San Pitch River Watershed

Water Quality Management Plan

Prepared by
Millennium Science and Engineering

Prepared for
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SAN PITCH RIVER WATERSHED
WATER QUALITY MANAGEMENT PLAN

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1.0 INTRODUCTION

This document presents a Water Quality Management Plan for the San Pitch River Watershed located in central Utah. The San Pitch River Watershed Stewardship Committee developed this Water Quality Management Plan with assistance from Millennium Science & Engineering, and their subcontractors. The Utah Division of Water Quality (DWQ) contracted Millennium Science & Engineering to assess water quality impairments of the San Pitch River, quantify loadings for limiting water quality parameters, develop Total Maximum Daily Loads, and assist the San Pitch River Watershed Stewardship Committee to develop this Watershed Water Quality Management Plan. Many private individuals, agencies, and consultants contributed to these efforts. A list of contributors is provided in **Appendix 1.**

The San Pitch River flows through the Sanpete Valley located in central Sanpete County, central Utah. For the purpose of this study, the San Pitch River is divided into upper, middle, and lower segments. The upper San Pitch River begins north of Fairview, Utah (near Oak Creek Ridge on the Northern Wasatch Plateau) and flows south to Moroni (where it crosses State highway U132). The middle San Pitch River runs from U132 to Gunnison Reservoir. The lower San Pitch River flows from Gunnison Reservoir to where it meets the Sevier River, west of Gunnison, Utah.

Utah's Year 2002 303(d) list (DWQ, 2002) identifies two segments of the San Pitch River as being impaired due to water quality numeric exceedences of total dissolved solids (TDS). These two segments are the middle and lower San Pitch River. The upper San Pitch River is not listed on the 303(d) list as impaired for TDS.

Section 1 of the Water Quality Management Plan introduces the EPA Total Maximum Daily Load (TMDL) process, the water quality impairments of the San Pitch River, and Utah’s watershed management approach. **Section 2** contains a description of the San Pitch 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 San Pitch River Watershed. An assessment of the water quality of the San Pitch River is presented 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) 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, for submittal to EPA, which 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. All maps are provided in **Appendix 2**.

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 agricultural uses (including irrigation of crops and stock watering). 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 (EPA, 1999). As part of the TMDL process, the maximum amount of the parameter of concern is allocated to its contributing sources. Therefore, a TMDL is the sum of the allowable loads of the parameter of concern from all contributing point and nonpoint sources. The calculation must include a margin of safety to account for future growth and changes in land use, 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, pathogens, and other load parameters (e.g., TDS) 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 (DWQ, 2002). 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. 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 the target load (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 (DWQ, 2002).

> *"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."* (EPA, 1999).
>
> *The objective...is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. (*Clean Water Act).

The middle and lower San Pitch River are listed on Utah's Year 2000 303(d) list as being impaired for 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 this water quality constituent (DWQ, 2000b). Therefore, DWQ prompted this TMDL to identify and quantify point source and nonpoint source pollution in the San Pitch River Watershed.

1.2 Utah's Watershed Approach

Utah's watershed approach is aimed at improving and protecting 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 the Utah Department of Natural Resources - Division of Water Resources for the State Water Plan project (Utah Division of Water Resources, 1990). The watershed management units provide boundaries for evaluating the impact of various stressors on commonly shared resources, provide boundaries for evaluating 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 establish 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 (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 participation 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 participation 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 stakeholders can become more comfortable that the monitoring and modeling programs generate reliable data that are scientifically defensible. Further, effluent limits and Best Management Plans (BMPs) 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 BMPs, then become involved in stewardship activities.

In the San Pitch River Watershed, both governmental and non-governmental entities worked to achieve a skillful and honest presentation of technical information to the San Pitch River Watershed Stewardship Committee 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 San Pitch River flows through the Sanpete Valley located in central Sanpete County, central Utah, about 90 miles south of Salt Lake City. The San Pitch River Watershed boundary is defined by the United States Geological Survey (USGS) Hydrologic Accounting Unit (HUC) #16030004 and is shown on **Map 1**. The watershed boundary is almost entirely within Sanpete County. A few small areas of land on the west side of the watershed are within Juab County.

The San Pitch River flows generally from north to south through the Sanpete Valley and at the south end of the watershed it curves west to its confluence with the Sevier River. The San Pitch River Watershed forms the northeast portion of the larger Sevier River basin.

Sanpete Valley is a north-south-trending, Y-shaped valley bordered on the east by the Wasatch Plateau, which reaches elevations of 11,000 feet, and on the west by the San Pitch Mountains (also known as the Gunnison Plateau), which reach a maximum elevation of about 9,700 feet. The valley is divided in the north by Cedar Hill, which forms the center of the "Y" and reaches a maximum elevation of about 8,300 feet. Sanpete Valley is about 40 miles long and up to 13 miles wide. The west branch of Sanpete Valley runs from Moroni toward Fountain Green. The east branch heads up to Fairview. The San Pitch River begins on the Wasatch Plateau north of Fairview and flows through the east branch of Sanpete Valley. The Sanpete valley floor has an area of about 240 square miles; it ranges in elevation from 7,400 feet near the northern end of the eastern arm to about 5,040 feet where the San Pitch River meets the Sevier River.

The Sanpete Valley fill thickness range from about 100-350 feet in the Mt. Pleasant-Fairview and Moroni-Fountain Green areas to 100-500 feet in the Ephraim-Manti areas (Robinson, 1971). Generally the valley fill is thicker on the west side. Groundwater wells on the west are under artesian and water table conditions. Wells on the east side are under water table conditions. Throughout the watershed there are areas of seepage and recharge.

2.1 Historic Perspective

The first settlers in Sanpete Valley were Mormons who arrived in the area in 1849. Sanpete County was created in 1850 with Manti as the county seat. In 1992 Manti had a population of approximately 2,000 people. Sanpete County had a 1990 Census population of 16,259 (Utah Division of Water Resources, 1999); its 1999 Census population was 21,408 (Utah League of Cities and Towns, 2000).

Since settlement, Sanpete County's economy has been based on agriculture. In its first few decades it served as Utah's granary. Principal crops are alfalfa, small grains, and corn for silage. Irrigation of all croplands is necessary because the climate at Manti is semi-arid. During the 1980s some irrigation practices converted from the ditch-and-furrow to the more sophisticated sprinkler types, both in town and farmlands.

The nearly 1,000 farms in the county comprise about two thirds of the total land area. Average farm size, including the privately owned range land, is about 655 acres, with about 10 percent of the farm acreage under irrigation. Total agricultural income, which runs approximately $24.9 million annually, is sufficient to rank Sanpete fourth among the counties of the State of Utah based on this important economic resource (UtahReach, 2002).

Livestock and poultry are the mainstays of Sanpete agriculture. Livestock is grazed on both private and public range land. The irrigated acreage is devoted to raising feed for the livestock. Vital to the economic well being of the Sanpete area is the production of turkeys for the national market. For many years Sanpete has ranked among the top 8 counties in the US based on total volume of turkey production. A typical year's output of Moroni Feed Company, an integrated farmer's cooperative which has been largely responsible for the rise of the turkey industry, is in excess of 35 million pounds of dressed turkey. Sanpete County ranks among the top ten turkey-producing counties in the country.

2.2 Climate

The climate of the San Pitch River Watershed is influenced by the large variations in topography. The elevation of the Sanpete valley floor ranges from 5,040 to 7,400 feet above sea level and the adjacent mountains rise to over 9,000 feet.

The Sanpete Valley climate is semi-arid despite its high elevation. The average annual precipitation ranges from approximately 8 inches in the lower valley to more than 30 inches in the higher mountains. Most of the precipitation in the San Pitch River watershed falls as snow in the mountains, particularly the Wasatch Plateau, from November to April (Robinson, 1971). Table 2.1 summarizes the annual temperature and precipitation for Manti, Utah.

Table 2.1
Climate and Precipitation

Temperature (˚F)		**Precipitation (inches)**	
Annual Mean Daily Maximum	Annual Mean Daily Minimum	Annual Mean Rainfall	Annual Mean Snowfall
62	32.5	13	55

For Manti, Utah (USDA Soil Conservation Service, 1981)

The climate of the San Pitch River Watershed can also 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 San Pitch River Watershed is located within the Middle-Latitude Desert region and can be described by two climate types: Steppe (Semiarid) and Desert (Arid). 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. Table 2.2 summarizes the annual temperature and precipitation for climate and zones in the San Pitch River Watershed.

Table 2.2
Climatic Zones

Climatic Zone	Precipitation (inches)	Temperature (˚F)	Frost Free Period (days)	Elevation (feet)
High Mountain	22-40	34-45	40-90	8,000-10,000
Mountain	16-22	42-50	70-170	6,000-8,200
Upland	12-16	45-59	120-170	4,500-6,900
Semidesert	8-12	52-59	120-190	4,500-6,300
Desert	6-8	50-59	120-200	4,500-5,800

2.3 Geology / Soils

The San Pitch River watershed is in the Basin and Range-Colorado Plateau transition zone (Stokes, 1988). Geologic units exposed in the Sanpete Valley area range from Jurassic to Quaternary in age. The San Pitch Mountains and Wasatch Plateau both consist of Tertiary to Jurassic sedimentary rocks. Tertiary limestone and mudstone cap both ranges.

Cretaceous sandstones and conglomerates underlie the Tertiary rocks and are folded as a monocline in the Wasatch Plateau on the eastern side of the valley and as a syncline in the San Pitch Mountains. Beneath the Cretaceous units is the Jurassic Arapien Shale, which contains evaporite deposits. The Cedar Hills consist of the Tertiary volcaniclastic and pyroclastic Moroni Formation, mostly tuff and andesite. Consolidated rocks have a maximum combined thickness of more than 29,000 feet. Unconsolidated valley-fill deposits are at least 500 feet thick in Sanpete Valley along the western margin (Robinson, 1971). Because of the many faults, there are numerous springs along the east edge of the valley. Geothermal warm springs occur near Manti.

Outcrops and road cuts near Gunnison Reservoir expose the Green River formation (Eocene), which varies from sand to silt and limestone. Ridges of the Green River formation, landslide blocks similar to those farther south, help contain the water in Gunnison Reservoir. Near and north of the reservoir, ridges of the Green River formation are half-buried beneath the flat floor of the San Pitch Valley. One of them forms the hill on which Manti temple stands. Another, about two miles north of town, provided limestone for the temple from the Green River formation. The limestone is oolitic, made of small spheres that look like fish eggs but are really formed as sand-like grains that roll around in the agitated water. The formation contains fossils of fish, alligators, turtles, and other inhabitants of the early Tertiary lakes.

Southwest of Manti (near STORET 494645) the Sanpete Valley narrows and is constrained by bedrock outcrops which impede most groundwater flow out of the valley, and is referred to as a "bottleneck" (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). In this area, confined groundwater is forced to the surface and forms a large marshy area extending as far north as Manti, about 2 miles north of the north end of Gunnison Reservoir (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). Therefore, the only outlet for this groundwater is the San Pitch River.

At Gunnison, an east-west fault crosses the valley. To the southeast Tertiary (Paleocene) lakebeds can be seen behind hogback slices, essentially landslide blocks of the slightly younger Green River formation.

Beneath the Green River formation are Paleocene rocks. These Paleocene rocks appear in road cuts as highly fractured, along with the grayish and yellowish Arapien shale, a Jurassic Unit. Grey yellow and pink badlands of Arapien shale appear in the Arapien Valley to the southeast.

The Arapien shale forms hills along the west side of Arapien Valley and in the vicinity of Sterling at the lower end of Sanpete valley. The Arapien shale is also exposed as a narrow discontinuous band along the base of the San Pitch Mountains in Sanpete Valley. Outcrops of evaporite deposits of the Arapien Shale are located on the west side of Sanpete Valley from Big Mountain south to the mouths of Axhandle and Rock canyons (Wilberg and Heilweil, 1995). This area was identified by Wilberg and Heilweil, (1995) as one of the two areas in the Sanpete Valley with higher TDS concentrations in groundwater and is near STORET 494654 (San Pitch River west of Manti above Gunnison Reservoir at Creek crossing). The other area is on the east side of the valley near outcrops of the Green River and Crazy Hollow Formations from Chester to Pigeon Hollow. Robinson (1971) reported that the Arapien Shale underlies the narrow "bottleneck" in the vicinity of Gunnison Reservoir. Therefore, the Arapien shale is an important natural source of TDS loading to groundwater beneath the Sanpete Valley and the San Pitch River.

The Arapien shale, which is mined west and south of Sanpete Valley for salt, can be seen between some of the ridges (Chronic, 1990). The Arapien Shale consists of lower limestone beds overlain by gray siltstone, shale, gypsiferous shale, and salt-bearing, red-weathering shale and siltstone (Lawton, 1985). The Arapien Shale was deposited in a marine environment. Complex deformation geometries are common in the Arapien Shale, likely due to the thin-bedded nature and incompetent lithologies, especially salt. Most of the Arapien Shale in Sanpete Valley is exposed as intrusive masses from salt and evaporite diapirism that has likely been moving upward since it was deposited during Middle Jurassic (Witkind, 1982).

Many authors attribute the cause of increased groundwater salinity/TDS beneath the Sanpete Valley to the evaporites from the Arapien Shale, and the Green River and Crazy Hollow Formations (Utah Division of Water Resources, 1999; Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971; and Richardson, 1907).

Soil data for the Sanpete Valley were collected from the USDA Soil Conservation Service (USDA SCS, 1981) and the State Soil Geographic Database (STATSGO) dataset.

The Soil Survey of Sanpete Valley (USDA SCS, 1981) provides a general soil map and detailed soil maps drawn on aerial photographs with detailed descriptions of each soil type. The USDA Soil Conservation Service informed MSE that digitized electronic files of the soil survey were not available. Therefore, the dominant soil types adjacent to the San Pitch River are summarized below from the USDA Soil Conservation Service Soil Survey of Sanpete Valley, and a soil map generated from the STATSGO dataset is provided as **Map 2**.

The general soil map included in the Soil Survey of Sanpete Valley (USDA SCS, 1981) shows 16 soil associations. The dominant soils adjacent to the San Pitch River are listed as follows, in order of abundance:

1. Poganeab-Shumway-Chipman Association (map code 12)
2. Xerofluvents and Fluvaquent - Mellor Association (map code 11)
3. Genola - Woodrow - Quaker Association (map code 1)
4. Rock Land - Atepic - Amtoft Association (map code 8)

More detailed information about the soils in these associations, and the individual soil mapping units, are summarized below. The USDA SCS mapping symbol is provided in parenthesis for each soil unit. Soil units preceded by an asterisk are potential sources of salinity to the San Pitch River.

<u>Poganeab-Shumway-Chipman Association</u>

Soils in this association are dominant on the east side of the San Pitch River from Chester to Gunnison Reservoir. North of Chester these soils continue up the valley toward Fountain Green. They discontinue in a small area near Moroni, and then follow the San Pitch River up toward Fairview. The dominant soils in this association include the following:

Poganeab silt loam (Pg)
This soil is found on flood plains and valley bottoms. The soil is used for pasture and for native wild hay. The available water capacity is high (8 to 12 inches, USDA SCS, 1981). This soil mapping unit is present west of Pigeon Hollow and west of Chester.

**Poganeab silt loam, strongly saline-alkali (Ph)*
This soil has a profile similar to the soil described above, but it is strongly saline-alkali affected. The available water capacity is low (2 to 3 inches) and the high salt content reduces the water available to plants (USDA SCS, 1981). This soil mapping unit is present east of the San Pitch River between Chester and Pigeon Hollow.

Shumway silty clay loam (Sm)
This soil is on valley bottoms in fairly large areas. This soil is used for native grass pasture and native grass hay. A dominant strip of this soil mapping unit can be found from Johnson Spring to STORET 494645 (San Pitch River northwest of Manti).

Xerofluvents and Fluvaquent - Mellor Association

This soil association is dominant on the west side of the San Pitch River from Gunnison Reservoir to north of Ephraim. The dominant soils in this association include:

**Xerofluvents and Fluvaquents (XE)*
These soils consist of recently deposited alluvium on the flood plains of the streams or rivers. Salinity is generally moderate, but it ranges from non-saline to strongly saline affected (USDA SCS, 1981). The dominant vegetation on the strongly saline affected areas is salt grass, alkali sacaton, and greasewood.

This soil is used for pasture or grazing and in places for native grass hay. The soil can be found west of Chester in the San Pitch River flood plain and north of Moroni in the San Pitch River flood plain. It is also present in the San Pitch River flood plain below STORET 494645 to Gunnison Reservoir.

**Xerofluvents and Fluvaquents, saline (XF)*
This soil is strongly saline affected and there is typically a fluffy, granular salt crust on the surface (USDA SCS, 1981). Vegetation is usually sparse and is greasewood, pickleweed, kochia, bassia, and salt grass (USDA SCS, 1981). The soils are used as rangeland. These soils are abundant along Silver Creek and along the San Pitch River in the area west of Johnson Spring.

**Mellor silt loam (Md)*
This soil is on alluvial fans, flood plains, and lake terraces. Runoff is rapid and there is moderate sheet and rill erosion. The available water capacity is very low (1 to 2 inches). The high content of salt drastically reduces the amount of water available to plants (USDA SCS, 1981). This soil is used as spring and late fall range by sheep and cattle. This soil can be found near STORET 494654 on the San Pitch River.

Genola - Woodrow - Quaker Association

This soil association is present on both sides of the San Pitch River near Moroni and toward Chester. It is also present near the San Pitch River on the west side between Chester and Ephraim. Isolated areas of this soil are also located near the San Pitch River west of Manti. This is the dominant soil association of the lower San Pitch River.

**Quaker and Mellor soils (Qm)*
This mapping unit is on alluvial fans and alluvial plains. This soil is strongly saline-alkali, runoff is medium, and the available water capacity is low (2 inches). The high salt content reduces the amount of water available to plants. This soil is used as spring and late fall range by sheep and cattle. This soil unit is abundant west of Johnson Springs, and on the west side of the San Pitch River near STORET 494654.

Other dominant types not shown on the USDA Soil Conservation Service Soil Survey "General Map" of Sanpete Valley

Abcal silty clay loam (Aa)
This soil is on flood plains and alluvial plains. It is slightly to moderately affected by salts and alkali. The available water capacity is high (8-12 inches). The soil is used for wet meadow pasture or hay. This soil can be found along the San Pitch River from Chester to Pigeon Hollow.

Fluvaquents (Fn)
These soils are recent alluvial deposits on stream flood plains and vegetation is wiregrass, tules, and cattails. These soils are used for pasture and native grass hay. These soils can be found northwest of Ephraim.

Kjar peaty silt loam (Kp)
This soil is found on valley bottoms and used for pasture and range. It can be found northwest of Manti.

Rock Land - Atepic - Amtoft Association

This soil association is present near and on the west side of the San Pitch River from Chester to Gunnison Reservoir.

2.4 Land Use / Land Cover

Land use/land cover data were acquired from the USGS Land Use and Land Cover (LULC) dataset. The LULC data files describe the vegetation, water, natural surface, and cultural features on the land surface. The USGS provides these datasets and associated maps as a part of its National Mapping Program. Manual interpretation of aerial photographs acquired from NASA high-altitude missions and other sources were first used to compile the land use/land cover maps. Secondary sources from earlier land use maps and field surveys were also incorporated into the LULC maps as needed. At a later time, the LULC maps were digitized to create a national digital LULC database. In addition, land cover/crop type data were acquired from the Utah Division of Water Resources. Land use and crop type in Sanpete County is varied and shown on **Map 3** and discussed below.

Land Cover

Like all areas in the mountainous west, the San Pitch 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.

Cultural Characteristics/Land Use

Nearly all of the land within the San Pitch River Watershed is presently used for some designed activity and most areas have several concurrent uses. The primary land uses in Sanpete County are grazing and agriculture.

Sanpete County has 1,022,609 total acres. According to 1999 survey by the Utah Department of Community and Economic Development, Sanpete County contains approximately 528,591 acres of federal land (52%), 434,105 acres of private land (42%), and 59,914 acres of state land (6%).

There are 94,000 acres of irrigated cropland in Sanpete County (Utah Division of Water Resources, 2002); most irrigated cropland is in the central portions of the Sanpete and

Arapien Valleys. Most of the cropland is irrigated by flood methods (55%), with the remaining irrigated with sprinklers (Utah Division of Water Resources, 2002).

Land ownership is shown on **Map 4**. The county is rural with the population estimated at 16,259 in 1990 (Utah Division of Water Resources, 1999). It is interesting to note that the population has essentially remained the same since the turn of the century when the population was estimated at 16,313. However, it has been growing since 1990 and is expected to continue growing throughout the next few decades. The annual rate of population growth is expected to be about 1.8 percent. Ephraim is the major population center in Sanpete valley with 3,838 people (Utah Division of Water Resources, 1999).

<u>Plant Distributional and Crop Information</u>

There are five general vegetation types that occur within the San Pitch River Watershed from the mountain plateaus that are located above 8,000 feet and receive 20-35 inches of precipitation annually; to the valley floors that receive less than 8 inches of precipitation annually (see **Map 3**).

