the Fremont River are shown in **Map 10.** The location of these inputs is indicated by River Mile (RM) starting at Mill Meadow Dam at RM 0.0. Within a short distance of Mill Meadow Reservoir, several major withdrawals (Fremont Bench sprinkler mainline, the Highline Canal, and the Fremont Loa Ditch) divert surface water from the river during the irrigation season (April 1-15 to November 1). During the non-irrigation season (November 1 to April 1-15), no water is spilled from the reservoir, however, springs or seeps that arise below the dam provide some channel flow (approximately 0.5 to 3 cfs). In essence, no contributing nutrient load is possible from the upper watershed above Mill Meadow Reservoir to the lower watershed because the water is either stored (during the non-irrigation season), or is diverted prior to its entering the river during the irrigation season.

The Fremont River below the Highline Canal (RM 2.6) to Spring Creek (RM 10.6), an 8-mile section of the river, is essentially dewatered during the irrigation season. Water that arises from springs, seeps, and return flows is backed up behind "dry dams" and applied to pastures and cropland via flood or sprinkler irrigation methods. During the non-irrigation season, the river only flows where springs and seeps make it to the river. Even during this period, the river channel contains minimal flows (approximately 0.5 cfs) because water is diverted for stock watering where feasible.

The Fremont River begins flowing again at the confluence of Spring Creek (RM 10.6). Several sources contribute to the flow observed at Spring Creek where it joins the river. Spring Creek originates at Brian Spring, which is the source of water for the Loa Fish Hatchery and flows at a constant rate of 15 cfs. At 0.7 miles below the source, Slough Ditch joins Spring Creek, contributing water from spring/seeps in the area. The Loa Town Ditch is diverted out of Spring Creek during the irrigation season at approximately 0.8 miles below the source. Road Creek, another continuous spring source, contributes 6.2 cfs of flow to Spring Creek. Road Creek joins Long Hollow Canyon and enters Spring Creek approximately 4.6 miles below the source. Spring Creek joins the Fremont River, with the combined flow of Road Creek and Spring Creek, during the non-irrigation season. A number of other exchanges of water occur in the Spring Creek system; however, these flows would have minimal to no influence on the ultimate phosphorus load balance and are not discussed further.

The Fremont River flows below Spring Creek during the non-irrigation season due to the combined discharge of Spring Creek and Road Creek. During the irrigation season, this water is entirely diverted for irrigation, and therefore a 4-mile section of the river, from Spring Creek (RM 10.6) to the springs/seeps in the vicinity of Dab Keele Springs (RM 14.5), is essentially dewatered. Dab Keele Springs flows at 3.7 cfs, however this water is diverted into a parallel channel and used most of the year, so very little water enters the river from this spring. Other springs that arise in the vicinity of Dab Keele Springs provide a consistent discharge of approximately 0.5 cfs to the river. Additional springs originating near the Pace property contribute 6 cfs of flow to the river. Numerous other springs join the river in Bicknell Bottoms, and thereby incrementally increase the flow in the river. The section of Fremont River from Dab Keele Springs to the Fremont River at Bicknell, the lower 5 miles, flows year-round.

As indicated on the flow diagram, three major tributaries (Big Hollow, Pine Creek, Government Creek) join the Fremont River in Bicknell Bottoms. These tributaries contribute surface runoff, but the major source of water is associated with springs in these drainages and those arising in Bicknell Bottoms. Springs arising in the Bicknell Bottoms at the mouth of Tommy Hollow (RM 16.8) contribute approximately 8 cfs year-round to the river. Pine Creek contributes both surface and spring water. The Pine Creek watershed above the spring complex contributes approximately 2 - 2.5 cfs to the river. This water flows into the river during the non-irrigation season, but is diverted out during the irrigation period. Several springs contribute to the Pine Creek drainage: a spring at J.P. Egan Hatchery - 17.2 cfs; a spring near the hatchery - 1 cfs; Bullard Spring - 1 cfs year-round; and another spring near Bullard Spring - 1 cfs. Government Creek contributes 0.5 cfs to the river during the non-irrigation season, and flows approximately 1 cfs during the irrigation season, but it is entirely diverted during that period. Surface runoff from these tributaries occurs infrequently and only rough estimates of flow rates are available. Surface runoff occurs for a short period in the spring due to snowmelt. Local observers estimate significant runoff from snowmelt occurs in Big Hollow Creek infrequently, at approximately 50 cfs for 1 week duration once every 5 years.

Table 4.26 summarizes the flow data by major sub-reach in the river segment. Summarizing information by reach facilitates the association between loading and flows into meaningful geographic sections. Flows are averaged for the non-irrigation and irrigation season to facilitate computation of loadings based on seasonal average concentrations.

**Table 4.26**
**Flow by Reach - Mill Meadow Reservoir to Fremont River near Bicknell**

| Segment | Segment Name | River Mile | Non-irrigation | | Irrigation | |
|---|---|---|---|---|---|---|
| | | | Average Flow (cfs) | Percent of Flow in Fremont River | Average Flow (cfs) | Percent of Flow in Fremont River |
| A | Fremont River: Mill Meadow Reservoir to Spring Creek | 0.1 - 10.6 | 3 | 3% | 0 | 0% |
| B | Spring Creek | 10.6 | 21.2 | 22% | 0 | 0% |
| C | Fremont River: Spring Creek to Dab Keele Springs | 10.6 - 14.5 | 21.2 | 22% | 0 | 0% |
| D | Fremont River: Dab Keele Springs to Tommy Hollow | 14.5 - 16.8 | 37.8 | 39% | 14.5 | 16% |
| E | Pine Creek | 18.2 | 22.7 | 24% | 19.2 | 22% |
| F | Fremont River: Tommy Hollow to Pine Creek | 16.8 - 18.2 | 57.7 | 60% | 33.5 | 38% |
| G | Fremont River: Pine Creek to Fremont River near Bicknell | 18.2 - 19.5 | 95.7 | 100% | 88.4 | 100% |

Source Load Contributions

Potential P loads were estimated for livestock operations and the smaller, non-permitted fish production facilities in the watershed.  The TAC of the Fremont River Watershed Steering Committee developed information for calculating P loads for livestock sources in the watershed.  The technical group provided the source locations, description of methods used, and a spreadsheet summarizing the load calculations.

Phosphorus loading estimates from the three non-permitted production facilities were calculated based on the total production of fish (tons/year) (Cho et al., 1994). Phosphorus loading from the three permitted fish hatcheries and production facilities will be covered within Section 4.2.3.

Phosphorus Loads Originating From Croplands, Pastures and Feedlots

Field reconnaissance of livestock operations within the upper Fremont River watershed was performed on April 18, 2001 by a technical group of the watershed committee: Paul Pace (Farm Service Agency), Tom Jarman (Natural Resources Conservation Service) and Carl Adams (Utah Division of Water Quality).  The trip began near the confluence of Red Creek and the Fremont River below Mill Meadow Reservoir and proceeded downstream to the Fremont River near Bicknell monitoring station.  Data were recorded on a form including site number, geographic location the number of animals at the site, the duration of time the animals were present, the setting of the site (pasture, alfalfa, feedlot), the proximity of the site to live water, the presence or absence of vegetative buffer and its width, and any other notes including hydrologic setting of the site (e.g. seasonally dewatered or tributary to Fremont River).

The information from these data sheets was then transferred into a spreadsheet along with the area of each site, taken either from FSA aerial maps (where possible) or from calculations based on a GIS coverage. In several cases, where there were no well defined boundaries of the area, it was assumed that animals were restricted to within ¼ mile of the river channel which, upon review, fit the local topography.

The potential P output of animals within each site was calculated by multiplying the number of animals, the P content of manure for that type of animal (cow, sheep, etc.) measured in lb/day/1000 lbs and the equivalent animal unit for that type of animal (See Table F-2, in **Appendix F**). The P content of manure values were derived from the NRCS Animal Manure Nutrient Balance Worksheet (Goodrich 2000, manure24.xls) and summarized in Table 4.27.

**Table 4.27**
**Data Used to Derive Phosphorus Production From Livestock.**

| Category | P production (lb/day/1000#) | Equivalent Animal Unit |
|---|---|---|
| Pasture Cow | 0.11 | 1 |
| Feedlot Cow | 0.14 | 1 |
| Sow | 0.105 | 0.375 |
| Sheep | 0.07 | 0.2 |
| Horse | 0.05 | 1.2 |

Values from NRCS, 1992.

The P output (lb/day) was then multiplied by the duration in days animals are present at the site to derive the total amount of P (lbs) generated at that site. Next, the total P at each site was multiplied by a mineralization factor derived from the Animal Manure Nutrient Balance spreadsheet version 2.4 developed by Utah NRCS (Goodrich 2000, manure24.xls). For pastures, 80% of the P from animal manure is available for plant uptake or runoff and 90% is available from confined sites.

Next the potential plant uptake of P was calculated by multiplying the area of the site (acres) by a plant uptake coefficient. The plant uptake coefficient was derived from another worksheet of manure24.xls in which alfalfa is shown to take up 13.3 lbs of $P_2O_5$/ton of production / year and grass pasture takes up 12.7 lbs of $P_2O_5$ / ton of production/year. Phosphate ($P_2O_5$) mass is converted into P by multiplying it by 0.437. It was estimated that on average the total yield of alfalfa and grass pasture in the Rabbit Valley area is 4 tons/year/acre. Therefore the total uptake of P by alfalfa is 23.2 lbs/yr/ac and 22.2 lbs/yr/ac for grass pasture.

The plant uptake of P was then subtracted from the P remaining after mineralization to arrive at the amount of P available for runoff to surface waters. No plant uptake occurs on feedlots because by definition they have no vegetation present.

In one case it was found that the potential plant uptake of P was greater than the amount of P deposited through animal manure due to the pasture's size and the duration of grazing and number of animals within the pasture. In these cases the potential contribution of P was negated. The P load remaining that is potentially available for delivery to the river system from these agricultural sources is listed in Table 4.28 by river reach.

**Table 4.28**
**Estimated P Load from Agricultural Sources -**
**Fremont River below Mill Meadow Reservoir**

| Segment | Segment Name | P Load (lbs) |
|---|---|---|
| A | Fremont River: Mill Meadow Reservoir to Spring Creek | 11,996 |
| B | Spring Creek | 3,304 |
| C | Fremont River: Spring Creek to Dab Keele Springs | 12,109 |
| D | Fremont River Dab Keele Springs to Tommy Hollow | 2,682 |
| E | Pine Creek | 776 |
| F | Fremont River Tommy Hollow to Pine Creek | 0 |
| G | Fremont River Pine Creek to Fremont River near Bicknell | 926 |
| Total Load | | 31,793 |

Phosphorus Loads from Non-Permitted Fish Production Facilities

Due to a lack of data on these fish raising facilities, P loading from these operations was estimated by multiplying their total annual fish production by a standard phosphorus excretion value (Cho et al., 1994).

**Table 4.29**
**Estimated Annual P Load from Non-Permitted Fish Production Facilities for the Fremont River Below Mill Meadow Reservoir**

| | **Annual Production (tons)** | **Phosphorus produced (lb/ton)*** | **Annual Phosphorus Load (lbs)** |
|---|---|---|---|
| Pace | 10 | 9.7 | 97 |
| Brinkerhoff | 25 | 9.7 | 243 |
| Blackburn | 25 | 9.7 | 243 |
| Total Load | | | 583 |

* From Cho et al., 1994

Phosphorus Source Load Balance

As noted in the above sections, all load calculations were based on a series of assumptions and result in an “estimation” of P loading. Estimates are required where measured data are lacking. To see how well these estimates perform it is useful to compare the current load estimated at the Fremont River near Bicknell with the estimated source loads from hatcheries and other agricultural sources. Note that actual in-stream concentrations will always be lower than external loading estimates due to the uptake of P by plants and animals and loss through sedimentation.

The current annual mass of P in the Fremont River was calculated as 11,263 pounds. The P load from cropland pastures, and feedlots was estimated at 31,793 pounds, and the load from the smaller hatcheries as 583 pounds. This does not include any potential loading from rangelands in the Big Hollow, Pine Creek, and Government Gulch areas. The developed Fremont River valley is characterized by flat terrain and very minimal surface water runoff; conditions that prevent continuous and direct delivery of P from livestock wastes to the river and tributaries. Secondly, the Fremont River in this reach is virtually dewatered in several sections for a large part of the year, effectively preventing P from being delivered from agricultural lands to surface waters. Additionally, the distance between sources in the upper watershed and tributaries will further reduce the P from reaching the River at Bicknell.

To address these hydrologic characteristics we can speculate on some delivery ratios that are less than 1 (less than 100%). For the purposes of speculation, the following assumptions were made relative to delivery ratios (Table 4.30).

1) During the period when there is no water in a stream channel the delivery ratio is zero.
2) During the period when there is very little water (1-3 cfs) for transport in the stream, as is the case with the section of the river from Mill Meadow Reservoir to Spring Creek, the delivery ratio is 0.25 or 25%.
3) When there is sufficient water in the stream, but when the distance is large or the source is a tributary (Pine Creek, for example) the delivery ratio is 75%, and
4) When the source is close to the monitoring station and water is available for transport, the delivery ratio is 100%. Because hatcheries and production facilities are in the waterway the delivery ratio for hatcheries is estimated at 100%.

**Table 4.30**
**Estimated P Load from Agricultural and Non-Permitted Fish Production Facility Sources - Fremont Near Bicknell Gage**

| | | | Non-irrigation Season | | Irrigation Season | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Segment | Segment Name | Ag. P Load (lbs) | Percent of Flow - Fremont River Bicknell | Ag. Delivery Potential | Percent of Flow - Fremont River Bicknell | Ag. Delivery Potential | Ag. Delivered Load (lbs) | Hatchery/ Production Facilities Load (lbs) | Total Annual P Load (lbs) |
| A | Fremont River: Mill Meadow Reservoir to Spring Creek | 11,996 | 3% | 25% | 0% | 0% | 1,500 | | |
| B | Spring Creek | 3,304 | 22% | 75% | 0% | 0% | 1,239 | | |
| C | Fremont River: Spring Creek to Dab Keele Springs. | 12,109 | 22% | 75% | 0% | 0% | 4,541 | | |
| D | Fremont River: Dab Keele Springs to Tommy Hollow. | 2,682 | 37% | 75% | 16% | 75% | 2,012 | | |
| E | Pine Creek | 776 | 24% | 75% | 22% | 75% | 582 | | |
| F | Fremont River: Tommy Hollow to Pine Creek | 0 | 61% | 100% | 38% | 100% | 0 | 583 | |
| G | Fremont River: Pine Creek to Fremont River near Bicknell | 926 | 100% | 100% | 100% | 100% | 926 | | |
| Phosphorus Load Subtotals | | 31,793 | | | | | 10,800 | 583 | 11,383 |

## Best Management Practices

The primary land uses for the upper Fremont River watershed defined in this plan as extending from the Forest Service boundary to Bicknell Bottoms include several different agricultural enterprises and residential uses. Agricultural land uses include raising crops including alfalfa and grains, livestock feeding on pasture and small feedlots, dairy operations, and several fish hatcheries.

Croplands within this portion of the watershed are already under intensive management to maximize production under the relatively short growing season. Practically all of the cropland is under sprinkler irrigation, which minimizes the potential for surface runoff although this area periodically experiences intense thundershowers that can produce significant runoff. Runoff also occurs during Spring thaw, which normally does not present water quality concerns unless nutrients as chemical fertilizers or manure had been applied on frozen ground. Best management practices for cropland include minimizing the potential for runoff to enter the Fremont River and matching soil fertility with crop needs through nutrient management. Relevant practices include Conservation Cover (327), Critical Area Planting (342), Filter Strip (393), Grassed Waterway (412), Irrigation Water Management (449), Irrigation System (442, 443, 444), Mulching (484), Nutrient Management (590), Pipeline (430), and Strip Cropping (585, 586). Numeric codes following practices coincide with NRCS standards and specification numbers from the NRCS Field Office Technical Guide.

Pastures, dairies, livestock feeding areas and fish hatcheries all share the same water quality concern, the potential for animal wastes to leave the site where they are produced and contribute to the nutrient enrichment of the Fremont River. Principles of nutrient management on pastures are similar to those of croplands in which plant uptake of nutrients should be matched with the supply, usually in the form of manure. However, since livestock are present and it is usually more difficult to control the amount and distribution of manure, extra precaution is required. The majority of pasturelands in this area are also flood irrigated or sub-irrigated so the potential for runoff is higher in some areas. Troughs and salt should be located away from live water and direct access to streams and ditches discouraged. To facilitate plant uptake of nutrients, manure can be harrowed into the soil and demand increased by establishing productive cultivars of pasture grasses such as Garrison creeping foxtail. Specific practices pertinent to pasture management for water quality include Filter Strip (393), Grassed Waterway (412), Use Exclusion (472), Heavy Use Area Protection (561), Pipeline (516), Trough or Tank (614), Irrigation Water Management (449), Irrigation System (442, 443, 444), Nutrient Management (590), Pasture and Hayland Planting (512), and Critical Area Planting (342).

Riparian areas adjacent to or within pastures also require special attention to enhance their nutrient uptake and filtering functions. Practices that benefit riparian area function include Channel Vegetation (322), Riparian Herbaceous Cover (390), Streambank Protection (580) and Stream Channel Stabilization (584).

The primary water quality challenge facing the several dairy and feedlot operations in the watershed is containing and beneficially utilizing the animal waste generated by their animals. There are currently financial and technical resources available to assist dairy and feedlot owners in developing animal waste management systems. As an example, a 319 demonstration project is currently underway on the Fremont River to relocate a large feeding operation away from the river. Practices designed to assist in containing and utilizing animal waste include Composting Facility (317), Filter Strips (393), Nutrient Management (590), Roof Management System (570), Roof Runoff Management (558), Use Exclusion (472), Waste Management Systems (312), Waste Storage Pond (425), Waste Storage Facility (313), Waste Treatment Lagoon (359) and Waste Utilization (633).

Fish hatcheries are presented with a unique water quality challenge in that animal waste and nutrient rich feed is immediately incorporated into live water. The only option available is to provide sufficient treatment of hatchery outflow to minimize nutrient loading. Hatcheries managed by the Division of Wildlife Resources have constructed settlement ponds at their outflows to trap solid wastes and excess feed and provide some treatment through anaerobic decomposition (Valentine, 2001). The State hatcheries and production facilities also utilize specially formulated feed that is low in P. However, little treatment is provided by the private fish production facilities. Although there are no standardized practices for treatment of hatchery outflow in Utah, several types of treatments used for municipal wastewater and urban runoff would be useful such as settlement ponds, constructed wetlands and filter screens. The use of low P feed should also be considered for each of these facilities.

Finally, Best Management Practices for residential and other developed areas generally fall into two categories, wastewater management and stormwater runoff. Since there is no centralized sewer system within the watershed all wastewater is treated through septic leach field systems. Given the low density of septic systems throughout the watershed and the location of most of these systems away from stream channels, it is believed that they do not provide a significant source of nutrients into the Fremont River. However, periodic maintenance and inspection of septic systems is required to ensure their proper function. The potential for nutrient loading from stormwater runoff is also considered negligible due to the very low percentage of impervious cover within Rabbit Valley although the potential for disconnecting road ditch lines from the stream channel network should be investigated.

### 4.2.3 Point Sources

There are three permitted point sources within the upper Fremont River watershed, Loa Fish Hatchery, Road Creek Trout Farm and J.P. Egan Fish Hatchery. Cold-water fish hatcheries (trout) that produce more than 20,000 pounds or more of fish per year are covered under a state-wide general permit issued by the Division of Water Quality which regulates the levels of total suspended and dissolved solids and pH permissible in the hatchery outfall.

Table F-3, in **Appendix F**, summarizes the data from these three hatcheries. There is a good set of flow data for these three hatcheries, but inconsistent total phosphorus data. To calculate loading from the hatcheries, the data for flow and P was averaged over the period of record (Jan. 1997 to Oct. 1999). These data were then used to estimate an average annual P load from the hatcheries (the equation used to calculate annual load is: Annual Load = flow (cfs) x P concentration (mg/L) x 365 x 5.4), see Table 4.31.

**Table 4.31**
**Estimated Annual P Load from Permitted Fish Hatcheries and Production Facilities for the Fremont River Below Mill Meadow Reservoir**

| | Flow (cfs) | Average Phosphorus (mg/L) | Annual Phosphorus Load (lbs) |
|---|---|---|---|
| J P Egan 2 | 18.9 | 0.064 | 2,384 |
| J P Egan 1 | 0.5 | 0.037 | 37 |
| Loa Fish Hatchery | 13.7 | 0.051 | 1,377 |
| Road Cr. Trout Farm | 5.6 | 0.060 | 662 |
| Total Load | | | 4,460 |

Necessary load reductions from the permitted fish hatcheries and production facilities was determined by calculating the difference between the current load of TP from each facility and the load associated with the water quality target of 0.05 mg/L (Table 4.32).

**Table 4.32**
**Necessary Load Reductions from Permitted Fish Hatcheries and Production Facilities for the Fremont River Below Mill Meadow Reservoir**

| | Current Load (lbs) | Target Load (lbs) | Load Reduction (lbs) |
|---|---|---|---|
| J P Egan | 2,421 | 1,912 | 509 |
| Loa Fish Hatchery | 1,377 | 1,350 | 27 |
| Road Cr. Trout Farm | 662 | 552 | 110 |
| Total Load Reduction | | | 646 |

The fish runs on Spring Creek associated with the Loa Fish Hatchery and Road Creek Trout Farm deserve special attention due to the nuisance algae growth that occurs within Spring Creek every summer. The excessive algal growth is a result of high nutrient loading that chokes the stream channel and requires annual dredging in order to satisfy downstream water rights. The Division of Water Rights, Stream Alteration Permits Section is requiring the Fremont Irrigation Company to develop a nutrient control plan for Spring Creek before they will approve a request to remove the nuisance algae growth. It is the intent of this plan and the Watershed Steering Committee to identify sources of nutrient loading into the Fremont River and its tributaries, including Spring Creek, and address this problem through the voluntary implementation of Best Management Practices.

