317 - California Land Stewardship Institute, Russian River Watershed Agricultural Water Conservation & Water Supply Reliability Program

California Land Stewardship Institute Technical and Scientific Documentation Table		
Technical and Scientific Document Name	**Document Description**	**Relevant page #**
City of Ukiah. Recycled Water Master Plan. Feb 2012	This master plan provides preliminary design and feasibility analysis	all
Supporting Documents provided digitally via the BMS upload and by CD		
Natural Resource Conservation Service. Technical Guides Practices 436- Irrigation reservoir; 378 – Pond; 430 – Irrigation pipeline; 533 Pumping plant; 521A Pond liner	These practices define the specifications to be used for the agricultural ponds	all
Edwards, C. and Cluer, B. Data Report: Stream Flow Monitoring in Tributaries to the Russian River (Sonoma and Southern Mendocino Counties) 2010 and 2011, NOAA Fisheries Habitat Conservation Division Southwest Region. 2011.	The use of water in the Russian River basin peaks during spring when the highest demand for agricultural water is for frost protection of sensitive crops during cold weather episodes that generally occur from March to May. This time of year is when juvenile salmonids are particularly vulnerable as they emerge from gravel redds, adapt to riverine habitat and migrate to suitable summer rearing locales.	1, 13, 24-25, 39-41,

City of Ukiah

Recycled Water Master Plan

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City of Ukiah

RECYCLED WATER MASTER PLAN

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February 2012

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City of Ukiah

RECYCLED WATER MASTER PLAN

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LIST OF ABBREVIATIONS

AACE	Association for the Advancement of Cost Estimating
af	Acre Feet
ac	Acre
AFY	Acre Feet per Year
ENR	Engineering News Record
ft	Feet
ft/kft	Feet per Thousand Feet
ft/sec	Feet per Second
gpm	Gallons per Minute
GW	Groundwater
M	million
Max	Maximum
MG	Million Gallons
mgd	Million Gallons per Day
Min	Minimum
Mod	Moderate
psi	Pounds per Square Inch
RRFCD	Russian River Flood Control District
SWRCB	State Water Resources Control Board
UUSD	Ukiah Unified School District
WWTP	Wastewater Treatment Plant

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Chapter 1

STUDY AREA CHARACTERISTICS

1.1 INTRODUCTION

The City of Ukiah (City) contracted with Carollo Engineers to provide engineering services to develop the City's first Recycled Water Master Plan (RWMP). The purpose of the RWMP is to determine the feasibility of constructing a recycled water system to replace/augment existing water supplies in Ukiah Valley. Recycled water use within the Valley would offset existing and future water demands for irrigation and frost protection of agricultural land, and in doing so, would support the local agricultural industry. It would also offset urban irrigation demands, ease storage limitations at the Ukiah Wastewater Treatment Plant (UWWTP) and reduce treated wastewater discharges to the Russian River.

The City of Ukiah (City), as shown in Figure 1.1, is located in Mendocino County in the northern coastal region of California. The City is situated in the Ukiah Valley approximately 60 miles north of Santa Rosa, 20 miles south of Willits, and 5 miles south-west of Lake Mendocino, and is surrounded by coastal ranges in southern Mendocino County. The Valley is bordered on the west by the Mendocino Range and on the east by the Mayacamas Mountains. Elevations in the nearby mountains reach over 1,800 feet above mean sea level (MSL), while elevations in the Valley range from about 560 feet above MSL in the south near El Robles Ranch to 670 feet above MSL in the north near Calpella. Interstate Highway 101 runs north to south through the City along its eastern boundary and the Russian River flows from north to south through the Ukiah area. Ukiah is the county seat for Mendocino County.

Originally part of a Mexican Land Grant, the City began its history as a Valley settlement in 1856. Due to the City's moderate climate and productive soil, lumber production became a major industry by the end of the 1940s. Agriculture is currently the largest industry in Ukiah and the rest of Mendocino County (www.cityofukiah.com). Ukiah is home to wineries, grape vineyards, pear orchards, and wood production plants, in addition to up-and-coming non-agricultural manufacturers.

1.1.1 IMPETUS FOR RECYCLED WATER USE

Surface waters, namely the Russian River (River) and Lake Mendocino, and groundwater are the major water resources that sustain the people and industries of Ukiah area. The City and several other water service providers in the area use a combination of these water supplies to support the urban demands within their service area boundaries. Agricultural entities also draw groundwater and surface water to both irrigate their crops and protect them from frost and heat events. Over the years, these water resources have become

Legend

- City/Community
- Major Roads
- Water Body
- Recycled Water Master Plan Study Area
- County Boundary

N

0 7.5 15 Miles

Figure 1.1
LOCATION MAP
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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increasingly taxed to meet urban and agricultural demands as well as in-stream flow requirements for endangered species. As a result, the need to procure alternative water supplies, including recycled water, has increased.

Environmental groups have increasingly studied how river and groundwater diversions have negatively affected the species of the Russian River stream system and have requested increased regulation of these diversions. In 2009, The National Oceanic Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) presented the State Water Board with information that water withdrawn from the Russian River for frost protection of agricultural crops poses a threat to federally threatened and endangered salmonids in the Russian River watershed. They documented two episodes of fish stranding mortality that occurred in April 2008, one on Felta Creek in Sonoma County and the second on the mainstream of the Russian River near Hopland in Mendocino County (Draft EIR Russian River Frost Protection Regulation, 2007). NOAA Fisheries requested the State Board take regulatory action immediately to regulate diversions for frost protection to prevent salmonid mortality. The State Board is currently considering regulatory action that would deem any diversions for frost protection from March 15 through May 15 unreasonable, unless approved by the State Water Board through the completion of an extensive Water Demand Management Program (WDMP). In February 2012, the Courts granted a stay of the State Board regulations that declare frost protection diversions unreasonable in Mendocino and Sonoma Counties.

Faced with this future regulatory consideration, farmers in the Ukiah area are looking for alternative water supplies to sustain their agricultural practices. In addition to this, during dry years water service providers in the surrounding area are limited on the amount of water they can withdraw from the River and Lake Mendocino. Developing recycled water supplies in the Ukiah Valley and surrounding area would increase the overall water supply and its reliability under a range of hydrologic conditions.

The recycled water supply that is being considered under this study is the treated wastewater effluent of the UWWTP. While water users are being limited by the water they can take out of the River, the City is limited on the treated effluent they can put in the River. The City must comply with increasingly stringent discharge requirements that regulate both the volume and quality of the water that can be discharged to the Russian River. As a result, when discharging to the River, the City currently discharges very high quality effluent that meets recycled water needs. Limited on the volume and time at which treated effluent can be discharged, the City could benefit from additional disposal alternatives including delivery of recycled water to irrigation customers.

This report includes the City's plan for implementing recycled water use in the City of Ukiah and surrounding area. This report follows the July 2008 State Water Resources Control Board Water Recycling Funding Program Guidelines. These guidelines can be found on the Board's website at the following website:

http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/final_wrfpguidelines071508.pdf.

1.2 VISIONING WORKSHOP

The City of Ukiah held a visioning workshop on February 28, 2011 early in the master planning process to ensure the RWMP aligned with the goals and values of the City and other potentially affected interests. To ensure the master plan addressed both local and regional issues and provided local and regional benefits, the City of Ukiah invited City engineering, planning, management, and operations staff, water service providers in the surrounding area from Redwood Valley to Willow County Water District, and agricultural entities to partake in the visioning workshop. Attendees included representatives from the following entities:

- City of Ukiah
- Ukiah Valley Sanitation District
- Mendocino County Russian River Flood Control and Water Conservation Improvement District
- Mendocino County Farm Bureau
- Millview Water District
- Rogina Water District
- Willow Water District
- Redwood Valley Water District

The group discussed values and challenges pertaining to the RWMP and identified several goals and objectives. Some of the identified goals and objectives included:

- Implementing a recycled water program that is safe and meets the needs of the City and surrounding communities, including local agricultural businesses.
- Reducing withdrawals from the Russian River and Lake Mendocino surface waters.
- Implementing a program that is financially viable and minimizes costs to ratepayers.

It was agreed during the workshop that implementing recycled water anywhere within Ukiah Valley and the surrounding area would improve the regional water supply from Redwood Valley to Hopland. The attendees also identified major water uses located near the recycled water source – the UWWTP.

1.3 STUDY AREA

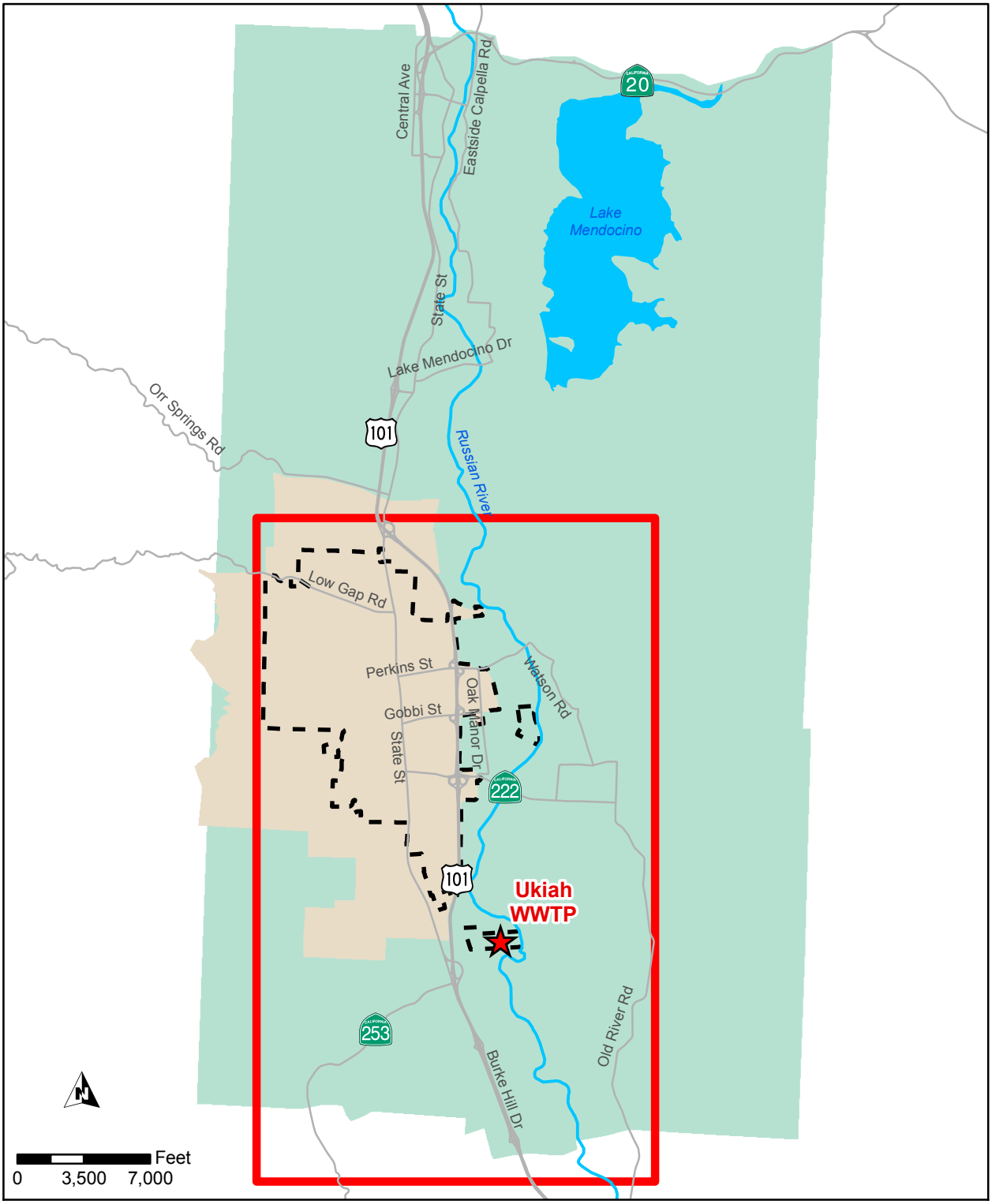
As described above, at the onset of the recycled water master planning effort, the City considered the water needs within the entire Ukiah Valley and surrounding areas. Understanding that implementing recycled water anywhere in the Valley would have regional benefits and that minimizing project costs was a major objective, the City narrowed the focus of the master planning effort to the area surrounding the UWWTP. A major cost of recycled water programs can be the infrastructure associated with distributing the water to recycled water customers. The closer the customers are to the source, less distribution is needed, which leads to a more cost effective program.