Conifer-Aspen forests are found on mountain slopes with elevations over 8,000 feet that receive 20-35 inches of precipitation annually. These forests contain mostly white fir, douglas fir, ponderosa pine, spruce, and quaking aspen. On steep slopes with elevations ranging from 7,500 to 8,500 feet and 18-25 inches precipitation annually, the prominent vegetation consists of mountain brush including gamble oak, serviceberry, and curlleaf mountain mahogany. In the foothills that occur at elevations ranging from 5,000 to 7,500 feet and receive 10-20 inches of precipitation annually, pinyon Juniper trees lend a pigmy forest aspect. Here the prominent vegetation types include pinyon pine and Utah juniper with scattered areas of brush, grasses, and forbes. Throughout the watershed, sagebrush is found at nearly every elevation and range of precipitation on deep, well drained soils. A wide variety of grasses, browse, and forbes are found within the predominant big sagebrush. At elevations from 4,500 to about 5,000 feet, where precipitation ranges from 8-10 inches, grass and the northern desert shrub are found.

Other types of important vegetation include Indian ricegrass, needle and thread grass, winterfat, black greasewood, and shadscale. Most of these are found in the low lands where soils are affected by salts. In addition, barren areas include desert playas, recent extrusions of volcanic basalt, and areas covered predominantly with annual weeds such as pickleweed and gray Molly (Utah Division of Water Resources, 1999).

Robinson (1971) estimated the phreatophytes in Sanpete Valley, principally saltgrass, wiregrass, greasewood, and rabbitbrush, in the mid-1960s to cover about 45,200 acres in an area southwest of Manti (near STORET 494645). In this area the Sanpete Valley narrows and is constrained by bedrock outcrops which impede most groundwater flow out of the valley (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). In this area, confined groundwater is forced to the surface and forms a large marshy area extending as far north as Manti, about 2 miles north of the north end of Gunnison Reservoir (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971).

A 1997 census of agriculture by the US Department of Agriculture (USDA, 1997) indicates that the top 5 crop commodities in Sanpete County are: hay crops (51,313 acres), barley (7,304 acres), corn for silage (1,855 acres), wheat (1,097 acres), and oats (523 acres).

2.5 Surface Water Hydrology

The San Pitch River begins near Oak Creek Ridge on the Northern Wasatch Plateau, flows westward and southward through Sanpete Valley, and ends where it flows into the Sevier River at Gunnison, Utah. **Map 5** shows the general hydrology of the watershed including streams, diversions, canals, reservoirs, and ponds.

Approximately 11,000 acre feet per year (acre-ft/yr) of water from the Colorado River Basin is brought into the San Pitch River drainage basin via 13 tunnels and ditches (Wilberg and Heilweil, 1995). The amount of transbasin diversions represents less than 10 percent of the cumulative average annual streamflow (Wilberg and Heilweil, 1995). Major transbasin diversions include the Ephraim, Fairview, Manti, and Spring City tunnels; some of this water is from Fairview Lakes and Lower Gooseberry Reservoir (Wilberg and Heilweil, 1995). An additional transbasin diversion, the Narrows project, is planned to bring supplemental water supply to water users in north Sanpete County, Utah.

The primary purpose of the Narrows Project is to develop and irrigation (sprinkler) and municipal & Industrial (M&I) supply source for users in north Sanpete County via pipelines that will be constructed to deliver water to existing water distribution systems (USDI - BOR, 2001). This additional water supply is not planned to be used for flood irrigation or add surface flow to the San Pitch River below Moroni - the 303d listed section.

For the purposes of this study, the San Pitch River is divided into upper, middle, and lower segments. The upper San Pitch River is from the headwaters to Moroni (where it crosses State highway U132). The middle San Pitch River runs from U132 to Gunnison Reservoir. Lower San Pitch River flows from Gunnison Reservoir to the confluence with the Sevier River. The middle and lower San Pitch River are listed as impaired due to water quality numeric exceedences of TDS; therefore, the emphasis of this study is on the middle and lower segments and not on the upper San Pitch River.

Most surface water inflow in Sanpete Valley is diverted for irrigation purposes. The flow of the San Pitch River is managed according to the 1936 Cox Decree, which sets forth all the water rights for the Sevier River system. San Pitch River Water Commissioners, Lowell R. Anderson, and Roland Beck, provided information on surface water inputs and diversions along the river based on both measured and estimated flows. This information was combined with measured and estimated flows in the STORET database to develop a water budget for the middle and lower San Pitch River.

There is a general difference in irrigation practices in the middle and lower San Pitch River. The majority of irrigation water that is diverted from the middle San Pitch River is distributed to pastures and fields by means of flood irrigation methods. Irrigation water that is diverted from the lower San Pitch River is distributed to fields via sprinklers.

The flow of diverted water is recorded at the diversions using continuous recorders, or estimated from a flume or weir. Annual reports are prepared by the water commissioners and submitted to Utah Department of Natural Resources - Division of Water Rights (DWRt). Flow is recorded at nine diversions along the middle and lower San Pitch River. These diversions are listed in Table 2.3.

Table 2.3
Division of Water Rights Diversions

SEGMENT	DIVERSION
Middle San Pitch River	Upper Rock Dam
	Lower Rock Dam
	Bagnal Canal
	West Point Canal
	East Drainage Canal
	West Drainage Canal
	San Pitch River West of Manti
Lower San Pitch River	San Pitch River Below Old Field Canal
	Old Field Canal

A flow diagram showing the locations of inputs and diversions on the middle and lower San Pitch River is provided on **Map 6.** The locations of these inputs are indicated by river mile (RM) starting at the confluence with the Sevier River.

The following descriptions of the middle and lower San Pitch River 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 pollutant loading when combined with the TDS concentrations measured along the San Pitch River by DWQ.

A "typical" year description is feasible because flows in the San Pitch River are so closely managed. 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) 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 periodic surface runoff, it does adequately characterize water quantity during flow periods that may typically be associated with natural and human-caused sources of TDS.

2.5.1 Middle San Pitch River - Water Budget for Typical Year

Water diverted from the middle San Pitch River is used to flood irrigate croplands and pastures, and for stock watering. There are some sprinkler irrigation systems in this area; however, the water that supplies these systems comes almost entirely from wells, not from the San Pitch River. The irrigation season in the watershed is usually from

March 1st to September 30th. The first flush from low elevation snowmelt in Sanpete Valley occurs in February, a second flush, from higher elevation snowmelt, occurs in May.

Map 6 illustrates the flows diverted from the San Pitch River and quantifies the mean flows at these diversions during the irrigation and non-irrigation seasons of water year 1996-1997. In addition, Map 6 summarizes DWQ STORET TDS data collected for the 1996-1997 water year, including the percent exceedence for TDS, the mean TDS and the number of samples collected at each STORET location along the middle and lower San Pitch River.

The northernmost diversion on the middle San Pitch River is Upper Rock Dam. At this location the Moroni Wastewater Treatment Plant (WWTP), a combined plant serving the City of Moroni and the Moroni Feed Co., discharges effluent into the San Pitch River. This discharge mixes with the San Pitch River water below Upper Rock Dam and most of this water is taken out of the river at Lower Rock Dam. Flow gages are present at the Upper and Lower Rock Dam diversions.

Silver Creek and the San Pitch River mingle below the Rock Dam diversions. There is no flow gage on Silver Creek and therefore no flow record. The Water Commissioners commented that Silver Creek generally flows between the months February and June. Below the confluence with Silver Creek are the Bagnal and West Point Canal diversions. These are total diversions and the water diverted at the Bagnal diversion is used to flood pastures, and the water diverted at the Westpoint diversion is used to flood croplands. Flow gages are present at the Bagnal and West Point Canal diversions. Flood irrigation return flows are collected back in the San Pitch River following flooding from the Bagnal and Westpoint diversions.

Further down river, water in the San Pitch River is totally diverted at the Ephraim Olsen and Price diversions (east and west - see Map 6). There are no gages on the Ephraim Olsen and Price diversions. At river mile 32, spring water from Johnson Spring flows into the San Pitch River with an average seasonal flow of 0.7 cubic feet per second (cfs).

Farther south, water is diverted from the San Pitch River at the East Drainage Canal diversion. Adjacent to the East Drainage Canal is the West Drainage Canal, which was created along the original route of the San Pitch River. Along this reach, the San Pitch River was originally quite shallow and braided, and the West Drainage Canal was excavated deeper than the river bottom to more efficiently direct flows through this section. The East and West Drainage Canals are the last diversions on the middle San Pitch River. Flow data are available for the East and West Drainage Canal diversions.

Although there are no surface water tributaries that contribute flows to the middle San Pitch River between STORET 494654 "San Pitch River-NW Manti” and STORET 494645 "San Pitch River-W Manti”, flow data in the STORET database indicate that the river is generally gaining flows through this segment. The Water Commissioners indicated that flow contributions could be attributed to return flows from upstream irrigation.

Robinson (1971) conducted seepage runs on the San Pitch River in 1966 and determined that two of the major areas of surface water gain from groundwater were located above the bridge west of Ephraim (near the West Drainage Canal diversion), and within a phreatophyte patch north of Gunnison Reservoir (near STORET 494645). Seepage runs conducted by Sandberg and Smith (1995) between Moroni and Gunnison Reservoir showed two gaining sections and one losing section of the San Pitch River. The two groundwater discharge areas (gaining sections) on the San Pitch River are from Moroni to Wales (gain of about 1.8 cubic feet per second) and from west of Ephraim (near the West Drainage Canal, about 2 miles north of STORET 494654) to Gunnison Reservoir (gain of about 0.9 cubic feet per second). Between these gaining sections the water loss to groundwater is from 0.2 to 0.4 cubic feet per second (Sandberg and Smith, 1995).

Currently, flow data for the middle San Pitch River are available from only two flow gaging stations. Both gages are continuous recorders and are located at the West Drainage Canal diversion and the other at the San Pitch River West of Manti diversion. Although these locations are referred to as diversions, water is not diverted from the San Pitch River at these locations.

Estimated and measured flow data for the middle San Pitch River are also available in the STORET database. STORET stations with flow data along the middle San Pitch River include: 494696 "San Pitch River above Moroni WWTP"; 494665 "San Pitch River 1 mile west of Chester on U-117"; 494654 "San Pitch River northwest of Manti"; and 494645 "San Pitch River west of Manti above Gunnison Reservoir at creek crossing".

Because the majority of flow measurements in the STORET database are estimated, the DWRt gage station flow data were used to calculate TDS loading at select points along the middle San Pitch River (Section 4.2.2).

2.5.2 Lower San Pitch River - Water Budget for Typical Year

The lower San Pitch River Watershed section begins at the south end of the Gunnison Reservoir impoundment. During the irrigation season, all of the surface water released at the south end of Gunnison Reservoir is diverted to Highland Canal by way of Six Mile Creek. Pettyville Canal is the historic name for Highland Canal, thus is essentially the same canal and diversion. Sources of water to Highland Canal include Gunnison Reservoir, Six Mile Creek, and Twelve Mile Creek. On Six Mile Creek there is a flume that crosses Highland Canal before the confluence with the San Pitch River. This flume only transports water to the San Pitch River via Six Mile Creek when there is overflow. Otherwise, the water in Six Mile Creek is diverted to Highland Canal. Nine Mile Reservoir is located east of Highland Canal. Water stored in Nine Mile Reservoir is released for irrigation purposes between June 15th and September 1st. At the south end of Highland Canal, there is a flume that transports water in Highland Canal over Twelve Mile Creek. The water in Twelve Mile Creek is completely shut off at this point during most of the year, except for when there is overflow. This type of overflow generally occurs for about six weeks each year.

Flows that emerge in the San Pitch River below the Six Mile Creek/Highland Canal diversion are essentially from spring sources. However, some snowmelt runoff enters the river below this point between May 15th and mid-June.

Southwest and down river of Highland Canal is Old Field Canal. Old Field Canal was constructed in the 1800's and is possibly the oldest diversion in the watershed. Old Field Canal is a total diversion of water from the San Pitch River. A gaging station is located at the beginning of the Old Field Canal diversion. The Water Commissioners commented that the flows in Old Field Canal are representative of the flows in the San Pitch River above the diversion for Old Field Canal. Therefore, the flows recorded in Old Field Canal were used to reasonably estimate the flows in the San Pitch River above the Old Field Canal diversion.

One gaging station existed on the lower San Pitch River "San Pitch River at Old Field Canal" (also referred to as "San Pitch River below Old Field Canal"). However, the gage was moved from the river in 1994 (DWRt diversion flow records, 2001) and flows are estimated. Estimated and measured flow data for the lower San Pitch River are also available from STORET station 494615 "San Pitch River 2 miles east of Gunnison at U137 crossing".

2.6 Groundwater Hydrology

Groundwater in the Sanpete Valley area occurs in two types of aquifers: fractured bedrock and unconsolidated deposits. Groundwater in the Sanpete Valley area is obtained principally from unconsolidated deposits of the valley-fill aquifer (Wilberg and Heilweil, 1995). However, fractured-rock aquifers are important sources of water in Sanpete Valley; they yield water to springs and some wells in Sanpete Valley (Wilberg and Heilweil, 1995).

Groundwater in the valley-fill aquifer of Sanpete Valley occurs under confined and unconfined conditions in unconsolidated deposits (Robinson, 1971). Based on water-well data, the thickness of unconsolidated fill is estimated to be at least 500 feet in the widest part of Sanpete Valley, between Ephraim and Moroni (Robinson, 1971).

Two groundwater reservoirs including the Sanpete Valley Reservoir and the Redmond – Gunnison Reservoir affect the San Pitch watershed (Robinson, 1971). The Sanpete Valley Reservoir underlies almost the entire extent of the watershed from headwaters to the southern end of Gunnison Reservoir. Storage in the upper 200 feet of valley fill in Sanpete Valley is estimated at 3,000,000 acre-ft, and withdrawals from the Sanpete Valley Groundwater Reservoir are estimated at 6,300 acre-ft/yr (Wilberg and Heilweil, 1995). The Redmond – Gunnison Groundwater Reservoir underlies the southern extreme of the watershed including Ninemile Reservoir. Storage in the upper 200 feet of alluvial fill is estimated to be 150,000 acre-ft. Withdrawals are estimated at 4,500 acre-ft/yr (4,200 for irrigation and the balance for industrial and municipal purposes).

Four sources of recharge to the groundwater reservoir have been estimated by Wilberg and Heilweil (1995) including: 1) tributaries, 2) seepage from the San Pitch River, 3) deep percolation of unconsumed irrigation water, and 4) precipitation. Recharge from tributaries occurs where the streams flow across alluvial fans. The estimated loss is between 9 and 39 percent. Seepage from the San Pitch River varies through its length.

About 116,900 acre-ft/yr of water is used for irrigation in Sanpete Valley above Gunnison Reservoir (Wilberg and Heilweil, 1995). Groundwater recharge from percolation of unconsumed irrigation water was estimated to average 29,000 acre-ft, which is 25% of the applied irrigation water (range and average values were not estimated).

Precipitation is also a significant part of the recharge to the groundwater reservoir. Based on other studies in Utah, Wilberg and Heilweil estimated recharge due to precipitation at 10 percent of the annual precipitation. Groundwater recharge is variable through the year and between years, but is estimated to average from 74,000 to 103,000 acre-ft/yr (Table 2.4).

Table 2.4
Source of Groundwater Recharge

Recharge Source	**Estimated Averages (acre-feet per year)**
Tributaries	28,500 - 57,000
Seepage from the San Pitch River	1,500 - 1,800
Percolation of Unconsumed Irrigation Water	29,000
Precipitation	15,000
Total	74,000 - 103,000

Groundwater is discharged from the valley-fill aquifer by 1) evapotranspiration, 2) seepage into the San Pitch River, 3) withdrawals from wells, and 4) spring discharge (Wilberg and Heilweil, 1995). Groundwater discharge also varies seasonally and yealrly and is estimated to average from 76,000 to 224,000 acre-ft/yr (Table 2.5)

Table 2.5
Sources of Groundwater Discharge

Discharge Source	**Estimated Averages (acre-feet per year)**
Evapotranspiration	41,000 - 116,000
Seepage into the San Pitch River	18,500 - 80,300
Withdrawals from Wells	5,200 - 16,800
Springs	11,000
Total	76,000 - 224,000

The primary source of water for irrigation is surface water; however, groundwater is pumped when surface water supplies are inadequate. Groundwater withdrawals from wells are from pumped and flowing wells. Nearly all of the groundwater from well withdrawals is applied as irrigation water in Sanpete Valley (Wilberg and Heilweil, 1995). The average amount of well withdrawals was estimated at 10,300 acre-ft/yr and includes 6,300 acre-ft/yr of water from pumped wells, and 4,000 acre-ft/yr of water from flowing wells (Utah Division of Water Resources, 1999). Artesian wells drilled through valley sediments into limestone and sandstone of the Green River Formation are an important source of irrigation water near Manti (Snyder and Lowe, 1988). Groundwater from wells in the Green River Formation have yielded water that is saline and not suitable for culinary use (Robinson, 1971). A complete discussion of groundwater quality is presented in Section 4.4.2. Wilberg and Heilweil (1995) estimated groundwater spring discharge at 11,000 acre-ft/yr.

Southwest of Manti (near STORET 494645) the Sanpete Valley narrows and is constrained by bedrock outcrops which impede most groundwater flow out of the valley (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). In this area, confined groundwater is forced to the surface and forms a large marshy area extending as far north as Manti, about 2 miles north of the north end of Gunnison Reservoir (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). Therefore, the only outlet for this groundwater is the San Pitch River.

Numerous naturally occurring springs are located below Gunnison Reservoir. These springs were considered as a potential TDS source to the lower San Pitch River; however, no water quality data are available to estimate their loading potential. The approximate locations of the springs are shown on **Map 5**. Water from a spring, designated (D-18-2)23adb-S1, which discharges along a fault zone southwest of Manti, had a TDS concentration of 1,780 mg/L (Willberg and Heilweil, 1995).

3.0 CURRENT MONITORING PROGRAM

The most complete water quality monitoring station summaries and water quality observation data for the San Pitch 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 collected (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. Water quality data for the San Pitch River Watershed is maintained in the DWQ STORET database. Mr. Jim Harris, DWQ Project Manager, provided the water quality data for the basin on a compact disk.

All of the STORET data for the San Pitch Watershed were organized and sorted into tables provided in the Data Evaluation Report (MSE, 2001). In this report **Appendix 3 and Appendix 4** contain flow and TDS data and summary statistics, for 1995 to 2000, and water years 1996 to 1997, respectively. The statistics table lists the number, mean, median, standard deviation, minimum, and maximum for all TDS and converted specific conductivity measurements. In addition, the statistics table lists the number of criteria exceedences and percent exceedence for TDS. **Appendix 5** contains the Utah Division of Water Rights discharge records for the San Pitch River. **Appendix 6** contains recent Hydrolab measurements collected by DWQ. The Utah Geological Survey (UGS) groundwater TDS data are provided in **Appendix 7.**

3.1 STORET Locations

There are 35 documented STORET sampling sites within the San Pitch River Watershed (Table 3.1). The location of all STORET water quality sampling sites are provided in the in the Data Evaluation Report (MSE, 2001).

Table 3.1
STORET Sites in the San Pitch River Watershed

STORET#	Station Name
494605	San Pitch River west of Gunnison
494615	San Pitch River 2 miles east of Gunnison at U-137 crossing
494616	Twelve Mile Creek at U-137 crossing in Mayfield
494619	Highland Canal at US 89 below Nine Mile Reservoir
494620	Highland Canal east of Axtell
494621	New Field Canal west of Gunnison at U-137 crossing
494622	New Field Canal southeast of Centerfield
494632	Inlet Canal above Palisades Lake
494636	Six Mile Creek above confluence/San Pitch River northwest of Sterling
494637	Manti Creek at Forest Service Boundary
494645	San Pitch River west of Manti above Gunnison Reservoir at Creek crossing
494652	Johnson Spring North at Johnson Road crossing
494653	Johnson Spring South at Johnson Road crossing
494654	San Pitch River northwest of Manti
494655	Maple Creek
494656	Oak Creek at Spring City
494657	Ephraim Creek at Forest Service Boundary
494661	Spring City Lagoons
494665	San Pitch River 1 mile west of Chester on U-117
494669	Petes Canyon Creek NE1/4 SW1/4 Sec 2 T16 R2E on Private Land
494675	San Pitch River 2.5 miles west of Mt. Pleasant at U-116 crossing
494676	Pleasant Creek at Forest Service Boundary
494677	Cottonwood Creek east of Fairview at Forest Service Boundary
494678	Oak Creek north of Fairview at Creek 323 crossing
494679	San Pitch River at US-89 crossing north of Fairview
494689	Fountain Green Fish Hatchery East
494690	Fountain Green Fish Hatchery West
494691	Fountain Green Fish Hatchery Inflow 1
494694	Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent
494696	San Pitch River above Moroni WWTP
494698	San Pitch River at bridge below Moroni WWTP
594323	Highland Canal below Nine Mile Reservoir
594326	Nine Mile Reservoir Inflow
594354	San Pitch River below Gunnison Reservoir
599178	Big Hollow Creek T13S R03E Sec33 NW1/4 SW1/4

The STORET database for the San Pitch River Watershed was evaluated for available TDS and specific conductivity results. Thirteen of the STORET locations do not contain any TDS or specific conductivity data since 1990. These thirteen STORET locations are listed in Table 3.2. Because these stations do not contain any TDS or specific conductivity data for the past 12 years they were screened from further TDS analysis.