### 4.2.4 Water Quality Goals and Targets

The water quality goals for the upper Fremont River and tributaries including Spring Creek and Road Creek are to reduce nutrient and sediment loading, improve riparian habitat, and thereby increase dissolved oxygen concentrations.

The loading capacity for total phosphorus was calculated by substituting the water quality standard of 0.05 mg/L into the third column of Table 4.25 and recalculating the P load. The loading capacity is 8,300 pounds of P. Including a 5% margin of safety (415 pounds of P) the remaining 7,885 pounds are allocated to point sources (wasteload allocation) and non-point sources (load allocation). The wasteload allocation for point sources totals 3,814 lbs of TP and the remaining 4,071 lbs of TP are allocated to background and nonpoint sources (load allocation).

Based upon the watershed inventory there are approximately 25 livestock feeding areas that contribute P loading to the Fremont River or its tributaries. In order to address P loading from these feeding areas one of the goals of this plan are to implement 25 animal waste and/or grazing management systems. Of the six fish hatcheries or production facilities only two are currently utilizing some type of treatment. Another goal of this plan is to implement an appropriate level of effluent treatment for all six fish production facilities and to meet the effluent water quality target of 0.05 mg/L TP.

It must be stressed that since this is primarily a nonpoint source TMDL load reductions may not be evident for quite some time until the system has had the opportunity to flush out the excess nutrients.

## 4.3 Lower Fremont River Watershed

The lower Fremont River, as defined in this plan, begins at the eastern boundary of Capitol Reef National Park and ends at the confluence with the Dirty Devil River. The designated beneficial uses for this section of the watershed are:

- 2B – Secondary contact recreation (boating, wading, or similar uses);
- 3C – Nongame fish and other aquatic life; and
- 4 – Agricultural uses including irrigation of crops and stock watering.

This section is impaired for designated beneficial use 4, due to high levels of TDS.

### 4.3.1 Applicable Water Quality Standards

Utah water quality standards (Utah WQS) (State of Utah, 2000, UAC R317-2) and the 303(d) listing criteria (UDEQ - DWQ, 2000b) provide the criteria to make an initial assessment of water quality conditions. The Utah WQS establish a numeric criterion of 1,200 mg/L TDS for Class 4 waters, for protection of the agricultural beneficial use. In addition, the Utah WQS also provide numeric criteria for pH, boron, and metals as summarized in Table 4.32.

**Table 4.33**
**Utah Water Quality Criteria.**

| Parameter | Criterion, Maximum Concentration |
|---|---|
| **Target Parameters*** | |
| Total Dissolved Solids | 1,200 mg/L |
| **Secondary Parameters**** | |
| pH | 6.5 – 9.0 pH units |
| Boron | 0.75 mg/L |
| Arsenic | 0.10 mg/L |
| Cadmium | 0.01 mg/L |
| Chromium | 0.10 mg/L |
| Copper | 0.20 mg/L |
| Lead | 0.10 mg/L |
| Selenium | 0.05 mg/L |

**Notes:** * Utah WQS clarify that TDS limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water.

** Metals criteria as dissolved maximum concentration.

The 303(d) listing criteria provide guidance on evaluating beneficial use support status based on the number of violations of the water quality criterion as listed in Table 4.34.

**Table 4.34**
**303 (d) Criteria for Assessing Agricultural Beneficial Use Support (Class 4)**

| Degree of Use Support | Conventional Parameter (Total Dissolved Solids – 1,200 mg/L) | Toxic Parameters |
|---|---|---|
| Full | Criterion exceeded in less than two samples and in less than 10% of the samples if there were two or more exceedences. | For any one pollutant, no more than one violation of criterion. |
| Partial | Criterion was exceeded two times, and criterion was exceeded in more than 10% but not more than 25% of the samples. | For any one pollutant, two or more violations of the criterion, but violations occurred in less than or equal to 10% of the samples. |
| Non-support | Criterion was exceeded two times, and criterion was exceeded in more than 25% of the samples. | For any one pollutant, two or more violations of the criterion, and violations occurred in more than 10% of the samples. |

### 4.3.2 Water Quality Assessment

There are three water quality stations that are applicable to the lower Fremont River:

495483 - Pleasant Creek at U24 Crossing.

495506 -Caineville Wash at U24 Crossing

495433 - Fremont River at old U24 Crossing

Average flow and TDS concentrations for the three stations are listed in Table 4.35. These data were derived from the last 10 years of sampling (1991-2001). The upstream station, Fremont River - Hickman Bridge (495436), is shown as an upstream comparison. TDS increases in a downstream direction; median TDS increases from 424 mg/L in Fremont River at Hickman Bridge to 796 mg/L at the Fremont River at old U24 Crossing. The average TDS concentrations of tributaries in this reach include Pleasant Creek with a median of 541 mg/L and Caineville Wash with a median 3,048 mg/L and 100% exceedence of criteria. At the lower river site, Fremont River at Old U24 (495433), 23% of the samples exceeded the criterion of 1,200 mg/L.

**Table 4.35**
**TDS and Flow Data for the Lower Fremont River**

| | Fremont River at Hickman (495436) | | Pleasant Creek (495483) | | Caineville Wash (495506) | | Fremont River at old U24 (495433) | |
|---|---|---|---|---|---|---|---|---|
| **Statistic** | **Flow (cfs)** | **TDS (mg/L)** | **Flow (cfs)** | **TDS (mg/L)** | **Flow (cfs)** | **TDS (mg/L)** | **Flow (cfs)** | **TDS (mg/L)** |
| Number | 37 | 37 | 16 | 16 | 13 | 13 | 60 | 60 |
| Mean | 59 | 464 | 3.5 | 620 | 1.6 | 3021 | 59 | 1095 |
| Median | 60 | 424 | 3 | 541 | 1 | 3048 | 42.5 | 796 |
| Max | 130 | 918 | 7 | 1160 | 4 | 3218 | 328 | 3306 |
| Min | 12 | 288 | 0.2 | 326 | 0.3 | 2642 | 0.3 | 462 |

In Figure 1 the average monthly TDS values are plotted to show the monthly and seasonal patterns at the Fremont River at old U24 (495433). Because seasonal effects may be due to the seasonal variations in hydrology, average monthly flows are also included. Generally, the highest average concentrations occur from May through September. The irrigation season is typically from April through September.

In Figure 2 the relationship between flow and TDS is represented for all data points between 1991 and 2001 collected at Fremont River at old U24 (495433). There is a good relationship between the two ($R^2$=0.72) demonstrating that TDS increases as flows decrease. TDS concentrations are likely the highest during baseflow conditions when return irrigation flows and groundwater with elevated concentrations provides the majority of the stream flow.

**Figure 4.1**
**Average Monthly TDS Versus Flow at Fremont River at Old U24 (495433)**

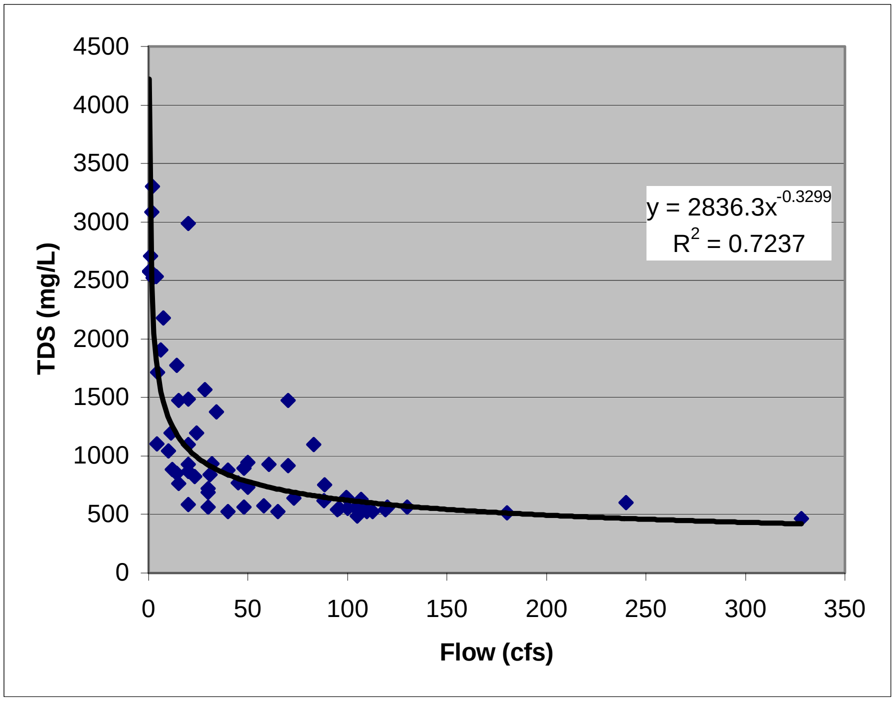
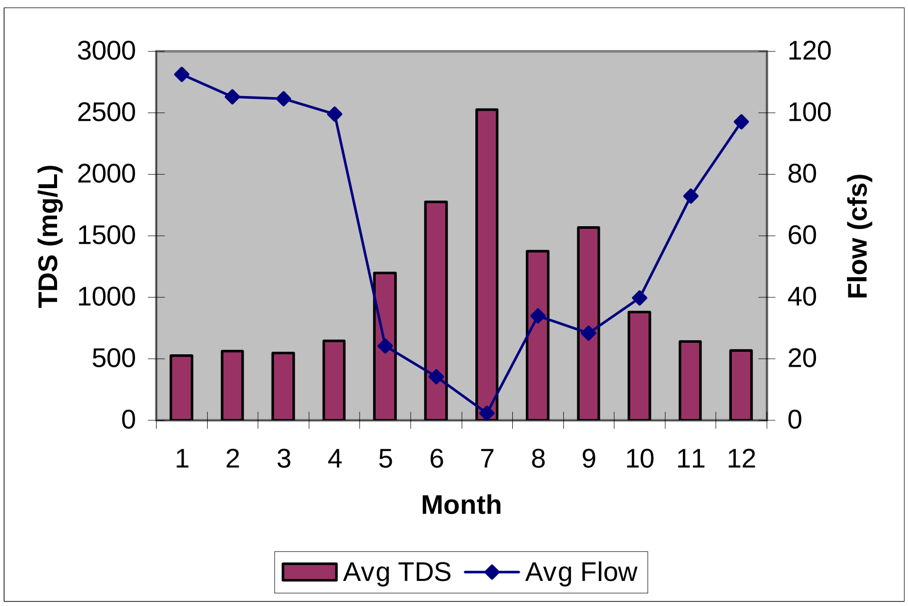



**Figure 4.2**
**Relationship Between Flow and TDS at Fremont River at Old U24 (495433)**



### 4.3.3 Nonpoint Sources

Cropland

In the lower Fremont River watershed, farmers must rely on a seasonal water supply from the Fremont River and flood irrigation practices are used primarily. There are 1,454 flood-irrigated acres adjacent to the Fremont River in the Caineville and Hanksville areas (Jones and Demille, 2000). Irrigation increases salinity by consuming water through evapo-transpiration and by dissolving and transporting salts present in the underlying saline soils and geologic formations, usually marine shales (USDI, 1997).

The irrigated tracts are located on a variety of soil units. They are comprised primarily of silt loams, silty clay loams, and sands. They are formed in alluvial and eolian deposits, and derived from shale, sandstone, and mixed sedimentary rocks. Slopes range from 0 to 2 percent and are medium to long in length. In a few areas the slopes are steeper and range from 2 to 8 percent. Salinity of these soils is moderate to high. Alfalfa grows well in these soils (USDA - SCS, 1990).

Upland and Streambank Erosion

Studies conducted on Mancos Shale in the Upper Colorado River Basin have shown a relationship between sediment and salt loading (Schumm and Gregory, 1986). Sediment loading results from either upland erosion or streambank and gully erosion. Sediment and salt load are highly dependent on landform type. The three major landform types associated with Mancos Shale include badlands, pediments and alluvial valleys. Badlands are the most prone to erosion with sediment yields as high as 15 tons per acre. Since salt production is closely related to sediment yield and badland soils have not been leached of their soluble minerals, they produce the greatest amount of salt loading of the landform types. Pediments are gently inclined planate erosion surfaces carved in bedrock and veneered with fluvial gravels. Slopes are generally flatter with deeper soils and higher infiltration rates than badlands. Alluvial valleys are stable except along the channel where headcutting and gullying occur. Most of the salts have been leached out so that they yield less salt per unit volume of sediment than the other two landform types. However, channels incised into alluvium incorporate both sediment and salt from sloughed channel banks and salts from efflorescence at the alluvium-bedrock contact.

Loading Calculations

The lower section of the Fremont River is listed on the 303(d) list only for TDS. The Utah Water Quality Standards establish a numeric criterion of 1,200 mg/L for TDS in Class 4 waters for protection of agricultural beneficial uses.

This section of the river encompasses the lower 36 miles of the Fremont River. The character of the landscape and the geologic setting are radically different from the upper Fremont River watershed. This section of the river intersects with the Mancos Shale formation, a known source of salinity to the West Colorado Basin. Water quality has been measured at three stations within this section, two tributaries and one river station. A monitoring station at Hickman Bridge, seven miles upstream of the official upstream boundary of the lower Fremont River, provides information on salinity conditions close to the section boundary. There is also one USGS gaging station located in the upper end of the lower section.

Data coverage for the lower Fremont River includes monthly sampling between 1991 and 2001 in order to fully capture the variability in TDS concentrations along with their associated flows. Given the annual fluctuations in flow for the river and tributaries, the existing data were used to develop average monthly flow and TDS data at each station, and to compute annual TDS loads based on the monthly load where water quality violations occur. This was done to develop the current load. The target load was based on the 1,200 mg/L criteria.

<u>Current and Target TDS Loads</u>

Because flows are variable over an annual cycle, the available data were used to construct average flows and TDS concentrations for each month (Table 4.35). .

**Table 4.36**
**Current and Target TDS Load - Lower Fremont River**
**(STORET 495433 - Fremont River at old U24)**

| Month | Days | Average cfs | Current TDS (mg/L) | Current Load (tons) | Target TDS (mg/L) | Loading Capacity (tons) |
|---|---|---|---|---|---|---|
| Jan | 31 | 113 | 524 | | | |
| Feb | 28 | 105 | 562 | | | |
| Mar | 31 | 105 | 546 | | | |
| Apr | 30 | 100 | 646 | | | |
| May | 31 | 24 | 1,196 | | | |
| Jun | 30 | 14 | 1,776* | 2,014 | 1,200 | 1,361 |
| Jul | 31 | 2 | 2,525* | 423 | 1,200 | 201 |
| Aug | 31 | 34 | 1,374* | 3,910 | 1,200 | 3,415 |
| Sept | 30 | 28 | 1,570* | 3,561 | 1,200 | 2,722 |
| Oct | 31 | 40 | 882 | | | |
| Nov | 30 | 73 | 640 | | | |
| Dec | 31 | 110 | 546 | | | |
| Annual Load (tons) | | | | 9,908 | | 7,699 |

Notes:
Load (tons/day) = flow (cfs) x TDS (mg/L) x 0.0027
Load (tons/month) = average load (tons/day) x Number of Days
* Critical condition – period of time that TDS exceeds water quality criteria.

Average TDS concentrations exceed water quality standards for four months in the summer, June through September. These four months are identified as the critical condition for TDS in the lower Fremont River. Critical condition represents the condition or conditions under which impairment (i.e., exceedence of water quality standards) occurs. Determination of the critical condition and analysis of the TMDL considering the critical condition ensure that water quality standards are met under all conditions. To calculate the target load, the 1,200 mg/L criterion was substituted in the table for these four months. The resulting target load totals 7,699 tons of TDS.

Source Loads

Caineville Wash contributes perhaps the most significant source of TDS loading into the lower Fremont River. The same procedure used above to calculate total and target loading into the Fremont River was used to determine the source load from Caineville Wash. The data is included in **Appendix F**. Caineville Wash accounts for 1,593 tons of TDS loading during the critical time period. This source alone constitutes 61% of the total reduction needed to meet the target TDS load.

Irrigation return flows are another potential source of TDS loading into the Fremont River. According to findings of the Price – San Rafael Salinity Control Project (USDI – BOR, 1991) located just north of the Fremont River Watershed, 3.65 tons of TDS loading is attributable to each acre-foot of irrigation return flow. In the West Colorado Water Plan (DNR-DWR, 1999) return flows into the lower Fremont River have been estimated at 4,900 acre feet per year. Using these average values, 17,885 tons of TDS loading into the lower Fremont River can be attributed to return flows per year. Since the critical condition for TDS occurs during 33% of the year the estimated loading attributable to return flows equals 5,978 tons.

Load Allocation

Since there are no permitted point sources of TDS in the lower Fremont River Watershed the wasteload allocation is set to zero. After applying a 5% margin of safety (385 tons of TDS), 7,314 tons of TDS remain to be allocated to non-point sources (load allocation) and natural background sources. The amount of TDS allocated to natural background sources was calculated by subtracting the identified sources of TDS (return flows and Cainville Wash) from the current total load (9,908 tons). Therefore 4,977 tons of TDS are allocated to return flows. Caineville Wash has no allocated load because of reasons discussed in Section 4.3.4 below. Necessary load reductions to meet the target load include 1,593 tons of TDS from Caineville and 1,001 tons of TDS from nonpoint source return flows.

Best Management Practices

Best management practices to address salt loading entering the lower Fremont River involve improving the efficiency of irrigation methods and conveyances to minimize surface runoff and deep percolation into the underlying alluvial aquifer. Irrigation water and precipitation that runs across the ground and / or percolates down and dissolves salts within the soil that are then transported into the Fremont River, Dirty Devil River and eventually to the Colorado River. Surface runoff and deep percolation is reduced or eliminated by improving the efficiency of irrigation through gated pipe, sprinkler or drip irrigation methods and / or by delivering irrigation water through lined canals or pipe. Much of this work is currently underway in other parts of the State under the auspices of the Salinity Control Program administered by the Departments of Interior (Bureau of Reclamation) and Agriculture (Natural Resources Conservation Service). Specific practices pertaining to salinity control include Irrigation Water Management (449), Irrigation System (442, 443, 444), Pipeline (430) and Ditch and Canal Lining (428).

Another potential source of salt loading is from sediments eroded from streambanks and uplands.  Since most of this area usually receives less than 6 inches of precipitation a year, the prospects of revegetating uplands to reduce erosion are limited.  There are more structural practices available to trap and retain floodwaters and sediment flows that arise from thunderstorms but their high cost may be prohibitive.  However, there are opportunities to reduce streambank erosion through implementation of the following practices; Stream Channel Stabilization (584), Streambank Protection (580), Tree/Shrub Establishment (612) and Riparian Herbaceous Cover (390).  Since riparian areas tend to receive the highest grazing pressures, other practices may be needed to allow vegetation to establish such as: Fence (382), Heavy Use Area Protection (561), Prescribed Grazing (556, 528A), Trough's or Tank (614) and Use Exclusion (472).

### 4.3.4 Potential Point Sources

Artesian Wells

There are four artesian wells in the Red Desert of Caineville Wash.  Two of these wells contribute flow to Caineville Wash, a tributary to the Fremont.  These wells are sources of TDS.  This is attributed to the local Mancos Shale geology.  The predominant soil type in the Red Desert is classified as eroded Robroost Goblin Complex.  Slopes range from 2 to 30 percent, are concave to convex, and are short in length.  The present vegetation in most areas is comprised mainly of Mormon-tea, shadscale, and eriogonum (USDA - SCS, 1990).

One of these wells supplies water to Caineville (known as the Colt Well), where it is treated and used as culinary water.  Two of the other three wells are flowing at the wellhead.  One well can be turned off and the other well has a valve that is broken in the open (flowing) position.  If water flowing from these wells is higher in TDS than the Fremont River, then they may be considered point sources according to DWQ permitting section (DWQ - NPDES Section, pers. comm. with Mike Herkimer, Oct. 3, 2000).  Both of these wells were sampled May 19, 1998 by the BLM in cooperation with the DWQ.  Site 599299 (Intermountain Consumers Power Association (ICPA) Test Well) had a TDS concentration of 2,754 mg/L and site 599300 (Intermountain Power Project (IPP) Test Well) had a concentration of 2,564 mg/L; both exceed the average concentration of TDS in the Fremont River at Caineville.  The approximate location of the wells is shown on **Map 9** and the water rights for the wells are summarized in Table 4.37.

**Table 4.37**
**Water Rights for Caineville Wash Wells That Flow into Fremont River**

| Water Right | Point of Diversion | Flow (cfs) | Water Uses | Depth (feet) | Diameter (inches) |
|---|---|---|---|---|---|
| 95-4708 | | | | | |
| (1) IPP Test Well (STORET 599300) | N1750 W1500 From SE Corner of Sec. 29 T28S R8E base SL | 0.67 | Irrigation | 0-45’ | 30” |
| | | | | 45-704’ | 20” |
| | | | | 704-1250’ | 18.5” |
| (2) ICPA Test Well (STORET 599299) | S37 E105 From NW Corner Sec.33, T28S, R8E | 1.16 | Irrigation | 0-22’ | 20” |
| | | | | 22-679’ | 16” |
| | | | | 679-761’ | Unknown |

Well data obtained from Utah Division of Water Rights database and State of Utah, Department of Natural Resources Technical Pub. No.66, Aquifer Tests of the Navajo Sandstone Near Caineville, Wayne County, Utah.