Through the visioning workshop and preliminary GIS analysis, the City identified major water users within a reasonable distance of the UWWTP and determined a study area that included those users. Figure 1.2 illustrates the RWMP Study Area. For reference, the figure also illustrates the City limits, the City Sphere of Influence (SOI), and the City Planning Area (General Plan).

The City's General Plan, adopted in December 1995 and revised in 2004, identifies boundaries associated with two planning areas: the incorporated area within the City limits and the unincorporated area, which is a combination of the Sphere of Influence (SOI) and an additional planning area. The City limits include the land currently within the City of Ukiah. The City's SOI represents the land limits to which the City may extend its services and project its growth over the next 20 years. The SOI must be adopted by the Local Agency Formation Commission (LAFCo) if the City wants to consider annexing land area. For comprehensive policy planning, the City's General Plan also incorporates an additional planning area, which encompasses the surrounding Ukiah Valley and includes the City of Ukiah. The planning area encompasses land area which is unlikely to be annexed by the City within the next 20 years, including rural communities Calpella, Talmage, and the Forks, and the North State Complex – a central point of business and commerce for portions of the unincorporated County (City General Plan).

1.4 HYDROLOGIC FEATURES

The City of Ukiah and the surrounding area are located in the Ukiah Valley groundwater basin (Basin). For planning purposes, the Department of Water Resources (DWR) has subdivided the State of California into ten separate hydrologic regions, corresponding to the State's major drainage basins. The Ukiah Valley groundwater basin (Number 1-52 as described in DWR Bulletin 118) is located in southeastern Mendocino County and is the largest basin along the Russian River. The Basin is approximately 22 miles long and 5 miles wide, and underlies Ukiah Valley and Redwood Valley, an area over sixty square miles. The groundwater is hydraulically connected to and interacts with surface water flows.



Legend

- Major Streets
- Major Water Way
- Major Water Body
- Recycled Water Master Plan Study Area
- City Limits
- Sphere of Influence
- General Plan Planning Area

Figure 1.2
RECYCLED WATER MASTER PLAN STUDY AREA
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Major surface waters in the Ukiah area include the Russian River and Lake Mendocino. The River flows from North to South through the Ukiah Valley. Lake Mendocino is a large reservoir located northeast of the City of Ukiah. The Lake was formed in 1958 with the construction of Coyote Dam. In addition to these hydrologic features, there are a number of minor streams and creeks that flow through the Ukiah area. In the past, the City has managed surface runoff by channelizing creeks passing through the downtown area. For many years, the pear orchards and vineyards along the river have served as de facto detention basis and floodwater storage areas for the City's and County's urbanized land uses (City General Plan) Figure 1.3 illustrates the hydrologic features in the Ukiah area.

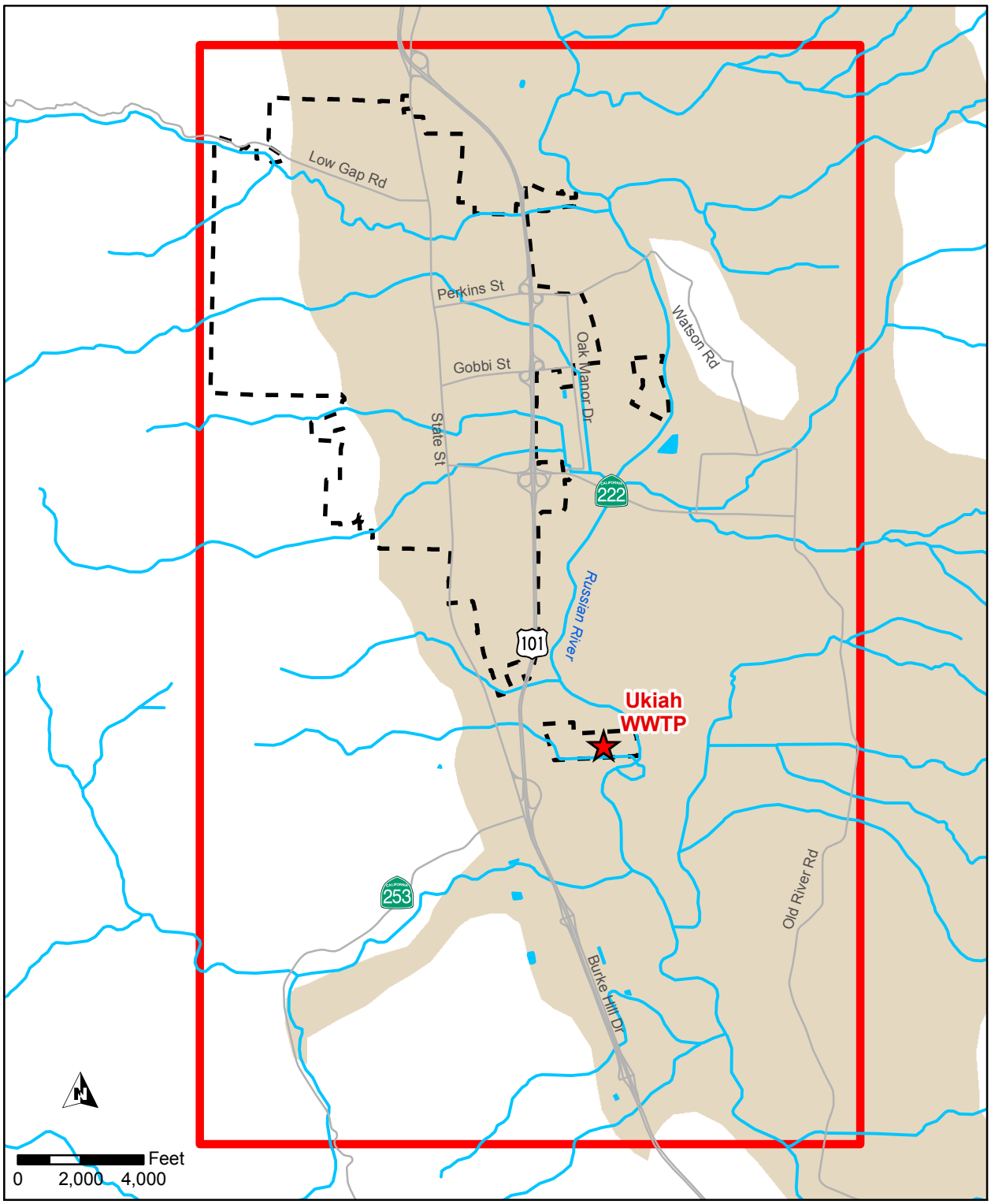
1.5 LAND USE AND POPULATION

Land use within the City of Ukiah is predominantly residential, rural residential, and commercial, while land use in the remaining portions of the RWMP Study Area is predominantly agricultural and rural residential with some industrial areas. Figure 1.4 illustrates the land use within the RWMP Study Area. A majority of the agricultural land is grape vineyards and pear orchards. Residential land use is generally located west of the Russian River (City of Ukiah General Plan, 2004).

The UWWTP is the primary source of recycled water considered under this plan. The wastewater supply conveyed to the UWWTP, that is ultimately available for recycled water reuse, is directly impacted by the population served by the UWWTP – the City of Ukiah. The incorporated City of Ukiah has a population of approximately 15,612 as of January 1, 2010[1], and represents approximately 18 percent of Mendocino County. The median annual growth rate between 1995 and 2010 was approximately 0.4 percent, although the City experienced a net decrease from its 2003 population of 15,942. The City population increased by 0.1 percent between 2009 and 2010.

Population projections, shown in Table 1.1 were included in the City's 2010 Urban Water Management Plan and were used to forecast water requirements for the City. Historical population statistics shown on Figure 1.5 are from California Department of Finance (DOF) estimates. These population projections pertain to the population served by the City's water distribution system. The SOI defined in the General Plan represents the ultimate limits to which the City will extend its water services over the next 20 years. The most recent population projection for the City of Ukiah was included in the 2010 Mendocino County General Plan, in which the annual population growth for the City is estimated at one percent through 2020. Based on this most recent estimate by the County, recent periods of slow growth, population decline, future annexation plans, and that build out is expected to occur by 2015; the annual population was projected in the Urban Water Management Plan to increase by 1 percent between 2015 and 2035. A population increase will result in increased wastewater supplies available for recycled water reuse.

[1] California Department of Finance.



Legend

- Major Streets
- Water Way
- Water Body
- Recycled Water Master Plan Study Area
- Ukiah Valley Groundwater Basin
- City Limits

Figure 1.3
HYDROLOGIC FEATURES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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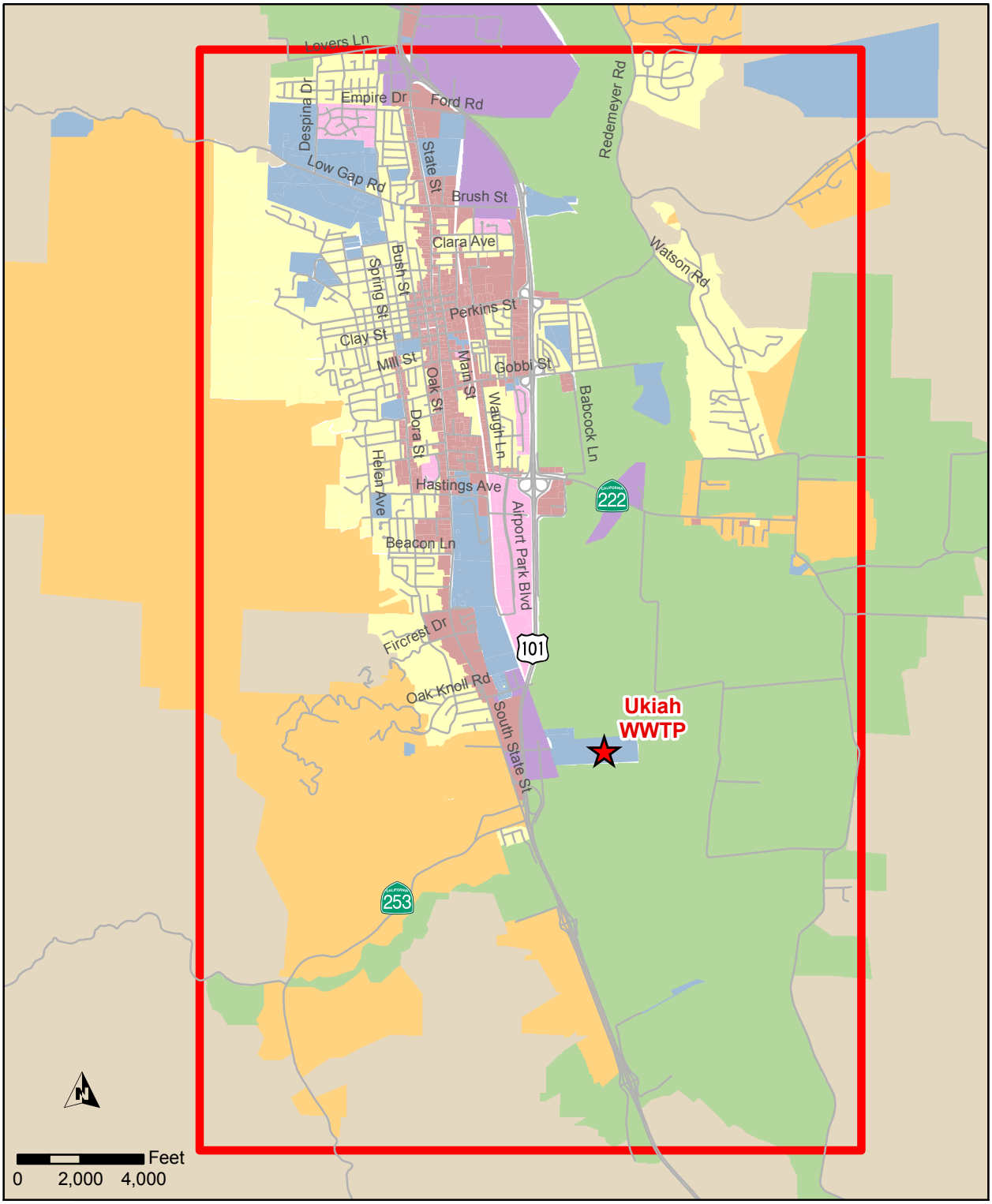

Legend

- Streets
- Recycled Water Master Plan Study Area

Land Use

- Agriculture
- Commercial
- Industrial
- Planned Development
- Public Facilities
- Rangeland
- Residential
- Rural Residential