Table 3.2
STORET Sites Without TDS or Specific Conductivity Data

STORET #	Station Name	Begin Date	End Date	#TDS Results	#TDS since 1990	#TDS since 1995
494605	San Pitch River west of Gunnison	03/28/79	06/08/84	12	0	0
494619	Highland Canal at US 89 below Nine Mile Reservoir	06/10/81	04/20/82	5	0	0
494620	Highland Canal east of Axtell	06/10/81	04/20/82	5	0	0
494621	New Field Canal west of Gunnison at U-137 crossing	06/10/81	04/20/82	5	0	0
494622	New Field Canal southeast of Centerfield	06/10/81	04/20/82	5	0	0
494655	Maple Creek	04/02/96	04/02/96	0	0	0
494661	Spring City Lagoons	02/01/96	07/20/00	0	0	0
494669	Petes Canyon Creek NE1/4 SW1/4 Sec 2 T16 R2E on Private Land	11/21/89	11/21/89	1	0	0
494691	Fountain Green Fish Hatchery Inflow 1	02/01/89	01/07/91	0	0	0
494698	San Pitch River at bridge below Moroni WWTP	04/20/77	04/20/79	6	0	0
594323	Highland Canal below Nine Mile Reservoir	06/10/81	04/20/82	5	0	0
594354	San Pitch River below Gunnison Reservoir	05/21/81	04/20/82	5	0	0
599178	Big Hollow Creek T13S R03E Sec33 NW1/4 SW1/4	03/28/86	03/28/86	1	0	0

Twenty-two stations were retained for TDS analysis. Table 3.3 provides a summary of TDS data available in the STORET database for the San Pitch River Watershed. The locations of these 22 stations are shown on **Map 7**.

Statistics for the retained STORET stations are provided in **Appendix 3**. The statistics include the number of samples, mean, median, standard deviation, minimum result, maximum result, number greater than the TDS criteria (1,200 mg/L), and the percent exceedence.

Table 3.3
Summary of TDS Data Available in the San Pitch River Database

STORET #	Station Name	Begin Date	End Date	No. TDS Results	Mean TDS	Max TDS	%TDS Exceed	No. TDS since 1990	No. TDS since 1995
494615	San Pitch River 2 miles east of Gunnison at U-137 crossing	09/02/76	07/20/00	172	1,547	2,858	**65%**	88	52
494616	Twelve Mile Creek at U-137 crossing in Mayfield	09/02/76	06/24/97	26	254	318	0%	19	19
494632	Inlet Canal above Palisades Lake	03/13/80	06/14/00	11	273	406	0%	9	4
494636	Six Mile Creek above confluence/San Pitch River northwest of Sterling	09/02/76	06/24/97	26	317	706	0%	18	18
494637	Manti Creek at Forest Service Boundary	09/02/76	06/24/97	21	345	464	0%	19	19
494645	San Pitch River west of Manti above Gunnison Reservoir at Creek crossing	07/16/76	07/20/00	66	1,015	2,353	**26%**	57	53
494652	Johnson Spring North at Johnson Road crossing	04/25/96	05/06/97	5	956	1,750	**20%**	5	5
494653	Johnson Spring South at Johnson Road crossing	04/25/96	06/24/97	12	836	1,984	**8%**	12	12
494654	San Pitch River northwest of Manti	04/02/96	06/24/97	15	862	1,916	**13%**	15	15
494656	Oak Creek at Spring City	09/02/76	06/24/97	17	221	274	0%	15	15
494657	Ephraim Creek at Forest Service Boundary	04/02/96	06/24/97	19	261	506	0%	19	19
494665	San Pitch River 1 mile west of Chester on U-117	09/02/76	07/20/00	52	695	5,954	**4%**	43	35
494675	San Pitch River 2.5 miles west of Mt. Pleasant at U-116 crossing	09/02/76	07/20/00	131	449	1,040	0%	86	51
494676	Pleasant Creek at Forest Service Boundary	09/02/76	06/24/97	21	241	280	0%	17	17
494677	Cottonwood Creek east of Fairview at Forest Service Boundary	04/02/96	06/24/97	17	254	328	0%	17	17
494678	Oak Creek north of Fairview at Creek 323 crossing	04/02/96	06/24/97	5	258	282	0%	5	5
494679	San Pitch River at US-89 crossing north of Fairview	04/02/96	06/24/97	18	354	470	0%	18	18
494689	Fountain Green Fish Hatchery East	02/07/78	07/20/00	129	287	564	0%	71	36
494690	Fountain Green Fish Hatchery West	02/07/78	07/20/00	97	286	346	0%	43	25
494694	Moroni WWTP & Turkey Plant combined effluent	11/20/75	07/20/00	58	768	1268	**2%**	29	29
494696	San Pitch River above Moroni WWTP	11/20/75	07/20/00	100	505	1,160	0%	58	36
594326	Nine Mile Reservoir Inflow	06/12/90	06/14/00	9	671	740	0%	9	4

3.2 STORET Sampling Frequency

Stream Monitoring

The DWQ stream monitoring program consists of intensive and long-term 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 and the last sampling event was completed in 1996-1997. The long-term water quality monitoring station data are 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 (STORET). These data are periodically uploaded to the EPA's STORET system.

River/stream STORET sites in the San Pitch River Watershed considered intensive and long-term are listed in Table 3.4.

Table 3.4
STORET Sampling Frequency

STORET Number	Station Name	Intensive	Long Term
494605	San Pitch River west of Gunnison		
494615	San Pitch River 2 miles east of Gunnison at U-137 crossing	X	X
494616	Twelve Mile Creek at U-137 crossing in Mayfield	X	
494619	Highland Canal at US 89 below Nine Mile Reservoir		
494620	Highland Canal east of Axtell		
494621	New Field Canal west of Gunnison at U-137 crossing		
494622	New Field Canal southeast of Centerfield		
494632	Inlet Canal above Palisades Lake		
494636	Six Mile Creek above confluence/San Pitch River northwest of Sterling	X	
494637	Manti Creek at Forest Service Boundary	X	
494645	San Pitch River west of Manti above Gunnison Reservoir at Creek crossing	X	X
494652	Johnson Spring North at Johnson Road crossing	X	
494653	Johnson Spring South at Johnson Road crossing	X	
494654	San Pitch River northwest of Manti	X	
494655	Maple Creek		
494656	Oak Creek at Spring City	X	
494657	Ephraim Creek at Forest Service Boundary	X	
494661	Spring City Lagoons	X	
494665	San Pitch River 1 mile west of Chester on U-117	X	
494669	Petes Canyon Creek NE1/4 SW1/4 Sec 2 T16 R2E on Private Land		
494675	San Pitch River 2.5 miles west of Mt. Pleasant at U-116 crossing	X	X
494676	Pleasant Creek at Forest Service Boundary	X	
494677	Cottonwood Creek east of Fairview at Forest Service Boundary	X	
494678	Oak Creek north of Fairview at Creek 323 crossing	X	
494679	San Pitch River at US-89 crossing north of Fairview	X	
494689	Fountain Green Fish Hatchery East	X	X
494690	Fountain Green Fish Hatchery West	X	X
494691	Fountain Green Fish Hatchery Inflow 1		
494694	Moroni WWTP & Turkey Plant combined effluent		X
494696	San Pitch River above Moroni WWTP	X	X
494698	San Pitch River at bridge below Moroni WWTP		
594323	Highland Canal below Nine Mile Reservoir		
594326	Nine Mile Reservoir Inflow		
594354	San Pitch River below Gunnison Reservoir		
599178	Big Hollow Creek T13S R03E Sec33 NW1/4 SW1/4		

Stations not identified as intensive or long term are historical sites.

3.3 STORET Sampling Parameters

The water quality and associated parameters included in the STORET database include the following. However, select parameters are included for each site depending on the focus of the sampling event.

Metals (dissolved):
- Aluminum
- Arsenic
- Barium
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Selenium
- Silver
- Zinc
- Calcium
- Magnesium
- Potassium
- Sodium

Inorganic Chemistry:
- Bicarbonate
- Carbonate
- Carbonate Solids
- Carbon Dioxide
- Chemical Balance
- Chloride
- Hydroxide
- pH
- Specific Conductance
- Sulfate
- Total Alkalinity
- Total Dissolved Solids
- Total Hardness
- Total Suspended Solids
- Turbidity

Nutrients:
- NH3(4X) Ammonia
- D-NO2+ Dissolved Nitrite & Nitrate
- Total Phosphorus
- Total Dissolved Phosphorus

3.4 USGS gage stations

There are ten historic USGS gaging stations in the San Pitch River Watershed. The location of these gage stations were provided in the Data Evaluation Report (MSE, 2001). The data coverage periods vary as shown in Table 3.5. The flow data may not be very useful from a pollutant loading basis, because most of the data coverage is quite old and does not overlap with the DWQ STORET water quality data.

Table 3.5
USGS Stream Gaging Stations in the San Pitch River Watershed.

USGS Gage Station #	USGS Gage Name	Data Coverage
09317500	Candland Ditch Near Mt Pleasant	1949 to 1958
09321500	Twin Creek Tunnel Near Mt Pleasant	1950 to 1958
09322500	Cedar Creek Tunnel Near Spring City	1949 to 1958
09323000	Spring City Tunnel Near Spring City	1960 to 1983
09326000	Madsen Ditch Near Ephraim	1950 to 1958
10208500	Oak Creek Nr. Fairview	1964 to 1989
10210000	Pleasant Creek Near Mount Pleasant	1954 to 1975
10211000	Twin Creek Near Mount Pleasant	1954 to 1966
10215700	Oak Creek Near Spring City	1964 to 1994
10216210	San Pitch River Near Sterling	1964 to 1980

4.0 WATER QUALITY

4.1 Designated Segments and Beneficial Uses

Utah's Year 2000 303(d) list identifies tributaries in two segments of the San Pitch River as being impaired due to water quality numeric exceedences of TDS (DWQ, 2002). These segments are described as:

San Pitch River - 1: San Pitch River and tributaries from confluence with Sevier River to tailwater of Gunnison Reservoir (excluding tributaries above USFS boundary). Hydrologic Unit Code (HUC) 16030004-001. Water body size: 15.82 miles.

San Pitch River - 3: San Pitch River and tributaries from Gunnison Reservoir to U132 crossing below USFS boundary. HUC 16030004-005. Water body size: 59.46 miles.

In this report the San Pitch River - 1 segment is referred to as the lower San Pitch River, and the San Pitch River - 3 segment is referred to as the middle San Pitch River. It should be noted that Utah's Year 2000 303(d) list does not define a segment as "San Pitch River - 2".

The above listing is based on an intensive water quality survey completed in 1996-1997 by DWQ. This survey found numerical criteria exceedences for TDS. The beneficial uses, as designated by the State of Utah (Utah Division of Water Resources, 1999), for the San Pitch River are:

- 2B – Protected for secondary contact recreation such as boating, wading, or similar uses;
- 3C – Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain;
- 3D – Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
- 4 – Protected for agricultural uses including irrigation of crops and stock watering

Due to water quality impairments, the San Pitch River and some of its tributaries are not currently meeting beneficial use requirements for designated beneficial use 4 (agricultural uses including irrigation of crops and stock watering).

4.2 Applicable Water Quality Standards

The Utah water quality standards (Utah WQS) establish a numeric criterion of 1,200 mg/L TDS for the protection of Class 4 waters (Utah Administrative Code R317-2, State of Utah, 2000). In addition, the Utah WQS also provide numeric criteria for secondary standards (pH, boron, and metals) that may be applicable to the evaluation of dissolved solids impact on beneficial uses. Utah water quality criteria applicable to the 303(d) listed segments of the San Pitch River are listed in Table 4.1.

Table 4.1
Utah Water Quality Criteria for Class 4 Waters

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.

Relation of Total Dissolved Solids to Beneficial Uses

TDS is listed as a criterion for protection of agricultural uses because of the negative effect of high salinity on crop production. 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 minor components of salinity. Salinity reduces crop growth by reducing the ability of plant roots to absorb water, and is evaluated by the relationship of salt tolerance to crops. Unlike 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 relation to the irrigation water TDS (Tanji, 1990).

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, as listed in the table above, 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 pollutant, 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 particular interest if the source of TDS is primarily a natural source and does not impair agricultural uses. As identified in the 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".

4.3 303(d) Listing Criteria

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 4.2.

Table 4.2
303 (d) Criteria for Assessing Agricultural Beneficial Use Support

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.

DWQ lists waterbodies assessed as 'partially supporting' or 'not supporting' 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 4.1, the designated beneficial uses for the San Pitch River include and are summarized as: 2B - secondary contact recreation (boating, wading, or similar uses); 3C - nongame fish and other aquatic life; 3D - waterfowl, shore birds and other water-oriented wildlife; and 4 - agricultural uses including irrigation of crops and stock watering.

According to DWQ's assessment of the San Pitch River and its tributaries, several segments are not meeting the water quality standards to support beneficial use 4 - agricultural uses including irrigation of crops and stock watering.

4.4 Water Quality Assessment

4.4.1 Surface Water

Secondary Parameters – pH, Boron, Metals, and Sodium

Water chemistry was evaluated with respect to the effect on agriculture uses - the unsupported designated beneficial use in the watershed. Irrigation on saline soils may increase the concentration of the dissolved constituents (boron, sodium, and heavy metals) to levels that are toxic to some crops. A review of the water quality data for the San Pitch River Watershed indicates that these secondary parameters do not occur at concentrations that are a concern for toxicity, and therefore the TMDL focuses on the magnitude and distribution of TDS in the watershed.

pH - There are 1,236 observations for pH in the San Pitch River Watershed database. The overall mean for pH is 8.1, with a range of 6.2 – 9.3. Six of the observations (at 4 different stations) are outside the water quality criteria for pH. These data and stations are identified in the Data Evaluation Report (MSE, 2001).

Boron - For agricultural uses, the Utah water quality criteria for boron is 0.75 mg/L. In the San Pitch River database there are 68 analyses for boron. The overall mean boron concentration is 0.20 mg/L with a maximum of 0.66 mg/L. There is no exceedence of boron criteria at any station in the database (MSE, 2001).

Metals - An initial screen of the San Pitch River database for exceedence of water quality criteria for arsenic, cadmium, chromium, copper, lead and selenium was completed (MSE, 2001). No exceedence of the water quality criteria for these metals was found in the database.

Sodium - The effect of sodium on irrigation water is estimated by evaluating the sodium absorption ratio (SAR) in combination with the type of soils and crops being irrigated. Of the 1,403 total observations in the database, there is sufficient data to calculate SAR for 668 observations. The overall mean SAR was 3.3 with a maximum of 18.7. Water with a SAR between 1 and 10 is considered low-sodium hazard and can be used for irrigation on most soils with little danger of developing harmful levels of exchangeable sodium (Tanji 1990). Water with a SAR between 10 and 18, is considered medium-sodium hazard water, and may present a sodium hazard in some fine textured soils under low leaching conditions. Evaluating sodium hazard takes into account soil types, irrigation practices, and crops grown. This type of analysis may be useful for agricultural assessment, but is outside the scope of the water quality assessment for TMDL purposes.

Total Dissolved Solids

Of the 35 STORET locations in the San Pitch River Watershed, twenty-two contained TDS data over the period of record, dating back to 1975 (Table 3.3). However, much of this data does not overlap in time between stations and is not comparable. Therefore, to increase data comparability, the data were compiled for stations that contained data in the most recent six-year period, 1995 to 2000. TDS concentrations exceed the criteria of 1,200 mg/L at five of the twenty-two stations. The data for this period (1995 - 2000) are listed in **Appendix 3**. For each station, the raw data are listed, and followed by a summary statistics table showing number, mean, median, standard deviation, minimum, maximum, number of samples exceeding the criteria, and percent exceedence. Statistics for the twenty-two stations are discussed in the following sections for the upper, middle, and lower San Pitch River.

TDS - Upper San Pitch River

STORET sampling locations on the upper San Pitch River, and its tributaries, are listed in Table 4.3. Note that TDS concentrations do not exceed water quality criteria at any of the sampling locations. The upper San Pitch River is not on the 303(d) list.

Table 4.3
Summary of TDS Data Available for the Upper San Pitch River (1995 - 2000)
(mg/L)

STORET #	Station Name	Begin Date	End Date	No. TDS Results	Mean TDS	Min TDS	Max TDS	%TDS Exceed
494675	San Pitch River 2.5 miles west of Mt. Pleasant at U-116 crossing	1/24/95	7/20/00	51	414	284	597	0%
494676	Pleasant Creek at Forest Service Boundary	1/24/95	6/24/97	17	240	202	280	0%
494677	Cottonwood Creek east of Fairview at Forest Service Boundary	1/24/95	6/24/97	17	254	160	328	0%
494678	Oak Creek north of Fairview at Creek 323 crossing	1/24/95	6/24/97	5	258	238	282	0%
494679	San Pitch River at US-89 crossing north of Fairview	1/24/95	6/24/97	18	354	272	470	0%
494689	Fountain Green Fish Hatchery East	1/24/95	7/20/00	36	289	174	341	0%
494690	Fountain Green Fish Hatchery West	1/24/95	7/20/00	25	291	234	330	0%

TDS - Middle San Pitch River

STORET sampling locations on the middle San Pitch River, and its tributaries, are listed in Table 4.4 from upstream to downstream. STORET stations located on tributaries of the middle San Pitch River include:

494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent
494656 Oak Creek at Spring City
494652 Johnson Spring North at Johnson Road crossing
494653 Johnson Spring South at Johnson Road crossing
494657 Ephraim Creek at Forest Service Boundary
494637 Manti Creek at Forest Service Boundary

Note that TDS concentrations do not exceed water quality criteria in surface water tributaries to the San Pitch River. The geology of the tributary watersheds is not expected to significantly contribute to salinity. Also, note that surface water tributaries in this reach do not flow into the San Pitch River as illustrated by the dashed lines on **Map**

1. Water from these tributaries is diverted into irrigation canals and reservoirs within the valley, and does not reach the San Pitch River under most circumstances.

In the middle San Pitch River, TDS concentrations exceed the criteria of 1,200 mg/L at four of the ten STORET stations (Table 4.4). The TDS data are displayed spatially on **Map 6,** along with average flow data for the irrigation and non-irrigation seasons.

Table 4.4
Summary of TDS Data Available for the Middle San Pitch River (1995 - 2000)
(mg/L)

STORET #	Station Name	Begin Date	End Date	No. TDS Results	Mean TDS	Min TDS	Max TDS	%TDS Exceed
494696	San Pitch River above Moroni WWTP	1/24/95	7/20/00	36	545	306	1160	0%
494694	Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent	1/24/95	7/20/00	29	683	75	913	0%
494665	San Pitch River 1 mile west of Chester on U-117	1/24/95	7/20/00	35	569	312	914	0%
494656	Oak Creek at Spring City	1/24/95	6/24/97	15	219	182	274	0%
494652	**Johnson Spring North at Johnson Road crossing**	**1/24/95**	**5/06/97**	**5**	**956**	**442**	**1750**	**20%**
494653	**Johnson Spring South at Johnson Road crossing**	**1/24/95**	**6/24/97**	**12**	**836**	**560**	**1984**	**8%**
494654	**San Pitch River northwest of Manti**	**1/24/95**	**6/24/97**	**15**	**862**	**468**	**1916**	**13%**
494657	Ephraim Creek at Forest Service Boundary	1/24/95	6/24/97	19	261	186	506	0%
494645	**San Pitch River west of Manti above Gunnison Reservoir at Creek crossing**	**1/24/95**	**7/20/00**	**53**	**1035**	**291**	**2353**	**26%**
494637	Manti Creek at Forest Service Boundary	1/24/95	6/24/97	19	345	246	464	0%

Bolded entries exceed TDS water quality criteria

None of the TDS data exceed criteria for STORET stations located on tributaries of the San Pitch River between the headwaters and Gunnison Reservoir (except at Johnson Spring); although these tributaries are included in the Section 303(d) List. This information should be used to update the 303(d) listing for these segments; the San Pitch River tributaries, listed as "San Pitch River - tributaries: from Gunnison Reservoir to U132 crossing" should be deleted from the 303(d) listing.

As indicated above and in Table 4.4 the exception to the tributary TDS concentrations is Johnson Springs (494652 and 494653). These springs rise within the valley floor (not a sub-watershed) and the elevated TDS could result from higher TDS groundwater or shallow subsurface irrigation return flows. However, it should be noted that at each STORET there was only one exceedence in the data set, and the mean flow from the springs is less than 0.8 cfs.

TDS exceeds criteria at two STORET sites located northwest and west of Manti on the San Pitch River (494654 and 494645). At these locations, the mechanism for salinity increase is irrigation on saline soils within the valley, potential contributions from naturally occurring groundwater, and the lack of dilution from surface water inflows.