### 4.3.5 Water Quality Goals and Targets

The water quality goals for the lower Fremont River and tributaries are to reduce salt loading by improving the efficiency of irrigation systems and thereby reducing return flows, restoring stream channel stability and eliminating TDS loading from the two artesian wells in Caineville Wash.

As indicted in Table 4.35, average TDS concentrations exceed criteria for four months in the summer, from June through September. To calculate the target load, the 1,200 mg/L criterion was substituted in the table for these four months. The waste load allocation is set to zero because there are currently no permitted dischargers and the load allocation is estimated at 7,699 tons. Including a 5% margin of safety, the remaining load is 7,314 tons of TDS. The required load reduction is 2,594 tons of TDS per year, or 26%. The majority of this load reduction will come through capping the artesian wells in Caineville Wash (1,593 tons) while the remaining 1,001 tons will be controlled through improved irrigation practices and management. Using the information developed by the Price-San Rafael Salinity Control Project which found that irrigation return flows contribute 3.65 tons of salt per acre foot of irrigation return flows, approximately 274 acre feet of return flows need to be reduced in order to meet the target loading. This reduction makes up 6% of the current total return flows of 4,900 acre feet as estimated by the Division of Water Resources in the West Colorado River Basin Water Plan (UDNR-DWR, 1999). To achieve this reduction approximately 158 acres of irrigated land need to implement improved irrigation techniques and / or 10 miles of canals need to be lined.

## 5.0 TMDL

The following section is a stand-alone document that outlines the findings of the Water Quality Management Plan and establishes Total Maximum Daily Loads for the parameters of concern for each waterbody listed on the State of Utah's 303d list.

**Utah Department of Water Quality, Division of Water Quality**

**TMDL Section**

**Johnson Valley Reservoir**

**September 27, 2002**

| | |
|---|---|
| **Waterbody ID** | Upper Fremont River Watershed: Johnson Valley Reservoir, HUC #14070003 |
| **Location** | Sevier County, South Central Utah |
| **Pollutants of Concern** | Total Phosphorus |
| **Impaired Beneficial Uses** | Class 3A: Cold water species of game fish and other cold water aquatic life |
| **Loading Assessment** | |
| **Current Loading** | 1,916 lbs/yr total phosphorus |
| **Loading Capacity** | 958 lbs/yr total phosphorus |
| **Margin of Safety** | Explicit MOS of 5% (48 lbs/yr), implicit MOS through conservative assumptions |
| **Wasteload Allocation** | No point sources, wasteload allocation set to zero |
| **Load Allocation** | 910 lbs/yr total phosphorus |
| **Load Reduction** | 1006 lbs/yr total phosphorus |
| **Defined Targets/Endpoints** | 1) Total phosphorus concentrations less than 0.025 mg/L (in-lake) and 0.05 mg/L (tributary inflow)<br>2) Trophic State Index Values less than 50 (mesotrophy)<br>3) Dissolved Oxygen concentrations greater than 4.0 mg/L (one day average for at least 50% of the water column)<br>4) Reduction in blue-green algal dominance |
| **Implementation Strategy** | 1) Improve upland range condition through application of best management practices identified in Fremont River Watershed Water Quality Management Plan (WQMP)<br>2) Improve riparian area function through application of best management practices identified in WQMP<br>3) Restrict animal access below the high water line of reservoir<br>4) Reduce nonpoint source pollution from roads by applying best available technologies identified in WQMP |
| This document is identified as a TMDL for Johnson Valley Reservoir and is officially submitted under §303d of the CWA for USEPA approval. | |

**Utah Department of Water Quality, Division of Water Quality**

**TMDL Section**

**Forsyth Reservoir**

**September 27, 2002**

| | |
|---|---|
| **Waterbody ID** | Upper Fremont River Watershed: Forsyth Reservoir, HUC #14070003 |
| **Location** | Sevier County, South Central Utah |
| **Pollutants of Concern** | Total Phosphorus and Dissolved Oxygen |
| **Impaired Beneficial Uses** | Class 3A: Cold water species of game fish and other cold water aquatic life |
| **Loading Assessment** | |
| **Current Loading** | 2,747 lbs/yr total phosphorus |
| **Loading Capacity** | 1,319 lbs/yr total phosphorus |
| **Margin of Safety** | Explicit MOS of 5% (66 lbs/yr), implicit MOS through conservative assumptions |
| **Wasteload Allocation** | No point sources, wasteload allocation set to zero |
| **Load Allocation** | 1,253 lbs/yr total phosphorus |
| **Load Reduction** | 1,494 lbs/yr total phosphorus |
| **Defined Targets/Endpoints** | 1) Total phosphorus concentrations less than 0.025 mg/L in–lake and 0.05 mg/L tributary inflow<br>2) Trophic State Index Values less than 50 (mesotrophy)<br>3) Dissolved Oxygen concentrations greater than 4.0 mg/L (one day average for at least 50% of the water column)<br>4) Reduction in blue-green algal dominance |
| **Implementation Strategy** | 1) Improve upland range condition through application of best management practices identified in Fremont River Watershed Water Quality Management Plan (WQMP)<br>2) Improve riparian area function through application of best management practices identified in WQMP<br>3) Restrict animal access below the high water line of reservoir<br>4) Reduce nonpoint source pollution from roads by applying best available technologies identified in WQMP |
| This document is identified as a TMDL for Forsyth Reservoir and is officially submitted under §303d of the CWA for USEPA approval. | |

**Utah Department of Water Quality, Division of Water Quality**

**TMDL Section**

**Mill Meadow Reservoir**

**September 27, 2002**

| | |
|---|---|
| **Waterbody ID** | Upper Fremont River Watershed: Mill Meadow Reservoir, HUC #14070003 |
| **Location** | Wayne and Sevier Counties; South Central Utah |
| **Pollutants of Concern** | Total Phosphorus |
| **Impaired Beneficial Uses** | Class 3A: Cold water species of game fish and other cold water aquatic life |
| **Loading Assessment** | |
| **Current Loading** | 8,564 lbs/yr total phosphorus |
| **Loading Capacity** | 5,481 lbs/yr total phosphorus |
| **Margin of Safety** | Explicit MOS of 5% (274 lbs/yr), implicit MOS through conservative assumptions |
| **Wasteload Allocation** | No point sources, wasteload allocation set to zero |
| **Load Allocation** | 5,207 lbs/yr |
| **Load Reduction** | 3,357 lbs/yr total phosphorus |
| **Defined Targets/Endpoints** | 1) Total phosphorus concentrations less than 0.025 mg/L in–lake and 0.05 mg/L tributary inflow<br>2) Trophic State Index Values less than 50 (mesotrophy)<br>3) Dissolved Oxygen concentrations greater than 4.0 mg/L (one day average for at least 50% of the water column)<br>4) Reduction in blue-green algal dominance |
| **Implementation Strategy** | 1) Improve upland range condition through application of best management practices identified in Fremont River Watershed Water Quality Management Plan (WQMP)<br>2) Improve riparian area function through application of best management practices identified in WQMP<br>3) Restrict animal access below the high water line of reservoir<br>4) Reduce nonpoint source pollution from roads by applying best available technologies identified in WQMP |
| This document is identified as a TMDL for Mill Meadow Reservoir and is officially submitted under §303d of the CWA for USEPA approval. | |

## Utah Department of Water Quality, Division of Water Quality

## TMDL Section

### Upper Fremont River from the US Forest Service boundary (at the outflow of Mill Meadow Reservoir) to Bicknell (STORET 495438)

**September 27, 2002**

| | |
|---|---|
| **Waterbody ID** | Upper Fremont River Watershed, HUC #14070003 |
| **Location** | Wayne County; South Central Utah |
| **Pollutants of Concern** | Total Phosphorus and Dissolved Oxygen |
| **Impaired Beneficial Uses** | Class 3A: Cold water species of game fish and other cold water aquatic life |
| **Loading Assessment** | |
| **Current Loading** | 11,263 lbs/yr total phosphorus |
| **Loading Capacity** | 8,300 lbs/yr total phosphorus |
| **Margin of Safety** | Explicit MOS of 5% (415 lbs), implicit MOS through conservative assumptions |
| **Wasteload Allocation** | 3,814 lbs/yr total phosphorus |
| **Load Allocation** | 4,071 lbs/yr total phosphorus |
| **Load Reduction** | 3,378 lbs/yr total phosphorus |
| **Defined Targets/Endpoints** | 1) Total Phosphorus concentrations less than 0.05 mg/L<br>2) Dissolved Oxygen concentrations greater than 6.5 mg/L<br>3) Elimination of nuisance algae growth in main stem and tributaries. |
| **Implementation Strategy** | 1) Improve upland range and pasture conditions through application of best management practices identified in Fremont River Watershed Water Quality Management Plan (WQMP)<br>2) Improve riparian area functionality through application of best management practices identified in WQMP<br>3) Implement 25 animal waste and/or grazing management plans<br>4) Implement appropriate level of effluent treatment on all six hatcheries and fish production facilities. |
| This document is identified as a TMDL for the upper Fremont River and is officially submitted under §303d of the CWA for USEPA approval. | |

**Utah Department of Water Quality, Division of Water Quality**

**TMDL Section**

**Lower Fremont River from the eastern boundary of Capitol Reef National Park to the confluence with the Dirty Devil River**

**September 27, 2002**

| | |
|---|---|
| **Waterbody ID** | Lower Fremont River Watershed, HUC #14070003 |
| **Location** | Wayne County; South Central Utah |
| **Pollutants of Concern** | Total Dissolved Solids |
| **Impaired Beneficial Uses** | Class 4: Agricultural uses including irrigation of crops and stock watering |
| **Loading Assessment** | |
| **Current Loading** | 9,908 tons of TDS during critical period (June 1 – Sept. 30) |
| **Loading Capacity** | 7,699 tons of TDS during critical period (June 1 – Sept. 30) |
| **Margin of Safety** | Explicit MOS of 5% (385 tons), implicit MOS through conservative assumptions |
| **Wasteload Allocation** | No point sources, wasteload allocation set to zero |
| **Load Allocation** | 7,314 tons of TDS during critical period (June 1 – Sept. 30) |
| **Load Reduction** | 2,594 tons of TDS |
| **Defined Targets/Endpoints** | Total Dissolved Solids concentrations less than 1,200 mg/L at mouth of Fremont River |
| **Implementation Strategy** | 1) Reduce return flows by 274 acre feet through implementation of irrigation best management practices identified in Fremont River Watershed Water Quality Management Plan<br>2) Cap artesian wells or implement NPDES permit |
| This document is identified as a TMDL for the lower Fremont River and is officially submitted under §303d of the CWA for USEPA approval. | |

# I. Introduction

The Fremont River watershed is located in south-central Utah and encompasses an area of approximately 1,970 square miles. The boundaries of the watershed are defined by USGS Hydrologic Accounting Unit (HUC) #14070003 (**Map 1**). The majority of the Fremont River watershed is located in Wayne County, including the central portion of the watershed, the course of the Fremont River, and all the major settlements within the Fremont basin. However, the headwaters (located in the northwestern portion of the watershed) are within Sevier County, a small portion of the watershed on the western extreme is located in Piute County, and the southeast portion of the basin, is within Garfield County. The elevation of the watershed ranges from over 11,000 feet at the headwaters to less than 5,000 feet at the outlet. The Fremont River is the principal drainage flowing in an eastward direction through the watershed.

Several waterbodies within the watershed were identified as a high priority for TMDL development in the State of Utah's 2000 303d list including; Johnson Valley Reservoir, Forsyth Reservoir, Mill Meadow Reservoir, Lower UM Creek, Fremont River near Bicknell to U.S.F.S. boundary, and Fremont and tributaries from the confluence with the Dirty Devil River to the east boundary of Capitol Reef National Park.

The principal waterbodies in the watershed and other hydrologic features are shown on **Map 7**. The headwater streams, lake and reservoirs are located within Fishlake National Forest on Fish Lake Plateau, the sixth highest mountain in the state of Utah and the highest of the high plateaus in the southern portion of the state. Fish Lake is the highest impoundment in the Fremont River watershed system and the largest natural mountain lake in the State of Utah. The watershed highpoint, 11,633 feet, is located on the south shoulder of Fish Lake Hightop Plateau, directly north of the lake. Inflow sources to Fish Lake include Jorgenson Creek, Bowery Creek, Twin Creek, and Doctor Creek. The outlet is Lake Creek, a headwater stream of the Fremont River. Johnson Valley Reservoir is located northeast of Fish Lake. It is a shallow, intermediate sized impoundment of a mountain meadow. It receives inflow from Lake Creek, Tasha Creek and Sevenmile Creek. The outlet is the Fremont River. Forsyth Reservoir is located at the base of the Fish Lake Mountains. It is an intermediate size impoundment of a stream valley. It receives water from UM Creek and Tidwell Canyon. The outlet is UM Creek. Mill Meadow Reservoir is located below Johnson Valley and Forsyth Reservoirs on the Fishlake National Forest boundary. It receives inflow from the Fremont River and UM Creek. All of the surface runoff from the upper watershed is captured by this reservoir system ending at Mill Meadow Reservoir. The outlet of Mill Meadow Reservoir is the Fremont River.

Below Mill Meadow Reservoir the Fremont River enters Rabbit Valley where most of the river water is diverted for irrigation purposes. The major irrigation pathways in the Rabbit Valley portion of the watershed are Highline Canal, Fremont/Loa Ditch, Spring Ditch (south of Bicknell), and Spring Creek north of Road Creek. The flow of the Fremont River from Mill Meadow Reservoir to the Fremont River at Bicknell is managed to maximize the use of a limited supply of water for irrigation, stock water, fish hatcheries, and communities. Inputs of flow to the river and residual flows left in the river result from an intensive water management system combined with numerous spring sources. East of Rabbit Valley, the Fremont River flows through Capitol Reef National Park toward Hanksville. In the lower portion of the watershed, east of Capitol Reef National Park, water from the Fremont River is diverted above Caineville for flood irrigation of pastures and haylands.

The number of people residing within the boundaries of the watershed is estimated to be approximately 2,500 (Governor's Office of Planning and Budget, 1994). The area is primarily rural with numerous farms in the Rabbit Valley area.

The primary land uses in the watershed are associated with livestock production, including grazing on rangelands and alfalfa and grass hay production on croplands. Approximately 5% of the land in Wayne County is privately owned, 12% is administered by the state of Utah and 83% is administered by one of three federal agencies (Bureau of Land Management, Forest Service or National Park Service). The watershed contains approximately 16,000 acres of irrigated land and 70,000 acres of private and state rangelands. The remaining acres are federally administered public lands. There are two distinct physiographic units within the basin that affect land use. The first is the upper Fremont River basin, which is defined by high mountain valleys, volcanic rocks, wet meadows, irrigated agriculture, and coldwater fisheries. The second unit is the lower Fremont River basin, which is characterized by desert landscapes, Mancos Shale, sandstone, significant sedimentation, and warm water fisheries. Both areas attract a visiting population from outside the basin that comes for the fishing, hunting, camping, and sightseeing that both of these physiographic regions offer.

The State’s Division of Wildlife Resources and Trust Lands Administration manage a significant proportion of the watershed for multiple purposes including wildlife, grazing and mineral extraction. The Division of Wildlife Resources maintains a fish hatchery between Loa and Fremont (Loa Fish Hatchery), and one south of Bicknell (JP Egan Fish Hatchery). In addition, they administer approximately 700 acres of land in the Bicknell Bottoms, which provides important waterfowl habitat. They also manage the lake and stream fisheries as well as many game species in the area. The Trust Lands Administration manages approximately 142,000 acres within the river basin (UDNR-DWR, 1975).

Five federal agencies are active within the watershed. The Natural Resources Conservation Service (NRCS) provides financial and technical assistance to agricultural producers. The Farm Service Agency (FSA) administers programs including crop insurance, farm loans and the Conservation Reserve Program. The US Forest Service (USFS) manages the Fishlake and Dixie National Forests, which include most of the headwaters within the watershed. The Bureau of Land Management (BLM) administers the majority of land within the watershed, which consists primarily of mid and low elevation desert rangelands. The National Park Service administers Capitol Reef National Park, located in the middle of the watershed (**Map 4**).

### Climate and Streamflow

There are wide local variations in climate within the watershed primarily due to topography, but the variability in weather also depends on general air circulation, the relative position of the continental landmass, and latitude. The high mountainous portions of the watershed have different temperature and precipitation characteristics than the low elevation desert sections of the watershed.  Temperatures range from lows of -20º F during the Winter at the higher elevations to over 100º F during the summer in the lower portion of the basin.

Precipitation in the watershed also varies with topography.  Weather Bureau records indicate that average annual precipitation has historically ranged from over 40 inches in the high plateaus at the headwaters to less than six inches in the low-lying desert area near the outlet of the watershed.  Approximately two-thirds of annual precipitation falls between the months of October – April, and the remainder occurs during the months of May – September.  In general, Winter precipitation falls in the form of rain or snow, while summer precipitation is characterized by random convective thunderstorm activity, resulting from the northward flow of warm, moist air masses from the Gulf of Mexico. Two major storm paths affect Fishlake National Forest.  During the Winter and Spring months, frontal storm systems from the Pacific Northwest predominate.  These Winter storms affect mostly the northern half of the forest.  During the late summer and early Fall, thunderstorms move in from the south and southwest.  These thunderstorms occur in isolated areas, are of great intensity, and have the potential to produce flood events.

### Impaired Waters

The Fremont River is listed on Utah's Year 2000 303(d) list as impaired for three water quality parameters of concern – total phosphorus (TP), dissolved oxygen (DO), and total dissolved solids (TDS).  The listing is based on an intensive water quality study that was completed in 1997-1998 by DWQ.  This survey found numerical criteria exceedences for these water quality constituents (UDEQ-DWQ, 2000b).

The DWQ has subdivided the Fremont River watershed into two sections based on beneficial use classifications (**Map 8**).

The upper section is from the headwaters to the eastern boundary of Capitol Reef National Park and is also referred to as the upper Fremont River watershed.  The beneficial uses for the upper Fremont River watershed are:

- 1C – Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water;
- 2B – Secondary contact recreation (boating, wading, or similar uses);
- 3A – Cold water species of game fish and other cold water aquatic life; and
- 4 – Agricultural uses including irrigation of crops and stock watering.

Two river segments of upper the Fremont River watershed are impaired for designated beneficial use 3A.  These segments include UM Creek from Mill Meadow to Forsyth Reservoir, and the Fremont River from the US Forest Service boundary (at the outflow of Mill Meadow Reservoir) to Bicknell (STORET 495438).  UM Creek is listed only for depressed dissolved oxygen concentrations (DO) while the Fremont River is listed for both low DO and elevated TP concentrations.  In addition, three reservoirs located near the headwaters of the Fremont River are listed as impaired.  Johnson Valley Reservoir and Mill Meadow Reservoir are listed for TP.  Forsyth Reservoir is listed for TP and DO.

The lower Fremont River, as defined by DWQ, begins at the eastern boundary of Capitol Reef National Park and ends at the confluence with the Dirty Devil River. The beneficial uses for this section of the watershed are:

- 2B – Secondary contact recreation (boating, wading, or similar uses);
- 3C – Nongame fish and other aquatic life; and
- 4 – Agricultural uses including irrigation of crops and stock watering.

The lower Fremont River watershed is impaired for designated beneficial use 4, due to high levels of TDS.

The waterbodies on the 2000 303(d) list , the parameters of concern, and the impaired beneficial uses identified within the Fremont River watershed are shown on **Map 8** and **Table 1** below:

**Table 1**
**303(d) Listed Segments and Waterbodies in the Fremont River Watershed**

| Upper Fremont River Watershed Stream Segment or Waterbody | Waterbody ID | Waterbody Size | Listed Parameter of Concern | Impaired Beneficial Use | Date First 303(d) Listed |
|---|---|---|---|---|---|
| Mill Meadow Reservoir | Not available | 156 Acres | Total Phosphorus | 3A | 1998 |
| Lower UM Creek from Mill Meadow to Forsyth Reservoir | UT14070003-003 | 0.8 Miles | Dissolved Oxygen | 3A | 1998 |
| Forsyth Reservoir | Not available | 158 Acres | Dissolved Oxygen & Total Phosphorus | 3A | 1998 |
| Johnson Valley Reservoir | Not available | 285 Acres | Total Phosphorus | 3A | 1998 |
| Fremont River near Bicknell to the USFS Boundary | UT14070003-005 | 24 Miles | Dissolved Oxygen & Total Phosphorus | 3A | 1998 |
| Fremont River from the Confluence with the Dirty Devil River to the Eastern Boundary of Capital Reef National Park | UT14070003-014 | 100 Miles | Total Dissolved Solids | 4 | 1998 |

Source: UDEQ-DWQ, 2000b

### Statement of Intent

This TMDL addresses the water quality impairments in the Fremont River watershed for TP, DO and TDS for submittal to the United States Environmental Protection Agency. The goal of the TMDL is to meet water quality standards associated with each waterbody's designated beneficial uses .