Figure 1.4
LAND USE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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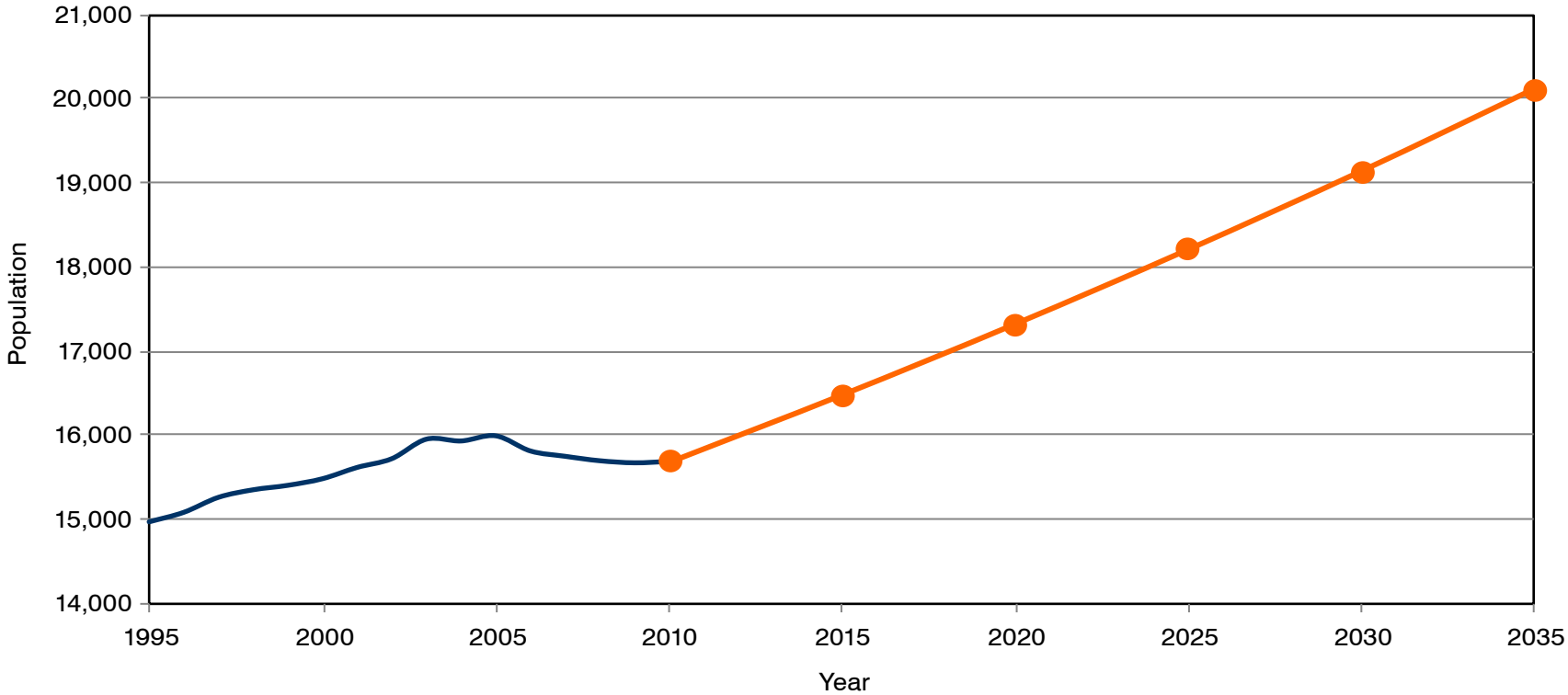

LEGEND
Historical Population(1)
Projected Population(2)

Notes:
(1) Source: California Department of Finance
(2) Source: 2010 Mendocino County General Plan

Figure 1.5
HISTORICAL AND PROJECTED POPULATION
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Table 1.1 Current and Projected Population
Recycled Water Master Plan
City of Ukiah

Years	2010	2015	2020	2025	2030	2035	Data Source
Service Area Population[1]	15,682	16,482	17,323	18,206	19,135	20,111	Source[2]

Notes:
(1) Service area population is defined as the population served by the water distribution system.
(2) Projected estimates based on expected population growth from the Mendocino County General Plan, adopted March 2010. An annual growth rate of one percent was used.

WATER SUPPLY CHARACTERISTICS AND FACILITIES

2.1 WATER SOURCES

A combination of water supplies are used to meet the needs of the Ukiah Valley area, namely groundwater, surface water from the underflow of the Russian River, and project water available from the Mendocino County Russian River Flood Control and Water Conservation Improvement District.

2.1.1 Overview of Water Sources

The Ukiah Valley area includes four major watersheds: Ukiah Valley, Redwood Valley, Potter Valley, and Hopland Valley. These watersheds are shown in Figure 2.1.

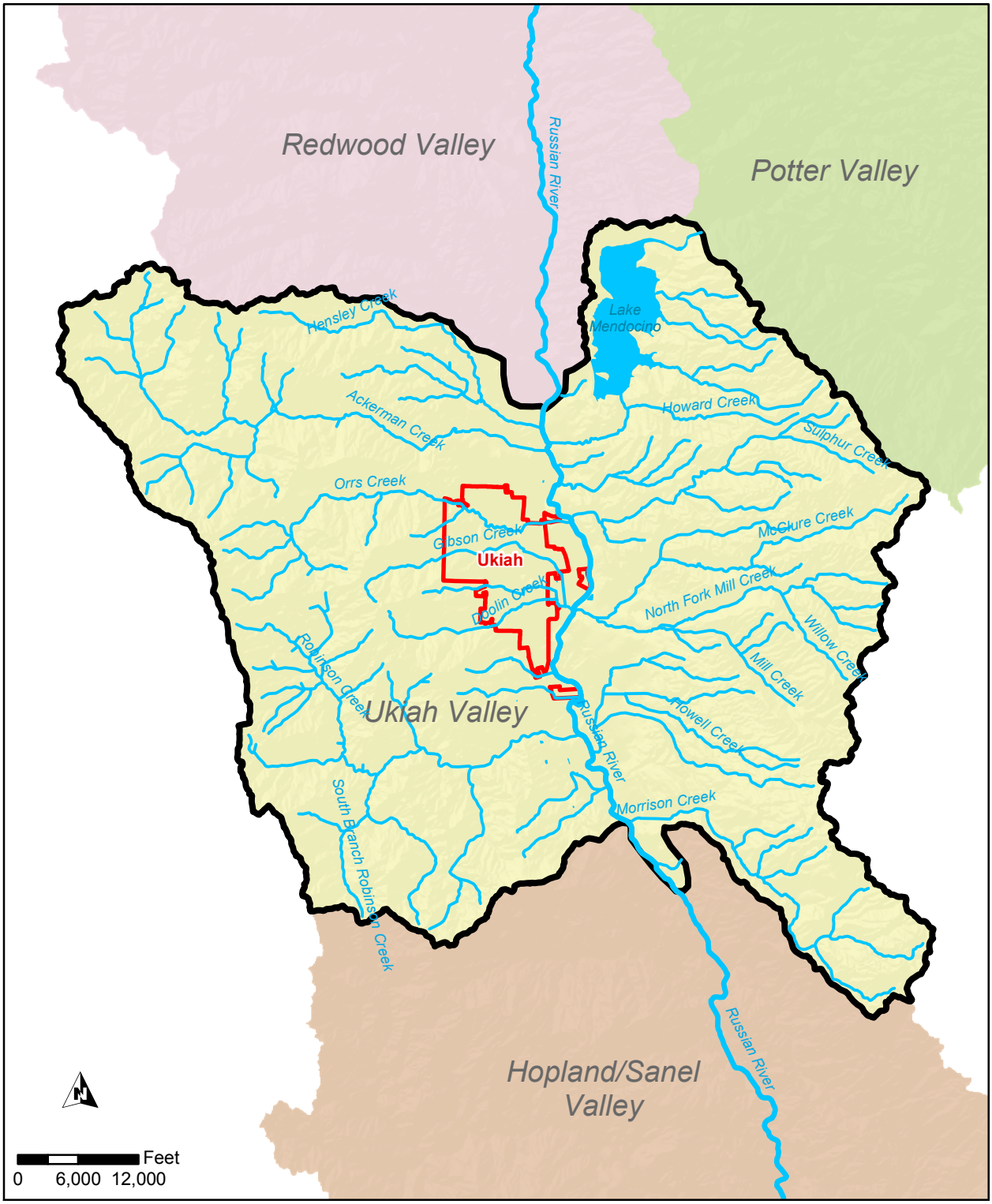
2.1.2 Surface Water

Surface water sources in the Ukiah Valley and surrounding areas (including Redwood Potter, and Hopland Valleys) include the Russian River, the Potter Valley Hydroelectric Project (PVP), and Lake Mendocino. These three sources are the Ukiah area's primary water supply and provide significant recharge of the Ukiah Valley Groundwater Basin (Mendocino County Water Supply Assessment, 2010).

Historically, the Russian River has had high flows in the winter and spring and low or no flows in the summer and fall; however, the construction of the Coyote Dam and Lake Mendocino in 1959 transformed the Russian River into a perennial surface water which has supported agricultural and urban development in Ukiah Valley.

The Potter Valley Hydroelectric Project began operating in 1912 and includes two water impoundments along the Upper Eel River and a diversion tunnel and powerhouse located along the East Fork of the Russian River. Waters from the project are ultimately discharged to the East Fork which runs through Potter Valley and to Lake Mendocino. The PVP has turned the East Fork into a perennial stream, which has allowed agricultural and urban development in Potter Valley.

Lake Mendocino and Coyote Valley Dam is a federal facility that was constructed by the United States Army Corps of Engineers (USACE) in 1959. It is located along the East Fork of the Russian River about three miles north of Ukiah. Lake Mendocino is the Valley's primary water storage facility providing storage for flood control, municipal and industrial water supplies, recreation, and power generation. Lake Mendocino has a maximum storage capacity of 122,000 acre-feet (af), of which 50,000 af is reserved for flood control purposes. The remaining portion is potentially available for water supply storage (Mendocino County Water Supply Assessment, 2010).



Legend

- Waterway
- Water Body
- City Limits

Watersheds

- Ukiah Valley
- Potter Valley
- Redwood Valley
- Hopland/Sanel Valley

Figure 2.1
UKIAH VALLEY AND NEIGHBORING WATERSHEDS
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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2.1.3 Groundwater

In addition to surface water, groundwater is a major water source for municipal and industrial use. As mentioned in Chapter 1, the Ukiah Valley Groundwater Basin (Number 1-52 as described in DWR Bulletin 118) is located in southeastern Mendocino County and is the largest basin along the Russian River. The Basin is approximately 22 miles long and 5 miles wide, and underlies Ukiah Valley and Redwood Valley. This basin is not adjudicated.

The United States Geological Survey (USGS) published a Water Resources Investigation Report 85-4258 in 1986 on the Groundwater Resources in Mendocino County, California (USGS Investigative Report). Storage capacities and groundwater elevations within the Basin were evaluated in the USGS Investigative Report. USGS concluded that groundwater wells in the Basin, monitored over a 30-year period, show no prominent long-term declines. In addition, hydrograph analysis indicates that the Basin is recharged fully each year except when precipitation falls below 60 percent of normal.

DWR Bulletin 118 suggests that groundwater in storage is approximately 90,000 af in the upper 100 feet of the most productive area of the Ukiah Valley, and an additional 45,000 af within the margins of the Ukiah Valley. Therefore, the volume of water available from pumping from the upper 100 feet of the most productive portion of the aquifer is estimated at 90,000 af. Groundwater is hydraulically connected to and interacts with surface flows.

2.2 WHOLESALE AND RETAIL ENTITIES

Water service providers in the Ukiah Valley include:

- Mendocino County Russian River Flood Control and Water Conservation Improvement District (RRFC)
- Calpella County Water District
- Millview County Water District
- The City of Ukiah
- Rogina Water Company
- Willow County Water District
- Redwood Valley County Water District
- Hopland Public Utility District

The service area of each of these entities is illustrated on Figure 2.2.

Property owners without access to the City or one of the district systems obtain water from individual wells or springs (Mendocino County Water Supply Assessment, 2010).