TDS - Lower San Pitch River

As indicated in Table 4.5, TDS exceeds criteria at one STORET location on the lower San Pitch River (494615 - San Pitch River east of Gunnison). Two major tributaries, Six Mile Creek and Twelve Mile, occur within this reach, but water from these tributaries does not flow into the San Pitch River, but are stored in Gunnison and Nine Mile Reservoirs. The remaining tributaries are diverted to sprinkler irrigation systems. It should also be noted that Six Mile Creek is specifically excluded from the current 303(d) list.

Table 4.5
Summary of TDS Data Available for the Lower San Pitch River (1995 - 2000)
(mg/L)

STORET #	Station Name	Begin Date	End Date	No. TDS Results	Mean TDS	Min TDS	Max TDS	%TDS Exceed
494636	Six Mile Creek above confluence/San Pitch River northwest of Sterling	1/24/95	6/24/97	18	304	218	706	0%
494632	Inlet Canal above Palisades Lake	1/24/95	6/14/00	4	258	236	302	0%
594326	Nine Mile Reservoir Inflow	1/24/95	6/14/00	4	668	586	718	0%
494616	Twelve Mile Creek at U-137 crossing in Mayfield	1/24/95	6/24/97	19	254	202	318	0%
494615	San Pitch River 2 miles east of Gunnison at U-137 crossing	1/24/95	7/20/00	52	1414	214	2550	**54%**

None of the TDS data exceed criteria for STORET stations located on tributaries of the lower San Pitch River; although these tributaries are included in the Section 303(d) List. This information should be used to update the 303(d) listing for these segments; the San Pitch River tributaries, listed as "San Pitch River - tributaries: from confluence with the Sevier River to tailwater of Gunnison Reservoir" should be deleted from the 303(d) listing.

As with the middle San Pitch River, the mechanism for increased TDS in this reach is likely a combination of natural and human causes. STORET 494615 occurs within the groundwater zone (see description in Section 2.6) influenced by Arapien Shale, which contributes to high salinity. Highly mineralized springs occur at the surface within this section of the river and contribute to natural TDS loads. Water from a spring, designated (D-18-2)23adb-S1 that discharges along a fault zone southwest of Manti had a TDS concentration of 1,780 mg/L (Willberg and Heilweil, 1995). In addition, the soils within the contributing area are alkaline as readily observed by the white residue (caliche) visible on the soil surface in this area.

TDS - 2001 Hydrolab Data

In May 2001, Mr. Jim Harris of DWQ collected water quality measurements using a Hydrolab and estimated flows. The Hydrolab recorded measurements of temperature, pH, specific conductivity, salinity, and dissolved oxygen. The locations of these sampling points are shown on **Map 9**, and the Hydrolab water quality results are provided in **Appendix 6**.

TDS concentrations were calculated from the specific conductivity measurements by applying a conversion factor of 0.678. The conversion factor was determined by regression analysis of existing laboratory TDS results and specific conductivity measurements. Summary statistics for the calculated TDS are provided in Table 4.6.

These data provide some additional information on the spatial distribution of TDS concentrations in the watershed. The data were useful in adding to the information base on TDS occurrence and linkages to nonpoint sources; however, since these data are single points in time the information was not further used in the TMDL calculations.

Table 4.6
DWQ 2001 Hydrolab Data Summary Statistics

Statistic	Result
Number of Samples	61
Mean TDS	821 mg/L
Median TDS	472 mg/L
Standard Deviation	1,169 mg/L
Minimum TDS	238 mg/L
Maximum TDS	8,738 mg/L
Number of Criteria (1,200 mg/L) Exceedences	10
Percent Exceedences	16%

4.4.2 Groundwater

Water quality of the Sanpete Valley groundwater has been studied extensively by the Utah Division of Water Resources (1999); Snyder and Lowe (1998); Wilberg and Heilweil (1995); and Robinson (1971). Additional groundwater quality data were collected by the Utah Geological Survey (UGS) from 107 wells during the summer and autumn of 1996 and spring of 1997 to evaluate TDS. The findings of these investigations, as they relate to groundwater TDS, are summarized below.

Agricultural irrigation, especially flood irrigation, can potentially degrade groundwater and surface water quality. A positive correlation between high TDS concentrations in shallow wells and flood irrigated lands has been noted by previous investigators mentioned above.

The concentration of TDS in groundwater varies throughout the valley. In many areas in the central part of the valley, TDS in groundwater is less than 500 mg/L. In the northwestern, central, and southern part of the valley there are TDS concentrations of over 500 mg/L. Water with higher TDS is generally concentrated in two areas of the valley (Wilberg and Heilweil, 1995). One area is downgradient from outcrops of the Green River and Crazy Horse Formations in the east-central part of the valley from Chester to Pigeon Hollow. In this area, groundwater is generally less than 200 feet below the surface. The other area is down gradient from outcrops of evaporite deposits of the Arapien shale on the west side of the valley from Big Mountain southward to the mouths of Axehandle and Rock canyons. Water quality STORET station 494654 is located 2 miles south of this area.

In another groundwater study conducted by the UGS (1988), groundwater samples from 107 wells showed TDS concentrations ranging from 234 to 2,752 mg/L; with an average TDS concentration of 531 mg/L. The groundwater TDS data are listed in **Appendix 7,** and illustrated spatially in **Map 10**. In this study groundwater with TDS concentrations greater than 1,000 mg/L were found in the Moroni area at the south end of the Cedar Hills, along the west side of the bedrock hills south and south-southeast of Chester, north of Sterling between Gunnison and Pallisades Reservoirs, and along the east side of the West Hills south of Mayfield (**Map 10**).

Lowe et al. (2000) studied the distribution of TDS concentrations in groundwater with respect to perforated-interval-depth category and hydrogeologic setting (recharge/discharge area category). Of the 118 wells (the database provided to MSE contained 107 wells) sampled and analyzed for general chemistry, 51 were shallow wells (less than 100 feet deep), 48 were medium-depth wells (100 to 200 feet deep), and 19 were deep wells (greater than 200 feet deep). TDS concentrations in shallow wells range from 234 to 2,490 mg/L and average 602 mg/L, in medium-depth wells range from 244 to 1,068 mg/L and average 468 mg/L, and in deep wells range from 260 to 2,752 mg/L and average 541 mg/L. No significant trends in the spatial distribution of TDS in groundwater could be identified. In general, wells with groundwater containing higher TDS concentrations (>1000 mg//L) are located near Moroni and Chester, and near Sterling and Mayfield (lower San Pitch River). Groundwater with low TDS (<500 mg/L) is present in wells located in and north of Spring City, and mixed with moderate TDS concentrations (500 - 1000 mg/L) in groundwater in the middle San Pitch River valley.

Water from shallow wells in areas where flood irrigation is common typically have high TDS concentrations (Lowe et al. 2000). The source of the dissolved solids was reported to be from naturally occurring shallow groundwater and from irrigation. Richardson (1907) also states that water derived from shallow wells, especially in irrigated areas, typically contains abundant dissolved salts due to return irrigation flows leaching dissolved salts accumulated in soils from evaporation.

Excess irrigation and irrigation return water leach soil in valley lowlands where groundwater is within the zone of capillary action and the accompanying “alkali” salt-rich soil (Richardson, 1907). These dissolved salts in the soil are concentrated by flood irrigation processes as near surface water evaporates into dissolved salts (Pipkin, 1994). Reducing rates of flood irrigation, in some areas, can produce higher concentrations of salts in irrigation return flows as the quantity of salts removed by periodic leaching decreases (National Academy of Sciences, 1978). To leach out these unwanted salts and maintain soil salinity within crop tolerance, the amount of water applied must exceed plant requirements (Feth, 1966).

The type of water and quantity of dissolved solids is also influenced by local geology. Groundwater with high TDS concentrations and high sulfate and chloride concentrations along the west side of Sanpete Valley is likely due to soluble salts in the Jurassic Arapien Shale and gypsum in the Tertiary Green River and Crazy Hollow Formations (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971; and Richardson, 1907).

Groundwater quality is described as fair and of lower quality than in upstream subbasins. More specifically, the water is higher in salinity and is unsuitable for domestic uses. According to the Utah Division of Water Resources (1999) this is due to mineral constituents dissolved from the Arapien shale. One well near Axtell produces water with dissolved solids of 2,270 mg/L. The groundwater quality in the Gunnison area ranges from about 1,300 mg/L on the east side of the valley to 1,535 mg/L on the west side near the Sevier River (Utah Division of Water Resources, 1999). Numerous naturally occurring springs are also located below Gunnison Reservoir. These springs were considered a potential TDS source; however, limited water quality data are available to estimate their loading potential.

Therefore, multiple causes and sources of TDS loading are apparent in the Sanpete Valley that effect the water quality of the San Pitch River.

4.5 Flow Characterization

4.5.1 Surface Water and the San Pitch River

As described in Section 2.5, flows in the San Pitch River are regulated for irrigation, storage, and release. Segments of the river are dewatered to various degrees. Consequently, the best available flow information is collected at the water diversion gages operated by DWRt. Where the river is totally diverted, these diversion gages provide the best estimate of the flow in the river prior to diversion.

Middle San Pitch River

Flow patterns in the middle San Pitch River near Chester (approximately RM 38, see Map 6) are characterized by flows measured at two diversions. The Bagnal Dam and West Point Canal divert water out of the river west of Chester; Bagnal Dam diverts water to the east and West Point Canal to the west. The combined flows, measured at these two stations, represent the flow pattern in the San Pitch River prior to diversion (Figure 1). Water flows in the San Pitch River primarily during the period from March through July, and again for a short period in October and November. No flows were measured at these diversions between December and February, or in July and August. There is no other reliable information on flows to indicate whether water is flowing in the San Pitch River and not being diverted during these dry months.

Flows are also measured at the head of the West Drainage Canal, RM 30. Although this canal is called a diversion, it is the San Pitch River at this location, and for approximately 9 miles downstream. As shown in Figure 2, flows occurred from October to June in water years 1996 and 1997. Figure 2 illustrates the variability in flows due to climatic differences between water years. Water year (WY) 1996 was apparently much drier with little runoff in May and June, in contrast to WY 1997 when high flows were measured in the river. This variability increases the uncertainty in estimating current TDS loads even when there are good flow data.

Flows measured at San Pitch River west of Manti, RM 20, (Figure 3) show the increased influence of both groundwater and surface water inflows. Flows during the base flow period between July and September are likely due to return irrigation and groundwater flows that are high in salinity as indicated in the groundwater quality discussion (Section 4.4.2). The increased flows in May and June are attributed to uncontrolled flood return flows that will be highly variable from year to year as indicated in the graph between WY 1996 and 1997.

Figure 1: Flows in the Middle San Pitch River - River Mile 38
"Bagnal Canal" & "West Point Canal" Combined

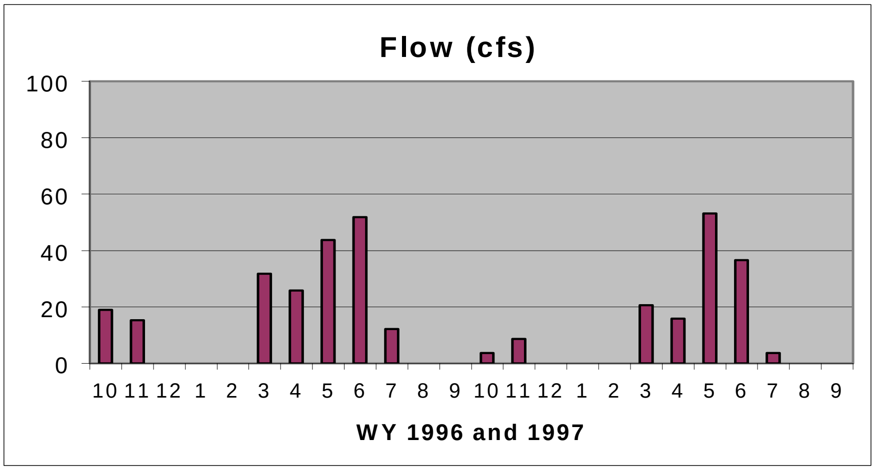


Figure 2: Flows in the Middle San Pitch River - River Mile 30
"West Drainage Canal" (The San Pitch River)

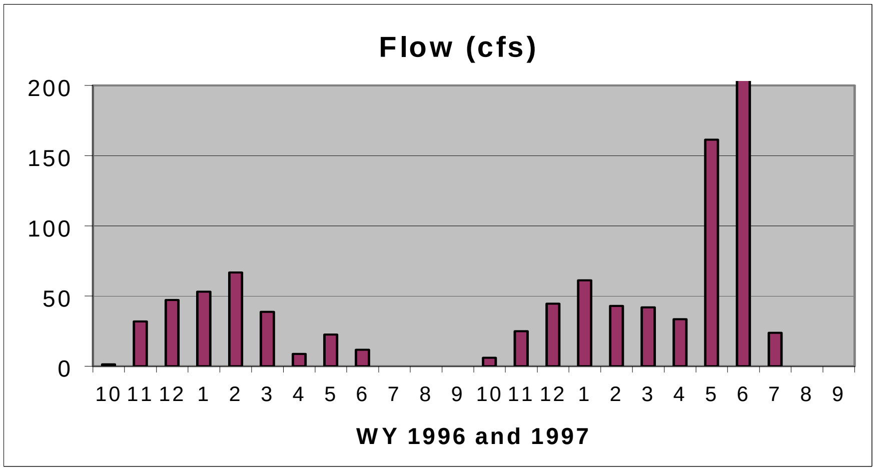
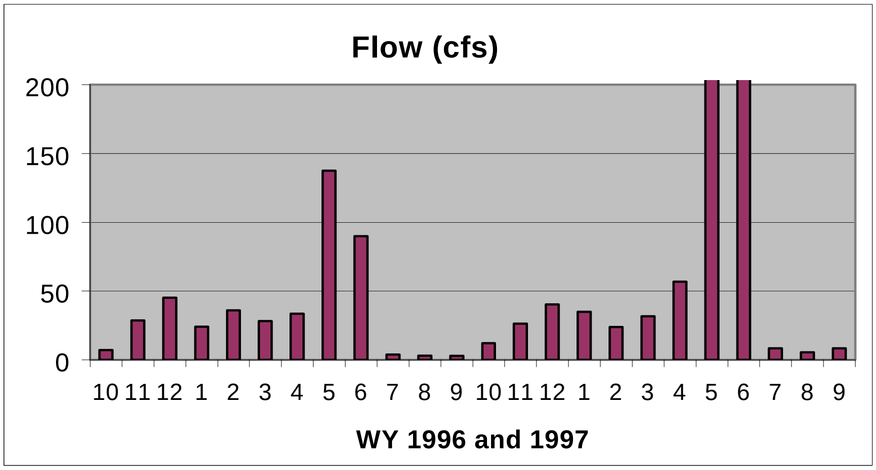


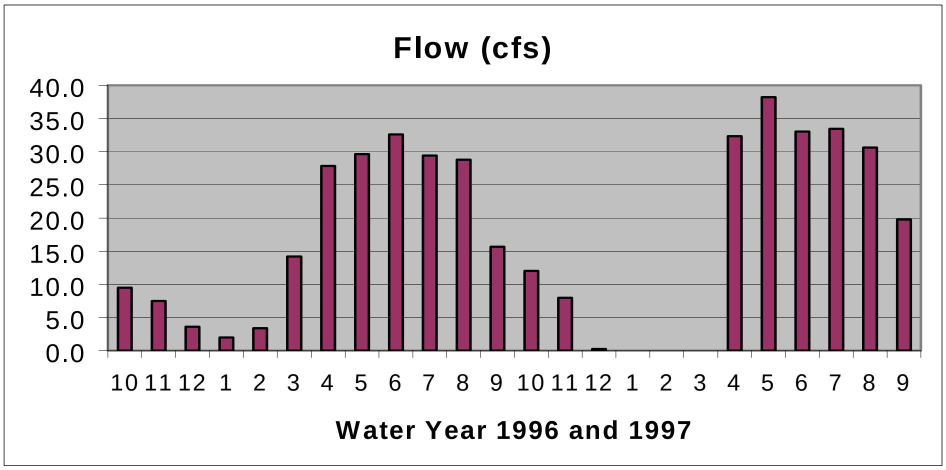
Figure 3: Flows in the Middle San Pitch River - River Mile 20
"San Pitch River West of Manti"



Lower San Pitch River

Flow patterns for the lower San Pitch River are indicated by flow measured at the Old Field Canal, RM 3, considered a total diversion. Flows are less variable in the lower San Pitch, because flows are controlled by releases from Gunnison Reservoir. Between October and February the flows in the lower San Pitch River are zero to minimal, and then are regulated by releases from the reservoir from March to September for irrigation (see Figure 4).

Figure 4: Flows in the Lower San Pitch River - River Mile 3
Old Field Canal: San Pitch near Gunnison



4.6 Pollutant Sources and Linkages

4.6.1 Point Sources

There are three active point source permits in the San Pitch River Watershed (State of Utah NPDES Permitting Section). The locations of these permitted point sources are shown on **Map 8**.

Active Permits:

- UT0020222 – Moroni Feed/Wastewater. This permit replaced the former Moroni City Corporation permit that was identified as UTD00085217.
- UTG130004 – Fountain Green Fish Hatchery. Under this current general permit, the Fountain Green Fish Hatchery may discharge to the irrigation canal system that flows to Silver Creek, a tributary of the San Pitch River. This permit replaced the former Utah Division of Wildlife individual permit UT0022144.
- UT0025216 – Spring City Corp Waste Water Treatment Plant

The Moroni Feed/Wastewater Treatment Plant is the only point source that occurs in a 303(d) designated stream segment. This treatment plant is evaluated as a point source in the middle San Pitch River segment. The treatment plant processes domestic wastewater for the City of Moroni and wastewater from the Moroni turkey processing plant. In the remainder of the document this point source is referred to as the “Moroni WWTP”. Water samples tested for TDS from the Fountain Green Fish Hatchery outflow

(226 TDS measurement since 1978) show a maximum TDS concentration of 564 mg/L with an average of 287 mg/L TDS. Therefore, this point source of TDS is not considered significant. The Spring City Corp Waste Water Treatment Plant does not discharge water.

4.6.2 Nonpoint Sources

Nonpoint sources of pollution include sources that reach a waterbody by way of surface runoff or subsurface flow to groundwater. Nonpoint sources in the San Pitch River Watershed are both natural and human-caused. Natural sources are often referred to as “background” sources and include naturally occurring salts in local soils, geology, and springs. Human-caused nonpoint sources of pollution in the San Pitch watershed include irrigated and non-irrigated lands used for grazing and crop production.

In a hydrology study of the Sanpete Valley, Wilberg and Heilweil (1995) state that the cause of the high concentrations of TDS in the San Pitch River near Manti could result from shallow groundwater that discharges into this reach of the river (see Sections 2.3 and 2.6 for a discussion of geology and groundwater). Groundwater in this local flow system is recharged along outcrops of Arapien Shale in the nearby San Pitch Mountains, flows eastward, and discharges to the San Pitch River. This groundwater recharge is a natural source of TDS to the San Pitch River.

In the middle San Pitch River farmers must rely on a seasonal water supply from the San Pitch River, springs and wells, and flood irrigation practices are used. Flood irrigation is identified because this irrigation method contributes to salt loading by shallow and deep percolation to groundwater, and leaching of salts into the water that runs off. Therefore, the potential for TDS loading from these flood irrigated tracts was considered. Approximately 15,000 acres of land are flood irrigated along the middle San Pitch River. Flood irrigation along the middle San Pitch River is controlled and uncontrolled. **Map 11** shows the areas irrigated by uncontrolled flood, controlled flood and sprinkler methods along the middle San Pitch River.

Controlled and uncontrolled flood irrigation in the middle San Pitch River watershed contributes to TDS loading to the river. Poor efficiency irrigation systems contribute to salt loading by shallow and deep percolation to groundwater, and leaching of salts into the water that runs off. This leaching of salts also contributes to soil health concerns, creating soils with high salt concentrations. Excess irrigation and irrigation return flows leach salt from soils in valley lowlands where groundwater is within the zone of capillary action and the accompanying “alkali” salt-rich soil (Richardson, 1907). These dissolved salts in the soil are concentrated by flood irrigation processes as near surface water evaporates into dissolved salts (Pipkin, 1994). This process is compounded with the presence of high saline soils in and adjacent to the middle San Pitch River.

Another potential source of TDS loading to the middle San Pitch River is the land application of animal manure. Turkey and cow manure is applied to lowlands of the middle San Pitch River watershed. Application rates for turkey manure and beef/dairy cow manure were provided by the Natural Resources Conservation Service (NRCS) in Manti, Utah (Table 4.7). A total of 396,980 tons of manure (381 tons salt) are land-applied annually. Table 4.7 also shows the manure application rates on lands that are irrigated by uncontrolled flood and controlled flood/sprinkler methods.