## II. Water Quality Standards and Impairments

### Upper Fremont River Watershed – Reservoirs and Tributaries and Upper Fremont River / Fremont River near Bicknell to USFS Boundary

Mill Meadow, Forsyth, and Johnson Valley Reservoirs are currently listed as impaired for Class 3A (protected for cold water species of game fish and other cold water aquatic life, including necessary organisms in their food chain). Forsyth Reservoir is currently not meeting its cold water fisheries beneficial use because of low DO in the water column and high concentrations of TP leading to excessive algal production. Mill Meadow and Johnson Valley Reservoirs are not meeting their cold water fisheries beneficial use due to high concentrations of TP. The apparent effects of TP loading on waterbodies differs depending on the prevalence of other limiting factors such as temperature, shading and depth. However, excess phosphorus concentrations in lakes and reservoirs over a prolonged period of time usually lead to increased productivity of macrophytes and algae, which results in decreased DO levels during decomposition. This succession of events has been shown to lead to periodic fish kills in these and other waterbodies. These eutrophic reservoirs exhibit blue-green alga species dominance and/or high (>50) Trophic State Index (TSI) values.

UM Creek between Forsyth and Mill Meadow Reservoirs is listed as impaired for low levels of DO. The Fremont River near Bicknell to the USFS boundary is listed as impaired due to excessive levels of TP and low levels of DO. The cause-effect relationship between low DO and elevated nutrient concentrations indicated a need to establish endpoints/targets associated with a reduction of TP. Often, excess nutrient levels will lead to depressed DO concentrations due to increased biomass of periphyton (organisms, such as some algae, that live attached to underwater surfaces) in streams. This DO decline is associated with the respiration cycle of periphyton and may result in fish kills or the death of organisms necessary for fish survival such as invertebrates (UDEQ-DWQ, 2000d).

In a review of scientific literature, Carpenter et al. (1998), have shown that nonpoint sources of phosphorus have lead to eutrophic conditions for many lakes and reservoirs across the country. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of their designated beneficial uses, the rates of recovery are variable among lakes and reservoirs. This supports the Division of Water Quality's viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, although this process takes a significant amount of time (5-15 years).

In Lake Erie, heavy loadings of phosphorus have impacted the lake severely. Monitoring and research from the 1960's has shown that large mats of decaying algae were responsible for depressed DO levels and large fish kills. Programs to reduce nutrients into the lake have resulted in a downward trend of phosphorus concentrations and oxygen depletion rates since monitoring began in the 1970's. The trend of oxygen depletion has lagged behind that of P reduction, but this was expected (See http://www.epa.gov/glnpo/lakeeerie/dostory).

Nurnberg (1995, 1995a, 1996, 1997) developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual total phosphorus (TP) concentrations. Nurnberg (1996) developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes and reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. The DWQ has calculated morphometric parameters such as surface area ($A_o$), mean depth (z), and the ratio of mean depth to surface area ($z/A_o^{0.5}$) for the concerned reservoirs in the upper Fremont River Watershed (**Table 2**). The results show that these parameters are within the range of lakes used by Nurnberg. Thus, Nurnberg's empirical nutrient-oxygen relationship holds true for these reservoirs, and the prescribed BMPs will reduce external loading of nutrients to the reservoirs, resulting in reduced algae blooms and an increase in dissolved oxygen levels over time.

Utah's approach is to treat the sources of nutrients and reduce or eliminate nutrient loads to impaired waterbodies and this approach is consistent with accepted watershed strategies to treat sources rather than symptoms (low DO). If after treatment of sources and a sufficient period for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. However, in-lake treatments should not be implemented without control of nutrient sources within the watershed. This view is also supported by Carpenter et al. (1998).

**Table 2**
**Morphometry Data for Fremont River Watershed Reservoirs**

| Lake | Nurnberg Range | Johnson Valley | Forsyth | Mill Meadow |
|---|---|---|---|---|
| z (m) | 1.8 - 200 | 4.3 | 8 | 10.2 |
| $A_o$ (ha) | 5 – $8.2 \times 10^6$ | 285 | 64 | 63 |
| $z / A_o^{0.5}$ | 0.14 – 48.1 | 2.55 | 10 | 1.28 |

**Applicable Water Quality Standards: Upper Fremont River Watershed – Reservoirs and Tributaries and Upper Fremont River / Fremont River near Bicknell to USFS Boundary**

DWQ lists any waterbody assessed as ‘partially supporting’ or ‘not supporting’ its beneficial uses on the 303(d) list with the exception of those waterbodies for which a TMDL study has already been completed and approved by the EPA. According to DWQ's assessment of these waterbodies, all three reservoirs and some stream segments in the upper Fremont River watershed are not meeting the water quality standards to support beneficial use 3A. Therefore, this explanation of the applicable water quality standards will focus on the standards for beneficial use 3A.

Throughout the State of Utah, essentially the same criteria are used to assess lakes and reservoirs, and rivers/streams for beneficial uses 3A (cold water game fish), 3B (warm water game fish), and 3C (warm water nongame fish). The applicable numeric and narrative criteria for assessing beneficial use support for fisheries in all of the above mentioned waterbody types is presented in the following tables. In addition, supplementary criteria are applied to assess conventional parameters in lakes and reservoirs including pH, DO, and temperature. These additional criteria are described in the narrative following the tables.

The total phosphorus method for identifying waterbodies as “needing further study” is not applied to lakes and reservoirs. The State of Utah exercises discretion in using data or information that go beyond the criteria listed in the following tables and/or narrative for listing waterbodies and can include other types of information and best professional judgment. **Table 3** and **Table 4** include the criteria used for determining beneficial use support of waterbodies for beneficial use 3A.

**Table 3**
**Numeric Criteria for Aquatic Wildlife**

| Parameter | Aquatic Wildlife 3A |
|---|---|
| Minimum Dissolved Oxygen (mg/L) [1] | |
| 30 Day Average | 6.5 |
| 7 Day Average | 9.5 / 5.0 |
| 1 Day Average | 8.0 / 4.0 |
| Maximum Temperature (C) | 20 |
| Maximum Temperature Change (C) | 2 |
| pH (range) | 6.5 – 9.0 |
| Turbidity Increase (NTU) | 10 |
| Nitrate as N (mg/L) | 4 |
| Total Phosphorus as P (mg/L) [2] [3] | 0.05 |
| Total Suspended Solids (mg/L) [3] | 35 |

[1] These limits are not applicable to lower water levels in deep impoundments. First number in column is for when early life stages are present, second number is for when all other life stages are present.

[2] Total Phosphorus as P (mg/l) limit for lakes and reservoirs shall be 0.025.

[3] Indicators of pollution.

**Table 4**
**Narrative Criteria for Assessing Aquatic Life Beneficial Support Classes 3A, 3B, 3C, 3D in Streams**

| Degree of Use Support | Conventional Parameters (pH, DO, temperature) | Toxic Parameters (priority pollutants, chlorine, and ammonia) |
|---|---|---|
| Full | For any one pollutant, no more than one violation of criterion or criterion was not exceeded in < 10% of the samples if there were two or more exceedences. | For any one pollutant, no more than one violation of acute criteria. |
| Partial | For any one pollutant, criterion was exceeded two times, and criterion was exceeded in more than 10%, but not more than 25% of the samples. | For any one pollutant, two or more violations of the acute criterion, but violations occurred in ≤ 10% of the samples. |
| Non | For any one pollutant, criterion was exceeded two times, and criterion was exceeded in more than 25 % of the samples. | For any one pollutant, two or more violations of the acute criterion, and violations occurred in more than 10% of the samples. |

(Source: UDEQ-DWQ, 2000b)

For total phosphorus, the following criteria were used to identify waters as "needing further evaluation". If the pollution indicator value for TP (0.05 mg/L) was exceeded in more than 10% of the samples, and the mean of all samples was greater than 0.06 mg/L the waterbody was identified as "needing further evaluation or study" before a decision was made to list a stream waterbody on the 303(d) list. Additional evaluations including benthic macroinvertabrate data, diurnal DO data, and habitat quality evaluations can be used to determine beneficial use support (UDEQ-DWQ, 2000b).

Initial evaluation targets were developed to screen impaired waters. These initial evaluation targets were collected from the following sources:

- Utah Administrative Code (UAC) Rule R317-2 - Standards of Quality for Waters of the State (State of Utah, 2000, UAC R317-2);
- Utah's Year 2000 303(d) List of Waters (UDEQ-DWQ, 2000b);
- Utah Water Quality Assessment Report to Congress 2000 (305(b) Report) (UDEQ-DWQ, 2000e); or
- An interpretation of the standards where no numeric criteria are provided.

The evaluation targets include numeric criteria for DO, TP, TSI, TDS, temperature, and pH as indicated in **Table 5**.

**Table 5**
**Initial Evaluation Criteria**

| Parameter | Lakes/Reservoirs | Rivers/Streams |
|---|---|---|
| DO | 4.0 mg/L[1] | 6.5 mg/L[2] |
| TP [1] | 0.025 mg/L | 0.05 mg/L |
| TSI[3] | >50 | not applicable |
| TDS[2] | not applicable | 1,200 mg/L |
| Temperature[2] | 20 C | 20 C |
| pH[2] | 6.5 - 9.0 | 6.5 - 9.0 |

1. Utah's Year 2000 303(d) List of Waters (UDEQ-DWQ, 2000b)
2. UAC R317-2. Standards of Quality for Waters of the State
3. Utah Water Quality Assessment Report to Congress 2000 (305(b) Report) (UDEQ-DWQ, 2000e)

The interpretation of full, partial, and non-support are discussed in Section II of "Methodology for Developing the 303(d) List". Part B of Section II describes the "Criteria for Listing Waterbodies on the 303(d) List" and Part C discusses "Additional Criteria for Listing Lakes and Reservoirs". These criteria are summarized below to develop a rule set that can be applied to the evaluation of support status for the Fremont River watershed.

**Lakes and Reservoirs Listing Criteria**

The numeric listing criteria for reservoirs include DO, TP, TSI, pH, and temperature. The Fremont basin reservoirs are not listed for pH or temperature, and the data summaries (**Appendix D**) support that decision. Therefore, this summary focuses only on the listing criteria as they apply to DO, TP, TSI, and other biological evidence of impairment.

To determine the beneficial use support for aquatic life - 3A in listing lakes and reservoirs, DWQ applies the following additional criteria. An initial support status is determined for three conventional parameters (DO, temperature, and pH) according to the national 303(b) criteria. The data for these three parameters were analyzed for the entire water column and a percent of the readings exceeding State standard is determined. However, State standards account for the fact that anoxic or low DO conditions may exist in the bottom of deep reservoirs and therefore, an exceedence of the lower 25% of the water column is allowed for DO concentrations against the State standard. Current 303(d) guidelines indicate that for any one pollutant or stressor, when the criteria were exceeded in less than or equal to 10% of the measurements, a designation of fully supporting was assigned. When the criteria were exceeded in greater than 10, but less than 25% of the measurements, a designation of partially supporting was assigned. When the criteria were exceeded in greater than 25% of the measurements, a designation of non-supporting was assigned. Exceedence percentages used to assess support status are those identified in the 303(d) guidelines with the exception of DO.

Exceedence criteria for DO in lakes and reservoirs are defined using the 1-day minimum DO concentration of 4.0 mg/L (UDEQ-DWQ, 2000a). Evaluation of profile data is specific to each sampling period and is not averaged over a seasonal or annual basis. When the DO is greater than 4.0 mg/L for greater than 50% of the water column depth, a fully supporting status is assigned; partial support when 25-50% is greater than 4.0, and non-support when less than 25% of the water column is greater than 4.0 mg/L. Unless a reservoir is classified as fully supporting (50% of total water column is above the 4.0 mg/L DO standard) it meets the criteria for listing. Reservoir DO profiles provided by DWQ (**Appendix E**) were used to evaluate the support status according to the criteria described above.

For Class 3 (aquatic life) lakes and reservoirs the TP pollution indicator is 0.025 mg/L. The general listing rule in the current 303(d) guidelines indicate that less than 10% exceedance is fully supporting, 10% to 25% partially supporting, and greater than 25% is non-supporting. It should be noted that the process for listing lakes for TP is based upon TSI rankings. Other evidence of impairment includes an evaluation of Winter DO with reported fish kills, and presence of blue green algae in the phytoplankton community. Additionally, trends in the data are evaluated to account for hydrology and seasonality in reservoirs.

A final determination to list the waterbody was made through an evaluation of the historical beneficial use support trends since 1989. It was necessary to include such an evaluation to incorporate the hydrology and seasonality associated with lakes and reservoirs. In general, if a waterbody exhibited a beneficial use that was consistently partially supporting or not supporting, DWQ will place it on the 303(d) list. However, if a waterbody exhibits a mixture of partially and fully supporting conditions over a period of time, DWQ will not list the waterbody, but continue it's evaluation (UDEQ-DWQ, 2000b).

### Rivers and Streams Listing Criteria

The listing criteria applicable to the Fremont River Watershed streams and rivers are included in Tables 3 and 4 of the 303(d) list of waters document (UDEQ-DWQ, 2000b). The 30 day average DO criteria for Class 3A waters (6.5 mg/L) were applied to the rivers/streams data for this screening exercise.

For DO, in streams and rivers, the general listing rule applies: less than 10% exceedence is interpreted as full support, 10% to 25% partial support, and greater than 25% exceedence is interpreted as non-support. This was applied to the 6.5 mg/L criterion.

For TP, the following criteria were used to identify waters as "needing further evaluation": if the value for TP (0.05 mg/L) was exceeded in more than 10% of the samples, and the mean of all samples was greater than 0.06 mg/L, the waterbody was identified as 'needing further evaluation or study'. Additional information that were considered includes: benthic macroinvertebrate data, diurnal DO, habitat quality evaluations, and fisheries data.

### Phosphorus

Impairments to the fisheries beneficial use in the upper watershed are due to elevated levels of TP and depressed levels of DO. Phosphorus is typically scarce in undisturbed aquatic environments. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus and releases of these deposits occur through weathering, leaching, erosion, and mining. Other natural sources of phosphorus include plant matter, wildlife and atmospheric deposition. Phosphorus can be transported to aquatic systems via water, wind or terrestrial cycling (terrestrial phosphorus cycling includes immobilizing inorganic phosphorus into calcium or iron phosphates, incorporating inorganic phosphorus into plants and microorganisms, and breaking down organic phosphorus to inorganic forms by bacteria [USEPA, 1999a]). The measurement of all phosphorus forms in a water sample, including all inorganic and organic particulate and soluble forms, is known as total phosphorus.

The organic and soluble forms of phosphorus are of particular concern with regards to water quality because it is immediately available for uptake by algae whereas the inorganic or mineral forms of phosphorus must first be broken down into its constituent parts through complex chemical reactions

Anthropogenic sources of phosphorus have resulted in excess loading into many freshwater systems. Excess loading results in an imbalance of the natural nutrient cycling processes. Excess available phosphorus in freshwater systems can result in accelerated plant growth if other factors (e.g., light availability, temperature, water velocity, substrate, and algae consuming grazers) are not limiting (USEPA, 1999a).

Excess nutrients in a waterbody can have many detrimental effects on its designated beneficial uses especially with respect to fisheries. These impairments primarily occur when dead plant matter settles to the bottom of a waterbody initiating microbial decomposition. Eventually, oxygen in the hypolimnion of lakes and reservoirs is depleted due to consumption of oxygen in the decomposition process, creating an environment for the re-introduction of phosphorus from underlying sediments. Oxygen depletions also occur at night due to plant respiration. Extreme oxygen depletion can stress or eliminate desirable aquatic life (USEPA, 1999a).

### Water Quality Standards and Impairments: Lower Fremont River Watershed

The lower Fremont River, as defined by DWQ, begins at the eastern boundary of Capitol Reef National Park and ends at the confluence with the Dirty Devil River. This section is impaired for its designated agricultural beneficial use (Class 4), due to high levels of TDS.

### Applicable Water Quality Standards: Lower Fremont River Watershed

Utah water quality standards (Utah WQS) (State of Utah, 2000, UAC R317-2) and the 303(d) listing criteria (UDEQ - DWQ, 2000b) provide the criteria to make an initial assessment of water quality conditions. The Utah WQS establish a numeric criterion of 1,200 mg/L TDS for Class 4 waters, for protection of their agricultural beneficial use. In addition, the Utah WQS also provide numeric criteria for pH, boron, and metals as summarized in **Table 6**.

**Table 6**
**Utah Water Quality Criteria**

| Parameter | Criterion, Maximum Concentration |
|---|---|
| **Target Parameters*** | |
| Total Dissolved Solids | 1,200 mg/L |
| **Secondary Parameters**** | |
| pH | 6.5 – 9.0 pH units |
| Boron | 0.75 mg/L |
| Arsenic | 0.10 mg/L |
| Cadmium | 0.01 mg/L |
| Chromium | 0.10 mg/L |
| Copper | 0.20 mg/L |
| Lead | 0.10 mg/L |
| Selenium | 0.05 mg/L |

**Notes:*** Utah WQS clarify that TDS limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water.
** Metals criteria as dissolved maximum concentrations.

The 303(d) listing criteria provide guidance on evaluating beneficial use support status based on the number of violations of the water quality criterion as listed in **Table 7**.

**Table 7**
**303 (d) Criteria for Assessing Agricultural Beneficial Use Support (Class 4)**

| Degree of Use Support | Conventional Parameter (TDS – 1,200 mg/L) | Toxic Parameters |
|---|---|---|
| Full | Criterion exceeded in less than two samples and in less than 10% of the samples if there were two or more exceedences. | For any one pollutant, no more than one violation of criterion. |
| Partial | Criterion was exceeded two times, and criterion was exceeded in more than 10% but not more than 25% of the samples. | For any one pollutant, two or more violations of the criterion, but violations occurred in less than or equal to 10% of the samples. |
| Non-support | Criterion was exceeded two times, and criterion was exceeded in more than 25% of the samples. | For any one pollutant, two or more violations of the criterion, and violations occurred in more than 10% of the samples. |

### Total Dissolved Solids

TDS is listed as a criterion for protection of agricultural uses because of the negative effect of high salinity on crop production. The Agricultural Salinity Assessment and Management Manual (Tanji, 1990) provides guidance on assessment of water used for irrigation. The following material is paraphrased from the manual (Tanji, 1990).

> Measurements of water samples should include salinity, soluble salts, toxic elements, and pH. Salinity is defined as the total sum of inorganic ions and molecules. The major components of salinity are the cations calcium,

magnesium, and sodium, and the anions chlorine, sulphate, and bicarbonate. The potassium and nitrate ions are usually minor components of the salinity. Salinity reduces crop growth by reducing the ability of plant roots to absorb water, and is evaluated by the relationship to salt tolerance of crops.

Unlike the salinity hazard, excessive sodium does not impair the uptake of water by plants, but does impair the infiltration of water into the soil. The growth of plants is, thus, affected by an unavailability of water. The reduction in infiltration of water can usually be attributed to surface crusting, the dispersion and migration of clay into the soil pores, and the swelling of expandable clays. The hazard from sodium is evaluated using the Sodium Absorption Ratio (SAR), a ratio of sodium to calcium and magnesium in the irrigation water, in relationship to the TDS.

## III. Pollutant Assessment

Nonpoint and point sources of pollution in the Fremont River watershed are discussed in relation to headwater reservoirs and streams, the Fremont River between Bicknell Bottoms and the USFS boundary, and the lower Fremont River, respectively.

### Upper Fremont River Watershed – Reservoirs and Tributaries

### Nonpoint Sources of Phosphorus

#### Natural Background

Natural sources of phosphorus include atmospheric deposition (dust), weathering of rock, stream erosion, wildlife wastes, and leaf fall. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus. Release of these deposits occurs through weathering, leaching, erosion, and mining. Where background loading is significant a reference stream or lake is usually used to determine the level. Reference sites are relatively undisturbed by human influences or represent the least-impaired conditions. However, there are currently no established reference sites within Utah.

Another approach to determine background loading is to utilize literature values. According to Novotny and Olem (1994) the approximate contribution of phosphorus attributable to atmospheric deposition is 0.015 mg/L.

#### Silviculture

Historic logging has been identified as a potential source of nonpoint source pollution to Forsyth Reservoir (Judd, 1997). Depending upon the logging practices employed and the magnitude of associated road building, there is a potential for accelerating runoff and erosion rates and therefore transporting sediments to receiving waters. Four timber harvests have occurred in the area over the last few years (**Table 8**), although according to the Watershed Steering Committee (WSC, 2000), these areas have been replanted and either drain away from impaired waterbodies, or are located a significant distance from the Fremont River and its tributaries. Therefore, logging is not considered a nonpoint source of pollution.

**Table 8**
**Logging Sales – USFS Fishlake National Forest**

| Year | Volume | Slope | Location | Acres | Type |
|---|---|---|---|---|---|
| 1995-Current | 615 MBF | ≤ 15% | 1000 Lake Mountain | 40 | Spruce |
| 1997-1998 | 500,000 MBF | ≤ 20% | Hens Peak - burn area | 200 | Spruce |
| 1998 | 2069 CCF | ≤ 15% | Sevenmile Drainage | 197 | Spruce |
| 1999 | 1231 CCF | ≤ 15% | Briggs Hollow | 72 | Aspen |

MBF = Thousand Board Feet
CCF = Hundred Cubic Feet
Source: USFS correspondence 10/12/00

Prescribed fires on the Tidwell slopes have the potential to increase runoff and soil erosion. The goals of these burns are to rejuvenate decadent sagebrush, increase forage for livestock and wildlife and reduce conifer encroachment into aspen stands. The burns are conducted either in late Fall or early Spring to minimize damage to grass root crowns. Depending upon the timing and intensity of rainfall there is potential for increased runoff and soil erosion originating from treated areas. However, in the long-term prescribed fire has been shown to decrease runoff and erosion through the rejuvenation of native vegetation. Therefore prescribed burns are not considered a nonpoint source of pollution.