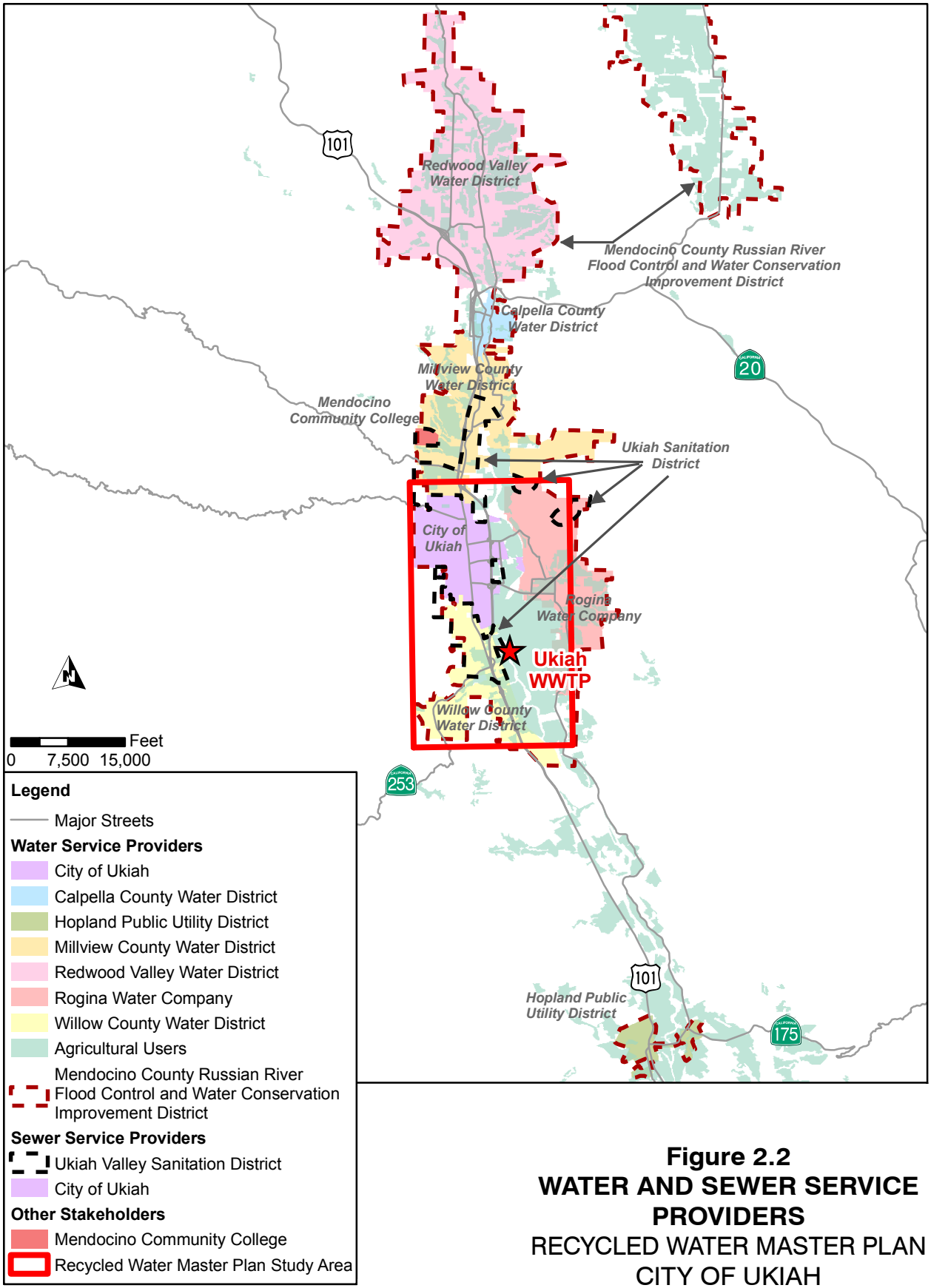

Figure 2.2
WATER AND SEWER SERVICE PROVIDERS
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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2.2.1 RRFC

The RRFC is a wholesale water provider of water to Mendocino County for domestic, municipal, irrigation, and recreational purposes. The RRFC holds Water Right Permit 12947B for storage and use of up to 8,000 af per year. This water supply includes water stored in Lake Mendocino and water directly diverted from the East Fork of the Russian River. The water is sold to public water systems for urban use and to private agricultural entities for irrigation and frost protection. Of the 8,000 af provided each year, only 500 af has yet to be contracted to public water systems and entities. Water that is not contracted is currently sold to Redwood Valley County Water District for municipal and agricultural use.

2.2.2 The City of Ukiah

The City of Ukiah is the largest public water service provider in the Ukiah Valley, providing roughly half of Ukiah Valley's public water supply (Mendocino County Water Supply Assessment, 2010). The City's water supply sources include groundwater, surface water from the underflow of the Russian River, and project water available from the RRFC. During dry periods, when surface and underflows are insufficient the City can purchase up to 800 af of water annually from the RRFC per Water Right Permit 12947B.

2.2.3 Other Water Service Providers

The other water surface providers listed above use a combination of the following water supplies:

- Surface water diverted from the Russian River
- Surface water diverted from Lake Mendocino
- Groundwater
- Water supply contracts with the RRFC

2.3 WATER RIGHTS

Both public and individual agricultural entities have water rights to divert surface water from the Russian River. Appropriate water rights to Lake Mendocino were established on January 28, 1949 and from that point forward, appropriate water rights to Russian River drainage were grouped into three major categories: Pre-1949 rights, Lake Mendocino Rights and Post-1949 rights (Mendocino County Water Supply Assessment, 2010).

2.3.1 Pre-1949 Water Rights

Pre-1949 water rights include approximately 8,000 af that is primarily comprised of direct diversions from the Russian River. These rights are subject to the availability of stream flows during authorized diversion seasons, i.e., water right holders only have water supply if there is stream flow.

Many agricultural entities in the upper Valley have Pre-1949 rights and rely on these rights to supply irrigation and frost protection waters to their crops.

2.3.2 Lake Mendocino Water Rights

Lake Mendocino rights allow for substantial storage of water in Lake Mendocino to accommodate water needs during dry periods. Consequently, there are times when all, or nearly all, of the Russian River flow is attributed to Lake Mendocino releases and the water rights associated with Lake Mendocino. These rights allow diversions from Lake Mendocino even in times when little or no water is legally available to Pre-1949 water right holders. As a result, these water rights make Lake Mendocino an essential water supply source during dry and critically dry years.

2.3.3 Post-1949 Water Rights

Post-1949 rights are junior to Pre-1949 and Lake Mendocino rights. Consequently, during extended or critically dry periods, Russian River flows may be to low to legally exercise these rights.

2.3.4 Water Rights of Public Water Providers

The RRFC has Pre-1949 rights; the City of Ukiah has a combination of Pre-1949 and Post-1949 rights; and the Millview County Water District and Willow County Water District have Post-1949 water rights (Russian River Division of Water Rights 2005).

2.3.5 Legislation and Water Rights

Water availability for all users in Mendocino County is an increasingly contentious and acute issue. Regulations and policies are being implemented In part to reduce impacts to instream habitat, including critical habitat for chinook salmon and steelhead trout in the Russian River. The California State Water Resources Control Board required water purveyors in the Russian River to reduce their water use by 15%. In addition to this, the state passed Assembly Bill 2121 (AB2121) in 2004, which added Water Code section 1259.4 and required the SWRCB to implement guidelines to maintain instream flows in northern California Coastal streams (Mendocino Irrigated Agricultural Water Needs and Management, 2008).

There is concern that the Russian River waters are fully allocated, with no water remaining for future water rights applicants. As a result, agricultural applications for water rights are

being delayed by the SWRCB, in some cases, for over a decade (Mendocino Irrigated Agricultural Water Needs and Management, 2008).

In addition to the lack of water available for future water rights, existing water rights may be further regulated. AB2121 may prohibit Russian River underflow diversions. While this does not impact water rights holders located along the main stem of the Russian River, this will impact water rights holders located along the tributaries of the River.

As discussed in Chapter 1, the National Oceanic and Atmospheric Administration's National Marine Fishers Service has requested the SWRCB address concerns that water diversions from the Russian River stream system for purposes of frost protection of crops will cause significant salmonid mortality. In response to this, the SWRCB is proposing regulation that would provide that diversions from the Russian River stream system for purposes of frost protection from March 15 through May 15 are unreasonable, unless they are in accordance with a Water Demand Management Program (WDMP) approved by the State Water Board. In order to be approved the WDMP would be required to include: (1) an inventory of the frost diversion systems within the area subject to the WDMP, (2) a stream stage monitoring program, (3) an assessment of the potential risk of stranding mortality [of salmonids] due to frost diversion, (4) identification and implementation of necessary corrective actions, and (5) an annual reporting program. The SWRCB is scheduled to hold a public hearing to receive comments and to consider adopting a proposed Russian River frost protection regulation on September 20, 2011.

If the regulation is adopted, agricultural entities may lose the right to divert water from the Russian River for frost protection from March 15 – May 15. While frost season typically occurs from March through May, this regulation could be detrimental to the Ukiah Valley agricultural industry if additional water supplies are not secured for frost protection. (Mendocino Irrigated Agricultural Water Needs and Management, 2008) (SWRCB Notice of Proposed Frost Protection Regulation Hearing, 2011)

2.4 BENEFITS OF RECYCLED WATER USE

Implementation of recycled water in the Ukiah Valley area could provide several regional water resource benefits. Not only could it be used for frost protection to sustain the local agricultural industry, it could also be used for agricultural irrigation and urban irrigation. Any amount of recycled water reuse in the area will decrease water that is diverted from the Russian River and Lake Mendocino. In making more water available in these surface waters, water service providers, including those with junior water rights, will have a more reliable water supply over a wider range of hydrologic conditions.

2.5 CITY OF UKIAH WATER FACILITIES

The City's water supply facilities include five active wells and a Ranney Collector. Table 2.1 below provides a summary of the water supply sources, including description of the type of supply source for each facility.

Table 2.1 Water Supply Sources[1]
Recycled Water Master Plan
City of Ukiah

Facility	Type of Supply	Current Status	Production Capacity (GPM)
Ranney Collector[2]	Surface water	Active	3,194
Well #3	Groundwater influenced by surface water	Active	600
Well #4	Groundwater	Active	799
Well #5	Groundwater influenced by surface water	Active	300
Well #7	Groundwater	Active	799
Well #8	Groundwater	Active	694
		Total Active Well Capacity (GPM)	**6,386**
		Total Active Well Capacity (AFY)	**10,308**

Notes:
(1) Source: City staff records.
(2) The Ranney Collector can only be used during the dry season when surface water turbidity is low.

The City's surface water is obtained from the Ranney Collector and Wells 3 and 5, which draw water from an alluvial zone along the Russian River. Water taken from these sources is considered under the influence of surface water by the California Department of Public Health (DPH). Accordingly, water diverted from the Ranney Collector and Wells 3 and 5 is classified as surface water. The City also draws groundwater from Wells 4, 7, and 8.

2.6 AGRICULTURAL WATER FACILITIES

Agricultural farmers within the area maintain their own onsite pumping and distribution systems to supply water to their crops. Depending on their access and water rights, they rely on water from the Russian River and its tributaries as well as groundwater. Some farmers maintain onsite storage ponds. With this storage, farmers are able to divert flows during low demand seasons when river flows are high (e.g., the winter) and store the water for future use during high demand seasons when river diversions are more restricted (e.g., frost season).

Farmers typically have two types of distribution systems: one for irrigation, and a second for frost protection. The irrigation system usually includes a small, electric pump(s) that distributes water to one irrigation block at a time and rotates through each irrigation block. The frost protection system usually includes a lager pump(s) that distributes water to the entire lot at one time.

2.7 GROUNDWATER MANAGEMENT, RECHARGE AND OVERDRAFT PROBLEMS

2.7.1 Groundwater Management Plan

A groundwater management plan has not been prepared for the City, Ukiah Valley, or Mendocino County. In the future, the City may consider coordination with other agencies within the Basin to develop a more comprehensive groundwater management plan.

2.7.2 Groundwater Levels and Historical Trends

In general, the Basin experiences seasonal and year-to-year variation in groundwater elevations due to relative rainfall and pumping, as described in Bulletin 118 and the USGS Investigative Report. However, these variations tend to be small and water levels, in general, recover.

Groundwater elevations fluctuate seasonally, being the highest level in March or April at the end of the wet season and lowest in October at the end of the dry season. Seasonal fluctuations range on the order of about 5 to 20 feet. Long-term measurements are taken and recorded from several wells within the Ukiah Valley.

The USGS Investigative Report found that, from the available hydrographs of the Basin, none of the hydrographs show prominent long-term declines. In fact, water levels measured during the 1980s are similar to those measured during the 1960s and 1970s.

DWR Bulletin 118 concurs with this assessment. According to Bulletin 118, groundwater levels in the Basin have remained relatively stable in the past 30 years. As expected, there is increased drawdown during summer months and less recovery in winter months when the area experiences drought conditions. Post-drought groundwater conditions rebound to approximately the same levels as pre-drought conditions.

Based on historical information available for the Basin, groundwater supplies are expected to adequately meet existing and future demands.