Table 4.7
Animal Manure Land Application Rates

	Irrigation Type	Annual Application Rate (Tons)	Annual Salt Load (Lbs)	Annual Salt Load (Tons)
Turkey Manure[1]	Uncontrolled Flood	7,500	37,500	18.8
	Controlled Flood/Sprinkler	40,000	200,000	100.0
Beef / Dairy Cow Manure (all ages)[2]	Uncontrolled Flood	92,900	139,350	69.7
	Controlled Flood/Sprinkler	256,580	384,870	192.4
Total Manure Applied by Land Irrigation Type	Uncontrolled Flood	100,400	176,850	89
	Controlled Flood/Sprinkler	296,580	584,870	292
TOTAL		**396,980**	**761,720**	**381**

1. 5 Lbs salt per ton manure
2. 1.5 Lbs salt per ton manure

(Lbs Salt/Per Ton from Dr. Frame USU, Beef-Dairy estimated from manure test taken in Sanpete)

Salts from manure could be transported to the San Pitch River by several transport mechanisms: erosion, overland surface water flow, and percolation to groundwater.

Salt loading to the San Pitch River by erosion is not expected to be a significant because manure is applied on lowlands of the middle San Pete Valley where slopes are gentle and soil loss is low. Overland surface water flow could be a significant transport mechanism for salt in manure in areas where uncontrolled flood irrigation is used. Percolation of surface water and leaching of manure salts to groundwater can transport salts to the San Pitch River via subsurface flow.

To evaluate the potential significance of this salt load to the San Pitch River, it can be assumed that 100% of the annual manure salt load is delivered to the river. Using this highly conservative assumption, and the existing TDS load in the San Pitch River (see Table 4.14), the potential manure salt contribution is 1% of the total load. Similarly, the salt contribution from manure applied to uncontrolled flood areas (89 tons salt) is 0.3% of the total load.

Therefore, salt (TDS) loading to the San Pitch River from land application of animal manure is not considered a significant source. However, the potential nutrient loading to the San Pitch River from this source should be evaluated.

4.7 Load Calculations

4.7.1 TMDL Equations and Terminology

As described in the introduction, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. The calculation of a TMDL is described by the following relationships and associated terminology.

TMDL = WLA + LA + MOS = Target Load

TMDL - Total Maximum Daily Load.

WLA - Waste Load Allocation for point sources.

LA - Load Allocation for nonpoint sources (includes background/natural sources).
LA = Target Load - MOS (if no WLA).

MOS - Margin of Safety.

Target Load - The maximum pollutant load for the waterbody, set at the water quality criteria (Target Load is also referred to as load capacity).

Current Load - Pollutant load based on measured flows and TDS concentrations.

Load Reduction - Current Load minus Load Allocation.
Load Reduction = Current Load - LA (if no WLA).

Percent Reduction - Load Reduction divided by Current Load, expressed as percent.
Percent Reduction = Load Reduction / Current Load *100.

TMDL Measurement Point - A water quality monitoring station located at the bottom of the listed reach.

The Target Load is estimated by calculating the load based on the water quality criteria. The target TDS concentration of 1,200 mg/L is multiplied by representative flows at the measurement point for the critical period. The critical period is discussed below in Section 4.7.2. The Margin of Safety (MOS) is calculated expressly as 5% of the Target Load. The Load Allocation (LA) is calculated by subtracting the MOS from the Target Load.

4.7.2 Approach and Assumptions

The selection of measurement point, method of calculating the current load and target load, and method of load allocation are tailored to the unique characteristics of this watershed.

Water is almost entirely diverted prior to flowing in the San Pitch River for cropland irrigation, livestock water, and domestic water. Surface water tributaries no longer flow directly into the San Pitch River, but are diverted into reservoirs or irrigation systems. Surface water is diverted out of the San Pitch River at many locations. The result is that tributary subbasins and segments of the San Pitch River are disconnected. A standard approach of summing tributary or segment inputs, therefore, does not apply in estimating the source loads for the San Pitch River.

A water sample taken from the middle and lower San Pitch River most often characterizes groundwater or irrigation return flows surfacing at that point rather than a surface water source. The primary mechanism for human-caused increases in salinity of surface water and groundwater is associated with irrigation of the highly saline soils in the valley. Naturally high groundwater salinity occurs when the water comes in contact with sedimentary deposits such as limestones (calcium carbonate) and evaporites (salt, sodium chloride), which readily dissolve in water. Limestone bearing rocks such as the Green River and Crazy Horse Formations, and evaporites such as contained in the Arapien Shale are present in Sanpete Valley (see Section 2.6). There is no ready mechanism for distinguishing the contribution from human-caused versus natural sources of salinity for water samples collected from the middle and lower San Pitch River.

Load Calculation Alternatives

Various alternatives for calculating load were reviewed in cooperation with the DWQ Project Manager. Three alternatives, listed as A, B and C below, and a final selected alternative (D) were evaluated for calculating current loading for this TMDL. Each of these approaches is limited by the existing TDS data set available for use. The preferred alternative (D) for calculating TDS loads, best represents ambient TDS loading that occurs during representative water years, and also demonstrates the year-to-year variability inherent with climate-dependent data. Alternative D was approved by the DWQ Project Manager to calculate loads for the San Pitch River TDS data set.

A. Annual TDS Load, Monthly Averages

The six-year period of record, Calendar Year 1995-2000, was used. Monthly averages for both flow and TDS concentrations across the six years were calculated. The advantage of this method is that is smoothes the annual variability to provide one "current load" estimate, and applies measurements from similar periods to periods without TDS measurements. However, an inspection of the calculations shows that the method of averaging TDS eliminates many of the TDS concentrations that exceed criteria (averaging dropped the resulting value to below 1,200 mg/L TDS, eliminating the TDS exceedence for most months). The analysts felt that this method underrepresented the actual TDS loading.

B. Seasonal TDS Load, Monthly Averages

Instead of calculating annual loads directly, an intermediate step of calculating loads by seasons for each of the six years was completed. It was thought that the increased analysis interval would increase the accuracy of the estimate. An inspection of the results, however, shows that there were too many missing season-year combinations or an entire season was represented by a single sample even when flows varied dramatically.

C. Correlation between TDS and Flow

Because TDS varies with flow, use of a regression equation for filling in missing TDS values was evaluated. TDS concentration was plotted against flow and the regression equation calculated at one data rich station. This analysis showed considerable scatter across flow values, and the regression coefficient did not support using flow to predict TDS in this situation.

D. Selected Alternative: Daily Loads for Water Year 1996 & Water Year 1997

DWQ conducted an intensive water quality survey during 1996 and 1997. This period has a greater frequency of TDS measurements than other periods, and so provides an opportunity to estimate loading more accurately than the other alternatives discussed. Because pollutant load is comprised of two major factors, flow and TDS, measuring one factor with improved accuracy increases the overall accuracy of the estimate. Flow is reported on a daily basis at the DWRt stream gages for irrigation diversions, and therefore provides an opportunity to calculate loading on a daily basis. Flows from representative gages (measuring channel diversions) were used to assemble a daily flow measurement for the two water years. The TDS data, in comparison to the flow data, is available only when it was measured at a STORET station, which is at longer time intervals - approximately from 30 to 60 days (or more) depending on the specific station. To build the daily record for TDS, a single TDS data point was assumed to be representative of the TDS for that month. For example, if a TDS sample was collected on June 15, the TDS value is assumed to be representative of the period from June 01 to June 30. The TDS load was then calculated from the paired values - the actual daily flow reported at the DWRt stream gage and the representative daily TDS value. These daily loads can then be summed by month, season, or water year to estimate the TDS load for that time period.

For the selected alternative (D) the following method was used to apply TDS values across time periods.

1) Where a TDS value occurred during the month, it was applied to all days during the month.
2) When two values occurred during the month, the value occurring in the first two weeks was applied to the first half of the month; the value occurring in the second two weeks was applied to the second half of the month.
3) When data are missing for a one month period, the value was interpolated from the two bracketing sample dates.
4) When data were missing for a quarter of the water year, the TDS concentration was not estimated. This is indicated in the loading tables (Section 4.7.3) by the notation "No TDS Data".

<u>Selection of STORET Stations</u>

The TDS load was calculated at individual STORET stations to evaluate TDS sources or logical river segment breaks. The STORET stations chosen for load calculation were selected strategically based on the availability of TDS data, percent TDS exceedence from 1995 to 2000, and potential point and/or nonpoint sources.

As discussed above in Section 4.4 (TDS - Upper San Pitch River), none of the TDS concentrations measured at upper San Pitch River STORETs stations (Table 4.3) exceed the water quality standard. The range of TDS measured at the upper San Pitch River STORET stations is 280 mg/L to 597 mg/L. Furthermore, the upper San Pitch River is not listed on the 303(d) list as impaired for TDS. Therefore, no load calculations were made for the upper San Pitch River.

For the middle San Pitch River, TDS loads were calculated for the following four STORET stations:

494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent
494665 San Pitch River 1 mile west of Chester on U-117
494654 San Pitch River northwest of Manti
494645 San Pitch River west of Manti above Gunnison Reservoir at Creek crossing

The Moroni WWTP is the only known point source in the watershed. Current TDS loading was calculated for station 494694 "Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent", even though TDS has not exceeded water quality criteria, and the range of TDS concentrations is 75 mg/L to 913 mg/L (see Table 4.4). The load allocation was calculated by multiplying the design capacity of the facility (1.1 million gallons per day) by the water quality standard of 1,200 mg/L for TDS and a conversion factor of 8.34 to derive a value of 11,000 lbs/day (5.5 tons/day).

Station 494665 "San Pitch River 1 mile west of Chester on U-117" provides an upper bound for the middle San Pitch River; TDS does not exceed criteria at this station.

Station 494654 "San Pitch River northwest of Manti" represents the middle reach of the San Pitch River, and is the terminus of the channelized river section, which is the West Drainage Canal.

Station 494645 "San Pitch River west of Manti above Gunnison Reservoir at Creek crossing" is the last STORET on the middle San Pitch River, and is the TMDL measuring point.

TDS loads were not calculated at Johnson Spring STORETS (494652 and 494653) because only one measurement was above the TDS water quality criteria and the flows are very low (0.2 to 0.8 cfs).

The lower San Pitch River has its origin at the outlet of Gunnison Reservoir, but little water flows down the original San Pitch River channel at this point; flows from Gunnison Reservoir are diverted into canals. There are five STORETS stations in the lower San Pitch River basin. Four of these STORETS are located on tributaries to the lower San Pitch River. From 1995 to 2000, TDS did not exceed water quality criteria at any of these stations and the range of TDS concentrations is 202 mg/L to 718 mg/L for all stations (see Table 4.5). Therefore, on the lower San Pitch River, TDS loads are calculated at STORET station 494615 "San Pitch River two miles east of Gunnison at U-137 crossing". This is the TMDL measurement point for the lower San Pitch River.

To calculate TDS loads, a concentration and flow rate are required. The best available flow information is collected at the water diversion gages operated by DWR (see Section 4.5). Where the river is totally diverted, these diversion gages provide the best estimate of the flow in the river prior to diversion. The DWRt gages that best estimate flows in the river were matched with the nearest DWQ STORET water quality monitoring locations to calculate TDS loads. These concentration and flow data pairs are summarized in Table 4.8 for the middle and lower San Pitch River TMDL loading calculations.

Table 4.8
Selected STORETs and Flow Stations for TMDL Calculation

STORET	Flow Station	Remarks
Middle San Pitch River 494694 - Moroni WWTP & Turkey Plant (Moroni Feed Co.) Combined Effluent	Same	No Data for WY 1996 Data used for 1997
494665 - San Pitch River 1 mile west of Chester on U-117	Bagnal Canal plus West Point Canal Diversions	Bagnal and West Point are described as total diversions.
494654 - San Pitch River northwest of Manti	West Drainage Canal	West Drainage Canal is the San Pitch River channel at this location
494645 - San Pitch River west of Manti above Gunnison Reservoir at Creek crossing	San Pitch River West of Manti	Good data pair. This diversion gage is located on the San Pitch River
Lower San Pitch River 494615 - San Pitch River 2 miles east of Gunnison at U-137 crossing	Old Field Canal Diversion	Assumes entire flow is diverted into the canal during irrigation season.

<u>TMDL Measurement Points</u>

Two hydrologically distinct segments are identified for the 303(d) listed reach of the San Pitch River: the middle San Pitch River, from U132 to Gunnison Reservoir, and the lower San Pitch River from Gunnison Reservoir to the confluence with the Sevier River. It should be noted, however, that the San Pitch River does not generally flow into the Sevier River. During the non-irrigation season water is stored in Gunnison Reservoir, and during the irrigation season water is diverted entirely into the Old Field Canal; therefore, water flow of any magnitude occurs very infrequently in the San Pitch River. The measurement points at the bottom of the middle and lower San Pitch River are identified by a combination of the DWQ water quality stations and DWR gage stations that most closely measure water flow and quality at the end of each reach. Specifically, the TMDL measurement points are:

1. **Middle San Pitch River**
   STORET Number 494645
   San Pitch River West of Manti above Gunnison Reservoir at creek crossing.
2. **Lower San Pitch River**
   STORET Number 494615
   San Pitch River 2 miles East of Gunnison at U-132 crossing.

<u>Critical Period</u>

The critical period for TDS contribution and effects on the beneficial use (agricultural use) is the irrigation season. Water for irrigation and stock water is the beneficial use of concern, which is potentially impacted by increased salinity. For the purposes of comparing year-to-year loads, the irrigation season is standardized to the time period March 01 to September 30.

Water quantity in the San Pitch River is managed for irrigation use. Water is stored in reservoirs where feasible during the non-irrigation season, and released during the irrigation season depending on water rights appropriation. As a result very little water flows down the San Pitch River channel during the non-irrigation season as described in the section on Flow Characterization (Section 4.5). As a result, the current load measured during the non-irrigation season is fairly minimal. The estimated seasonal loads (irrigation versus non-irrigation season) are discussed below.

Current and Target Loads are calculated for the middle and lower San Pitch River (Sections 4.7.3 and 4.7.4, respectively) for the two water years, WY 1996 and WY 1997. The water year encompasses a period of time that corresponds with the annual hydrologic cycle (e.g., WY 1996 is the period from October 01, 1995 through September 30, 1996).

The stations of primary interest in calculating the TMDL for the San Pitch River are the two STORET measurement points: 494645 for the middle San Pitch River, and 494615 for the lower San Pitch River. TDS loading occurs during the irrigation season at both locations. TDS concentrations also exceed criteria in the lower San Pitch River during the non-irrigation season, but most TDS loading occurs during the irrigation season.

Water Quality Target

The Utah Water Quality Standards provide an explicit numeric criterion for TDS in Class 4 waters. The TDS concentration of 1,200 mg/L established in the state standards is used as the water quality target for this TMDL.

4.7.3 Middle San Pitch River

Point Source Load (Waste Load Allocation)

The Moroni WWTP is the only known point source in the middle watershed. TDS loading was calculated for station 494694 "Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent". The 1997 TDS load was 480 tons (see Table 4.10). No TDS data are available in 1996 for the Moroni WWTP. In 1997, TDS does not exceed the water quality criteria. The range of TDS concentrations in 1997 was 75 mg/L to 913 mg/L.

Therefore the WWTP is not contributing TDS to the San Pitch River above the water quality standard. Furthermore, water is diverted out of the San Pitch River several times between station 494694 and the downstream river STORET stations. Based on the available TDS data, the WWTP has little or no opportunity to contribute TDS directly to downstream segments of the San Pitch River. However, since the WWTP discharges into a listed segment of the San Pitch River they will be allocated a load limit of 1,177 tons during the critical season (March 1 – September 30), or 2,009 tons per year which is equivalent to the WWTP's design capacity of 1.1 million gallons per day multiplied by the 1,200 mg/L water quality standard.

Nonpoint Source and Background Load (Load Allocation)

Current TDS loads for the selected water quality stations within the middle San Pitch River watershed are shown in Table 4.9 and Table 4.10 for water years 1996 and 1997.

These tables show the sum of TDS loading for the non-irrigation, irrigation, and annual periods by month.

Table 4.9
Current TDS Load - Middle San Pitch River - Water Year 1996
(tons)

Month	494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) Combined Effluent	494665 San Pitch River 1 mile west of Chester on U-117	494654 San Pitch River northwest of Manti	494645 San Pitch River west of Manti above Gunnison Reservoir at Creek crossing
Oct - 95	No TDS Data	1,105	No TDS Data	701
Nov - 95	No TDS Data	773	No TDS Data	2,085
Dec - 95	No TDS Data	No Flow	No TDS Data	2,383
Jan - 96	No TDS Data	No Flow	No TDS Data	1,438
Feb - 96	No TDS Data	No Flow	No TDS Data	2,223
Mar - 96	No TDS Data	1,640	No TDS Data	**3,317**
Apr - 96	No TDS Data	1,707	**961**	**4,497**
May - 96	No TDS Data	1,275	1,102	**12,694**
Jun - 96	No TDS Data	3,438	872	7,194
Jul - 96	No TDS Data	787	No Flow	335
Aug - 96	No TDS Data	No Flow	No Flow	**338**
Sep - 96	No TDS Data	No Flow	No Flow	**249**
Non-Irrigation		3,518	0	12,147 (32%)
Irrigation		7,206	2,934	25,307 (68%)
Annual		10,724	2,934	37,453

"No TDS Data" indicates that no representative TDS sample result is available for the month.
Numbers underlined indicates that a sample during the month exceeded water quality criteria.

Station 494665 "San Pitch River 1 mile west of Chester on U-117" had no TDS results that exceeded the TDS water quality criteria. The TDS results from this station illustrate that surface water from the upper watershed contributes minimal TDS to the Middle San Pitch River. The annual TDS load measured in 1996 was 10,724 tons (Table 4.9) and in 1997 the TDS load was 5,460 tons (Table 4.10). Because these loads are based on TDS concentrations that do not exceed water quality standards, these loads are considered representative of natural background conditions. Station 494665 therefore, provides an upper bound for TDS exceedence of the middle San Pitch River.

The station "San Pitch River northwest of Manti" (494654) had only 1 out of 17 sample results above water quality criteria. This occurred in April 1996, but as can be observed in Table 4.9, there were only three months (April – June) during WY 1996 when a load could be calculated. In the following water year, 10 samples were collected and none exceeded the TDS water quality criteria (Table 4.10).

TDS loads could be calculated for all months of water years 1996 and 1997 at the TMDL measuring point, 494645 "San Pitch River west of Manti above Gunnison Reservoir at Creek crossing". This is the last STORET station on the middle San Pitch River and exceeded water quality criteria during five months of 1996 and two months of 1997 (see Table 4.9 and Table 4.10, respectively). It should be noted that all exceedences of water quality criteria occur during the irrigation season (March - September).

Table 4.10
Current TDS Load - Middle San Pitch River - Water Year 1997
(tons)

Month	494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) Combined Effluent	494665 San Pitch River 1 mile west of Chester on U-117	494654 San Pitch River northwest of Manti	494645 San Pitch River west of Manti above Gunnison Reservoir at Creek crossing
Oct - 96	56.3	163	346	823
Nov - 96	54.6	348	1,325	1,546
Dec - 96	27.8	No Flow	2,288	2,153
Jan - 97	3.6	No Flow	3,585	2,168
Feb - 97	5.2	No Flow	2,098	1,397
Mar - 97	14.9	996	2,378	1,959
Apr - 97	29.1	535	2,025	4,521
May - 97	32.9	1,595	7,158	14,916
Jun - 97	57.9	1,678	12,532	18,269
Jul - 97	72.4	145	No TDS Data	**965**
Aug - 97	60.1	No Flow	No TDS Data	**680**
Sep - 97	65.1	No Flow	No TDS Data	726
Non-Irrigation	162	1,507	12,019	10,046 (20%)
Irrigation	318	3,953	21,715	40,076 (80%)
Annual	480	5,460	33,734	50,122

"No TDS Data" indicates that no representative TDS sample result is available for the month.
Numbers underlined indicates that a sample during the month exceeded water quality criteria.

Load contribution during the irrigation season for STORET station 494645 "San Pitch River west of Manti above Gunnison Reservoir at Creek crossing" was 67% (1996) and 80% (1997) of the annual load.

Target Load

As discussed above, the Target Load is estimated by calculating the load based on the water quality criteria. The TDS water quality criteria, or target TDS concentration (1,200 mg/L) is multiplied by the representative flows at the TDS measurement point. Table 4.11 and Table 4.12 summarize the Target TDS Load for the middle San Pitch River during the 1996 and 1997 water years, respectively.

Table 4.11
Target TDS Load - Middle San Pitch River - Water Year 1996
(tons)

Month	494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) Combined Effluent	494665 San Pitch River 1 mile west of Chester on U-117	494654 San Pitch River northwest of Manti	494645 San Pitch River west of Manti above Gunnison Reservoir at Creek crossing
Oct - 95	No TDS Data	None Exceed	No TDS Data	701
Nov - 95	No TDS Data	None Exceed	No TDS Data	2,085
Dec - 95	No TDS Data	None Exceed	No TDS Data	2,383
Jan - 96	No TDS Data	None Exceed	No TDS Data	1,438
Feb - 96	No TDS Data	None Exceed	No TDS Data	2,223
Mar - 96	No TDS Data	None Exceed	No TDS Data	2,835
Apr - 96	No TDS Data	None Exceed	804	3,250
May - 96	No TDS Data	None Exceed	1102	10,009
Jun - 96	No TDS Data	None Exceed	872	7,194
Jul - 96	No TDS Data	None Exceed	No Flow	335
Aug - 96	No TDS Data	None Exceed	No Flow	306
Sep - 96	No TDS Data	None Exceed	No Flow	248
Non-Irrigation		0	0	11,665
Irrigation		0	2,777	21,341
Annual		0	2,777	33,006

"No TDS Data" indicates that no representative TDS sample result is available for the month.