### Recreation

Litter and wastes from recreational users have been identified as a potential source of nonpoint pollution to all three of the impaired reservoirs within the watershed (Judd, 1997). Johnson Valley Reservoir is used heavily for fishing and boating, and offers limited facilities for persons who utilize the reservoir for recreational activities. Forsyth and Mill Meadow Reservoirs offer fishing, boating, and camping. Recreation facilities provided at Mill Meadow include vault toilets and campsites. Vault toilets are also provided at Forsyth Reservoir.

Another recreational activity that is increasing within the upper watershed and has the potential to cause significant resource damage is the use of All Terrain Vehicles (ATVs). The majority of ATV users ride responsibly by staying on the trails and primitive roads provided for their use; however, some take advantage of the unprecedented access these vehicles provide. Areas where ATV use has caused problems include sensitive areas such as steep slopes that are prone to erosion and wet meadow and riparian areas where the tracks left behind can remain indefinitely providing a conduit for runoff that often leads to the formation of gullies.

Although estimates of phosphorus loading from recreational activities could not be determined with any reasonable degree of accuracy it is recognized that at times intense pressure is put on the natural resources that attract visitors and the public facilities that are provided for them. It is during these periods of heavy use that public education and the recommended best management practices within the Water Quality Management Plan are most needed. However, due to limited staff and budgets the responsibility for implementing these recommendations can not lie solely on the administrating agency but with the recreationists and watershed stakeholders as well.

### Agriculture

The only agricultural activity that occurs within the upper watershed is livestock grazing. Livestock grazing allotments are designated within Fishlake National Forest by the U.S. Forest Service (USFS). It must be emphasized that the Watershed Steering Committee in consultation with the Technical Advisory Committee does not feel that the carrying capacity of livestock is being exceeded on the grazing allotments. Water quality issues related to livestock grazing and the recommended best management practices identified to address them are designed to minimize the transport of nutrients into receiving waters, not reduce them altogether. In fact it has been shown that livestock grazing can improve upland conditions and have little to no impact on riparian areas depending on the season, duration and intensity of use.

When surface runoff occurs in grazing areas, contaminates, such as nutrients and bacteria, can wash directly into receiving waters if no vegetative buffers are present or these contaminates can sorb to sediments and then be transported to surface waters during storm or snowmelt events (USEPA, 1999c; Doran, et al, 1981). If livestock have direct access to a waterbody any waste that is deposited there is immediately incorporated into the water or during Spring runoff when water levels rise.

**Table 9** lists the allotments for grazing in the Fishlake National Forest portion of the basin. These allotments are located within the USFS area shown on **Map 9.** Only fractions of the Daniels, Last Chance, Solomon, and Thousand Lake allotments are within the Fremont River watershed boundaries.

**Table 9**
**Grazing Allotments – USFS Fishlake National Forest**

| Allotment | # of Permitted Animals | Acreage | Permitted Dates |
|---|---|---|---|
| Daniels | 400 Cow/Calf Pair | 14,157 | 7/1 – 9/30 |
| Hancock | 1300 Sheep | 20,728 | 7/15 – 10/15 |
| Sevenmile | 1129 Cow/Calf Pair | 32,114 | 5/11 – 10/16 |
| UM | 819 Cow/Calf Pair | 39,500 | 6/1 – 10/16 |
| Tidwell | 670 Cow/Calf Pair | 13,873 | 6/1 – 10/31 |
| Last Chance | 483 Cow/Calf Pair | 36,091 | 6/1 – 10/20 |
| Solomon | 408 Cow/Calf Pair | 35,299 | 6/1 – 10/31 |
| Thousand Lake | 406 Cow/Calf Pair | 70,982 | 6/1 – 10/15 |

Source: USFS Fishlake National Forest

Phosphorus loading from grazing allotments was estimated using Unit Area Loads. Unit Area Loads are a function of the average daily output of phosphorus from livestock, the number of animals within the allotment, the number of days they are present and the total area of the allotment. The proportion of the unit load that is transported to receiving waters was assumed to be equivalent to the total area of the allotment within a quarter mile of perennial water.

### Point Sources of Phosphorus

There are no point sources that affect the water quality of the reservoirs or tributaries in the Fishlake National Forest portion of the upper Fremont River watershed.

### Upper Fremont River – Fremont River near Bicknell to USFS Boundary

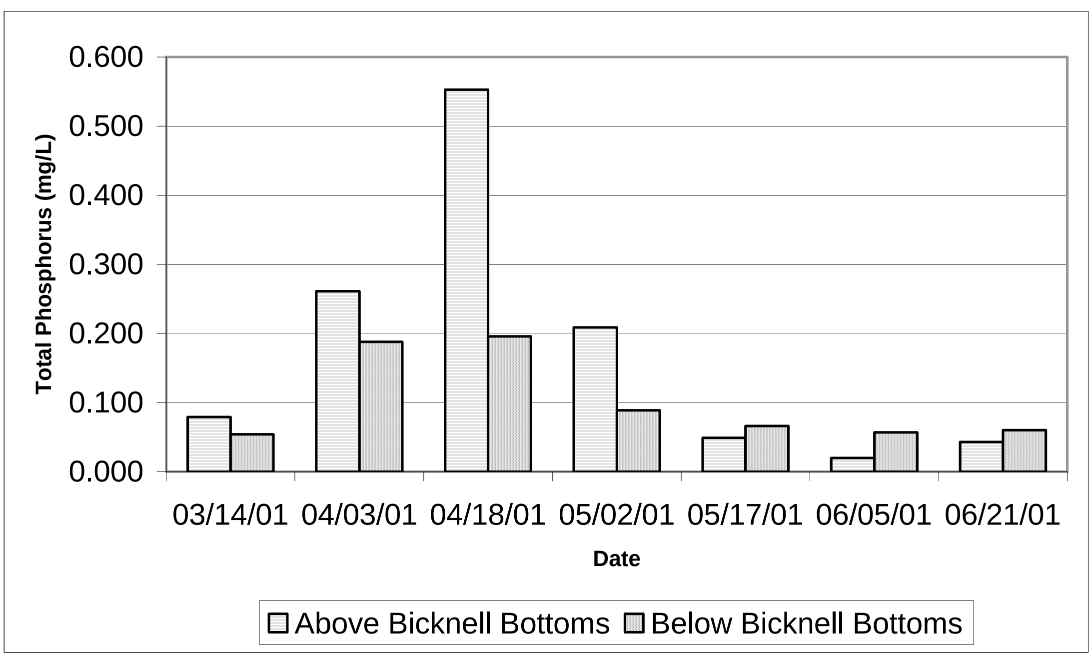
### Nonpoint Sources of Phosphorus

### Natural Background

Determining background levels of phosphorus loading found in mid-elevation streams based on reference conditions is difficult due to the fact that practically all of these areas throughout the state have been developed to some degree for agricultural, municipal, and recreational uses. In a national eutrophication study Omernik (1977) found that in predominantly agricultural areas total phosphorus concentrations average 0.045 mg/L.

The potential for phosphorus loading from the marshes of Bicknell Bottoms was investigated by comparing a site just upstream (Fremont River below Big Hollow, 495528) with one just below (Fremont River at Bicknell, 495438) (**Figure 1**).

**Figure 1**
**Total phosphorus concentrations above and below Bicknell Bottoms**



In the early Spring, the marshlands of Bicknell Bottoms reduces total phosphorus concentrations in the Fremont River by as much as 65% while the later samples show a slight increase apparently due to nutrient saturation. This pattern supports the theory that marshes serve more as a sink rather than a source of phosphorus (Richardson 1985; Johnston 1991; Walbridge and Struthers 1993). Phosphorus removal from water in marshes occurs through use of phosphorus by plants and soil microbes; adsorption by aluminum and iron oxides and hydroxides; precipitation of aluminum, iron, and calcium phosphates; and burial of phosphorus adsorbed to sediments or organic matter. Marshland soils can, however, reach a state of phosphorus saturation, after which phosphorus may be released from the system (Richardson 1985). Therefore the key in maintaining the nutrient-removal benefits of marshes is to balance the level of nutrient inputs to its assimilative capacity.

### Cropland

The majority of irrigated lands in Rabbit Valley are serviced by pressurized sprinkler systems. Sprinkler systems are efficient in terms of satisfying the water requirements of the crop while minimizing the potential for runoff. Therefore, sprinkler irrigated croplands are not considered a source of nonpoint pollution.

### Pastureland

Flood irrigation methods are used on approximately 345 acres of pasturelands in the Bicknell Bottoms area, south of the town of Fremont, and along Spring Creek. The predominant soils are calcareous clay loam with particle sizes ranging from fine to coarse. The slope of the landscape ranges from 0 to 5 percent. The location of the flood-irrigated pastures is shown in **Map 9** as a small area south and adjacent to the Fremont River in the vicinity of Bicknell Bottoms. These sites were investigated and supplementary data were acquired to assess their potential for nutrient loading.

### Livestock Grazing Allotments

The Bureau of Land Management manages the uplands surrounding Rabbit Valley, particularly to the south on Parker Mountain, for multiple uses including livestock grazing, wildlife and recreation. The predominant vegetation type is sagebrush grassland. Most of the grazing allotments are used in the early Spring.

In the Teasdale Ranger district of the Dixie National Forest there is one grazing allotment that drains into the Fremont River. The Dark Valley Common Use allotment includes 67,800 total acres of land. The southwestern portion of the allotment drains to the Sevier River Basin and is therefore not considered for the Fremont River watershed. The portion of the allotment that drains to the Fremont River basin includes approximately 44,748 acres. The soils in this area vary with the topography and are comprised primarily of sandy loams. The slope ranges from 0 to 20 percent. The numbers of permitted animals for various date ranges throughout the year are listed in **Table 10**.

**Table 10**
**Grazing Allotments – USFS Teasdale Ranger District**

| Allotment | Acreage (approximate) | # of Permitted Animals | Permitted Dates |
|---|---|---|---|
| Dark Valley Common Use | 44,748 | 1,105 Cattle | 6/16 – 10/15 |
| Dark Valley Common Use | 44,748 | 1,312 Sheep | 7/1 – 7/14 & 9/1 – 9/15 |
| Dark Valley Common Use | 44,748 | 1,487 Sheep | 6/21 – 7/14 & 9/1 – 9/15 |
| Dark Valley Common Use | 44,748 | 1,393 Sheep | 6/26 – 7/14 & 9/1 – 9/3 |

Source: USFS, 2000

The portion of this allotment that drains into the impaired portion of the Fremont River flows through the Big Hollow and Pine Creek drainages. Big Hollow flows intermittently while Pine Creek is seasonally dewatered. Based upon the large total size of the allotment, the relatively small portion that drains into the Fremont River above the impaired section and the intermittent nature of the drainages, the Dark Valley Common Use allotment is not considered a significant source of nutrients into the Fremont River above Bicknell Bottoms.

### Dairies

There are three dairy operations within Rabbit Valley. Two of the three dairies are currently implementing solid and liquid waste containment measures and will be developing Comprehensive Nutrient Management Plans in the near future. Due to the waste management practices in place, dairies are currently not considered to be a significant source of nutrient loading to the Fremont River; however, all dairy operations will participate in developing Comprehensive Nutrient Management Plans in the near future.

### Feedlots

There are approximately seventeen feedlots located in Rabbit Valley. A feedlot is defined here as an area where livestock are held and vegetation is absent. Several feedlots are located immediately adjacent to the Fremont River or its tributaries. These sites were investigated and supplementary data were acquired to assess their potential for nutrient loading.

### Municipal

All of the homes in Rabbit Valley have individual septic tanks (WSC, 2000). Due to their low density (average of less than one homesite per acre), septic tanks are not considered a significant source of nutrient loading relative to other sources.

### Point Sources

Cold-water fish hatcheries (trout) that produce 20,000 pounds or more of fish per year are covered under a state-wide general permit issued by the Division of Water Quality which regulates the levels of total suspended solids, dissolved solids and pH permissible in the hatchery outfall. There are three permitted fish hatcheries / farms where water quality samples were collected and analyzed for nutrients including phosphorus. Loading contributions from these facilities were calculated based upon these samples.

## Lower Fremont River Watershed

### Nonpoint Sources of Total Dissolved Solids

### Natural Background

The predominant soil type in the Red Desert is classified as eroded Robroost Goblin Complex. Slopes range from 2 to 30 percent, are concave to convex, and are short in length. The vegetation in most areas is comprised mainly of Mormon-tea, shadscale, and eriogonum (USDA - SCS, 1990).

Studies conducted on Mancos Shale in the Upper Colorado River Basin have shown a relationship between sediment and salt loading (Schumm and Gregory, 1986). Sediment loading results from either upland erosion or streambank and gully erosion. Sediment and salt load are highly dependent on landform type. The three major landform types associated with Mancos Shale include badlands, pediments and alluvial valleys. Badlands are the most prone to erosion with sediment yields as high as 15 tons per acre. Since salt production is closely related to sediment yield and badland soils have not been leached of their soluble minerals, they produce the greatest amount of salt loading of the landform types. Pediments are gently inclined planate erosion surfaces carved in bedrock and veneered with fluvial gravels. Slopes are generally flatter with deeper soils and higher infiltration rates than badlands. Alluvial valleys are stable except along the channel where headcutting and gullying occur. Most of the salts have been leached out so that they yield less salt per unit volume of sediment than the other two landform types. However, channels incised into alluvium incorporate both sediment and salt from sloughed channel banks and salts from efflorescence at the alluvium-bedrock contact.

### Cropland

In the lower Fremont River watershed, farmers must rely on a seasonal water supply from the Fremont River and therefore flood irrigation practices are used primarily. There are 1,454 flood-irrigated acres adjacent to the Fremont River in the Caineville and Hanksville areas (Jones and Demille, 2000). Irrigation increases salinity by consuming water through evapo-transpiration and by dissolving and transporting salts found in the underlying saline soils and geologic formations, usually marine shales (USDI, 1997).

The irrigated tracts are located on a variety of soil units. They are comprised primarily of silt loams, silty clay loams, and sands. They are formed in alluvial and eolian deposits, and derived from shale, sandstone, and mixed sedimentary rocks. Slopes range from 0 to 2 percent and are medium to long in length. In a few areas the slopes are steeper and range from 2 to 8 percent. Salinity of these soils is moderate to strong, although alfalfa grows well in these soils (USDA - SCS, 1990).

According to findings of the Price – San Rafael Salinity Control Project (USDI – BOR, 1991) an area located just north of the Fremont River Watershed, 3.65 tons of TDS loading is attributable to each acre-foot of irrigation return flow. In the West Colorado Water Plan (DNR-DWR, 1999) irrigation return flows into the lower Fremont River have been estimated at 4,900 acre feet. Using these average values, 17,888 tons of TDS loading into the lower Fremont River can be attributed to return irrigation flows during the entire irrigation season (May 1 - September 30).

## Potential Point Sources of Total Dissolved Solids

### Artesian Wells

There are two artesian wells flowing at the wellhead in the Red Desert that contribute flow to Caineville Wash, tributary to the Fremont River. Both of these wells (IPP Test Well, STORET 599300 and ICPA Test Well, STORET 599299) have a water right filed on them for irrigation uses. The water rights information is summarized in **Table 11** and their approximate location is shown on **Map 9**.

**Table 11**
**Water Rights for Caineville Wash Wells That Flow into Fremont River**

| Water Right | Point of Diversion | Flow (cfs) | Water Uses | Depth (feet) | Diameter (inches) |
|---|---|---|---|---|---|
| 95-4708 | | | | | |
| (1) IPP Test Well (STORET 599300) | N1750 W1500 From SE Corner of Sec. 29 T28S R8E base SL | 0.67 | Irrigation | 0-45'<br>45-704'<br>704-1250' | 30"<br>20"<br>18.5" |
| (2) ICPA Test Well (STORET 599299) | S37 E105 From NW Corner Sec.33, T28S, R8E | 1.16 | Irrigation | 0-22'<br>22-679'<br>679-761' | 20"<br>16"<br>Unknown |

Well data obtained from Utah Division of Water Rights database and State of Utah, Department of Natural Resources Technical Pub. No.66, Aquifer Tests of the Navajo Sandstone Near Caineville, Wayne County, Utah.

These wells contribute a significant loading of TDS to the Fremont River based on water quality data collected by the DWQ and BLM in 1998, 2000, and 2001 (**Table 12**).

**Table 12**
**Water Quality Data Collected from Caineville Wash Wells**

| STORET | Site Description | Date | TDS Concentration (mg/L) |
|---|---|---|---|
| 599300 | IPP Test Well | 5/19/98 | 2,564 |
| | | 9/26/00 | 2,590 |
| | | 6/20/01 | 2,526 |
| 599299 | ICPA Test Well | 5/19/98 | 2,754 |
| | | 9/26/00 | 2,770 |
| | | 6/20/01 | 2,730 |

Because water flowing from these wells is higher in TDS than the Fremont River they will require point source discharge permits unless they are capped according to the DWQ permitting section (DWQ - NPDES Section, pers. comm. with Mike Herkimer, Oct. 3, 2000).

## IV. Linkage Analysis

### Total Phosphorus

Limited data exist for the Fremont River watershed and therefore alternative modeling approaches applicable to the watershed is limited. A variety of methods were evaluated for estimating nutrient loads to waterbodies within the watershed. Due to the limited data available for the Fremont River watershed, it was determined that a simple spreadsheet approach would be the most appropriate. This approach is technically sound, using scientifically based principles and is consistent with State/EPA expectations for a phased approach to a TMDL. However, it should be kept in mind that any modeling approach provides an estimate, useful for relative ranking of pollution sources and evaluation of pollution control alternatives.

Nutrient loads from nonpoint sources were estimated using adjusted Unit Area Loads (UALs) applied to the areas of concern. UALs represent the average amount of a pollutant that enters receiving waters from a specific land use. For a first approximation, UALs were used to estimate TP loading to the reservoirs from rangeland in the upper portion of the watershed. Similarly, in Rabbit Valley, UALs were used to estimate TP loading to the Fremont River from pastures and feedlots in Rabbit Valley.

### TDS

Available data were used to construct average monthly flows and TDS concentrations for each station in the lower Fremont River, since flows are variable over an annual cycle. Where there were no data for a month, we interpolated by averaging from adjoining months or by extrapolating measured points to cover larger periods of time when flows had stabilized as determined from comparison to the flows at the USGS gaging station. This analysis indicated that average TDS concentrations exceed criteria for two months in the summer, during June and July. These two months were identified as the critical condition for TDS in the lower Fremont River. Critical condition represents the condition or conditions under which impairment (i.e., violations of water quality standards) occurs. Determination of the critical condition and analysis of the TMDL considering the critical condition ensured that water quality standards will be met under all conditions.

The water quality targets and endpoints for the Fremont River watershed were selected according to each waterbodies' impaired beneficial uses and their associated water quality standards. Because the water quality data available for this TMDL were limited, endpoints to attain water quality targets may be refined following implementation of best management practices and as additional data are collected.

The water quality goals for Johnson Valley, Forsyth and Mill Meadow reservoirs are to reduce nutrient loading into the reservoirs, reduce the occurrence of blue-green algae blooms and increase dissolved oxygen concentrations. The water quality goals for the upper Fremont River and tributaries including Sevenmile Creek and UM Creek are to reduce nutrient and sediment loading, improve riparian habitat, and increase dissolved oxygen concentrations in the lower reaches of UM Creek. Because the impaired section of UM Creek is between Forsyth and Mill Meadow Reservoirs it is expected that in meeting the water quality goals for Forsyth Reservoir, UM Creek will meet its water quality standards for dissolved oxygen. The water quality goals for the upper Fremont River and tributaries including Spring Creek and Road Creek are to reduce nutrient and sediment loading, eliminate nuisance algae growth in the mainstem and tributaries, improve riparian habitat, and increase dissolved oxygen concentrations. The water quality goals for the lower Fremont River and tributaries are to reduce TDS loading by capping or establishing NPDES permits for two artesian wells in Caineville Wash and improving the efficiency of irrigation systems and thereby reduce return flows.

**Summary of Water Quality Targets and Endpoints**

**Upper Fremont River Watershed - Reservoirs**

1) Total phosphorus concentrations of less than 0.025 mg/L (in-lake) and 0.05 (tributary inflows)
2) Trophic State Index Values of less than 50
3) Dissolved Oxygen concentrations greater than 4.0 mg/L one day average for > 50% of the water column in lakes
4) Reduction in blue-green algal dominance

**Upper Fremont River Watershed - Tributaries and Fremont River near Bicknell to USFS Boundary**

1) Total phosphorus concentrations less than 0.05 mg/L
2) Dissolved Oxygen concentrations greater than 6.5 mg/L
3) Elimination of nuisance algae growth in mainstem and tributaries

**Lower Fremont River Watershed**

1) Total dissolved solids concentrations less than 1,200 mg/L at mouth of Fremont River

## V. TMDL and Allocations

The following section outlines how the loading analysis was conducted for each parameter of concern and their results.

**Upper Fremont River Watershed – Reservoirs and Tributaries**

The critical condition for total phosphorus loading into the upper reservoirs and Fremont River above Bicknell Bottoms includes the entire year since the effects of nutrient loading can be delayed until conditions are suitable for algae growth.

Due to the scarcity of tributary inflow data on Johnson Valley and Forsyth Reservoirs current loading of total phosphorus was based upon a Unit Area Load analysis that estimated the total amount of phosphorus produced from anthropogenic sources within the reservoir's watershed. Other potential sources of phosphorus such as runoff from roads were not considered significant enough to be included in the loading analysis. However recommendations regarding best management practices and available technologies to reduce potential loading from these other sources are included within the Water Quality Management Plan.

The loading analysis for Mill Meadow Reservoir utilized the tributary inflow data from the Fremont River (STORET site #495455) and UM Creek (STORET site #595592). Since there are no point source discharges within this portion of the watershed the wasteload allocation is set to zero and all available TP loading was allocated to nonpoint sources.