2.7.3 Groundwater Overdraft

The current and historical groundwater trends for this Basin indicate that there is no long-term decline in water levels that suggest water shortage or overdraft. The Basin is not considered to be in a state of overdraft by DWR, and is not projected to be in a state of overdraft in the near future.

2.8 WATER USE TRENDS

Table 2.2 summarizes the City's current and projected water supply sources, excluding potential, future recycled water sources. As shown in the table, the City's water supply is not expected to increase in the future.

Table 2.2 Water Supplies - Current and Projected[1]
Recycled Water Master Plan
City of Ukiah

Water Supply Sources		Projected Water Supply (AFY)					
Water purchased from:	**Wholesale Supplied Volume**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Project Water (Mendocino County Russian River Flood Control and Water Conservation Improvement District)	Yes	800	800	800	800	800	800
Supplier-produced groundwater[2]	No	3,705	3,705	3,705	3,705	3,705	3,705
Supplier-produced surface water[3]	No	14,480	14,480	14,480	14,480	14,480	14,480
Supplier-produced surface water (pre-1914 Rights)	No	2,027	2,027	2,027	2,027	2,027	2,027
Transfers In	No	0	0	0	0	0	0
Exchanges In	No	0	0	0	0	0	0
Desalinated Water	No	0	0	0	0	0	0
Total		**21,012**	**21,012**	**21,012**	**21,012**	**21,012**	**21,012**

Notes:
(1) Excluding potential, future recycled water sources.
(2) Based on groundwater pumping capacities provided by the City.
(3) Permit 12952 (Application 15704) authorizes diversion of 20 CFS, with no annual limit. Therefore, the City's potential water right is reported above.

2.9 WATER COSTS

Current water costs are summarized in Table 2.3.

Table 2.3 Current Water Costs Recycled Water Master Plan City of Ukiah	
Water Source	**Cost**
City of Ukiah Potable Water[(1)]	$963/acre-foot ($2.21/unit)
Water Purchased from RRFC	$47/acre-foot
Notes: (1) Based on July 2011 water rates (see table in appendix).	

2.10 QUALITY OF WATER SUPPLIES

As reported in the 2010 Urban Water Management Plan, water quality issues are not anticipated to have significant impact on water supply reliability. Unforeseen future occurrences of chemical contamination or the lowering of maximum contaminant levels (MCLs) for naturally-occurring constituents can be mitigated with proper treatment. If water quality becomes an issue for water supply reliability in the future, the City will evaluate the need for upgrades to its current treatment system or construction of a new water treatment facility.

The City continually takes the necessary steps to comply with existing and future groundwater quality regulations and to continue to provide reliable water service to its residents.

2.11 PLANS FOR NEW FACILITIES OR ADDITIONAL WATER SOURCES

There are no current plans in the Ukiah Valley for new water facilities or additional water sources. As discussed in the Urban Water Management Plan, the City's firm water supply capacity is approximately 43 percent higher than the maximum projected demand through 2035. The total current supply capacity is 65 percent higher than projected 2035 demands. Therefore, the City has no planned projects to increase its water supply production capacity. Maintenance and well replacement projects may be performed on an as-needed basis.

WASTEWATER CHARACTERISTICS AND FACILITIES

3.1 WASTEWATER ENTITIES

There are several wastewater entities in the Ukiah Valley; however this study focuses on two wastewater entities – The City of Ukiah and the Ukiah Valley Sanitation District (UVSD) – because these two entities collect the wastewater flows that can potentially be used to provide recycled water to the Valley. The City of Ukiah and the UVSD provide sewerage collection and treatment services for a population of about 20,000 residential, commercial, and industrial customers.

3.2 WASTEWATER COLLECTION SYSTEM FACILITIES

The City collection system receives wastewater from about 82 percent of the City's service area and serves about 75 percent of the City's population. The UVSD serves the remaining portion of the City's service area and about 25 percent of the City's population, as well as an additional 5,000 residential customers from the urban areas surrounding the City. Both collection systems convey the collected wastewater to the Ukiah Wastewater Treatment Plant (UWWTP).

3.3 WASTEWATER TREATMENT FACILITIES

The Ukiah Wastewater Treatment Plant (UWWTP) is owned and operated by the City. The UWWTP includes primary, secondary, and tertiary treatment facilities, as well as solids handling facilities. The tertiary treatment facilities are referred to as the Advanced Wastewater Treatment (AWT) System. Table 3.1 summarizes the treatment capacity of the UWWTP and Table 3.2 summarizes the major components of the UWWTP facilities.

Table 3.1 Treatment Capacity of UWWTP
Recycled Water Master Plan
City of Ukiah

Design Flow Criterion	Units	Secondary Treatment	AWT System[1] (Tertiary Treatment)
Average Dry Weather Flow (ADWF)	mgd	3.01	N/A[2]
Average Wet Weather Flow (AWWF)	mgd	6.89	4
Peak Wet Weather Flow (PWWF)	mgd	24.5	8

Notes:
(1) The Advanced Wastewater Treatment (AWT) Facility produces effluent that meets Title 22 recycled water requirements.
(2) The AWT system is not operated during dry weather flows.

Table 3.2 Major Components of UWWTP Facilities Recycled Water Master Plan City of Ukiah		
Primary and Secondary Treatment Facilities	**AWT System (Tertiary Treatment Facilities)**	**Solids Handling Facilities**
• Influent pump station • Bar screen facility and grit removal system • Primary clarifiers • Trickling filter pump station and trickling filters • Solids contact tanks • Secondary clarifiers • Chlorine disinfection system • Effluent pump station	• AWT pump station • Coagulation system • Tertiary multimedia filters and backwash pump station • Chlorine contact basins • Dechlorination system	• Dissolved air flotation thickeners • Anaerobic digesters • Belt filter press for dewatering

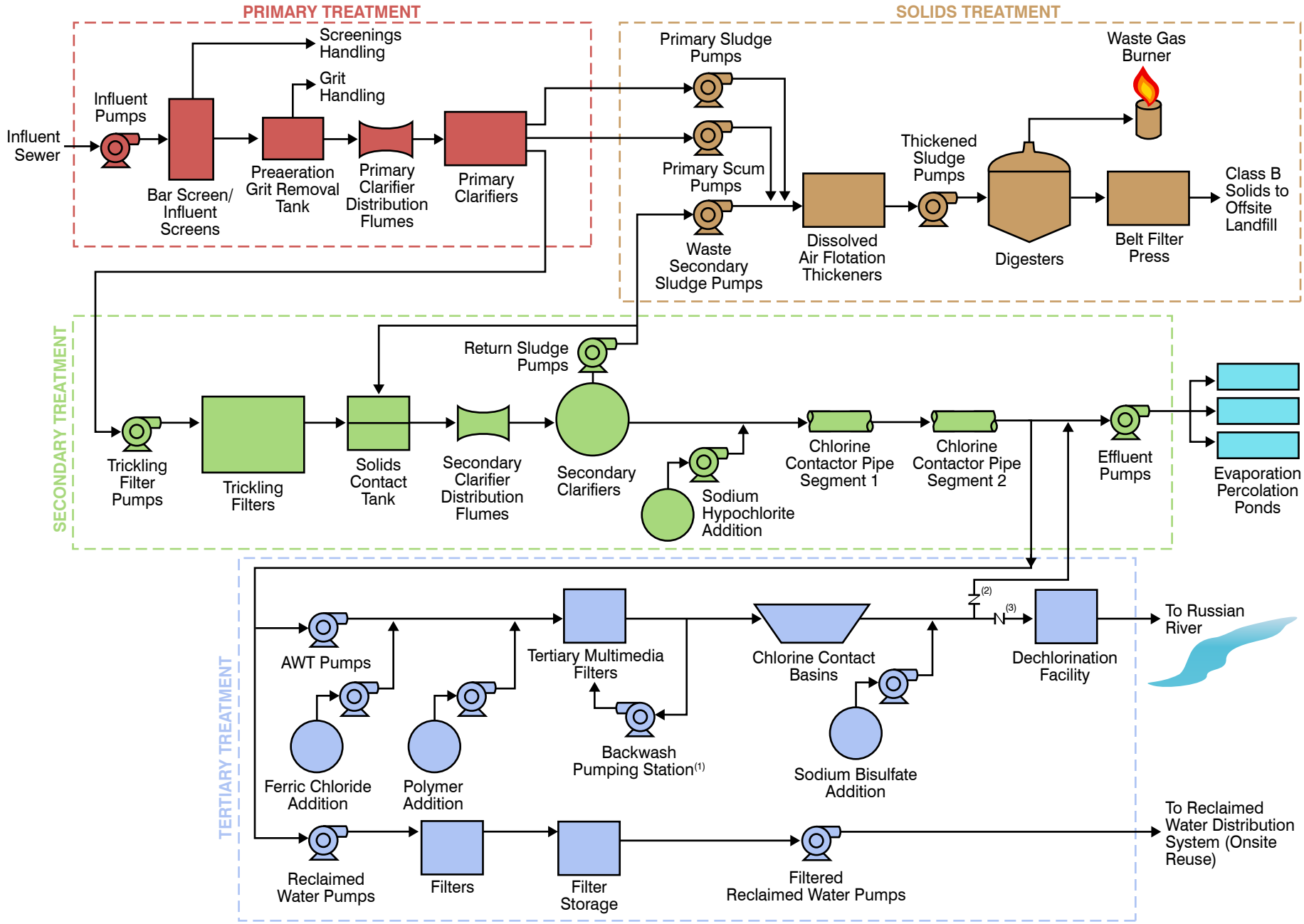
3.3.1 Treatment Process Description

A process flow diagram of the existing liquid and solids handling facilities is presented in Figure 3.1.

The UWWTP produces disinfected secondary effluent which is discharged to three percolation/evaporation ponds, and disinfected, dechlorinated tertiary effluent that is discharged to the Russian River. As shown in Figure 3.2, raw wastewater enters the plant through two gravity influent lines: one 42-inch influent line enters from the north, and one 18” influent line enters from the west. Wastewater entering the facility is pumped to influent screens and manually cleaned bar screens which remove large solids from the effluent. It then flows through a pre-aeration grit removal tank which removes grit and other solids from the flow. Screenings and grit slurry from the bar screens and grit tank are washed and discharged offsite.

The primary wastewater treatment process facilities include four primary clarifiers where additional solids settle from the effluent. Two primary sludge and two scum pumps pump sludge and scum to two dissolved air flotation thickeners for solids treatment, while four trickling filter pumps pump the clarified primary effluent to the trickling filters.

Secondary treatment is achieved with a fixed film biological treatment process followed by an activated sludge process. Primary effluent is pumped to the top of two trickling filters where it subsequently falls by gravity through the trickling filter media. A biofilm on the



Primary Treatment
Solids Treatment
Secondary Treatment
Tertiary Treatment

Notes:
(1) Includes backwash pumps and surface wash pump.
(2) Valve normally closed.
(3) Valve normally open.