"None Exceed" indicates that a target load is not calculated for the year because no samples exceeded water quality criteria for TDS.

Table 4.12
Target TDS Load - Middle San Pitch River - Water Year 1997
(tons)

Month	494694 Moroni WWTP & Turkey Plant (Moroni Feed Co.) Combined Effluent	494665 San Pitch River 1 mile west of Chester on U-117	494654 San Pitch River northwest of Manti	494645 San Pitch River west of Manti above Gunnison Reservoir at Creek crossing
Oct - 96	None Exceed	None Exceed	None Exceed	823
Nov - 96	None Exceed	None Exceed	None Exceed	1,546
Dec - 96	None Exceed	None Exceed	None Exceed	2,153
Jan - 97	None Exceed	None Exceed	None Exceed	2,168
Feb - 97	None Exceed	None Exceed	None Exceed	1,397
Mar - 97	None Exceed	None Exceed	None Exceed	1,959
Apr - 97	None Exceed	None Exceed	None Exceed	4,521
May - 97	None Exceed	None Exceed	None Exceed	14,916
Jun - 97	None Exceed	None Exceed	None Exceed	18,269
Jul - 97	None Exceed	None Exceed	None Exceed	849
Aug - 97	None Exceed	None Exceed	None Exceed	548
Sep - 97	None Exceed	None Exceed	None Exceed	726
Non-Irrigation	0	0	0	10,046
Irrigation	0	0	0	39,828
Annual	0	0	0	49,874

"None Exceed" indicates that a target load is not calculated for the year because no samples exceeded water quality criteria for TDS.

Current Load for the middle San Pitch River TMDL measuring point station for Water Year 1996 and 1997 is shown in Table 4.13. Underlined current load values indicate the TDS concentration exceeded the water quality criteria.

Table 4.13
TMDL TDS Load - Middle San Pitch River
San Pitch River West of Manti - 494645

Month	**1996**		**1997**	
	Current Load (tons)	**Target Load (tons)**	**Current Load (tons)**	**Target Load (tons)**
Mar	**3,317**	2,835	1,959	1,959
Apr	**4,497**	3,250	4,521	4,521
May	**12,694**	10,009	14,916	14,916
Jun	7,194	7,194	18,269	18,269
Jul	335	335	**965**	849
Aug	**338**	306	**680**	548
Sep	**249**	248	726	726
Period Load	28,624	24,176	42,035	41,787
TMDL Calculations				
MOS		1,209		2,089
Load Allocation		22,967		39,697
Load Reduction		5,657		2,338
% Reduction		19.8		5.6

Numbers underlined indicates that a sample during the month exceeded water quality criteria.

TMDL Load

Load calculations for the middle San Pitch River show high variability in loading for the two water years. TDS concentrations were lower and flows higher in WY 1997; resulting in a much lower current TDS load. Averaging the two water years provides the following values for the TMDL (

Table 4.14).

Table 4.14
TMDL Loading Estimate - Middle San Pitch
TMDL Estimate Based on Irrigation Season (tons)

Existing Load	35,329
Target Load	32,981
Waste Load Allocation	1,177
Load Allocation	30,155
Margin of Safety	1,649
Load Reduction	5,174
% Reduction	15

4.7.4 Lower San Pitch River

Point Source Load (Waste Load Allocation)

No point sources are identified for the lower San Pitch River.

Nonpoint Source and Background Load (Load Allocation)

Current TDS loads for the selected water quality stations within the lower San Pitch River watershed are shown in Table 4.15 and Table 4.16 for water years 1996 and 1997. These tables show the sum of TDS loading for the non-irrigation, irrigation, and annual periods by month.

Table 4.15
Current TDS Load - Lower San Pitch River - Water Year 1996
(tons)

Month	494615 San Pitch River 2 miles east of Gunnison at U-137 crossing
Oct - 95	**2,007**
Nov - 95	**1,471**
Dec - 95	**698**
Jan - 96	**272**
Feb - 96	248
Mar - 96	1,254
Apr - 96	**2,568**
May - 96	**3,292**
Jun - 96	**2,605**
Jul - 96	**4,240**
Aug - 96	**4,494**
Sep - 96	**3,122**
Non-Irrigation	5,950 (23%)
Irrigation	20,321 (77%)
Annual	26,271

Numbers underlined indicates that a sample during the month exceeded water quality criteria.

TDS loads could be calculated for all month during the 1996 water year. The station "San Pitch River 2 miles east of Gunnison at U-137 crossing" (494615) had 12 out of 25 sample results above water quality criteria for the 1996 - 1997 water year. TDS loads could not be calculated for all months of water year 1997 because of no flow at the Old Field Canal Diversion.

Load contribution during the irrigation season for STORET station 494615 "San Pitch River 2 miles east of Gunnison" was 77% (1996) and 81% (1997) of the annual load.

Table 4.16
Current TDS Load - Lower San Pitch River - Water Year 1997
(tons)

Month	494615 San Pitch River 2 miles east of Gunnison at U-137 crossing
Oct - 96	**2,351**
Nov - 96	**1,513**
Dec - 96	**51**
Jan - 97	No Flow
Feb - 97	No Flow
Mar - 97	No Flow
Apr - 97	**2,963**
May - 97	**2,155**
Jun - 97	1,837
Jul - 97	2,623
Aug - 97	**4,187**
Sep - 97	**3,055**
Non-Irrigation	3,914 (19%)
Irrigation	16,819 (81%)
Annual	20,733

Numbers underlined indicates that a sample during the month exceeded water quality criteria.

Target Load

The Target Load for the lower San Pitch River was calculated using the same methodology for the middle San Pitch River. Table 4.17 and

Table 4.18 summarize the Target TDS Load for the lower San Pitch River during the 1996 and 1997 water years, respectively.

Table 4.17
Target TDS Load - Lower San Pitch River - Water Year 1996
(tons)

Month	494615 - San Pitch River 2 miles east of Gunnison at U-137 crossing
Oct - 95	954
Nov - 95	729
Dec - 95	362
Jan - 96	201
Feb - 96	248
Mar - 96	1,254
Apr - 96	2,403
May - 96	2,972
Jun - 96	2,583
Jul - 96	2,955
Aug - 96	2,890
Sep - 96	1,523
Non-Irrigation	3,747
Irrigation	15,326
Annual	19,073

Table 4.18
Target TDS Load - Lower San Pitch River - Water Year 1997
(tons)

Month	494615 - San Pitch River 2 miles east of Gunnison at U-137 crossing
Oct - 96	1,209
Nov - 96	774
Dec - 96	26
Jan - 97	No Flow
Feb - 97	No Flow
Mar - 97	No Flow
Apr - 97	2,960
May - 97	2,153
Jun - 97	1,837
Jul - 97	2,623
Aug - 97	3,075
Sep - 97	1,921
Non-Irrigation	2,009
Irrigation	14,569
Annual	16,578

Current Load for the lower San Pitch River TMDL measuring point station for water year 1996 and 1997 is shown in

Table 4.19.

Table 4.19
TMDL TDS Load - Lower San Pitch River
San Pitch River East of Gunnison - 494615

Month	1996		1997	
	Current Load (tons)	Target Load (tons)	Current Load (tons)	Target Load (tons)
Mar	1,254	1,254	No Flow	No Flow
Apr	**2,568**	2,403	**2,963**	2,960
May	**3,292**	2,972	**2,155**	2,153
Jun	**2,605**	2,583	1,837	1,837
Jul	**4,240**	2,955	2,623	2,623
Aug	**4,494**	2,890	**4,187**	3,075
Sep	**3,122**	1,523	**3,055**	1,921
Period Load	21,575	16,580	16,819	14,569
TMDL Calculations				
MOS		829		728
Load Allocation		15,751		13,840
Load Reduction		5,824		2,978
% Reduction		27.0		17.7

Numbers underlined indicates that a sample during the month exceeded water quality criteria.

TMDL Load

An evaluation of the geology, soils, hydrology, and irrigation system provides strong evidence that the high TDS concentrations are due to natural sources (see Sections 2.3, 2.5, 2.6, and 4.4.2). Therefore, instead of calculating a TMDL load, this study recommends adoption of a site-specific criterion for the lower San Pitch River. Site-specific criteria for the lower San Pitch River are discussed in Section 4.8.2.

For consistency with the middle San Pitch River loading assessment, the existing TDS load is compared to the TDS load based on the existing state criteria of 1,200 mg/L. Estimated loads for the lower San Pitch River show less annual variability than the middle reach as indicated in

Table 4.19. The TMDL estimate for the combined two-year period is shown Table 4.20.

Table 4.20
TMDL Loading Estimate - Lower San Pitch
TMDL Estimate Based on Irrigation Season (tons)

Existing Load	19,197
Load at Criteria (1,200 mg/L)	15,574
Waste Load Allocation	not applicable
Load Allocation	not applicable
Margin of Safety	not applicable
Load Reduction	not applicable
% Reduction	not applicable

4.8 Source Loads and Load Allocation

4.8.1 Middle San Pitch River Watershed

The primary sources of TDS in the middle San Pitch River include flood irrigated tracts, groundwater input, saline sediments from upland and streambank erosion, and springs. As discussed above, the total existing TDS load for the middle San Pitch River is 35,329 tons. This section discusses the TDS sources identified above and presents an allocation estimate of the TDS load from each source in Table 4.21 below.

The flood irrigated tracts are located on a variety of soil units. These soil units are comprised primarily of silt loams and silty clay loams with moderate to strong salinity. Flood irrigation increases the salinity of soil pore water by dissolving and transporting the salts in the underlying saline soils and geologic formations (USDI, 1997). According to findings of the Price/San Rafael Salinity Control Project (USDI – BOR, 1991), 3.65 tons of TDS loading is attributable to each acre-foot of irrigation return flow. Approximately 15,000 acres are flood irrigated along the middle San Pitch River. Irrigation return flows have not been measured for the San Pitch River; however, assuming 30% efficiency for flood irrigation at a rate of 4 inches per acre (0.3 acre-feet), the return flows can be estimated at 3,465 acre feet. Using these average values, a rough estimate of 12,647 tons of TDS loading into the middle San Pitch River can be attributed to return irrigation flows during the entire irrigation season.

Groundwater inflows account for a significant source of TDS to the San Pitch River. Stream flow diversion records show an average gain of 30 cfs to the middle San Pitch River from groundwater during the irrigation season (see Map 6 diversion flows for "West Drainage Canal" and SPR West of Manti"). This groundwater discharge rate is consistent with the findings of Wilberg and Heilweil (1995) who reported the groundwater discharge as seepage to the San Pitch River to range from 25 cfs to 110 cfs.

TDS concentrations in shallow wells range from 234 to 2,490 mg/L, with an average of 602 mg/L (Lowe et al., 2000). Using a groundwater inflow rate of 30 cfs and an average TDS concentration of 062 mg/L results in a TDS load of 10,228 tons to the San Pitch River from groundwater input.

Another potential source of TDS loading is from sediments eroded from uplands and streambanks. Saline soils are present on the western foothills and streambanks of the middle San Pitch River (see **Map 2**). The area usually receives less than 8 inches of precipitation a year; however storm events do occur. Thunderstorms can cause short term flooding on the western foothills potentially washing saline soils into the San Pitch River. However, 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. This potential TDS load is considered natural and not due to grazing or some other human-caused mechanism. The TDS load from eroded sediments has not been quantified, but rather assumed to account for the remainder of the quantifiable load.

Springs with high TDS waters discharge to the San Pitch River; however, the flow rate is generally less than 1 cfs. Johnson Spring discharges to the middle San pitch River with an average TDS concentration of 956 mg/L. Due to the low flow rate (0.8 cfs) this spring contributes approximately 450 tons TDS per irrigation season.

Table 4.21
Sources of Current TDS Loading in the Middle San Pitch River.

Allocation	Source	TDS Load (tons)	TDS Load (% of total)
Background	Upstream load at Station 494675	6,898	20%
Natural Sources	Groundwater inflow	10,228	29%
	Johnson Springs	450	1%
	Eroded Sediments	4788	14%
Human-Caused Sources	Flood Irrigation Return Flows	12,647	36%
	Moroni WWTP	318	<1%
	Sprinkler Irrigation Return Flows	negligible	
Total		35,329	100%

4.8.2 Lower San Pitch River Watershed

Natural Sources of TDS

An evaluation of the geology, soils, hydrology, and irrigation system provides strong evidence that the high TDS concentrations are due to natural sources. Therefore, instead of calculating a load allocation for nonpoint sources, this study recommends adoption of a site-specific criterion for the lower San Pitch River. The evidence for natural sources of TDS will only be briefly summarized in this section since this information has been provided in detail in previous sections of this report.

Geology and Soils: The Sanpete Valley is comprised of complex geology with geologic units ranging from Jurassic to Quaternary in age. The Jurassic Arapien shale in San Pete Valley consists of lower limestone beds overlain by gray siltstone, shale, gypsiferous shale, and salt bearing, red-weathering shale and siltstone. This geologic unit is mined for salt west and south of the Sanpete Valley. Many authors attribute the increased salinity in groundwater in Sanpete Valley to the evaporites from the Arapien shale and other geologic formations. Highly mineralized springs occur at the surface within this section of the river and contribute to natural TDS loads. In addition, the soils within the contributing area are alkaline as readily observed by the white residue (caliche) visible on the soil surface in this area. (See Section 2.3 for further details.)

Hydrology: During the irrigation season, all of the surface water released at the south end of Gunnison Reservoir is diverted into canals, which is eventually used for irrigation downstream of the watershed. Water from the major tributaries in this reach, Six Mile

Creek, Nine Mile Creek and Twelve Mile Creek, are also diverted to canals and do not reach the San Pitch River. However, some snowmelt runoff may enter the river below this point between May 15th and mid-June.

Southwest of Manti, the Sanpete Valley narrows and is constrained by bedrock outcrops which impede most groundwater flow out of the valley. In this area, confined groundwater is forced to the surface and forms a large marshy area. The only outlet for this groundwater is the San Pitch River. The lower San Pitch River below Gunnison Reservoir is therefore characterized by the highly saline groundwater that discharges to it (See Section 2.5 and Section 2.6 for further details.).

Groundwater Quality: Quality of the Sanpete Valley groundwater has been studied extensively by the Utah Division of Water Resources and Utah Geological Survey. Groundwater quality varies throughout the Sanpete Valley exhibiting high variability in TDS concentrations both spatially and by depth however, concentrations above 2,000 mg/L are regularly observed. The source of TDS in groundwater is influenced by irrigation practices, but the relative extent of this influence compared to natural sources can not be determined despite the extensive studies that have been undertaken. (See Section 4.4.2 for further details.)

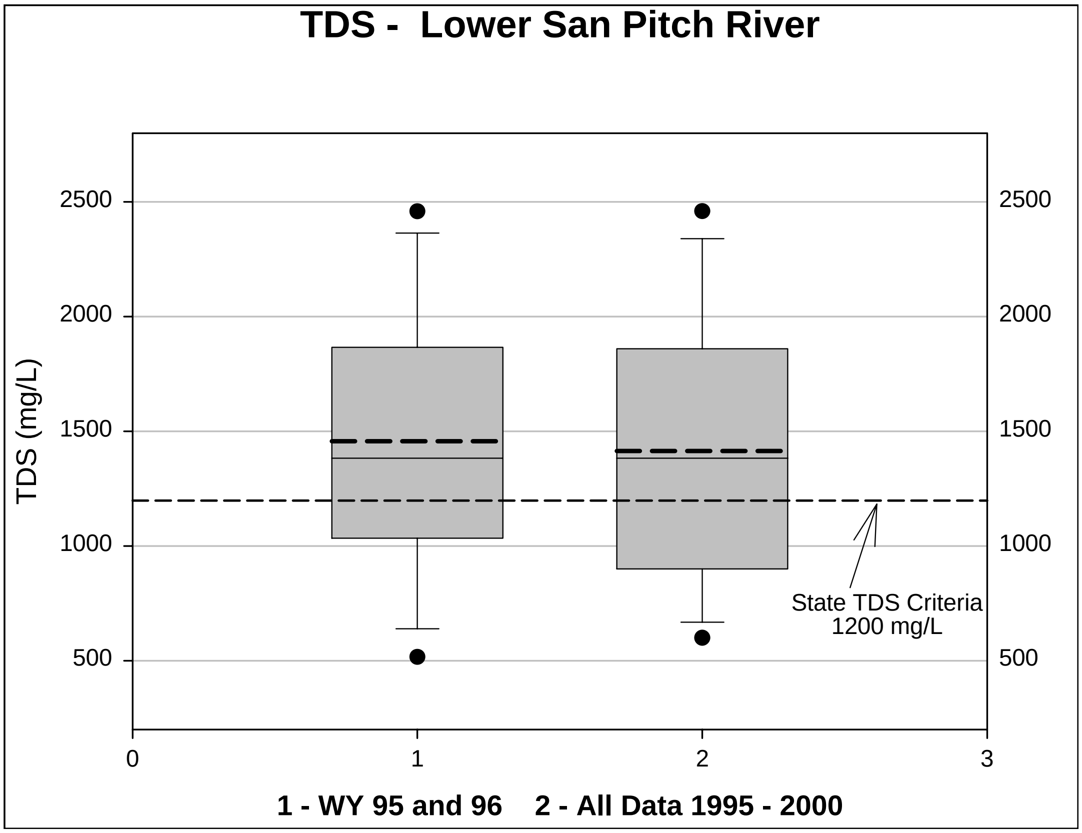
Site-Specific Criteria

Guidance for developing site-specific criteria is summarized in two memorandums issued by EPA. A Region 8 Memorandum (Moon 1997) addressed procedures for *Use Attainability Analysis and Ambient Based Criteria*, and a memorandum from EPA Office of Science and Technology (Davies 1997) addressed the subject, *Establishing Site-Specific Aquatic Life Criteria Equal to Natural Background*. These two memorandum were consulted for direction in developing site-specific criteria for the lower San Pitch River. The applicable points from these memoranda in developing site-specific criteria are:

1. Site-specific criteria are allowed by regulation subject to EPA review and approval.
2. Site-specific numeric aquatic life criteria may be set equal to natural background where Natural Background is defined *as background concentrations due only to non-anthropogenic sources*.
3. Previous guidance provided the direction to use the 85th percentile of the available representative data for natural ambient water quality conditions.

There is only one water quality station on the lower San Pitch River that provides sufficient data for estimating the natural background condition. This Station 494615, SPR 2 miles East of Gunnison at U-137 was used in calculating TDS loads. The data distribution for this station in illustrated in the box and whisker plots (Figure 5)

Figure 5: Background TDS concentration (mg/L) in the Lower San Pitch River.



Note: Shows 95th, 90th, 75th, 50th (median), 25th, 10th, and 5th percentile. Mean – dashed line.

Two time periods are compared in the box plot. WY 95 through WY 96 is the time period used consistently for estimating TDS loading. The second plot is for all data available for the project, January 1995 through July 2000. The plots illustrate similar data distribution for the two time periods; therefore the data set with the larger number of samples, the 1995-2000 data set, will be used for estimating a site-specific criterion.

Statistics for the data at Station 494615 are summarized in Table 4.22. Four potential percentiles are calculated for comparison to the existing criteria. Percent exceedence is calculated for the existing (1995 – 2000) data set to illustrate the potential effect on future water quality violations if this percentile were accepted as the site-specific criteria.

Table 4.22
Summary Statistics for Developing Site-Specific Criteria - Station 494615

Statistic	Value	% Exceedence
Number	52	
Mean	1,414	
Median	1,383	
Minimum	214	
Maximum	2,550	
95th Percentile	2,456	3.8%
90th Percentile	2,332	9.6%
85th Percentile	2,168	13.5%
75th Percentile	1,857	17.3%
Existing Criteria	*1,200*	*36.5%*

The 90th percentile, a value of 2,332 mg/L, results in less than 10% exceedences. A 90th percentile also provides some allowance for the unknown but minor anthropogenic contribution of TDS. For practical purposes the numeric value is rounded up to 2,400 mg/L. A TDS concentration of 2,400 mg/L is therefore suggested as the site-specific criteria applicable to the lower San Pitch River. (*Note: These criteria should only apply to the mainstem of the river, not to the adjacent tributaries. The surface tributaries are derived from a different geologic strata and do not exhibit a high natural TDS concentration.)*

4.9 Best Management Practices

The San Pitch River Watershed Stewardship Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the San Pitch River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Watershed Stewardship 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 San Pitch River and its tributaries.

Best management practices (BMPs) are presented in this section to attain water quality goals and targets. These BMPs are developed for the middle San Pitch River. The entire load allocation for the lower San Pitch River has been attributed to natural sources; therefore, no implementation strategies or BMPs are proposed for the lower San Pitch River.