The loading capacity for total phosphorus was calculated by substituting the water quality standard of 0.025 mg/L into a table of current in-lake phosphorus conditions and recalculating the P mass balance to determine the percent reduction needed to meet water quality standards (**Table 13**).

**Table 13**
**Upper Fremont River Watershed Reservoirs – In-lake Mass Reduction**

| Reservoir | Volume (L) | Water Quality Criteria (mg/L) | Mass Allocation (mg) | Mass Allocation (lbs) | Margin of Safety 5% (lbs) | Target Mass (lbs) | Current Mass (lbs) | Mass Reduction (lbs) | Mass Reduction (%) |
|---|---|---|---|---|---|---|---|---|---|
| Johnson Valley | 1.2E+10 | 0.025 | 3.1E+08 | 680 | 34 | 646 | 1,359 | 714 | 53% |
| Forsyth | 5.1E+09 | 0.025 | 1.3E+08 | 279 | 14 | 265 | 581 | 316 | 54% |
| Mill Meadow | 6.5E+09 | 0.025 | 1.6E+08 | 355 | 18 | 338 | 512 | 174 | 34% |

This percent reduction was then applied to the tributary loading in the case of Mill Meadow Reservoir or estimates from grazing allotments for Johnson Valley and Forsyth Reservoirs to obtain the necessary load reductions.

**Upper Fremont River – Fremont River near Bicknell to USFS Boundary**

The estimated target phosphorus load for the Fremont River Total Phosphorus TMDL was calculated by substituting the water quality standards target of 0.05 mg/L into a spreadsheet that calculated current phosphorus loading and recalculating the P load. The waste load allocation and load allocation are estimated as 8,300 pounds of P. By applying a 5% margin of safety, the target load, or TMDL, is 7,885 pounds of P. The required load reduction is 3,378 pounds or 30%. Load reductions will be obtained through a combination of animal waste management BMPs and pasture and rangeland improvements.

**Lower Fremont River Watershed**

For the lower Fremont River TDS TMDL the first step of the analysis included identification of the critical season. Average TDS concentrations exceed criteria for four months in the summer, June through September. To calculate the target load, the 1,200 mg/L criterion was substituted in the spreadsheet of calculated current loads for these four months. The waste load allocation is set to zero since there are no currently permitted dischargers and the load allocation is estimated at 7,699 tons. Including a 5% margin of safety, the remaining load is 7,314 tons of TDS. The required load reduction is 2,594 tons of TDS during the critical season, or 26%. The majority of this load reduction will come through capping the artesian wells in Caineville Wash (1,593 tons) while the remaining 1,001 tons will be controlled through improved irrigation practices and management. Using the information developed by the Price-San Rafael Salinity Control Project approximately 274 acre feet of return flows need to be reduced in order to meet the target loading.

If a NPDES permit is obtained for the wells the permit holder would be required to treat any discharge water to meet water quality standards (1,200 mg/L of TDS) and the necessary load reductions from return flows would increase to 2,594 tons or 711 acre feet to meet the target loading.

The wasteload allocations, load allocations, margins of safety, and load reductions are summarized for all waterbodies of concern in **Table 14.**

**Table 14**
**Loading Assessment**

| | Johnson Valley Reservoir (lbs/yr TP) | Forsyth Reservoir (lbs/yr TP) | Mill Meadow Reservoir (lbs/yr TP) | Upper Fremont River - Fremont River near Bicknell to USFS Boundary (lbs/yr TP) | Lower Fremont River Watershed (tons TDS for critical season, Jun-Sept.) |
|---|---|---|---|---|---|
| **Current Load** | 1,916 | 2,747 | 8,564 | 11,263 | 22,785 |
| **Loading Capacity** | 958 | 1,319 | 5,481 | 8,300 | 7,699 |
| **Wasteload Allocation** | 0 | 0 | 0 | 2,208 | 0 |
| **Load Allocation** | 910 | 1,253 | 5,207 | 5,677 | 4,977 |
| **Margin of Safety (5%)** | 48 | 66 | 274 | 415 | 385 |
| **Load Reduction** | 1,015 | 1,483 | 2,912 | 3,378 | 11,667 |

### Margin of Safety and Seasonality

A margin of safety (MOS) is a mechanism used to address the uncertainty of a TMDL. The MOS is a required part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA, 1991). One is to implicitly incorporate the MOS using conservative model assumptions to develop allocations. The other is to explicitly specify a portion of the total TMDL as the MOS, allocating the remainder to sources. For the Fremont River watershed TMDL, the MOS was included explicitly by allocating 5 percent of the loading capacity to the MOS for the parameters of concern. Therefore, only 95 percent of the loading capacity was allocated to point and nonpoint sources. The MOS may be adjusted based on additional sampling of runoff events and further evaluation of the seasonality of loading.

## VI. Monitoring Plan

Waterbodies in the upper section of the watershed are listed as impaired due to high levels of TP and low levels of DO. The data that were used to list the waterbodies were instantaneous readings for the parameters of concern. In the future it will be useful to obtain diurnal DO readings collected over a 24-hour period to better characterize the situation and assess progress towards meeting water quality goals. Other information such as benthic macroinvertebrates, habitat quality and fisheries data will also be helpful in assessing improvement in water quality. Furthermore, data for this TMDL were averaged over various periods of time to evaluate seasonal loads and consider the influence of irrigation practices. Additional analysis of the timing of loading events is recommended to further refine management efforts and assess whether water quality targets and endpoints are being met. Future monitoring in a process of evaluation and refinement of TMDL endpoints is recommended.

## IX. Public Participation

The public participation process for this TMDL was addressed through a series of public meetings with the local Watershed Steering Committee. The Watershed Steering Committee is comprised of individuals who represent the interest of stakeholders in the watershed. The committee has participated in this TMDL since the inception of the project, has supported the collection of relevant data and information, and has assisted with the development of management practices. In addition, the committee has developed Project Implementation Plans (PIPs) for implementation of management practices. With respect to the PIPs, the Fremont River Watershed Steering Committee will select project participants and give oversight to project planning and implementation, and pursue funding mechanisms to address water quality issues in the watershed. This group actively seeks public input into the prioritization of natural resource problems and concerns. They anticipate volunteer help to be provided at many phases of the project including streambank improvement, revegetation, tour planning, and media promotion.

A public hearing on the TMDLs was held on March 14, 2002 with notification of the hearing published in the local newspapers on February 20, 2002 (Richfield Reaper and Wayne County Insider). The comment period was opened on February 18 and closed on March 18, 2002. In addition, the TMDL and dates for public comment were posted on the Division of Water Quality's website at (www.deq.state.ut.us/EQWQ/TMDL/TMDL_WEB.HTM).

### Coordination Plan

### Lead Project Sponsor

The Fremont River Soil Conservation District will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

The Fremont River Watershed Steering Committee (Local Work Group) has brought together citizens who are concerned about the future condition of the Fremont River and its tributaries. They are the primary stakeholders in the future value and future problems that affect this watershed. Utah Association of Conservation Districts is a non-profit corporation that provides staffing for project coordination and financial administration to the Districts of the State of Utah, and specifically to the Fremont River Soil Conservation District.

The Fremont River Watershed Steering Committee or an empowered subcommittee, will provide oversight of project conceptualization, cooperator selection, volunteer efforts during implementation, and sharing of information generated by this project with others.

The Fremont River Soil Conservation District and the Fremont River Watershed Steering Committee will oversee detailed project development, planning, implementation, approval, creation of fact sheets and educational materials, administration and reporting. Some of these duties will be transferred to UACD, NRCS, DEQ, USU Extension Service and others as per Memoranda of Understanding. The Fremont River Watershed Steering Committee will be responsible for writing the final project report pursuant to EPA and State requirements.

UACD will oversee project administration, match documentation, and contracting with agencies and individuals. They will also provide staffing assistance at the direction of the District.

**Local Support**

The Fremont River Watershed Steering Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the Fremont River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Watershed Steering Committee, working with a Technical Advisory Committee will establish criteria and select cooperators for implementation of projects. This project will be used to show landowners and cooperators Best Management Practices (BMPs) for minimizing land use impacts on water quality in the Fremont River and its tributaries.

**Coordination and Linkages**

The District and Local Work Group anticipate coordinating efforts with the following other entities, agencies, and organizations:

Cooperators - provide match for cost share, implementation of water quality plans

Utah State University Extension - I&E, Technical assistance

NRCS - Technical planning design and oversight

Utah Department of Agriculture & Food - Technical assistance, I&E assistance

Utah Division of Water Quality - Standard program monitoring, Technical assistance

EPA - Financial assistance

Utah Association of Conservation Districts - Administration, contracting, staff and technical assistance

Utah Division of Wildlife Resources - Advisory and monitoring assistance

Utah Division of Water Rights- Permits advisory, and monitoring assistance

Utah Division of Water Resources - Advisory

U.S. Fish and Wildlife Service - Advisory and monitoring assistance

Fremont Irrigation Co.- Advisory and TAC coordination

Panoramaland RC&D- Additional funding and volunteer coordination

## Similar Activities

Funding of an Animal Waste System demonstration project was granted by the 319 program in fiscal year 2000. Contracts for this funding were awarded in June of 2001. A cooperator was selected and the project should begin Summer of 2002. The Fremont River Watershed is currently a Geographic Priority Area for EQIP program funding to assist with animal manure containment systems, additionally, three producers received funding from the Utah State Legislature fund for water quality. If this additional funding is granted, it will be combined with 319 monies to help more operators.

## Evaluation and Monitoring Plan

An evaluation and monitoring plan will be implemented to document progress in achieving improved water quality conditions, to review effectiveness of BMP's, and to provide feedback on the direction of overall watershed health. Based upon the results of this monitoring program management strategies and implementation priorities may change under the direction of the project sponsors. The Division of Water Quality has a strong commitment to demonstration of success of these pollution prevention and remediation strategies, but a limited monitoring budget. The use of volunteer monitoring conducted by watershed stakeholders must be a part of the overall monitoring strategy to develop a more comprehensive assessment of water quality conditions. Studies that present water quality and stream health on a point-in-time basis, before and after project implementation, can be conducted quickly and relatively inexpensively.

## Implementation Strategy

The following list of best management practices is provided to indicate the types and kinds of practices that are most likely to lead to achievement of water quality goals through a voluntary, incentive-based approach. The actual locations and scheduling of implementation practices will be determined by the voluntary participation of local stakeholders, the availability of funding, and the priorities of the Fremont River Soil Conservation District, Watershed Steering Committee and funding agencies.

## Upper Fremont River Watershed - Reservoirs

1) Grazing Management: improve livestock distribution through increasing forage availability on uplands, strategic placement of stock water and fencing or herding.
2) Riparian Area Management: enhancement and protection of woody vegetation.
3) Silvicultural Management (timber harvest): proper road construction/maintenance, erosion control, and reseeding surface disturbances.

**Upper Fremont River Watershed – Tributaries and Fremont River near Bicknell to USFS Boundary**

1) Grazing Management: improve livestock distribution through increasing forage availability on uplands, strategic placement of stock water and fencing or herding.
2) Riparian Area Management: enhancement and protection of woody vegetation.
3) Silvicultural Management (timber harvest): proper road construction/maintenance, erosion control, and reseeding surface disturbances.
4) Fish hatcheries and production facilities: settlement ponds, filter screens, constructed wetlands and low phosphorus feed.

**Lower Fremont River Watershed**

1) Irrigation Water Management
2) Stream Channel Stabilization
3) Riparian Herbaceous Cover
4) Eliminate loading from artesian wells

**Funding**

Funding for implementation of best management practices will originate from a variety of sources depending on several factors including where implementation occurs, whether loading is from nonpoint or point sources, and the potential for secondary benefits (e.g. Wildlife Habitat funds). The key to successful implementation projects is the participation of all the partners with funding, administration, technical assistance, equipment, and time. Of particular concern to the Watershed Steering Committee is how much financial burden for implementation is placed on grazing permitees. Typically, most of the cost of grazing land improvements such as fencing and stockwater are the responsibility of the permitee. But in situations such as this, where all will realize the benefits to water quality, the expense in obtaining these benefits should be shared as well. It is the belief of the Watershed Steering Committee that the primary sources of funding for implementation be dictated by the location of the project. If for example the project is located on Forest Service lands the Forest Service, with assistance and support from the Watershed Steering Committee, will be primarily responsible for soliciting funding through their watershed restoration funds and from other sources. The same applies to private lands (Section 319 cost-share funding), State lands (Habitat funds), and BLM lands.

Because all potential funding agencies have limited budgets and demands for funding elsewhere, the timing of implementation will be in part dictated by the discretion of these funding sources. But it is hoped that with the opportunity for multiple funding sources priority will be placed where the money will go the farthest.

**Parties Responsible for Implementation of Management Practices**

The Fremont River Watershed Steering Committee (WSC) is currently addressing water quality problems including excess nutrients in the upper portion of the watershed and salt loading in the lower portion of the watershed. Producers are increasingly aware of the need to totally contain animal wastes and reduce runoff but are reluctant to implement costly solutions. Successful projects combine a voluntary approach with cost-share assistance to identify key system components that properly contain manure while allowing management flexibility. In addition, assistance is needed in helping producers develop proper application and utilization methods for applying both liquid and solid manure and in reducing runoff from irrigated lands.

The WSC anticipates receiving cost share funding this year (2002) from USDA's EQIP program as well as some funding from the Utah Legislature. These projects will showcase proper storage and application ideas that if implemented area-wide, will improve water quality. Best Management Practices may include: Waste Storage Structures; Waste utilization; Nutrient and Pest Management; Composting; Prescribed Grazing; Streambank Stabilization. Projects will include total containment of manure along with proper application and utilization. Tours and Fact sheets will be developed highlighting project accomplishments.

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## 6.0 PROJECT IMPLEMENTATION PLANS

The Fremont River Watershed Steering Committee is currently addressing water quality problems including excess nutrients in the upper portion and salt loading in the lower portion of the watershed. Producers are increasingly aware of the need to totally contain animal wastes and reduce runoff but are reluctant to implement costly solutions. Successful projects combine a voluntary approach with cost-share assistance to identify key system components that properly contain manure while allowing management flexibility. In addition, assistance is needed in helping producers to develop proper application and utilization methods for applying both liquid and solid manure as well as reducing runoff from irrigated lands.

Cost share funding is anticipated this year (2002) from USDA's EQIP program as well as some funding from the Utah Legislature. These projects will showcase proper storage and application principles that, if implemented area-wide, will improve water quality to downstream users. Best Management Practices may include: Waste Storage Structures; Nutrient and Pest Management; Composting; Prescribed Grazing; and Riparian Restoration. Projects will include total containment of manure along with proper application and utilization. Tours and Fact sheets will be developed highlighting project accomplishments.

### 6.1 Statement of Need

Several waterbodies within the Fremont River Watershed are currently not meeting their designated beneficial uses due to excess nutrient and dissolved solids concentrations. A Total Maximum Daily Load (TMDL) analysis is currently underway and will be submitted to EPA for review and adoption by April 2002. This Project Implementation Plan (PIP) addresses the primary sources of nutrients and dissolved solids identified within the TMDL analysis. The upper Fremont River has several animal feeding operations located directly on or adjacent to the river or its tributaries. Manure is washed into the river during Spring snowmelt and rainstorms. During an inventory of nutrient sources for the TMDL, seventeen feedlots were identified that significantly contribute to nutrient loading. The lower Fremont River is used for irrigation of pasture, alfalfa and grains. The area is underlain by saline geology and when excess irrigation water is applied the return flows transport salt back into the river.

The intent of the proposed program is to reduce nonpoint source pollution in the Fremont River by the application of manure containment, improved irrigation practices and Best Management Practices. By demonstrating these practices to area producers and stakeholders we will encourage them to adopt and implement similar activities to address their own water quality problems. With the support and direction of the Watershed Steering Committee, we will design and implement three projects in the upper watershed featuring manure containment and comprehensive nutrient management plans, and three projects in the lower watershed featuring improved irrigation water application and management. We will stabilize and revegetate an additional segment of the river corridor, and we will reduce overland erosion from grazing lands. We will conduct tours of these sites and publish news articles and fact sheets to encourage adoption.

### 6.1.1 Project Water Quality Priority

As required by 26-11-6 of the Utah Code Annotated 1953, the waters of the State of Utah are grouped into classes so as to protect State waters against controllable pollution. The Fremont River from its headwaters to its confluence with the Muddy River has been identified as a High Priority watershed, 303(d) list Unified Assessment Category IC. The designated uses for the Fremont River from its headwaters to the eastern boundary with Capitol Reef National Park are 2B, 3A and 4. Designated uses from the Capitol Reef boundary to its confluence with Muddy River are 2B, 3C and 4. Associated tributaries include UM Creek, which is also listed for impairments associated with its Class 3A beneficial use due to low dissolved oxygen concentrations.

The upper Fremont River and its tributaries were designated by Utah DWQ to be only partially supporting their designated beneficial use as a cold-water fishery because of low dissolved oxygen and total phosphorus. Nutrients are delivered to the river during Spring runoff, during summer storm events, and in canal return flows. The lower Fremont River and its tributaries were designated by Utah DWQ to be only partially supporting their designated beneficial use for agriculture because of high total dissolved solids concentrations (TDS). TDS is delivered to the river year-round and is derived from both natural runoff and irrigation return flows.

Nutrient contamination causes excessive algal growth and turbidity in the upper Fremont River. Water with higher biological productivity may result in lower oxygen concentrations that stress the aquatic community. It is possible that oxygen declines to harmful concentrations during the night, particularly during the summer when flows are low and temperatures are highest. Nutrients associated with poor land management are most likely to enter during Spring runoff or storm events. High TDS water impairs the ability of crop plants to take up water and concentrates salts in the soil where eventually it may become too saline for crop growth.

### 6.1.2 Project Goals

The overall project goals are to: reduce nonpoint source loading in the upper Fremont watershed by decreasing the amount of pollutants entering the watershed from animal feeding operations and enhance the riparian corridor to reduce sediment and nutrient loading; improve upland and pastureland management practices to reduce sediment and nutrient runoff; and inform and educate the community concerning nonpoint source pollution and the importance of managing natural resources within the watershed. The project goals in the lower Fremont watershed are to reduce TDS loads by improving irrigation systems and irrigation water management. By implementing these practices we hope to encourage adoption and implementation of similar activities to address water quality problems in the entire watershed.

Goal #1: Assist animal feeding operators in the Fremont River watershed to implement and demonstrate containment, proper application and utilization of animal manures using Best Management Practices.

Goal #2: Improve stability of the stream channel and enhance the riparian corridor to reduce sediment nutrient loading to the river and its tributaries.

Goal #3: Improve upland and pastureland management practices to reduce sediment and nutrient runoff to the river and its tributaries.

Goal #4: Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries.

Goal #5: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality within the watershed.

Goal #6: Provide administrative services to project sponsors documenting matching contributions, tracking individual project progress, coordinating team efforts, and generating reports and data in a timely manner.

### 6.1.3 Objectives and Tasks

Goal #1: Assist animal feeding operators in the Fremont River watershed to implement and demonstrate containment, proper application and utilization of animal manures using Best Management Practices (BMPs) and Comprehensive Nutrient Management Plans (CNMPs).

Objective 1: Develop animal waste systems to ensure total containment of animal manure and reduce pollutants entering the Fremont River drainage.

Task 1 - Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district (the "District") cooperatively with the local work group and will be conducted in the early Spring of the first contract year.

Task 2 - Develop Animal Waste Management (AWM) systems using BMPs and CNMPs.

Output - AWM project plans. This will be conducted in Spring of the first and third contract years. Design work will be performed by NRCS and District staff.

Task 3 - Implement projects.

Output - Implementation will occur between Fall of the first contract year through Spring of the second contract year and then again between the Fall of the third contract year though Spring of the fourth contract year. Projects will be implemented by landowners, NRCS and District staff will advise, review and certify implementation.

Task 4 - Monitor water quality above and below projects.

Output - water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during Spring runoff and once during summer base flows; after project completion -once during Spring runoff and once during summer base flow. These data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, UDWR, UT-DEQ, USU extension, etc.

Goal #2: Improve stability of the stream channel and enhance the riparian corridor to reduce sediment nutrient loading to the river and its tributaries.

Objective 1: Develop projects that reduce sediment and nutrient loading to the river through improved function of the streambank and riparian area.

Task 5 - Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district cooperatively with the local work group and will be conducted in the early Spring of the first contract year.

Task 6 - Develop streambank and riparian improvement plan using BMPs and bioengineering principles (like willow revetment, grassed waterways, etc.)

Output - Streambank improvement project plans. This will be conducted in Spring of the first and third contract years. Design work will be performed by NRCS and District staff.

Task 7 - Implement projects.

Output - Implementation will occur between Fall of the first and third contract years through Spring of the second and fourth contract years. Projects will be implemented by landowners, NRCS and District staff will advise, review and certify project implementation.

Task 8 - Monitor water quality above and below projects.

Output - Water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during Spring runoff and once during Summer base flows; after project completion -once during Spring runoff and once during Summer base flow. These data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, UDWR, UT-DEQ, USU extension, etc.

Goal #3: Improve upland management practices to reduce sediment and nutrient runoff to the river and its tributaries.

Objective 1: Reduce nonpoint pollution, sediment and nutrients, from improved upland/pastureland management.

Task 9 - Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district cooperatively with the local work group and will be conducted in the early Spring of the first contract year.

Task 10 - Develop upland/pastureland management plan using BMPs.

Output - Upland/pastureland management plans. This will be conducted in Spring of the first and third contract year. Design work will be performed by NRCS and District staff.