Figure 3.1
UKIAH WWTP TREATMENT PROCESS SCHEMATIC
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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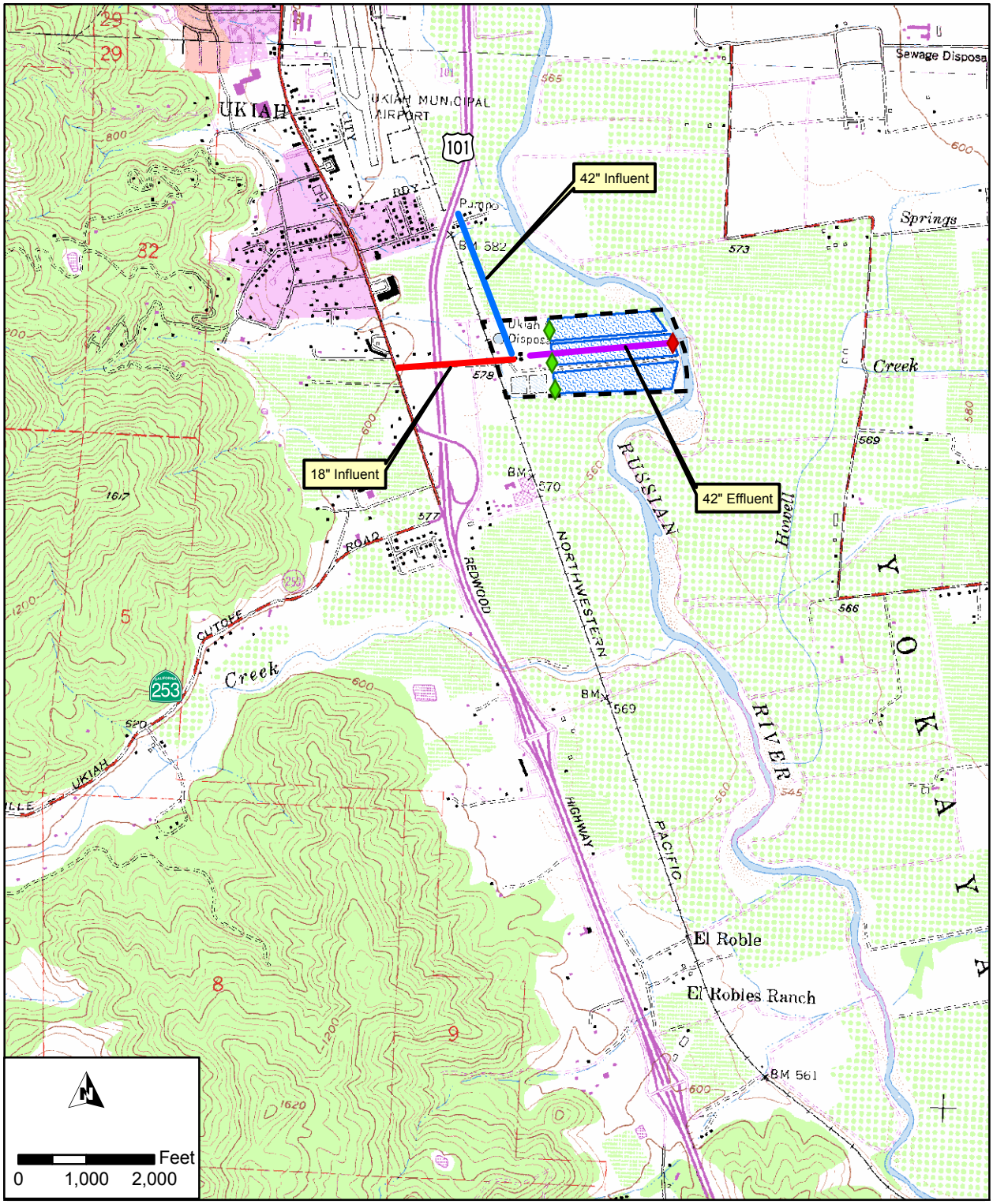

Legend

Pipelines

- 18" Influent
- 42" Effluent
- 42" Influent

- Discharge Point 001 - Russian River
- Discharge Point 002 - Percolation/Evaporation Ponds
- Ukiah WWTP

Figure 3.2
UKIAH WWTP OVERVIEW
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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surface of the media removes organic compounds from the primary effluent through absorption and adsorption. As the biofilm layer thickens, it sloughs off and passes with the trickling filter effluent to two aerated solids contact tanks. In the tanks, the flow undergoes further biological treatment through an activated sludge process. Effluent from the solids contact tanks then flows to two circular secondary clarifiers where solids settle from the effluent. Four pumps pump recycled activated sludge from the secondary clarifiers to the solids contact tank. A portion of the recycled activated sludge is wasted and pumped by waste secondary sludge pumps to the dissolved air flotation thickeners for further solids treatment.

Following secondary treatment, the effluent is chlorinated. The chlorine disinfection facilities include two chlorine contactor pipes and a sodium hypochlorite addition system. The effluent pump station, which includes two pumps, then pumps the disinfected secondary effluent to three evaporation/percolation storage ponds where the effluent ultimately evaporates or percolates through the bottom of the ponds. The City can discharge up to 4 million gallons per day (mgd) to the ponds which have a combined storage capacity of 115 million gallons (MG). To maximize percolation, the bottom of one pond per summer is alternately ripped to increase the ponds permeability.

A portion of the disinfected, secondary treated effluent undergoes additional filtration and is stored in storage units for various onsite reuse including: landscape irrigation, process washdown, and spray water. Approximately 300 – 325 af is reused onsite per year.

When the UWWTP is discharging effluent to the Russian River, all flows that are discharged to the river undergo tertiary treatment immediately following secondary treatment. Disinfected, secondary flows are pumped by three advanced water treatment pumps from the recycled water pump station to the Advanced Water Treatment System (AWT). Ferric chloride and polymer are added to the effluent as it is pumped to four tertiary, multimedia filters. Effluent from the filters then flows to two chlorine contact basins for disinfection. A sodium bisulfite feed pump dechlorinates the tertiary disinfected effluent as it flows by gravity to the Russian River discharge point. If needed, the tertiary disinfected effluent can be routed to the three evaporation/percolation ponds. The tertiary treatment facilities are further described in Table 3.3.

The solids handling facilities include: two dissolved air flotation thickeners and various ancillary pumps and equipment, three thickened sludge pumps, two anaerobic digesters and ancillary equipment, and a belt filter press. The solids handling facilities produces Class B solids that are disposed of at a landfill.

3.3.2 History of Expansions

The original wastewater treatment facility was constructed in 1958 and provided secondary treatment at an average dry weather flow capacity of 2.5 mgd and a peak wet weather flow capacity of 10.5 mgd. At that time, all treated effluent was discharged to the Russian River.

Table 3.3 Tertiary Facilities Design Criteria Recycled Water Master Plan City of Ukiah		
Element	**Existing[1]**	**Future**
Applied Water Pumps		
Type	Vertical Turbine	
Number	3	TBD
Capacity, each	4 mgd	
Polymer Feed System		
Storage Tote Capacity	275 gallon	
Number	1	TBD
Polymer Feed Pump Capacity	4.5 gph	
Flocculation Basins		
Number of basins	4	
Design capacity, each	2 mgd	TBD
Detention time	~ 14 min at 2 mgd	
Tertiary Multimedia Filters		
Number of filters	4	
Area, each	25 ft 9 in x 12 ft	
Anthracite media depth	18 inches	TBD
Sand, garnet sand, and gravel media depth	26.5 inches	
Capacity, at 5 gpm/sq ft, each	2 mgd	
Chlorine Disinfection		
Number of basins	2	
Design capacity, each	8 mgd	
Detention time	90 minutes	
Dose[2]	~ 5 mg/L	TBD
Dechlorination		
Type	In-pipe	
Dose	X mg/L	TBD
Effluent/Recycled Water Pumps		
Type	Vertical Turbine	
Number	3	
Capacity, each	360 gpm at 230 TDH	
Firm Capacity	720 gpm at 230 TDH	TBD

Notes:

(1) Source: California Regional Water Quality Control Board Order No. R1-2006-0049, NPDES No. CA0022888.

(2) Chlorine is dosed as needed for coliform removal.

The UWWTP has been expanded and upgraded several times since then. In 1983, the facility was expanded to increase the treatment capacity to an average dry weather flow capacity of 2.8 mgd and a maximum wet weather capacity of 7 mgd. In 1986, the third percolation/evaporation pond was constructed to increase the treated effluent storage capacity, and in 1989 an effluent pump station was constructed to convey secondary treated effluent to the third pond. In 1989, the Regional Water Quality Control Board (RWQCB) required tertiary treatment of all river discharges and secondary treatment for all

discharges to the evaporation/percolation ponds. To meet this requirement, the plant was upgraded again in 1995. The project included the construction of the fourth secondary clarifier, a new solids handling facility, and the AWT system, as well as upgrades to the headworks.

The most recent upgrade to the facility occurred in 2009 to expand the facility to its current treatment capacity and to upgrade the AWT system to meet Title 22 tertiary recycled water standards. This upgrade included a new headworks facility, a new bar screen facility and grit removal system, conversion of the existing secondary clarifiers to primary clarifiers, a new trickling filter pump station and upgrades to the trickling filters, conversion of the existing primary clarifiers to solids contact tanks, modifications to the chlorine disinfection facilities, and other miscellaneous upgrades.

3.3.3 Future Expansions

Although no expansion projects are planned for the near term, the City is expected to grow and the UWWTP will need to be expanded to accommodate this growth. In 2003, the City developed 2025 Design Criteria for the City's wastewater treatment capacity and projected that the total wastewater flows of the service area would increase steadily over the next few decades. The total flow in 2025 was projected to be approximately 6,363 AFY, equivalent to an average annual flow of about 5.7 mgd.

3.3.4 Water Recycling Facilities

The UWWTP's AWT system produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds. If operated at full capacity, the AWT could provide an average annual flow of 7 mgd given sufficient wastewater flows were available. Table 3.3 presents a summary of the tertiary treatment facilities design criteria.

3.4 EXISTING WASTEWATER QUALITY

The UWWTP's effluent discharges are regulated by a National Pollutant Discharge Elimination System (NPDES) permit – Order No. R1-2006-0049, NPDES No. CA0022888. The permit was adopted on September 20, 2006 and expires on November 9, 2011. Permit effluent limits are summarized in Table 3.4. A new permit is currently under negotiation and expected to be finalized in June 2012.

The UWWTP discharges disinfected secondary effluent to three percolation/evaporation ponds located at the UWWTP on a year-round basis, and discharges disinfected tertiary effluent to the Russian River as allowed during wet weather months. The UWWTP is only permitted to discharge disinfected tertiary wastewater to the Russian River from October 1

Table 3.4 Ukiah WWTP Effluent Limits in 2006 NPDES Permit[1]
Recycled Water Master Plan
City of Ukiah

Constituent	Units[2]	Effluent Limitations				
		Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Discharge Point 001 – Direct Discharge to Russian River[3][4][5]						
Biochemical Oxygen Demand (5 day at 20°C)[6]	mg/L	10	15	---	---	---
	lbs/day (wet weather)[7]	580	880	---	---	---
Total Suspended Solids	mg/L	10	15	---	---	---
	lbs/day (wet weather)[7]	580	880	---	---	---
pH	standard units	---	---	---	6.5	8.5
Nitrate (as N) [8]	mg/L	10	---	---	---	---
Copper[8]	µg/L	1.55	---	3.11	---	---
Dichlorobromomethane[8]	µg/L	0.56	---	1.1	---	---
Discharge Point 002 –Discharge to Evaporation/Percolation Ponds[9][10]						
Biochemical Oxygen Demand (5 day at 20°C)[6]	mg/L	30	45	60	---	---
Total Suspended Solids	mg/L	30	45	60	---	---
pH	standard units	---	---	---	6.0	9.0

Notes:

(1) Limits included in Waste Discharge Requirements Order No. R2-2006-0049, NPDES Permit No. CA0022888.

(2) Abbreviations: mg/L = milligrams per liter; µg/L = micrograms per liter.

(3) The advanced treated wastewater shall be adequately oxidized, filtered and disinfected as defined in Title 22, Division 4, Chapter 3, California Code of Regulations (CCR).

(4) The median coliform concentration shall not exceed a Most Probable Number (MPN) of 2.2 per 100 milliliters, using the bacteriological results of the last seven days for which analyses have been completed, nor shall the MPN exceed 23 per 100 milliliters in any sample.

(5) The effluent shall not contain detectable levels of total chlorine, any measureable settelable solids, or acute toxicity.

(6) The average monthly percent removal of BOD (5-day 20°C) shall not be less than 85 percent.

(7) Mass-based effluent limitations are based on the peak design flow of the AWT filters when the permit was issued (7.0 mgd).

(8) Limits presented are final effluent limits. Interim limits are: average monthly nitrate (as N) limit of 26.6, maximum daily copper limit of 30 µg/L, average monthly dichlorobromomethane limit of 0.68 µg/L, and maximum daily dichlorobromomethane limit of 1.1 µg/L. Interim copper and dichlorobromomethane limits were effective until May 18, 2010. Interim nitrate limitations shall be effective until September 20, 2011.

(9) The secondary treated wastewater shall be adequately oxidized and disinfected as defined in Title 22, Division 4, Chapter 3, CCR.

(10) The median coliform concentration shall not exceed a MPN of 23 per 100 milliliters, using the bacteriological results of the last seven days for which analyses have been completed, nor shall the MPN exceed 240 per 100 milliliters in any sample.

through May 14 at a discharge rate of up to one percent of the total Russian River flow. The Water Quality Control Plan for the North Coast Region (Basin Plan) prohibits the discharge of treated wastewater from the UWWTP from May 15 through September 30.

As mentioned above, the AWT system produces disinfected tertiary treated effluent suitable for recycled water use. This water is currently only produced during the river discharge season, October 1 through May 14.

3.5 ADDITIONAL FACILITIES NEEDED

No additional facilities are needed in the foreseeable future to comply with the existing waste discharge requirements.

3.6 PROBLEM CONSTITUENTS AND CONTROL MEASURES

There are no significant sources of industrial or problem constituents nor necessary control measures of such constituents at this time.