The following BMPs are recommended with respect to the middle San Pitch River to meet the reductions listed in

Table 4.14. These BMPs address salt loading entering the middle San Pitch River and improving the efficiency of irrigation methods and conveyances to minimize surface runoff and 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 San Pitch River. Surface runoff and 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 (numeric codes following practices coincide with NRCS standards and specification numbers from the NRCS Field Office Technical Guide): Irrigation Water Management (449), Irrigation System (441, 442), Pipeline (430), Ditch and Canal Lining (428), Irrigation Storage Reservoir (436), Irrigation Regulation Reservoir (522), Irrigation Pit (522a), Sediment Basin (350), Diversion and Diversion Dam (362 and 348), Pumping Plant for Water Control (533), Structure for Water Control (587), and Water Well (642). These practices are intended to improve irrigation system efficiency to increase yields; decrease irrigation induced erosion, and reduce tail water runoff.

Another potential source of salt loading is from sediments eroded from streambanks and uplands. Since most of this area usually receives less than 8 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 other management practices, such as: filter strips along streams to trap sediment, stabilization of streambanks with vegetative material as well as structures, to reduce streambank erosion, and grade stabilization to reduce incising of stream channels which can lower water tables and effect vegetation. Specific practices pertaining to reduction of streambank erosion include: Channel Vegetation (322), Clearing & Snagging (326), Critical Area Planting (342), Fencing (382), Filter Strip (393), Grade Stabilization Structure (410), Streambank and Shoreline Protection (580), Channel Stabilization (584), and Structure for Water Control (587).

BMPs that would also reduce TDS loading to the middle San Pitch River involve improving vegetation cover on rangeland pastures to reduce erosion: Brush Management (314), Prescribed Burning (338), Fencing (382), Pasture Planting (512), Prescribed Grazing (528a), Range Planting (550), and Pest Management (weed control) (595). Additional practices to reduce erosion involve management of livestock distribution. This in turn facilitates the control of livestock so that pastures are not over used in some areas. Uniform proper use grazing promotes healthy stands of grass which reduces runoff, increases water infiltration and buffers sediment / nutrient loading of streams. Specific practices pertaining to management of livestock distribution include: Livestock Pond (378), Use Exclusion (472), Livestock Water Pipeline (516), Pumping Plant for Water Control (533), Spring Development (574), Watering Trough/Tank, Storage Tank (614), and Water Well (642).

The San Pitch River Watershed Stewardship Committee has proposed the following implementation strategies for the middle San Pitch River watershed.

1) Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries;
2) Stream channel stabilization;
3) Improving vegetation cover on rangeland pastures; and
4) Management of livestock distribution.

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

Successful projects combine a voluntary approach with cost-share assistance to identify key system components that properly improve surface irrigation practices, irrigation water management, and in reducing runoff from irrigated lands - while allowing management flexibility. 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, Utah Association of Conservation Districts (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.

The largest reduction in TDS load to the San Pitch River would be realized by improved irrigation methods. Flood irrigation return flows are estimated to account for 36% of the TDS load to the middle San Pitch River (see Table 4.21). As mentioned above, by improving the efficiency of irrigation methods, return flows and the associated TDS load to the middle San Pitch River would be reduced or eliminated. As a conservative assumption and a semi-quantitative assessment, if half the TDS load from irrigation return flows is assumed to be eliminated by improved irrigation efficiency, the resulting reduction in load is 6,324 tons or an 18% reduction. This TDS reduction meets the TMDL goals of 5,174 tons or 15%.

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 State of Utah's 303d listed segments of the San Pitch River Watershed located in central Utah.

Utah Department of Water Quality, Division of Water Quality

TMDL Section

Middle San Pitch River

Waterbody ID	Middle San Pitch River, HUC #16030004
Location	Sanpete County; Central Utah
Pollutants of Concern	Total Dissolved Solids (TDS)
Impaired Beneficial Uses	Class 4: Agricultural uses including irrigation of crops and stock watering
Loading Assessment	
Current Loading	35,329 tons of TDS during critical period (March 1 – Sept. 30)
Loading Capacity	32,981 tons of TDS during critical period (March 1 – Sept. 30)
Margin of Safety	Explicit MOS of 5% (1,649 tons), implicit MOS through conservative assumptions
Wasteload Allocation	
Moroni WWTP	1,177 tons of TDS during critical period (March 1 – Sept. 30)
Load Allocation	30,155 tons of TDS during critical period (March 1 – Sept. 30)
Load Reduction	5,174 tons of TDS
Defined Targets/Endpoints	Total Dissolved Solids concentrations less than 1,200 mg/L at the bottom of the middle San Pitch River near Gunnison Reservoir.
Implementation Strategy	1) Improve irrigation techniques and management practices to reduce TDS return flows to the river; and 2) Stream channel stabilization.
This document is identified as a TMDL for the middle San Pitch River and is officially submitted under §303d of the CWA for EPA approval.	

Utah Department of Water Quality, Division of Water Quality

TMDL Section

Lower San Pitch River

Waterbody ID	Lower San Pitch River, HUC #16030004
Location	Sanpete County; Central Utah
Pollutants of Concern	Total Dissolved Solids (TDS)
Impaired Beneficial Uses	Class 4: Agricultural uses including irrigation of crops and stock watering
Loading Assessment	Current TDS criteria cannot be obtained due to high TDS input from natural sources.
Defined Targets/Endpoints	Delist based on unachievable standard. Adopt site-specific TDS criteria not to exceed 2,400 mg/L in San Pitch River below Gunnison Reservoir.
Implementation Strategy	1) Adopt site-specific TDS criteria 2) Continue water quality monitoring
This document is identified as a TMDL for the lower San Pitch River and is officially submitted under §303d of the CWA for EPA approval.	

I. Introduction

The San Pitch River flows through the Sanpete Valley located in central Sanpete County, central Utah, about 90 miles south of Salt Lake City. The San Pitch River Watershed boundary is defined by the United States Geological Survey (USGS) Hydrologic Accounting Unit (HUC) #16030004 (**Map 1)**. The watershed boundary is almost entirely within Sanpete County. A few small areas of land on the west side of the watershed are within Juab County, Utah.

The San Pitch River flows generally from north to south through the Sanpete Valley and at the south end of the watershed it curves west to its confluence with the Sevier River. The San Pitch River Watershed forms the northeast portion of the larger Sevier River basin.

Sanpete Valley is a north-south-trending, Y-shaped valley bordered on the east by the Wasatch Plateau, which reaches elevations of 11,000 feet, and on the west by the San Pitch Mountains (also known as the Gunnison Plateau), which reach a maximum elevation of about 9,700 feet. The valley is divided in the north by Cedar Hill, which forms the center of the "Y" and reaches a maximum elevation of about 8,300 feet. Sanpete Valley is about 40 miles long and up to 13 miles wide. The west branch of Sanpete Valley runs from Moroni toward Fountain Green. The east branch heads up to Fairview. The San Pitch River begins on the Wasatch Plateau north of Fairview and flows through the east branch of Sanpete Valley. The Sanpete valley floor has an area of about 240 square miles; it ranges in elevation from 7,400 feet near the northern end of the eastern arm to about 5,040 feet where the San Pitch River meets the Sevier River.

For the purpose of this study, the San Pitch River is divided into upper, middle, and lower segments. The upper San Pitch River begins north of Fairview, Utah (near Oak Creek Ridge on the Northern Wasatch Plateau) and flows south to Moroni (where it crosses State highway U132). The middle San Pitch River runs from U132 to Gunnison Reservoir. The lower San Pitch River flows from Gunnison Reservoir to where it meets the Sevier River, west of Gunnison, Utah.

Utah's Year 2002 303(d) list (DWQ, 2002) identifies two segments of the San Pitch River as being impaired due to water quality numeric exceedences of total dissolved solids (TDS). These two segments are the middle and lower San Pitch River. The upper San Pitch River is not listed on the 303(d) list as impaired.

Sanpete County was created in 1850 with Manti as the county seat. In 1992 Manti had a population of approximately 2,000 people. Sanpete County had a 1990 Census population of 16,259 (Utah Division of Water Resources, 1999); its 1999 Census population was 21,408 (Utah League of Cities and Towns, 2000).

Since settlement, Sanpete County's economy has been based on agriculture. In its first few decades it served as Utah's granary. Principal crops are alfalfa, small grains, and corn for silage. Irrigation of all croplands is necessary because the climate at Manti is semi-arid. During the 1980s some irrigation practices converted from the ditch-and-furrow to the more sophisticated sprinkler types, both in town and farmlands.

The nearly 1,000 farms in the county comprise about two thirds of the total land area. Average farm size, including the privately owned range land, is about 655 acres, with about 10 percent of the farm acreage under irrigation. Total agricultural income, which runs approximately $24.9 million annually, is sufficient to rank Sanpete fourth among the counties of the State of Utah based on this important economic resource (UtahReach, 2002).

Livestock and poultry are the mainstays of Sanpete agriculture. Livestock is grazed on both private and public range land. The irrigated acreage is devoted to raising feed for the livestock. Vital to the economic well being of the Sanpete area is the production of turkeys for the national market. For many years Sanpete has ranked among the top 8 counties in the US based on total volume of turkey production. A typical year's output of Moroni Feed Company, an integrated farmer's cooperative which has been largely responsible for the rise of the turkey industry, is in excess of 35 million pounds of dressed turkey. Sanpete County ranks among the top ten turkey-producing counties in the country.

Climate and Streamflow

The Sanpete Valley climate is semi-arid despite its high elevation. The average annual precipitation ranges from approximately 8 inches in the lower valley to more than 30 inches in the higher mountains. Most of the precipitation in the San Pitch River watershed falls as snow in the mountains, particularly the Wasatch Plateau, from November to April.

Temperatures range from mean daily minimums of 32º F during the winter at the higher elevations to mean daily maximums of 63º F during the summer in the lower portion of the Sanpete Valley.

Precipitation in the watershed also varies with topography. Weather Bureau records indicate that average annual precipitation has historically ranged from over 30 inches in the high plateaus to eight inches in the low-lying desert area near the outlet of the watershed.

Impaired Waters

Utah's Year 2002 303(d) list identifies tributaries in two segments of the San Pitch River as being impaired due to water quality numeric exceedences of TDS (DWQ, 2002). Both segments are within the Sevier Watershed Management Unit and described as:

San Pitch River - 1: San Pitch River and tributaries from confluence with Sevier River to tailwater of Gunnison Reservoir (excluding tributaries above USFS boundary. Hydrologic Unit Code (HUC) 16030004-001. Water body size: 15.82 miles.

San Pitch River - 3: San Pitch River and tributaries from Gunnison Reservoir to U1342 crossing below USFS boundary. HUC 16030004-005. Water body size: 59.46 miles.

The listing is based on an intensive water quality survey completed in 1996-1997 by DWQ. This survey found numerical criteria exceedences for TDS. The beneficial uses, as designated by the State of Utah (DWQ, 2000b), for the San Pitch River are:

- 2B – Protected for secondary contact recreation such as boating, wading, or similar uses;
- 3C – Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain;
- 3D – Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
- 4 – Protected for agricultural uses including irrigation of crops and stock watering

Due to water quality impairments, the San Pitch River and some of its tributaries are not currently meeting beneficial use requirements for designated beneficial use 4 (agricultural uses including irrigation of crops and stock watering).

Statement of Intent

This TMDL addresses the water quality impairment of the San Pitch River watershed for TDS for submittal to the United States Environmental Protection Agency. The goal of the TMDL is to meet water quality standards associated with the waterbody's designated beneficial uses.

II. Water Quality Standards and Impairments

Utah water quality standards (Utah WQS) (State of Utah, 2000, UAC R317-2) and the 303(d) listing criteria (UDEQ - DWQ, 2002) provide the criteria to make an initial assessment of water quality conditions. The Utah water quality standards 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 1.

Table 1
Utah Water Quality Criteria for Class 4 Waters

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.

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 the San Pitch River, the middle and lower San Pitch River watershed are not meeting the water quality standards to support beneficial use 4. 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 2**.

Table 2
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.

Relation of Total Dissolved Solids to Beneficial Uses

TDS is listed as a criterion for protection of agricultural uses because of the negative effect of high salinity on crop production. 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 minor components of salinity. Salinity reduces crop growth by reducing the ability of plant roots to absorb water, and is evaluated by the relationship of salt tolerance to crops. Unlike 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 relation to the irrigation water TDS (Tanji, 1990).

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, as listed in the table above, 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 pollutant, 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 particular interest if the source of TDS is primarily a natural source and does not impair agricultural uses. As identified in the 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”.

III. Pollutant Assessment

Nonpoint and point sources of pollution in the San Pitch River watershed are discussed for the middle and lower San Pitch River.

Nonpoint Sources of Total Dissolved Solids

Natural Background

The San Pitch River watershed is in the Basin and Range - Colorado Plateau transition zone and the geologic units exposed in the Sanpete Valley area range from Jurassic to Quaternary in age. These geologic units consist of Tertiary limestones, mudstones, Cretaceous sandstones and conglomerates, Jurassic shales, and Tertiary volcanics.

Many authors attribute the cause of increased groundwater salinity/TDS beneath the Sanpete Valley to the evaporites from the Arapien Shale, and the Green River and Crazy Hollow Formations (Utah Division of Water Resources, 1999; Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971; and Richardson, 1907).

The Arapien Shale was deposited in a marine environment. Complex deformation geometries are common in the Arapien Shale, likely due to the thin-bedded nature and incompetent lithologies, especially salt. Most of the Arapien Shale in Sanpete Valley is exposed as intrusive masses from salt and evaporite diapirism that is likely been moving upward since it was deposited during Middle Jurassic (Witkind, 1982). The Arapien shale is mined west and south of Sanpete Valley for salt.

Outcrops of evaporite deposits of the Arapien Shale are located on the west side of Sanpete Valley. This area was identified by Wilberg and Heilweil, (1995) as one of the two areas in the Sanpete Valley with higher TDS concentrations in groundwater. The other area is on the east side of the valley near outcrops of the Green River and Crazy Hollow Formations from Chester to Pigeon Hollow. Southwest of Manti, where the middle San Pitch River meets Gunnison Reservoir, the Sanpete Valley narrows and is constrained by bedrock outcrops which impede most groundwater flow out of the valley, and is referred to as a "bottleneck" (Snyder and Lowe, 1998; Wilberg and Heilweil, 1995; Robinson, 1971). In this area, confined groundwater is forced to the surface and forms a large marshy area. Therefore, the only outlet for this groundwater is the San Pitch River. Robinson (1971) also reported that the Arapien Shale underlies this narrow "bottleneck" in the vicinity of Gunnison Reservoir. Therefore, the Arapien shale is an important natural source of TDS loading to groundwater beneath the Sanpete Valley and the San Pitch River.

Soil types mapped by the USDA Soil Conservation Service in the Sanpete Valley show up to five different soil units classified as strongly saline soil groups adjacent to the San Pitch River. On many of these soils a fluffy, granular salt crust is noted on the surface.

Vegetation in these areas is usually sparse and is greasewood, pickleweed, kochia, bassia, and salt grass.

In the middle San Pitch River watershed, farmers must rely on a seasonal water supply from the San Pitch River and therefore flood irrigation practices are used primarily. There are 220,793 flood-irrigated acres adjacent to the San Pitch River in the middle San Pitch River. Irrigation increases salinity by consuming water through evapotranspiration 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 and silty clay loams. According to findings of the Price – San Rafael Salinity Control Project (USDI – BOR, 1991), 3.65 tons of TDS loading is attributable to each acre-foot of irrigation return flow. Irrigation return flows have not been measured for the San Pitch River. Assuming 30% efficiency for flood irrigation at a rate of 4 inches per acre (0.3 acre-feet), the return flows can be estimated at 3,465 acre feet. Using these average values, a rough estimate of 12,647 tons of TDS loading into the middle San Pitch River can be attributed to return irrigation flows during the entire irrigation season.

Potential Point Sources of Total Dissolved Solids

The Moroni Waste Water treatment Plant (WWTP) is the only known point source in the watershed. TDS loading was calculated for this potential point source using TDS STORET data from a station located downstream of the WWTP. TDS does not exceed the water quality criteria at this station and the range of TDS concentrations was 75 mg/L to 913 mg/L. Therefore the WWTP is not contributing TDS to the San Pitch River above the water quality standard and no other point sources are known.

IV. Linkage Analysis

TDS

Because flows are variable over an annual cycle, available data were used to construct average daily flows and TDS concentrations for each STORET station in the middle and lower San Pitch River.

This analysis indicated that average TDS concentrations exceed criteria during the irrigation season (March to September). This season was identified as the critical condition for TDS in the middle and lower San Pitch 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 San Pitch River watershed were selected according to the impaired beneficial use and the 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 the middle San Pitch River are to reduce TDS loading by improving the efficiency of irrigation systems and thereby reduce return flows.

Summary of Water Quality Targets and Endpoints

For the Middle San Pitch River, the water quality target is a total dissolved solids concentration less than 1,200 mg/L in the San Pitch River above Gunnison Reservoir of San Pitch River. For the lower San Pitch River, the water quality target for total dissolved solids concentrations less than 1,200 mg/L at the mouth of the San Pitch River.

V. TMDL and Allocations

For both the middle and lower San Pitch River TDS TMDL the first step of the analysis included identification of the critical season. The critical period for TDS contribution and effects on the beneficial use (agricultural use) is the irrigation season. Water for irrigation and stock water is the beneficial use of concern, which is potentially impacted by increased salinity. For the purposes of comparing year-to-year loads, the irrigation season is standardized to the time period March 01 to September 30.

Middle San Pitch River Watershed

On the middle San Pitch River, average TDS concentrations exceed criteria for six months during the irrigation season, March through May and July through September.

To calculate the target load, the 1,200 mg/L criterion was substituted in the spreadsheet of calculated current loads for these months. Although a load reduction is not recommended for the Moroni WWTP, a waste load allocation was calculated as 1,177 tons/year. The load capacity is estimated at 32,981 tons. Including a 5% margin of safety, the remaining load is 30,155 tons of TDS. The required load reduction is 5,174 tons of TDS during the critical season, or 15%. A load reduction will be realized through improved surface irrigation practices and irrigation water management. Using the information developed by the Price-San Rafael Salinity Control Project approximately 1,417 acre feet of return flows need to be reduced in order to meet the target loading (5,174 tons / 3.65 tons per acre foot).

The wasteload allocations, load allocations, margins of safety, and load reductions are summarized for the middle san Pitch River in **Table 3.**

Table 3
Loading Assessment

	Middle San Pitch River Watershed (tons TDS for critical season, March - Sept.)
Current Load	35,329
Loading Capacity (Target Load)	32,981
Waste Load Allocation	1,177
Load Allocation	30,155
Margin of Safety (5%)	1,649
Load Reduction	5,174

Lower San Pitch River Watershed

On the lower San Pitch River, average TDS concentrations exceed criteria for six months during the irrigation season, April through September. As with the middle San Pitch River, target loads were calculated using the 1,200 mg/L criterion in the spreadsheet of calculated current loads for these months. The waste load allocation is set to zero because there are no current point sources, and the load capacity is estimated at 15,574 tons. Including a 5% margin of safety, the remaining load is 14,796 tons of TDS. The required load reduction is 4,401 tons of TDS during the critical season, or 23%. This load is assumed to be natural or background due to the hydrogeology of the lower watershed and the springs that supply some of the water to the lower San Pitch River (see Sections 2.3 and 2.6 of the Water Quality Management Plan for a discussion of geology and groundwater).

The wasteload allocations, load allocations, margins of safety, and load reductions are summarized for the lower San Pitch River in **Table 4.**

Table 4
Loading Assessment

	Lower San Pitch River Watershed (tons TDS for critical season, March - Sept.)
Current Load	19,197
Loading Capacity (Target Load)	15,574
Wasteload Allocation	0
Load Allocation (attributed to natural sources)	14,796
Margin of Safety (5%)	779
Load Reduction	4,401

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 (EPA, 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 San Pitch River watershed TMDL, the MOS was included explicitly by allocating 5 percent of the target load to the MOS for the parameter of concern. Therefore, only 95 percent of the target load was allocated to 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

The middle and lower San Pitch River segments of the watershed are listed as impaired due to high levels of TDS. The data that were used to list these segments were instantaneous readings for TDS. In the future it will be useful to obtain TDS readings collected over a 24-hour period to better characterize the situation and assess progress towards meeting water quality goals. 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 San Pitch River Watershed Stewardship Committee. The Watershed Stewardship 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 San Pitch River Watershed Stewardship 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 water conservation, irrigation improvement, tour planning, and media promotion.

A public hearing on the TMDLs was held on February 6, 2003 with notification of the hearing published in the local newspapers. The comment period was opened on February 6, 2003 and closed on March 6, 2003. 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 Sanpete Soil Conservation District (the 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 San Pitch River Watershed Stewardship Committee (Local Work Group) has brought together citizens who are concerned about the future condition of the San Pitch 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 Sanpete Soil Conservation District.

The San Pitch River Watershed Stewardship 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 Sanpete Soil Conservation District and the San Pitch River Watershed Stewardship 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 San Pitch River Watershed Stewardship 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 San Pitch River Watershed Stewardship Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the San Pitch River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Watershed Stewardship 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 San Pitch River and its tributaries.