Task 11 - Implement projects.

Output - Implementation will occur between Fall of the first and third contract year through Spring of the second and fourth contract years. Projects will be implemented by landowners, NRCS and District staff will advise, review and certify project implementation.

Task 12 - Monitor water quality above and below projects.

Output - water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during Spring runoff and once during summer base flows; after project completion -once during Spring runoff and once during summer base flow. This data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, UDWR, UT-DEQ, USU extension, etc.

Goal #4: Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries.

Objective 1: Reduce TDS loading in the lower Fremont River from improved irrigation techniques and management.

Task 13 - Select and identify project cooperators.

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district cooperatively with the local work group and will be conducted in the early Spring of the first contract year.

Task 14 - Develop irrigation water management plan using BMPs.

Output - Irrigation water management plans. This will be conducted in Spring of the first and third contract years. Design work will be performed by NRCS and District staff.

Task 15 - Implement projects.

Output - Implementation will occur between Fall of the first and third contract year through Spring of the second and fourth contract year. Projects will be implemented by landowners, NRCS and District staff will advise, review and certify project implementation.

Task 16 - Monitor water quality above and below projects

Output - Water quality data for project use and long-term monitoring. Data will be collected four times; before implementation -once during Spring runoff and once during summer base flows; after project completion -once during Spring runoff and once during summer base flow. These data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, UDWR, UT-DEQ, USU extension, etc.

Goal #5: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality within the watershed.

Objective 1: Three tours will be conducted focusing on: 1) animal waste system designs and proper manure application; 2) functioning riparian areas, stable streambanks, and properly managed uplands/pasture lands; 3) improved irrigation techniques and management.

Task 17 - Conduct animal waste system design and proper manure application tour.

Output - The tour will be conducted either near project completion or shortly after. USU Extension, UACD, District staff and the landowner will jointly plan this tour.

Task 18 - Conduct riparian area/streambank and pasture/upland tour.

Output - The tour will be conducted either near project completion or shortly after. USU Extension, UACD, District staff and the landowner will jointly plan this tour.

Task 19 - Conduct improved irrigation technique and management tour.

Output - The tour will be conducted either near project completion or shortly after. USU Extension, UACD, District staff and landowners will jointly plan this tour.

Objective 2: Share general and technical information with producers and area stakeholders.

Task 20 - Develop Fact Sheets and Newspaper Articles

Output - Fact Sheet series, Newspaper articles. These products will be completed during implementation of the project and will be disseminated during tours after project completion and other times of the year. USU Extension, UACD, and NRCS will collaborate on the content of these products. USU Extension and UACD will jointly produce and disseminate them.

Goal #6: Provide administrative services to project sponsors documenting matching-fund contributions, tracking individual project progress, coordinating team efforts, and generating reports and data in a timely manner.

Objective 1: Provide administrative services.

Task 21 - Track Match and Prepare Reports

Output - Documented matching fund records and prepare Semiannual, Annual and Final reports. Ongoing for duration of project. UACD staff will coordinate this effort. Completed semiannually, at the end of the first contract year and again at the completion of the project. UACD staff will prepare these products.

The following is a list of proposed BMP's that may be used along with the information and education efforts to improve water quality in the Fremont River watershed.

- Cropland Practices include: irrigation water techniques and management, crop sequencing, field borders, conservation tillage and filter strips.
- Riparian practices include: enhancement and protection of streambank vegetation, fencing, herding, filter strips, livestock exclusion, channel stabilization, off-site stock watering, and forest riparian buffers.
- Grazing land practices include: off-site stock watering, range seeding, fencing, prescribed grazing and pasture plantings.
- Manure management practices include: manure management and utilization systems, nutrient management, and runoff management systems.

All projects will include BMP's and will be planned to the level of a total resource management system in accordance with NRCS standards and specifications.

The following procedures will be used to achieve Project Goals:

1. Isolate water quality problem sources.
2. Select and implement projects for watershed nonpoint source problems.
3. Promote fair and cost effective nonpoint source pollution control.
4. Monitor progress and evaluate economic benefits of implementing water quality improvements.
5. Create a public awareness of water quality concerns and educate the public on how they can protect water quality for themselves and the community. Promote community involvement in project implementation activities by use of volunteer groups.

### 6.1.4 Permits

All appropriate permits will be secured as needed, project sponsors will ensure compliance with all local, state, and federal regulations pertaining to project activities such as not disturbing sensitive habitats, not filling or degrading wetlands.

### 6.1.5 Lead Sponsor

The Fremont River Soil Conservation District will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

### 6.1.6 Assurance of Project Operation and Maintenance

No long-term funding is planned for operation or maintenance of these projects. Individual landowners are responsible for operation and maintenance of BMPs throughout the projected life of the practices. Projects will be inspected by the project lead sponsor, UACD and NRCS staff. The operation and maintenance of the designed systems will be thoroughly explained to the landowner and they will sign a document indicating their comprehension. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding.

## 6.2 Coordination Plan

### 6.2.1 Lead Project Sponsor

The Fremont River Soil Conservation District will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint source water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

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The Fremont River Watershed Steering Committee or an empowered subcommittee, will provide oversight of project conceptualization, cooperator selection, volunteer efforts during implementation, and sharing of information generated by this project with others.

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UACD will oversee project administration, matching fund documentation, and contracting with agencies and individuals. They will also provide staffing assistance at the direction of the District.

### 6.2.2 Local Support

The Fremont River Watershed Steering Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the Fremont River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Watershed Steering Committee, working with a Technical Advisory Committee will establish criteria and select cooperators for implementation of projects. This project will be used to show landowners and cooperators Best Management Practices (BMPs) for minimizing land use impacts on water quality in the Fremont River and its tributaries.

### 6.2.3 Coordination and Linkages

The District and Local Work Group anticipate coordinating efforts with the following other entities, agencies, and organizations:

Cooperators - provide match for cost share, implementation of water quality plans

Utah State University Extension - I&E, Technical assistance

NRCS - Technical planning design and oversight

Utah Department of Agriculture & Food - Technical assistance, I&E assistance

Utah Division of Water Quality - Standard program monitoring, Technical assistance

EPA - Financial assistance

Utah Association of Conservation Districts - Administration, contracting, staff and technical assistance

Utah Division of Wildlife Resources - Advisory and monitoring assistance

Utah Division of Water Rights- Permits advisory, and monitoring assistance

Utah Division of Water Resources - Advisory

U.S. Fish and Wildlife Service - Advisory and monitoring assistance

Fremont Irrigation Co.- Advisory and TAC coordination

Panoramaland RC&D- Additional funding and volunteer coordination

### 6.2.4 Similar Activities

Funding of one Animal Waste System demonstration projects was granted by the 319 program in fiscal year 2000. Contracts for this funding were awarded in June of 2001. A cooperator was selected by the Steering Committee and the project should begin Fall of 2001. The Fremont River Watershed is currently a Geographic Priority Area for EQIP program funding to assist with animal manure containment systems. Additionally, three producers received funding from the Utah State Legislature fund for water quality improvements.

## 6.3 Evaluation and Monitoring Plan

### 6.3.1 Sampling and Analysis Plan

The monitoring goals of this project are: to document progress in achieving improved water quality conditions as nonpoint source control programs are implemented, and to document and review the effectiveness of BMPs. The project lead sponsor has a strong commitment to demonstration of success of these pollution prevention and remediation strategies, but a limited monitoring budget. Studies that present water quality and stream health on a point-in-time basis, before and after project implementation, can be conducted quickly and relatively inexpensively. Statistically rigorous studies that can defensibly predict overall watershed health and trend are beyond the scope of this monitoring effort, and should be coordinated closely with the Division of Water Quality at the State level.

Work activities associated with these goals include the following:

1) Monitor directly above and below the project sites to demonstrate reduced pollutant loads and environmental improvements. This will be conducted by a team of agency professionals. Sample processing will be billed to the project.
2) Monitor long-term sites (established and maintained by Utah Division of Water Quality) for water quality and macroinvertebrates to demonstrate sustained and overall improvements in water quality. This will be conducted by a team of agency professionals. Sample processing will be billed to the project.
3) Qualitatively monitor fisheries for overall improvement in habitat and population responses. This will be conducted by a team of agency professionals.
4) Monitor riparian areas for overall improvement of vegetation, and riparian structure and function. This will be conducted by a team of agency professionals.
5) Maintain a common database of all data collected pertaining to the projects. The database will be developed and maintained by lead agency support staff at UACD in Richfield.
6) Review data and include data summaries in annual reports. This activity will be performed as sub-tasks within tracking and reporting tasks.

### 6.3.2 General Design and Parameters

Sampling is designed to isolate and quantify the pollutant load reductions of individual projects through upstream/downstream sampling and to identify long-term trends through continued input to long-term monitoring.

<u>Sampling Design</u>

Sampling will include targeted (upstream/downstream) samples taken at runoff and base flow before and after implementation of projects. In addition, Utah's Division of Water Quality will continue to monitor several sites on the Fremont River and its tributaries as part of its long-term water quality monitoring efforts.

Monitoring of stream corridor health and function will be conducted by rapid assessment where appropriate. Macroinvertebrates will be collected and analyzed at sites established by the Utah Division of Water Quality for an additional measure of the health of the stream community. These samples will be analyzed by the USU aquatic ecology laboratory.

<u>Sampling and Sampling Site Locations</u>

Exact locations of upstream/downstream sites will be determined following project identification. The sites will be located to isolate inputs from the sites to the extent possible. Monitoring sites for stream corridor function will be established at the closest appropriate stream reach directly above and below the site. Macroinvertebrate samples will be collected at these sites as well.

The Division of Water Quality will monitor water quality at established sites according to their statewide monitoring schedule. The additional sites will be monitored by a team of agency professionals. Sample processing will be billed to the project.

Concentration, Velocity, and Discharge
Upstream/downstream sites will be monitored for the following chemical parameters, to be analyzed at an EPA and State of Utah certified laboratory: total Kjeldahl nitrogen, nitrate + nitrite, ammonia, dissolved total phosphorus, total phosphorus, total coliforms, fecal coliforms and total suspended solids. In addition, the following field parameters will be measured, using calibrated field probes: dissolved oxygen, temperature, pH, turbidity and conductivity (as an indicator of TDS). Flow will be measured at each sampling site on each sampling date.

Water quality monitoring at the Division of Water Quality sites, macroinvertebrate monitoring, and stream channel monitoring will all be done according to protocols established by the Division of Water Quality.

Sampling Frequency or Pattern
The State of Utah's sampling frequency for chemical water quality sites is typically every 6 weeks throughout the year. Sites on the Fremont River are not monitored every year but are included in the more intensive monitoring of watersheds conducted on a 5-year rotation.

Upstream/downstream monitoring will be conducted twice before implementation of the project: once during runoff and once during base flow. Following implementation, this monitoring will be repeated under both flow conditions.

Stream corridor monitoring will be conducted once prior to implementation of the projects by a team of agency professionals, then repeated after project implementation.

Macroinvertebrate, and fishery monitoring will be conducted once prior to implementation of the projects by a team of agency professionals, then repeated after project implementation.

Methodology
Water quality samples and field water samples will all be collected as subsurface grab samples from the main channel of the stream. All samples will be kept cold and dark and will be delivered to laboratories and analyzed within the established holding times.

Macroinvertebrate sampling and stream corridor assessments will be conducted according to protocols established by Utah's Division of Water Quality.

Other Monitoring Methods (e.g. fish, photo points, acres under treatment)
Utah Division of Wildlife Resources will monitor stream fisheries at selected sites using electrofishing to determine species, numbers and production in pounds for each species. Fish habitat will also be evaluated qualitatively.

Photo points will be established for each project site, and for each of the stream channel monitoring sites. Additional monitoring will include parameters appropriate for the specific project. Such parameters may include acreage (of plantings, seeding or weed control), linear feet of streambank stabilization, or estimated volume of manure converted from inappropriate disposal to appropriate utilization measures.

### 6.3.3 Data Management, Storage, and Reporting

The data from this project will be maintained in an accessible common database. In addition, water quality and other relevant data will be transferred electronically to the Utah Division of Water Quality database. Data will be compiled, analyzed and used in completing progress reports to the State NPS coordinator, NPS Task Force, DEQ, EPA and others. All water quality monitoring data will be transferred electronically to the Utah Division of Water Quality who regularly enter data into the STORET system. These data will be available to all interested parties and organizations. Quality Assurance and Quality Control will by conducted according to the guidelines established in the Utah Water Quality Manual. Only those data that meet QA/QC standards will be entered into the project database.

### 6.3.4 Models used

It is not anticipated that mechanistic models will be used in developing or evaluating the projects. Mass loadings will be calculated, however, for each of the sites for pollutants of concern. This will allow us to evaluate changes at specific sites and to also evaluate the total impact on the Fremont River loads. Finally, it will provide useful information to predict changes from similar implementations at other locations in the basin.

### 6.3.5 Long-Term Funding Plans for Operation and Maintenance

No long-term funding is planned for operation or maintenance of these projects. Maintenance of these projects will be the responsibility of the private landowner. Projects will be inspected by the project lead sponsor, UACD and NRCS staff. The operation and maintenance of the designed systems will be thoroughly explained to the landowner and they will sign a document indicating their understanding and cooperation. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding. We do anticipate increased interest in participation of BMP application and anticipate moving to a watershed-wide implementation phase in the future.

## 6.4 Public Involvement

There has been public involvement from the inception of the project, through proposal development, review, and submission. The Fremont River Watershed Steering Committee will select project participants and give oversight to project planning and implementation. This group actively seeks public input into the prioritization of natural resource problems and concerns. We anticipate volunteer help to be provided at many phases of the project; streambank cleanup, revegetation, tour planning, and media promotion.

## 7.0 FUTURE LAND USE

Future land use for the Fremont River Watershed is contained in the 1994 General Plan for Wayne County. This plan was written by the citizens of Wayne County and includes land use, transportation and circulation, environmental issues, public services and facilities, rehabilitation and development, economic concerns, and recommendations for plan implementation.

According to the U.S. Census Bureau, the 1990 population of Wayne County was 2,177 persons with the majority of those people residing in the city of Loa (about 20 percent of the total county population). Wayne County was the only county in the state to lose population from 1991 to 1992 (-2.3%). An estimated 2,150 people currently live in Wayne County. Net out-migration has occurred in Wayne County in eight of the last ten years.

Expansive rangelands contribute to the economic importance of sheep and cattle ranching within Wayne County. The United States Forest Service, the Bureau of Land Management, and the National Park Service manage significant amounts of land in the County and thus provide many economic and recreational opportunities and help to make grazing and tourism important parts of the Wayne County economic base. Raising livestock is the oldest industry in Wayne County. Beef cattle have had the most economic impact and produce the most income, but dairy cows, sheep, and poultry have all contributed to the local economy in the past.

A county steering committee was formed in November 1992 and served as the decision making body to what would be included in the General Plan. This steering committee further divided into subcommittees based on functional areas of the plan: natural resources, economic development, and infrastructure.

The purpose of the natural resource/land use subcommittee was to evaluate natural resource issues as identified and prioritized by county citizens. In addition to those issues identified at the public scoping meeting, the subcommittee addressed other natural resource/land use issues as they were identified during subcommittee work sessions. Beyond these responsibilities, the subcommittee performed numerous other tasks: they became familiar with federal and state land/resource decision making processes; they determined how the county can most effectively influence public land/resource decisions; they evaluated existing county can most effectively influence public land/resource decisions; they evaluated existing county development/zoning ordinances; and they proposed options addressing natural resource/land use issues for steering committee review and final plan consideration.

The individuals involved in the natural resource/land use subcommittee included county citizens and residents involved in traditional resource uses such as timber harvesting, mining and grazing; individuals from recreational/tourism industry; individuals with recreational/sportsman interests; representatives from several countries developing resources within the county; and public land and resource managers - several from federal agencies such as the BLM, USFS, and the National Parks System.

Because 97 percent of the land area in Wayne County is publicly owned, it is important that consideration be given to coordination and consistency with the Federal and State resource management plan that exists for these areas. Three percent of Wayne County is private land and most of the value of this private land is tied directly to public lands, i.e., grazing, water rights, timber, mining, and visitation by tourists. Because the tax base of this county is tied directly to public lands, Wayne County, in their General Plan, have reminded all public land managers - including Forest Service, BLM, National Parks Service, and state lands - of their responsibility to the citizens of Wayne County to consider any impact their public land decisions will have on the private property of Wayne County.

As of the 1994 General Plan, building permits were not required in Wayne County. However, city ordinances require building permits in Bicknell and Loa. There are basic zoning ordinances within the incorporated cities. There were no county zoning ordinances at the time of the 1994 General Plan. The county commissioners have adopted the Utah Uniform Building Code as the minimum standard for structures in the county, but there are no building inspectors to inspect new buildings for structural, electrical, or plumbing code compliance before the structure is occupied. The State Board of Health representative from the Richfield office inspects new septic systems for installation and adequate drain field size before a new structure is occupied.

## 8.0 RECOMMENDED WATER QUALITY MONITORING PLAN

This water quality monitoring plan is designed to provide information on the effectiveness of the selected BMPs in reducing point and nonpoint sources of pollution into the Fremont River Watershed. The monitoring plan is presented for the upper Fremont River reservoirs, upper Fremont River, and lower Fremont River. The plan includes a description of the objectives, monitoring station locations, sampling frequency, and analytical parameters.

This water quality monitoring plan is designed to be adopted by the DWQ monitoring program that consists of ambient, intensive, cooperative, lake/reservoir, municipal/industrial, and biological water quality monitoring. Samples collected from long-term ambient monitoring stations are collected once every six weeks (eight times per year) to evaluate long-term water quality trends.

DWQ's intensive monitoring survey is structured to determine if the rivers and streams, or segments of them, are meeting their designated beneficial uses. Samples collected for intensive monitoring are collected twice a month during runoff and once a month with the exception of December the rest of the year. Samples are collected for a 1-year period from July 1 to June 30 once every 5 years. The last intensive monitoring cycle for the West Colorado watershed management unit was completed in 1997-1998 and will start again in 2002-2003.

The cooperative monitoring program allows the State to extend its water quality monitoring program and assists the cooperating agencies in meeting their water quality management needs at the same time. Cooperating agencies within the Fremont River Watershed include the Fishlake National Forest, Capitol Reef National Park and the Bureau of Land Management in Richfield. Samples are collected by the cooperating agencies once a month every year.

The objectives of the State's lake and reservoir monitoring plan are to determine existing water quality conditions, evaluate lake water quality trends, protect and enhance lake water quality, and to determine beneficial use support. DWQ currently samples lakes and reservoirs twice a year during May/June and August/September. This lake and reservoir sampling is conducted every other year. The objectives of the State’s lake monitoring plan are to determine Carlson Tropic State Index (TSI) values for each lake or reservoir, provide essential lake assessment data to determine long-term water quality trends and develop goals for implementation projects to restore or protect existing water quality.

The Municipal and Industrial (Point Source) Oversight monitoring program is designed to provide data to determine if the permitted dischargers are meeting their permit requirements. Samples from the permittee’s discharge are collected 8 times per year and analyzed for parameters in their permit. Facilities that currently have discharge permits include Loa Fish Hatchery, JP Egan Fish Hatchery and Road Creek Trout Farm.

Biological sampling conducted by DWQ includes benthic macroinvertebrates and periphyton. Biological data is most useful for establishing baseline conditions that are monitored over several years to help determine the effectiveness of watershed projects on improving water quality and improving biological habitat. Biological sampling differs from water quality data in that it represents the composite of water quality conditions in the stream over the entire life cycle of the present biota. Therefore biological sampling is conducted once a year during the productivity season (summer). In cases where multiple monitoring programs are listed for a particular site the most intensive program will be conducted on the year they overlap. The locations of all monitoring stations are shown on **Map 11**.

## 8.1 Upper Fremont River Reservoir and Tributary Monitoring

The objectives of reservoir and tributary monitoring are to focus on TP concentrations entering the reservoirs, and to monitor TP and DO in the reservoir water column in response to the selected BMPs.

**Upper Fremont River Reservoir and Tributary Monitoring**

| Waterbody | Monitoring Station | Sampling Location Rationale | Parameters of Concern | Monitoring Program |
|---|---|---|---|---|
| Lake Creek below Fish Lake | 495492 | Monitor TP inflow to Johnson Valley Reservoir from Fish Lake | TP & Flow | Cooperative (Fishlake NF) |
| Sevenmile Creek above Johnson Valley Reservoir | 595615 | Monitor TP inflow to Johnson Valley Reservoir | TP & Flow | Cooperative (Fishlake NF) |
| Right Fork of UM Creek at Black Flat | 595601 | Monitor TP inflow to Forsyth Reservoir | TP & Flow | Cooperative (Fishlake NF) |
| UM Creek at Forest Service Road 015 | 595600 | Monitor TP inflow to Forsyth Reservoir | TP & Flow | Cooperative (Fishlake NF) |
| UM Creek above Forsyth Reservoir | 595599 | Monitor TP and diel DO inflow to Forsyth Reservoir | TP, DO & Flow | Lake / Reservoir (Even Years) |
| Johnson Valley Reservoir above Dam | 595610 | Monitor TP and DO in the water column | TP & DO | Lake / Reservoir (Odd Years) |
| Forsyth Reservoir above Dam | 595595 | Monitor TP and DO in the water column | TP & DO | Lake / Reservoir (Even Years) |
| UM Creek above Mill Meadow Reservoir | 595592 | Monitor TP inflow to Mill Meadow Reservoir from Forsyth Reservoir | TP & Flow | Intensive, Lake / Reservoir (Odd Years) |
| Fremont River above Mill Meadow Reservoir | 495455 (595591) | Monitor TP inflow to Mill Meadow Reservoir from Johnson Valley Reservoir | TP & Flow | Ambient, Intensive, Lakes / Reservoirs (Odd Years) |
| Mill Meadow Reservoir – Midlake | 595589 | Monitor TP and DO in the water column | TP & DO | Lake / Reservoir (Odd Years) |
| Mill Meadow Reservoir above Dam | 595588 | Monitor TP and DO in the water column | TP & DO | Lake / Reservoir (Odd Years) |

## 8.2 Upper Fremont River

This reach is defined as from the outlet of Mill Meadow Reservoir to Bicknell Bottoms. Certain sections are seasonally dewatered. The objectives for sampling the upper Fremont River is to characterize pollutant loading from different land use categories (sprinkler irrigated lands, rangelands, animal feeding areas, hatcheries and fish production facilities), determine the occurrence and severity of dissolved oxygen depression in the river, and monitor the effectiveness of the selected BMPs. This monitoring plan focuses on sampling nutrient inputs and concentrations into the river and the effect of high nutrients on influencing the dissolved oxygen in the river.