3.7 CURRENT AND PROJECTED WASTEWATER GENERATION

Table 3.5 includes the historical and projected wastewater flows collected and treated within the service area. Projected wastewater flows are based on actual wastewater flow data from 2001 – 2010 and population data and projections presented herein.

3.8 WASTEWATER FLOW VARIATIONS

Discharge of treated wastewater effluent is a critical component of the City's water balance. Wastewater flow and disposal varies seasonally, as depicted in Figures 3.3 and 3.4. During dry weather months, wastewater flows to the UWWTP are low enough that the full flow is stored in the percolation ponds. During these months, the AWT System is not in operation. During wet weather flows, the AWT System is operated to provide tertiary treatment of flows in excess of that which can be stored in the ponds. Flows in excess of that which can be stored in the ponds and that which can be discharged to the Russian River must be disposed of by other means including reuse of treated effluent onsite. The UWWTP currently reuses an average of about 0.3 mgd of treated effluent onsite (323 AFY). In recent wet years, the UWWTP has discharged the maximum flow that can be stored in the ponds and discharged to the river. As flows increase in the future, additional pond storages will be needed or an additional discharge alternative, such as distribution to recycled water customers, must be developed.

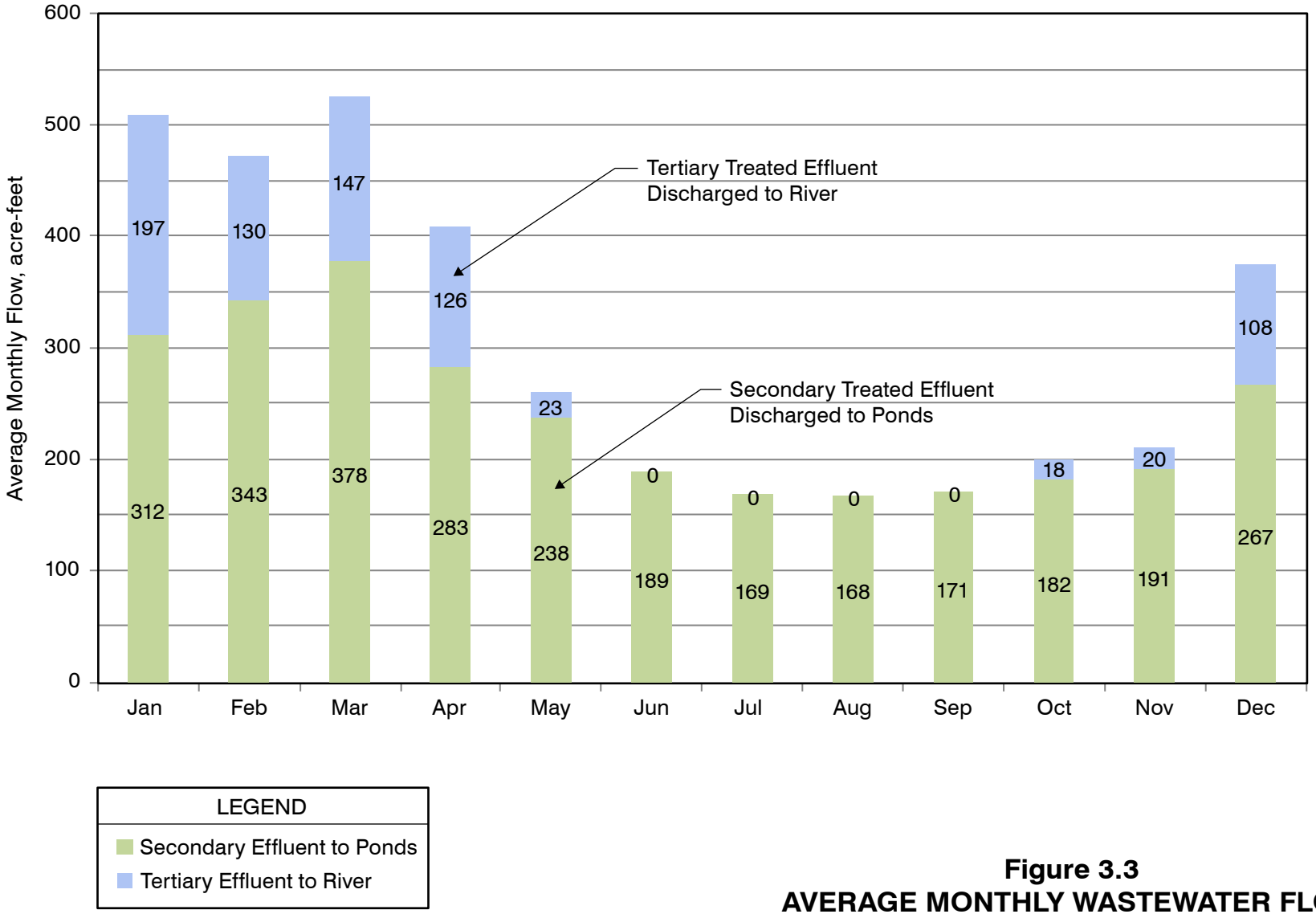

Figure 3.3
AVERAGE MONTHLY WASTEWATER FLOW IN ACRE-FEET FROM 2001 - 2011
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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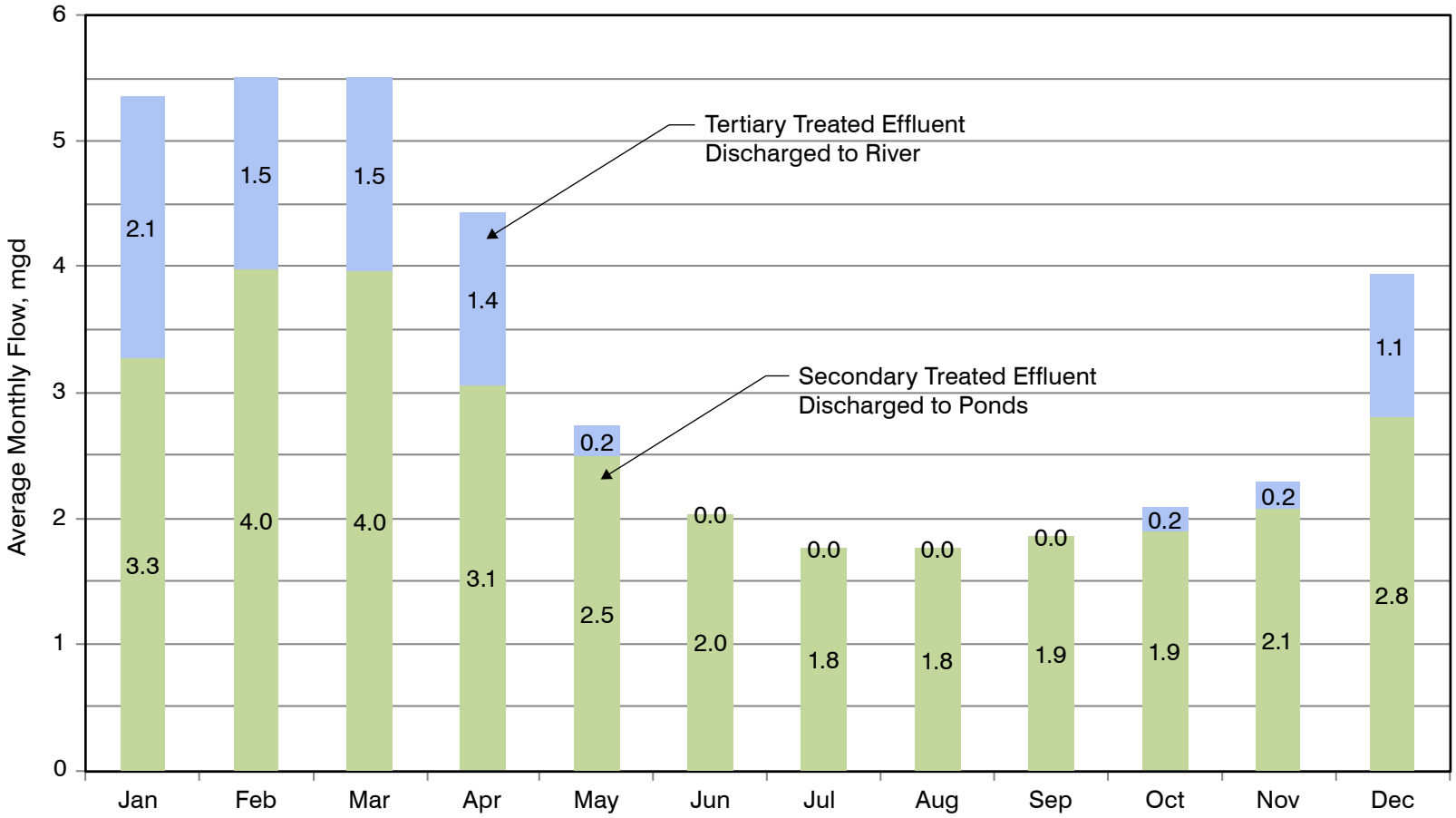

LEGEND
Secondary Effluent to Ponds
Tertiary Effluent to River

Figure 3.4
AVERAGE MONTHLY WASTEWATER FLOW
IN MGD FROM 2001 - 2011
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

uk711f4-8660.ai

Table 3.5 Historical and Projected Wastewater Flows Recycled Water Master Plan City of Ukiah							
	Volume (AFY)						
Type of Wastewater	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Wastewater Collected and Treated in Service Area	4,570	4,650	4,650	4,780	4,910	5,060	5,200

Notes:
(1) 2005 and 2010 wastewater flows based on actual plant data.
(2) Wastewater flow projections for 2015 – 2035 based on wastewater flows from 2001 – 2010 and population projections presented herein.

3.9 EXISTING RECYCLED WATER USERS

The City's only existing recycled water user is the UWWTP. The UWWTP reuses treated effluent produced at the UWWTP for on-site landscape irrigation, process water, and spray down.

3.10 RECYCLED WATER RIGHTS

Ukiah Valley water users do not have existing rights to use treated effluent after discharge.

TREATMENT REQUIREMENTS FOR DISCHARGE AND REUSE

4.1 TREATMENT REQUIREMENTS

The Ukiah wastewater treatment plant (UWWTP) produces tertiary treated water in the wet months when river discharge requirements can be met. Otherwise, the UWWTP produces secondary effluent and discharges the effluent to evaporation/percolation ponds. Tertiary treated recycled water is approved for all uses except for drinking or food preparation. This includes irrigation of all types including food crops and pastures for milking animals, commercial uses such as toilet/urinal flushing, process uses such as in cooling towers, supply for impoundments, and many more. The UWWTP's AWT system produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The City is currently developing a RWMP to determine how this effluent can be put to its highest and best use to increase the reliability and maximize the capacity of the City's wastewater treatment facilities. Detailed analysis of the tertiary effluent water quality is underway to determine the various applications the recycled water could be used for, especially with respect to irrigation.

The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds.

The primary regulation governing recycled water use is the California Water Code Regulations, Title 22. The primary laws regulating water quality are the Clean Water Act (CWA) and the California Water Code. Under the CWA, the Environmental Protection Agency or a delegated State agency regulates the discharge of pollutants to waterways through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. NPDES permits set limits on the amount of pollutants that can be discharged into the waters of the United States. The State Water Resources Control Board (SWRCB) is the state agency that has jurisdiction over water quality throughout California. Under the SWRCB, nine Regional Water Quality Control Boards (RWQCB's) have authority to exercise rulemaking and regulatory activities by water basins. The UWWTP is located in the North Coastal Region (Region 1) and is regulated by the North Coastal RWQCB. The SWRCB and the RWQCBs have regulatory authority along with the California Department of Public Health (DPH) over projects using recycled water. The roles of the SWRCB, RWQCB, and DPH are further discussed in the following paragraph.

The SWRCB establishes general policies governing the permitting of recycled water projects consistent with its role of protecting water quality and sustaining water supplies. The SWRCB also exercises general oversight over recycled water projects, including review of RWQCB permitting practices. The DPH is charged with protection of public health and drinking water supplies and with the development of uniform water recycling criteria

appropriate to particular uses of water. The RWQCB is charged with protection of surface and groundwater resources and with the issuance of permits that implement DPH recommendations.

4.2 WASTEWATER DISCHARGE REQUIREMENTS

As discussed in Chapter 3, the UWWTP's effluent discharges are regulated by a National Pollutant Discharge Elimination System (NPDES) permit – Order No. R1-2006-0049, NPDES No. CA0022888. The discharge limitations defined by this permit are described in further detail in Chapter 3, Section 3.4 of this report.