Coordination and Linkages

The District and San Pitch River Watershed Stewardship Committee 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 Water Rights- Permits advisory, and monitoring assistance

Utah Division of Water Resources - Advisory

Sanpete County Irrigation Companies - Advisory and TAC coordination

Similar Activities

Price-San Rafael Salinity Control--Ferron Subunit

The Ferron Watershed is located in west central Emery County, Utah. The watershed area covers 191,000 acres of which 15 percent is privately owned. The project area's 8,747 acres of irrigated land is presently creating water quality problems in the form of salts and other dissolved solids entering the Colorado River System. The Ferron Subunit is a portion of the much larger Price-San Rafael Rivers Unit of the Colorado River Salinity Control Program. The concerns, costs, benefits, and project effects are estimated in the final joint Environmental Impact Statement published by the Bureau of Reclamation and the Natural Resources Conservation Service. The Bureau of Reclamation is receiving federal funding (over $10 million per year) to implement its Colorado River Salinity Control Program. These funds are being used to install off-farm (main line and laterals), salinity reducing irrigation system improvements. The Bureau's funds are allocated to salinity control projects on a Request for Proposals (RFP) basis. Also, once the Bureau accepts a bid from project sponsors, the successful bidder has to install its project at the agreed to price, or drop out and resubmit a new proposal at a later RFP.

Uintah Basin--Duchesne River

This river basin priority area is located in Eastern Utah and is a major drainage to the Upper Colorado River Basin. This area is a national priority area for salinity control in the Colorado River system. This priority area covers private lands in Duchesne county; that contribute salinity to the Colorado River. The Duchesne River consists of 1,500 acres of irrigated pasture, hayland, and cropland with the balance of privately owned grazing lands. Program objectives in the Uintah Basin EIS consist of treatment on irrigated lands. Primary benefit of the salinity control program is reduction of salt loading by 106,800 tons of salt annually to the Colorado River System. Poor efficiency irrigation systems contribute to salt loading by deep percolation and leaching of salts into the water that runs off. This leaching of salts also contributes to soil health concerns, creating soils with major salt concentrations. The current treatments in the Uintah Basin are achieving greater efficiencies than anticipated, the salt savings are higher than projected, and the wetland effects are far lower than projected in the EIS. Plant response is double that under the old systems. OIG, EPA, USGS, and state agencies have given credit to the salinity program administration and positive environmental effects.

Uintah and Ouray Agency

The area is located in Eastern Utah in a major drainage to the Upper Colorado River Basin. This area has been identified as a key treatment area for salinity control in the Colorado River system. This area covers private lands in Uintah, Duchesne, and Carbon counties in Utah. The Uintah and Ouray Agency consists of over 927,164 acres of irrigated pasture, hayland, cropland, and rangeland. The problem is poor water distribution, leaking ditches, low irrigation efficiency, and poor plant communities. Primary benefit of the program is reduction of salt loading by 1,800 tons of salt annually to the Colorado River system. Treatment of the Ute Indian Tribe land is essential to the achievement of these goals. Targeted money for the tribal lands coupled with the tribe's water settlement funds from the Central Utah Completion Project would be an excellent way to address the resource needs.

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 Sanpete Soil Conservation District, Watershed Stewardship Committee and funding agencies.

Middle San Pitch River Watershed

1) Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries; and
2) Stream Channel Stabilization.

Lower San Pitch River Watershed

Impairment of the lower San Pitch River results from a combination of natural and man-made causes. Man-made causes are due to the total diversion of water from the San Pitch River, any water remaining in the river is from springs and groundwater. Due to the extreme difficulty in determining the level of contribution from man-made and natural sources the entire load allocation for the lower San Pitch River has been attributed to natural sources. Water quality monitoring is recommended on the lower San Pitch River to evaluate the suspected natural loading. No implementation strategies or BMPs are proposed for the lower San Pitch River.

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. 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 Stewardship Committee is how much financial burden for implementation is placed on grazing permitees. Typically, most of the cost of grazing land improvements such as irrigation 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.

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 San Pitch River Watershed Stewardship Committee is currently addressing water quality problems including salt loading in the middle and lower portion of the watershed. Successful projects combine a voluntary approach with cost-share assistance to identify key system components that properly improve surface irrigation practices, irrigation water management, and in reducing runoff from irrigated lands - while allowing management flexibility.

The Watershed Stewardship Committee anticipates receiving cost share funding this year {Year} from USDA's EQIP program as well as some funding from the Utah Legislature. These projects will demonstrate proper surface irrigation practices, irrigation water management ideas that if implemented area-wide, will improve water quality. Best Management Practices may include: Improved Surface Irrigation Practices; Improved Irrigation Water Management; and Stream Channel Stabilization. Tours and Fact sheets will be developed highlighting project accomplishments.

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6.0 PROJECT IMPLEMENTATION PLANS

The San Pitch River Watershed Stewardship Committee is currently addressing water quality problems including excess TDS in the middle and lower portion of the watershed. Successful projects will combine a voluntary approach with cost-share assistance to identify key system components that properly reduce the TDS loading of surface water while allowing management flexibility. In addition, assistance is needed in helping producers reduce runoff from irrigated lands.

Cost share funding is anticipated this year (2003) from USDA's EQIP program as well as some funding from the Utah Legislature. These projects will showcase proper irrigation and stream channel stabilization principles that, if implemented area-wide, will improve water quality to downstream users. Tours and Fact sheets will be developed highlighting project accomplishments.

6.1 Statement of Need

The middle and lower San Pitch River segments of the San Pitch River Watershed are currently not meeting their designated beneficial uses due to excessive TDS concentrations. A TMDL analysis is currently underway and will be submitted to EPA for review and adoption. This Project Implementation Plan (PIP) addresses the primary sources of dissolved solids identified within the TMDL analysis.

Water from the San Pitch River is used to flood irrigate croplands and pastures, and use for stock watering. At numerous points along the river, flow is completely diverted to irrigation canals. The area is underlain by saline soils and geology and as irrigation water is applied the return flows convey dissolved solids back into the river. Natural springs and groundwater also contribute to increased TDS in the San Pitch River watershed.

The intent of the proposed program is to reduce nonpoint source pollution in the San Pitch River by application of 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 Stewardship Committee, we will design and implement projects in the middle watershed featuring improved irrigation water application and management. 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 middle and lower San Pitch River from State highway U132 near Moroni to its confluence with the Sevier River has been identified as a High Priority watershed, 303(d) list Unified Assessment Category IC. The designated uses for the San Pitch River are 2B, 3C, 3D, and 4.

The San Pitch River is divided into upper, middle, and lower segments. The upper San Pitch River is from the headwaters to Moroni (where it crosses State highway U132). The middle San Pitch River runs from U132 to Gunnison Reservoir. Lower San Pitch River flows from Gunnison Reservoir to the confluence with the Sevier River. The upper segment of the San Pitch River has not been designated a 303(d) impaired water for TDS and will not be considered for any project implementation.

Water diverted from the middle San Pitch River is used to flood irrigate croplands and pastures, and for stock watering. There are some sprinkler irrigation systems in this area; however, the water that supplies these systems comes almost entirely from wells, not from the San Pitch River. The irrigation season in the watershed is usually from March 1st to September 30th. Impairment of the middle San Pitch River is a result of excess irrigation water percolating through underlying geology and conveying TDS back to the river. Of the total annual load to the river it has been shown that an average of 80% occurs during the irrigation season. Based on this determination, source reduction projects should be directed at irrigation practices and stream channel stabilization along the middle San Pitch River segment.

During the irrigation season, all of the surface water released at the south end of Gunnison Reservoir (the beginning of the lower San Pitch River segment) is diverted to Highland Canal by way of Six Mile Creek. This water is used to irrigate crop and pasture land via sprinkler systems. Impairment of the lower San Pitch River results from a combination of natural and man-made causes. Due to the extreme difficulty in determining the level of contribution from these two sources the entire load allocation for the lower San Pitch River has been attributed to natural sources. The entire load allocation for the lower San Pitch River has been attributed to natural sources; therefore, no implementation strategies or BMPs are proposed for the lower San Pitch River.

6.1.2 Project Goals

The overall project goals are to: reduce nonpoint source loading in the middle San Pitch River watershed by decreasing the amount of pollutants entering the watershed from irrigated lands and stream channel erosion to reduce TDS loading; improve upland and pastureland management practices to reduce sediment runoff; and inform and educate the community concerning nonpoint source pollution and the importance of managing natural resources within the watershed. The project goals for the middle San Pitch River watershed are to reduce TDS loads by improving irrigation systems, irrigation water management, and stream channel stabilization. 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: Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries.

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

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

Goal #4: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality within the watershed.

Goal #5: 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: Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries.

Objective 1: Reduce TDS loading to the middle San Pitch River from improved irrigation techniques and management.

Task 1 - Select and identify project cooperators.

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

Task 2 - 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 3 - 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 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 loading to the river and its tributaries.

Objective 1: Develop projects that reduce sediment 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 (like Garrison seeding and 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.

<u>Goal #3:</u> Improve upland management practices to reduce sediment runoff to the river and its tributaries.

Objective 1: Reduce nonpoint pollution (sediment) 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: 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) irrigation techniques, designs and proper management practices; 2) functioning riparian areas and stable streambanks; and 3) and properly managed uplands/pasture lands.

Task 13 - 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.

Task 14 - 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.

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

Task 15 - 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 #5: 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 16 - 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 middle San Pitch 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.

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 Sanpete Soil Conservation District (the 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.

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 San Pitch River Watershed Stewardship Committee has brought together citizens who are concerned about the future condition of the San Pitch River and its tributaries. 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 Sanpete Soil Conservation District.

The San Pitch River Watershed Stewardship 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 Soil Conservation District and San Pitch River Watershed Stewardship 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 San Pitch River Watershed Stewardship Committee will be responsible for writing the final project report pursuant to EPA and State requirements.

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 San Pitch River Watershed Stewardship Committee is coordinating with local stakeholders and agencies to develop a watershed plan to further define water quality problems in the San Pitch River watershed and to proceed with a coordinated approach to improve water quality within the watershed. The Soil Conservation District, 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 San Pitch River and its tributaries.

6.2.3 Coordination and Linkages

The District and San Pitch River Watershed Stewardship Committee 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 Water Rights- Permits advisory, and monitoring assistance

Utah Division of Water Resources - Advisory

6.3 Evaluation and Monitoring Plan

6.3.1 Sampling and Analysis Plan

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

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 DWQ) for water quality 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) 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 the Utah Association of Conservation Districts (UACD) in Chester, Utah
4) Review data and include data summaries in annual reports. This activity will be performed as sub-tasks within tracking and reporting tasks.

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 San Pitch River Watershed include {list agencies}.

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 Moroni Feed/Wastewater (UT0020222); Fountain Green Fish Hatchery (UTG130004); and the Spring City Corp Waste Water Treatment Plant (UT0025216).

This water quality monitoring plan is designed to be adopted by the DWQ monitoring program that consists of ambient, intensive, cooperative, and municipal/industrial 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.

Middle San Pitch River

This segment is defined as from where the San Pitch River crosses State highway U132 to Gunnison Reservoir. Certain sections are seasonally dewatered. The objectives for sampling the middle San Pitch River is to characterize pollutant loading from different land use categories (sprinkler irrigated lands, controlled and uncontrolled flood irrigated lands, and the combination of these land uses with soil types, and groundwater inputs) to determine the occurrence and severity of TDS in the river, and monitor the effectiveness of the selected BMPs. This monitoring plan focuses on sampling TDS concentrations into the river and the effect of irrigation methods/high saline soils on water quality in the river.

Middle San Pitch River Monitoring

Waterbody	Monitoring Station	**Sampling Location Rationale**	**Parameters of Concern**	**Monitoring Program**
San Pitch River above Moroni WWTP	494696	Monitor potential TDS loading above WWTP	TDS & Flow	Cooperative, Intensive
Moroni WWTP & Turkey Plant (Moroni Feed Co.) combined effluent	494694	Monitor potential TDS loading from WWTP	TDS & Flow	Cooperative, Ambient
San Pitch River 1 mile west of Chester on U-117	494665	Upper station for no historical TDS exceedence	TDS & Flow	Cooperative, Intensive
San Pitch River northwest of Manti	494654	Upper station for historical TDS exceedence	TDS & Flow	Cooperative, Intensive
San Pitch River west of Manti above Gunnison Reservoir at Creek crossing	494645	Monitor TDS at the bottom of listed section	TDS & Flow	Cooperative, Intensive

Lower San Pitch River

The lower San Pitch River flows from Gunnison Reservoir to where it meets the Sevier River, west of Gunnison, Utah. The monitoring objective of the lower San Pitch River is to evaluate the sources of TDS to this segment.

Lower San Pitch River Monitoring

Waterbody	Monitoring Station	**Sampling Location Rationale**	**Parameters of Concern**	**Monitoring Program**
Springs at base of Gunnison Reservoir dam flowing into San Pitch River	New Station #1	Monitor natural TDS loading	TDS & Flow	Cooperative, Intensive
San Pitch River 2 miles east of Gunnison at U-137 crossing	494615	Monitor TDS at the bottom of the historical flowing listed section	TDS & Flow	Cooperative, Intensive
San Pitch River west of Gunnison	494605	Monitor TDS and potential flow	TDS & Flow	Cooperative, Intensive

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.

Sampling Design

Sampling will include paired samples (upstream/downstream) 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 San Pitch River and its tributaries as part of its long-term water quality monitoring efforts.

Sampling and Sampling Site Locations

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.

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 specific conductivity, an indicator for TDS. Flow will be measured at each sampling site on each sampling date.

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 San Pitch River are not monitored every year but are included in the more intensive monitoring of watersheds conducted on a 5-year rotation.

Methodology

The likelihood of detecting a meaningful signal from grab samples is highly unlikely since this limited sample frequency cannot control the high variability in flow volume and salinity, which can occur on a daily frequency. Continuous-recording conductivity sensors should be installed during the irrigation season for longer periods, e.g. a week, to meaningfully measure changes in TDS between paired upstream-downstream stations. The comparison of plots over a week period between paired sites should adequately demonstrate a reduction (if any) in TDS associated with the implementation program. To increase quantification, pressure sensors can be used to estimate flows and TDS concentration can be calculated from the specific conductance measurements. Pressure sensors and conductivity sensors are integral parts of many multi-parameter water quality meters.

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 DWQ 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 DWQ 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 San Pitch 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 San Pitch River Watershed Stewardship 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

Land use policies for the San Pitch River Watershed are contained in the Sanpete County General Plan (1997). This plan was written by the citizens of Sanpete County and includes land use, land and natural resources inventory, economic base analysis, citizen's plan, land use recommendations, and land use policies. The Utah County Land Use Development and Management Act (U.A.C. Title 17, Chapter 27), provisions, and amendments have been adopted by reference in the Sanpete County General Plan.

Citizens and land owners in Sanpete County feel strongly about protecting their private property rights and rural lifestyle. Sanpete's land use management patterns are based on low-density residential units with farmlands on the peripheral areas of established communities. Residents of Sanpete County recognize that these patterns provide greater economy in infrastructure, public services, preserve established agricultural uses, open space, and protect the physical environment, sensitive lands, wetlands, and watershed areas. Citizens in Sanpete County favor planned growth and effective land use regulations that encourage low density building and development within or immediately adjacent to existing cities and towns in the county.

The Sanpete County General Plan includes Land Use Policies that are implemented through the County's land use ordinances. These land use policies represent broad-based input from Sanpete county residents in all areas of the county and include the following policies (in alphabetical order):

- Agriculture, Water, Minerals and Natural Resources;
- Culture, Historic Preservation, Recreation and Tourism;
- Economic Development and Employment;
- Education, Public Facilities, and Human Services;
- Housing, Infrastructure, and Services;
- Orderly Growth and Demographics; and
- County, Federal, Municipal and State Lands.

The Sanpete County General Plan recognizes that due to the current and projected population expansion, Sanpete County will require more water for culinary and irrigation uses. With careful management of groundwater through existing or new wells, and surface waters through storage reservoirs and trans-basin exchanges the supply of water could accommodate industrial expansion. However, such expansion will be dependent on added storage capacity and development of additional groundwater resources. This Water Quality Management Plan also presents Best Management Practices for improved irrigation methods and agricultural practices that will improve water quality.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This Water Quality Management Plan for the San Pitch River watershed has confirmed some of 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 middle and lower San Pitch River watershed, two river segments are 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. However, none of the TDS data exceed criteria on ***tributaries*** of the San Pitch River between the headwaters and the Sevier River; although these tributaries are included in the Section 303(d) List. This information should be used to update the 303(d) listing for these segments; the San Pitch River tributaries, listed as "San Pitch River - tributaries: from confluence with the Sevier River to tailwater of Gunnison Reservoir"; and "San Pitch River - tributaries: from Gunnison Reservoir to U132 crossing" should be deleted from the 303(d) listing. To achieve water quality standards in the impaired segments of the San Pitch River watershed, the following reductions in constituent loadings are recommended (Table 8.1).

Table 8.1
Recommended Reductions in Constituent Loadings

	Middle San Pitch River Watershed	**Lower San Pitch River Watershed**
Current Load (Mar. 1-Sept. 30)	35,329 tons TDS	19,197 tons TDS
Target Load (Mar. 1-Sept. 30)	32,981 tons TDS	15,574 tons TDS
Load Reduction (Mar. 1-Sept. 30)	5,174 tons	The entire load allocation for the lower San Pitch River has been attributed to background sources. No load reduction is proposed at this time.

Middle San Pitch River Watershed

The primary sources of TDS in the middle San Pitch River include flood irrigated agricultural, and natural salts from saline soils, geology, and groundwater flows to the San Pitch River. The irrigated tracts are located on a variety of soil units. They are comprised primarily of silt loams and silty clay loams. They are formed in alluvial and flood plain deposits, and derived from shale, limestone, and mixed sedimentary rocks. The salinity of these soils is moderate to strong. Irrigation increases salinity by consuming water through evapotranspiration and by dissolving and transporting salts found in the underlying saline soils, geologic formations and groundwater.

BMPs are recommended with respect to the middle San Pitch River to meet the reductions listed in Table 8.1. These BMPs address salt loading entering the middle San Pitch 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 San Pitch 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).

Another potential source of salt loading is from sediments eroded from streambanks and uplands. Since most of this area usually receives less than 8 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 other management practices, such as: filter strips along streams to trap sediment, stabilization of streambanks with vegetative material as well as structures, to reduce streambank erosion, and grade stabilization to reduce incising of stream channels which can lower water tables and effect vegetation.

BMPs that would also reduce TDS loading to the middle San Pitch River involve improving vegetation cover on rangeland pastures to reduce erosion, and management of livestock distribution. This in turn facilitates the control of livestock so that pastures are not over used in some areas. Uniform proper use grazing promotes healthy stands of grass which reduces runoff, increases water infiltration and buffers sediment / nutrient loading of streams.

The San Pitch River Watershed Stewardship Committee has proposed the following implementation strategies for the lower San Pitch River watershed.

1) Improve irrigation techniques and management practices to reduce TDS and runoff to the river and its tributaries;
2) Stream channel stabilization;
3) Improving vegetation cover on rangeland pastures; and
4) Management of livestock distribution.

These implementation strategies will be put into action throughout the next couple of years and will include water quality monitoring to evaluate their effectiveness. The water quality goals for the middle San Pitch River are to reduce TDS loading by improving the efficiency of irrigation systems and thereby reduce return flows. Successful projects combine a voluntary approach with cost-share assistance to identify key system components that properly improve surface irrigation practices, irrigation water management, and in reducing runoff from irrigated lands - while allowing management flexibility.

Lower San Pitch River Watershed

During the irrigation season, all of the surface water released at the south end of Gunnison Reservoir (the beginning of the lower San Pitch River segment) is diverted to Highland Canal by way of Six Mile Creek. This water is used to irrigate crop and pasture land via sprinkler systems. Impairment of the lower San Pitch River results from a combination of natural and man-made causes. Man-made causes are due to the total diversion of water from the San Pitch River, any water remaining in the river is from springs and groundwater. The entire load allocation for the lower San Pitch River has been attributed to natural sources. Water quality monitoring is recommended on the lower San Pitch River to evaluate the suspected natural loading. No implementation strategies or BMPs are proposed for the lower San Pitch River.

9.0 REFERENCES

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Appendix 1

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Appendix 10

List of Acronyms

Acre-ft/yr	Acre feet per year
BAT	Best Available Technology
BLM	Bureau of Land Management
BMP	Best Management Practice
BOR	Bureau of Reclamation
DEQ	Utah Department of Environmental Quality
DWQ	Utah Department of Environmental Quality - Division of Water Quality
DWRt	Utah Department of Natural Resources - Division of Water Rights
EPA	United States Environmental Protection Agency
GIS	Geographic Information Systems
MSE	Millennium Science & Engineering, Inc.
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
PIP	Project Implementation Plan
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
UACD	Utah Association of Conservation Districts
UDEQ	Utah Department of Environmental Quality
USDI	United States Department of the Interior
USFS	United States Forest Service
WQS	Water Quality Standard