### Upper Fremont River Tributary Monitoring

| Waterbody | Monitoring Station | Sampling Location Rationale | Parameters of Concern | Monitoring Program |
|---|---|---|---|---|
| Fremont River below Mill Meadow Reservoir | 595587* | Monitor TP. This station is optional because all the water from Mill Meadow Reservoir is diverted from the Fremont River. | TP & Flow | Biological |
| Loa Fish Hatchery Inflow | 495451 | Monitor TP and DO upstream of hatchery | TP, DO & Flow | Municipal / Industrial |
| Loa Fish Hatchery Outfall | 495450 | Monitor TP and DO of hatchery outflow | TP, DO & Flow | Municipal / Industrial |
| Road Creek Trout Farm Inflow | 495511 | Monitor TP and DO upstream of hatchery | TP, DO & Flow | Intensive |
| Road Creek Trout Farm Outfall | 495510 | Monitor TP and DO of hatchery outflow | TP, DO & Flow | Municipal / Industrial |
| Fremont River at confluence with Spring Creek | New Station #1 | Monitor TP. Station located at first flowing section of Fremont River south of Loa. Inflows to Fremont River are from Spring Cr. and Road Cr. | TP & Flow | Intensive |
| Fremont River at bridge below confluence of Big Hollow | New Station #2 | Monitor TP from Big Hollow | TP & Flow | Intensive |
| Spring located west of JP Egan Fish Hatchery | New Station #3 | Monitor TP in spring flowing to Fremont River | TP & Flow | Intensive |
| Spring located one mile south of confluence of Big Hollow and Fremont River | New Station #4 | Monitor TP in spring flowing to Fremont River | TP & Flow | Intensive |
| JP Egan Fish Hatchery Inflow | 495442 | Monitor TP and DO upstream of hatchery | TP, DO & Flow | Municipal / Industrial |
| JP Egan Fish Hatchery Outfall Hatchery Building | 495443 | Monitor TP and DO of hatchery outflow | TP, DO & Flow | Municipal / Industrial |
| JP Egan Fish Hatchery Outfall No. 2 below Pond | 495441 | Monitor TP and DO of hatchery outflow | TP, DO & Flow | Municipal / Industrial |
| Fremont River near Bicknell | 495438 | Monitor TP and DO | TP, DO & Flow | Ambient, Intensive and Biological |

* Existing station, last sampled November 1991

## 8.3 Lower Fremont River

The monitoring objective of the lower Fremont River is to evaluate the sources of TDS to this reach and monitor the effectiveness of the selected BMPs.

### Lower Fremont River Tributary Monitoring

| Waterbody | Monitoring Station | Sampling Location Rationale | Parameters of Concern | Monitoring Program |
|---|---|---|---|---|
| Pleasant Creek at U24 Crossing | 495483 | Monitor TDS at the top of the listed section | TDS & Flow | Cooperative, Intensive |
| Fremont River at U24 Crossing above Sandy Creek | 495434 | Monitor TDS in Fremont River | TDS & Flow | Cooperative |
| Fremont River above Caineville Wash | 495521 | Monitor TDS in Fremont River above Caineville Wash | TDS & Flow | Cooperative |
| Caineville Wash at U24 Crossing | 495506 | Monitor TDS in Caineville Wash | TDS & Flow | Cooperative, Intensive |
| Fremont River at Caineville | 495432 | Monitor TDS in Fremont River below Caineville Wash | TDS & Flow | Cooperative |
| Fremont River below Caineville Wash | New Station #5 | Monitor TDS in Fremont River below Caineville Wash | TDS & Flow | Cooperative |
| Fremont River below confluence with Neilson Wash | 495517 | Monitor TDS 2 miles below agricultural land uses | TDS & Flow | Cooperative |
| Fremont River at Hickman Bridge | 495436 | Monitor TDS | TDS & Flow | Ambient, Intensive |
| Fremont River at Old U24 Crossing | 495433 | Monitor TDS at the bottom of listed section - above confluence with the Dirty Devil River | TDS & Flow | Ambient, Intensive |

## 9.0 CONCLUSIONS AND RECOMMENDATIONS

This Water Quality Management Plan for the Fremont River watershed has confirmed the water quality impairments listed on Utah's Year 2000 303(d) list, determined the pollution reductions necessary to achieve water quality goals, and has established plans for the implementation of recommended management practices.

In the upper Fremont River watershed, two river segments are impaired for designated beneficial use 3A (cold water species of game fish and other cold water aquatic life). These segments include UM Creek from Mill Meadow to Forsyth Reservoir, and the Fremont River from the US Forest Service boundary (at the outflow of Mill Meadow Reservoir) to Bicknell (STORET 495438). UM Creek is listed only for depressed dissolved oxygen concentrations (DO) while the Fremont River is listed both for low DO and elevated total phosphorus (TP) concentrations. In addition, three reservoirs located near the headwaters of the Fremont River are listed as impaired. Johnson Valley Reservoir and Mill Meadow Reservoir are listed for TP. Forsyth Reservoir is listed for TP and DO.

The lower Fremont River, from the eastern boundary of Capitol Reef National Park to the confluence with the Dirty Devil River, is impaired for designated beneficial use 4 (agriculture uses including irrigation of crops and stock watering), due to high levels of total dissolved solids (TDS). These impairments have been confirmed as a part of developing this water quality management plan.

To achieve water quality standards in the impaired water bodies of the watershed, the following reductions in constituent loadings are recommended (Table 9.1).

**Table 9.1**
**Recommended Reductions in Constituent Loadings**

| | Johnson Valley Reservoir | Forsyth Reservoir | Mill Meadow Reservoir | Upper Fremont River - Fremont River near Bicknell to USFS Boundary | Lower Fremont River Watershed |
|---|---|---|---|---|---|
| **Current Load** | 1,916 lbs/yr TP | 2,747 lbs/yr TP | 8,564 lbs/yr TP | 11,263 lbs/yr TP | 22,785 tons/yr TDS |
| **Target Load** | 900 lbs/yr TP | 1,264 lbs/yr TP | 5,652 lbs/yr TP | 7,885 lbs/yr TP | 11,118 tons/yr TDS |
| **Load Reduction** | 1,015 lbs/yr | 1,483 lbs/yr | 2,912 lbs/yr | 3,378 lbs/yr | 11,667 tons/yr |

**Upper Fremont River Watershed – Reservoirs and Tributaries**

Sources of nutrients within this portion of the watershed are land use related nonpoint sources attributed to livestock grazing, recreation, and silviculture (logging). Nutrient loads in this WQMP were estimated with respect to contributions from grazing only, because available water quality data were inadequate to estimate loading from recreation and silvicultural sources. Nonetheless, recreation and silviculture have been identified as potential sources and best management practices (BMPs) were recommended to manage pollution originating from these sources as well as from grazing. The following BMPs are prescribed to meet the reductions listed in Table 9.1 for the upper Fremont River watershed reservoirs and tributaries.

Best Management Practices for grazing will include improving livestock distribution through the enhancement of upland forage availability, the strategic placement of stock water and fencing or herding. Cattle in particular prefer to graze in close proximity to water sources including streams and reservoirs; this typically results in over-utilization of bottomlands and under-utilization of uplands. Sheep generally prefer to graze on open slopes, trailing down to water only briefly before returning to upland areas. The key principle in grazing management for water quality is to distribute use more evenly between upland and bottom areas through development of alternative watering sites and limiting access to bottom areas through fencing or herding.

Livestock should be prevented from congregating below the high water line during times when the reservoirs are low. This will reduce the amount of animal waste that are deposited on the shoreline during times of low water that will eventually become inundated during the Winter and Spring when the water level rises and become a significant source of nutrients into the water column.

Changes in reservoir water management may also provide for improvement in water quality. Lakes and reservoirs tend to accumulate nutrient enriched water at the bottom due to accumulated sediments and organic matter. Discharging water from the bottom of a reservoir removes the nutrient enriched water that improves flushing.

Grazing management practices, with special relevance to water quality in the upper Fremont watershed include; Fence (382), Heavy Use Area Protection (561), Prescribed Grazing (556 & 528A), Proper Woodland Grazing (530), Spring Development (574), Trough's or Tank (614) and Use Exclusion (412). Numeric codes following practices coincide with NRCS standards and specification numbers from the NRCS Field Office Technical Guide.

Many of these same practices also apply to riparian area management, which deserves special attention due to the area's critical role in trapping sediment and nutrients providing fish and wildlife habitat. In riparian areas, where over-utilization has occurred, it is usually warranted to try and re-establish functionality through plantings and placement of in-stream structures. In-stream structures should only be used in worst case situations and after changes in management and/or streambank plantings have already occurred. In several cases, poorly designed and installed structures have actually exacerbated the problem. Relevant practices include Riparian Herbaceous

Cover (390), Riparian Forest Buffer (391A), Tree/Shrub Establishment (612), Streambank Protection (580) and Stream Channel Stabilization (584).

Some of the more popular recreational uses of the upper watershed include hunting, fishing, camping and sightseeing via horseback or all terrain vehicles. The primary means of reducing the potential impacts of recreational activities on water quality is through changing the public's behavior through education. Increased signage at road turnouts explaining the water quality goals of the watershed and how the public can assist in meeting these goals will be helpful. Another effective educational tool is working with local schools in educating students of the linkage between watershed health and water quality along with their role in maintaining and improving water quality.

Aside from education, public recreational facilities must be maintained (and added where needed) to encourage their use. The Forest Service, BLM, Park Service, and the local stakeholders all have a responsibility for maintaining and improving public facilities. There are numerous opportunities for volunteer assistance that would also encourage local stewardship.

Road and trail management are related to recreational uses although they are utilized for agricultural and silvicultural purposes as well. Roads and trails can be a significant source of excess sediment depending on many factors including slope, type of construction and bed material. A particular feature of roads design that justifies re-consideration is the draining of ditchlines directly into adjacent stream channels. A comprehensive roads survey will be completed which identifies problem areas including the location of ditchline drainages along with suggestions on how to disconnect them from the stream channel. BMPs for road construction and maintenance are contained in the manuals of the Forest Service and Utah Department of Transportation. The Uniform Building Code, Chapter 70, contains provisions for grading (UDEQ, 2000).

BMPs for silvicultural activities are well documented in Forest Service manuals and in the Nonpoint Source Management Plan Silviculture Activities July 1, 1998 addendum. The primary water quality concerns surrounding silvicultural activities include proper road construction and maintenance and erosion control measures such as minimizing skid trails and reseeding surface disturbances.

The Fremont River Watershed Steering Committee (WSC) has proposed the following implementation strategies for the Upper Fremont River watershed – reservoirs and tributaries. These strategies will be implemented throughout the next couple of years and will include water quality monitoring to evaluate the effectiveness of management practices.

1) Grazing Management: modify foraging behavior of livestock through the use of fence and strategic placement of stock water.

2) Riparian Area Management: plantings and placement of in-stream structures.

3) Silvicultural Management (timber harvest): proper road construction/maintenance, erosion control, and reseeding surface disturbances.

**Upper Fremont River – Fremont River near Bicknell to USFS Boundary**

The primary land uses that affect the water quality of the upper Fremont River include several different agricultural uses and residential uses. Agricultural land uses include raising crops including alfalfa and grains, livestock feeding on pasture and small feedlots, dairy operations, and several fish hatcheries. Estimating nutrient loading to water bodies in this portion of the watershed was complex because the water resources are highly managed and there are a number of different operations that may affect water quality. Load estimations in this WQMP considered livestock operations, including pastures, and fish hatcheries. Although, there are other probable sources of nutrients to the upper Fremont River to consider (such as septic systems, storm water runoff, fertilizer application to croplands, recreational activities, and wildlife), these sources were not considered to be sufficiently significant. Identifying and managing nutrient contributions from livestock operations and hatcheries will help reduce significant loading and allow for more accurate estimation of less significant sources in the future. Although loads from all sources were not estimated, all potential sources were considered in the recommendation of BMPs. The following BMPs are recommended in the upper Fremont River to meet the reductions listed in the table above.

Pastures, dairies, livestock feeding areas, and fish hatcheries all share the same water quality concern, the potential for animal wastes to leave the site where they are produced and contribute to the nutrient enrichment of the Fremont River. Principles of nutrient management on pastures are similar to that of croplands in which plant uptake of nutrients should be matched with the supply, usually in the form of manure. However, since livestock are present and it is usually more difficult to control the amount and distribution of manure, extra precaution is required. The majority of pasturelands in this area are also flood irrigated or sub-irrigated so the potential for runoff is higher in some areas. Troughs and salt should be located away from live water and direct access to streams and ditches discouraged. To facilitate plant uptake of nutrients, manure can be harrowed into the soil and demand increased by establishing productive cultivars of pasture grasses such as Garrison creeping foxtail. Specific practices pertinent to pasture management for water quality include Filter Strip (393), Grassed Waterway (412), Use Exclusion (472), Heavy Use Area Protection (561), Pipeline (516), Trough or Tank (614), Irrigation Water Management (449), Irrigation System (442, 443, 444), Nutrient Management (590), Pasture and Hayland Planting (512), and Critical Area Planting (342).

Riparian areas adjacent to or within pastures also require special attention to enhance their nutrient uptake and filtering functions. Practices that benefit riparian area function include Channel Vegetation (322), Riparian Herbaceous Cover (390), Streambank Protection (580) and Stream Channel Stabilization (584).

The primary water quality challenge facing the several dairy and feedlot operations in the watershed is containing and beneficially utilizing the animal waste generated by animals. There are currently financial and technical resources available to assist dairy and feedlot owners in developing animal waste management systems. As an example, a 319 demonstration project is currently underway on the Fremont River to relocate a large feeding operation away from the river. Practices designed to assist in containing and utilizing animal waste include Composting Facility (317), Filter Strips (393), Nutrient Management (590), Roof Management System (570), Roof Runoff Management (558), Use Exclusion (472), Waste Management Systems (312), Waste Storage Pond (425), Waste Storage Facility (313), Waste Treatment Lagoon (359) and Waste Utilization (633).

Fish hatcheries are presented with a unique water quality challenge in that animal waste and nutrient rich feed is immediately incorporated into live water. The only option available is to provide sufficient treatment of hatchery outflow to minimize nutrient loading. Hatcheries managed by the Division of Wildlife Resources have constructed settlement ponds at their outflows to trap solid wastes and excess feed and provide some treatment through anaerobic decomposition (Valentine, 2001). The State hatcheries and production facilities also utilize specially formulated feed low in P. However, little treatment is provided by the private fish production facilities. Although there are no standardized practices for treatment of hatchery outflow in Utah, several types of treatments used for municipal wastewater and urban runoff would be useful such as settlement ponds, constructed wetlands and filter screens. The use of low P feed should also be considered for each of these facilities.

Croplands within this portion of the watershed are already under intensive management to maximize production under the relatively short growing season. Practically all of the cropland is under sprinkler irrigation, which minimizes the potential for surface runoff although this area periodically experiences intense thundershowers that can produce significant runoff. Runoff also occurs during Spring thaw, which normally does not present water quality concerns unless nutrients as chemical fertilizers or manure had been applied on frozen ground. BMPs for cropland include minimizing the potential for runoff to enter the Fremont River and matching soil fertility with crop needs through nutrient management. Relevant practices include Conservation Cover (327), Critical Area Planting (342), Filter Strip (393), Grassed Waterway (412), Irrigation Water Management (449), Irrigation System (442, 443, 444), Mulching (484), Nutrient Management (590), Pipeline (430), and Strip Cropping (585, 586).

Finally, BMPs for residential and other developed areas generally fall into two categories, wastewater management and stormwater runoff. Since there is no centralized sewer system within the watershed all wastewater is treated through septic leach field systems. Given the low density of septic systems throughout the watershed and the location of most of these systems away from stream channels, it is believed that they do not provide a significant source of nutrients into the Fremont River. However, periodic maintenance and inspection of septic systems is required to ensure their proper function. The potential for nutrient loading from stormwater runoff is also considered negligible due to the very low percentage of impervious cover within Rabbit Valley although the potential for disconnecting road ditch lines from the stream channel network should be investigated.

The Fremont River Watershed Steering Committee (WSC) has proposed the following implementation strategies for the upper Fremont River watershed – Fremont River near

Bicknell to USFS boundary. These implementation strategies will be put into action throughout the next couple of years and will include water quality monitoring to evaluate their effectiveness.

1) Grazing Management: improve livestock distribution through increasing forage availability on uplands, strategic placement of stock water and fencing or herding.
2) Riparian Area Management: enhancement and protection of streambank vegetation.
3) Silvicultural Management (timber harvest): proper road construction/maintenance, erosion control, and reseeding surface disturbances.
4) Fish hatcheries and production facilities: settlement ponds, filter screens, constructed wetlands and low phosphorus feed.

**Lower Fremont River Watershed**

The primary sources of TDS in the lower Fremont River include flood irrigated agricultural, upland and streambank erosion, and four flowing artesian wells in the Red Desert that contribute flow to a tributary of the Fremont River. The irrigated tracts are located on a variety of soil units. They are comprised primarily of silt loams, silty clay loams, and sands. They are formed in alluvial and eolian deposits, and derived from shale, sandstone, and mixed sedimentary rocks. Salinity of these soils is moderate to strong, although alfalfa grows well in these soils (USDA - SCS, 1990). Irrigation increases salinity by consuming water through evapo-transpiration and by dissolving and transporting salts found in the underlying saline soils and geologic formations (USDI, 1997).

Studies conducted on Mancos Shale in the Upper Colorado River Basin have shown a relationship between sediment and salt loading (Schumm and Gregory, 1986). Sediment loading results from either upland erosion or streambank and gully erosion. Sediment and salt load are highly dependent on landform type. The three major landform types associated with Mancos Shale in the lower portion of the watershed include badlands, pediments and alluvial valleys. Badlands are the most prone to erosion with sediment yields as high as 15 tons per acre. Since salt production is closely related to sediment yield and badland soils have not been leached of their soluble minerals, they produce the greatest amount of salt loading of the landform types. Pediments are gently inclined planate erosion surfaces carved in bedrock and veneered with fluvial gravels. Slopes are generally flatter with deeper soils and higher infiltration rates than badlands. Alluvial valleys are stable except along the channel where headcutting and gullying occur. Most of the salts have been leached out so that they yield less salt per unit volume of sediment than the other two landform types. However, channels incised into alluvium incorporate both sediment and salt from sloughed channel banks and salts from efflorescence at the alluvium-bedrock contact.

The following BMPs are recommended with respect to the lower Fremont River to meet the reductions listed in Table 9.1. These BMPs address salt loading entering the lower Fremont River and improving the efficiency of irrigation methods and conveyances to minimize surface runoff and deep percolation into the underlying alluvial aquifer.

Irrigation water and precipitation that runs across the ground and / or percolates down, dissolves salts within the soil and are then transported into the Fremont River, Dirty Devil River and eventually to the Colorado River.  Surface runoff and deep percolation is reduced or eliminated by improving the efficiency of irrigation through gated pipe, sprinkler or drip irrigation methods, and / or by delivering irrigation water through lined canals or pipe.  Much of this work is currently underway in other parts of the state under the auspices of the Salinity Control Program administered by the Departments of Interior (Bureau of Reclamation) and Agriculture (Natural Resources Conservation Service).  Specific practices pertaining to salinity control include Irrigation Water Management (449), Irrigation System (442, 443, 444), Pipeline (430) and Ditch and Canal Lining (428).

Another important source of salt loading is from sediments eroded from streambanks and uplands.  Since most of this area usually receives less than 6 inches of precipitation a year, the prospects of revegetating uplands to reduce erosion are very slight.  There are more structural practices available to trap and retain floodwaters and sediment flows that arise from thunderstorms but their high cost may be prohibitive.  However there are opportunities to reduce streambank erosion through implementation of the following practices; Stream Channel Stabilization (584), Streambank Protection (580), Tree/Shrub Establishment (612) and Riparian Herbaceous Cover (390).  Since riparian areas tend to receive the highest grazing pressures other practices may be needed to allow vegetation to establish such as; Fence (382), Heavy Use Area Protection (561), Prescribed Grazing (556, 528A), Trough's or Tank (614) and Use Exclusion (472).

The Fremont River Watershed Steering Committee (WSC) has proposed the following implementation strategies for the lower Fremont River watershed.  These implementation strategies will be put into action throughout the next couple of years and will include water quality monitoring to evaluate their effectiveness.

**Lower Fremont River**

1) Irrigation Water Management
2) Stream Channel Stabilization
3) Riparian Herbaceous Cover
4) Control loading from artesian wells

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