The UWWTP's Advanced Water Treatment system AWT produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds. Although this effluent meets recycled water standards, it is not distributed to any recycled water users and is instead entirely discharged by gravity to the Russian River. Provided wastewater influent to the UWWTP was high enough, and recycled water demands were high enough, the AWT system could be operated on a daily basis to produce approximately 7.0 mgd of recycled water. However, during dry weather months the AWT can produce 4 mgd due to the limited flow volume.

A potential, future change to the current discharge requirements includes prohibition of all river discharges. The current permit allows discharge of disinfected, tertiary wastewater to the Russian River from October 1 through May 14 at a discharge rate of up to one percent of the total Russian River flow; river discharges from May 15 through September 30 are prohibited. If river discharges are prohibited year-round in the future, the City will need to determine alternative methods for disposing of its treated wastewater effluent. The City may need to construct additional pond storage or distribute treated effluent to recycled water customers.

4.3 WATER QUALITY-RELATED REQUIREMENTS

No water quality-related requirements are expected. Implementation of this project is anticipated to improve surface and groundwater water quality due to the reduced dependence on the groundwater basin.

4.4 SALT/NUTRIENT MANAGEMENT PLANS

Some groundwater basins in the state contain salts and nutrients that could threaten Basin Plan water quality objectives, whether the cause be natural soils/conditions, waste discharges, irrigation using surface or recycled water, or through groundwater. The State's recently adopted Recycled Water (RW) Policy requires that salt/nutrient management plans

for every basin in California be developed and adopted as Basin Plan Amendments by 2015. These Management Plans will be developed by local water and wastewater entities and stakeholders, and funded by the regulated community. Each salt and nutrient management plan shall include the following components:

- A basin-wide monitoring plan.
- A provision for annual monitoring of constituents of emerging concern (CECs).
- Water recycling use goals and objectives.
- Salt and nutrient source identification, basin assimilative capacity and loading estimates.
- Implementation measures to manage salt and nutrient loading in the basin.
- An antidegradation analysis.

After salt/nutrient management plans are developed, they will govern whether anti-degradation analyses are necessary for specific projects. While the plans are in the process of being drafted, antidegradation analyses will be required for recycling projects where the discharge will use more than 10 percent of the Basin's available assimilative capacity for one project, or 20 percent for multiple projects. It is assumed that this will not be the case in the City of Ukiah's area and therefore a salt/nutrient management plan will most likely not be needed. The RW program can proceed with permitting now, even though a salt/nutrient management plan has not been done. It is not the intent of the RW policy to hold up recycling projects to wait on those plans.

4.5 GENERAL USE GUIDELINES

4.5.1 Title 22 Use Area Requirements

Title 22 has two main requirements that could affect the potential users and will need to be considered on a case-by-case- basis during the design phase of the project. Per Title 22, no irrigation with disinfected tertiary recycled water shall take place within 50 feet of any domestic water supply well unless the well meets certain criteria such as:

- An annular seal.
- Well housing to prevent recycled water spray from contacting the wellhead.
- The owner approves of the elimination of the buffer zone, etc.

Also per Title 22, no impoundment of disinfected tertiary recycled water shall occur within 100 feet of any domestic water supply well. This will need to be considered during design where landowners have existing irrigation water storage on-site.

4.5.2 General Irrigation Use Guidelines

The successful long-term use of irrigation water depends more on rainfall, leaching, soil drainage, irrigation water management, salt tolerance of plants, and soil management practices than upon water quality itself. Figure 4.1 shows the typical monthly rainfall for the Ukiah Valley area, and since there is a considerable amount of rain it is assumed that salt build up would not be a problem with the use of the recycled water.

Since salinity problems may eventually develop from the use of any water, the following guidelines are given, should they be needed, to assist water users to better manage salinity in either agricultural or community-based irrigation:

- Irrigate more frequently to maintain an adequate soil water supply.
- Select plants that are tolerant of an existing or potential salinity level.
- Routinely use extra water to satisfy the leaching requirements.
- If possible, direct the spray pattern of sprinklers away from foliage. To reduce foliar absorption, try not to water during periods of high temperature and low humidity or during windy periods. Change time of irrigation to early morning, late afternoon, or night.
- Maintain good downward water percolation by using deep tillage or artificial drainage to prevent the development of a perched water table.
- Salinity may be easier to control under sprinkler and drip irrigation than under surface irrigation. However, sprinkler and drip irrigation may not be adapted to all qualities of water and all conditions of soil, climate, or plants.

General management/use guidelines are shown for landscape and crop irrigation based on the average constituent quantity. A wastewater sample of the UWWTP effluent was collected on May 23, 2011 and analyzed for typical irrigation constituents. These constituents and management/use guidelines compared to the UWWTP sample are summarized in Table 4.1. When comparing the information in Table 4.1 it can be seen that the Ukiah effluent is very high quality recycled water that is in the acceptable range for irrigation. It is recommended the City do additional water quality sampling at various times during the year to determine any seasonal variations in treated effluent quality.

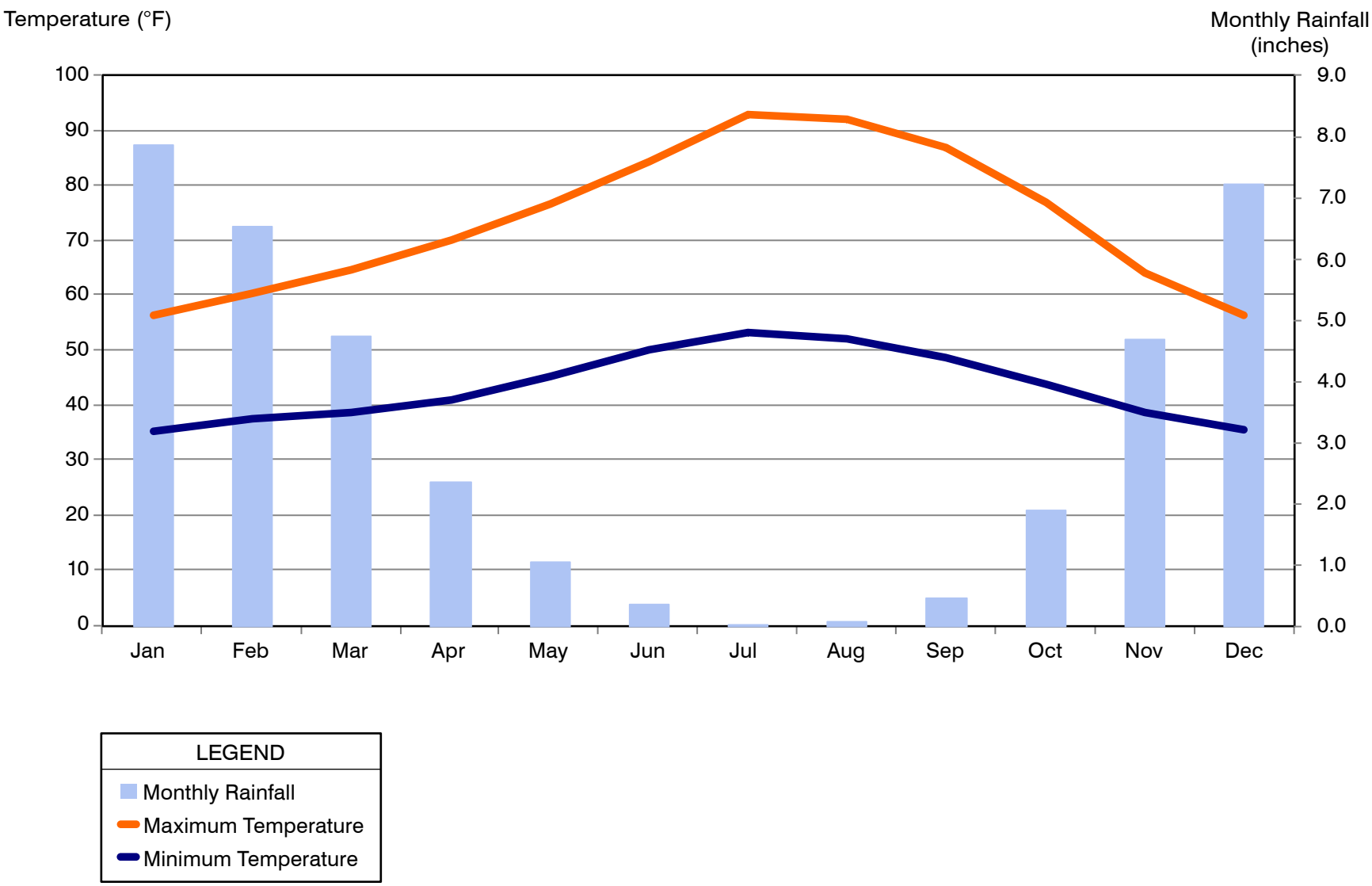

Figure 4.1
AVERAGE PRECIPITATION AND TEMPERATURE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Source: Ukiah Station #049122 Data from the Western Regional Climate Center Precipitation Gauges, 1893-2010.

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Table 4.1 Comparison of City of Ukiah Water Quality with Established Guidelines for Interpretations of Water Quality for Irrigation
Recycled Water Master Plan
City of Ukiah

Parameter	Units	Established Criteria Degree of Use Restriction[1,2] None	Slight	Severe	Ukiah WWTP Effluent [3]
Salinity					
Electrical Conductance	ds/m	**<0.7**	0.7 - 3.0	>3.0	0.5
Total Dissolved Solids (TDS)	mg/L	**<450**	450 - 2000	>2000	250
Permeability					
aSAR = 0 - 3 and EC		>0.7	**0.7 - 0.2**	<0.2	(Based on
= 3 - 6 and EC		>1.2	1.2 - 0.3	<0.3	SAR = 1.6;
= 6 - 12 and EC		>1.9	1.9 - 0.5	<0.5	EC = 0.5)
= 12 - 20 and EC		>2.9	2.9 - 1.9	<1.9	
= 20 - 40 and EC		>5.0	5.0 - 2.9	<2.9	
Sodium					
Root Absorption	SAR	**<3**	3 - 9	>9	1.9
Foliar Absorption	mg/L	**<70**	>70		43
Chloride					
Root Absorption	mg/L	**<140**	140 - 355	>365	38
Foliar Absorption	mg/L	**<100**	>100		38
Boron	mg/L	**<0.7**	0.7 - 3.0	>3.0	0.2
pH[4]	–	**6.5 - 8.4 (normal range)**			6.5 - 7.5
Ammonia (NH_4)[4]	mg/L	(see combined N values below)			7.1
Nitrate (as NO_3)	mg/L	(see combined N values below)			9.3
Nitrate (as N)[4]	mg/L	(see combined N values below)			2.1
Total Kjeldahl Nitrogen (N)[5]	mg/L	<5	**5 - 30**	>30	12
Bicarbonate (HCO_3)[6]	mg/L	**<90**	90 - 500	>500	68

Notes:
(1) Adapted from University of California Committee of Consultants (1974) and Water Quality for Agriculture (Ayers and Westcot 1984).
(2) Definition of the "Degree of Use Restriction" terms:
None = Reclaimed water can be used similar to the best available irrigation water.
Slight = Some additional management will be required above that with the best available irrigation water in terms of leaching salts from the root zone and/or choice of plants.
Severe = Typically cannot be used due to limitations imposed by the specific parameters.
(3) The Ukiah WWTP effluent data is based on secondary effluent sampling done May 23, 2011, unless noted otherwise.
(4) pH, ammonia, and nitrate (as N) data are based on average effluent values measured at the Ukiah WWTP.
(5) Total Kjeldahl Nitrogen (TKN) is the sum of the ammonia nitrogen and organic nitrogen. Organic nitrogen is bound in living material. Ammonia and nitrate are inorganic forms of nitrogen.
(6) Presence of bicarbonate can result in unsightly foliar deposits.

RECYCLED WATER MARKET

This chapter summarizes the market identification and quantification process and the landscape irrigation requirements for the City of Ukiah and the surrounding Ukiah Valley area.

5.1 MARKET ASSESSMENT PROCEDURES

Over 30 potential recycled water customers were identified within the study area, many representing multiple parcels and several acres of land that could be served with recycled water. The customers were identified using multiple sources including:

- Previous reports.
- Discussions with City engineering and planning staff.
- GIS mapping.
- Discussions with various regulatory industrial agencies including the Mendocino County Russian River Flood Control and Water Conservation Improvement District and the Mendocino County Farm Bureau.
- A recycled water questionnaire.

The types of acceptable uses identified include urban irrigation (i.e. school yards, parks, cemeteries, golf courses, Home Owners Associations (HOAs)) and agricultural irrigation (i.e. vineyards, orchards and miscellaneous row crops).

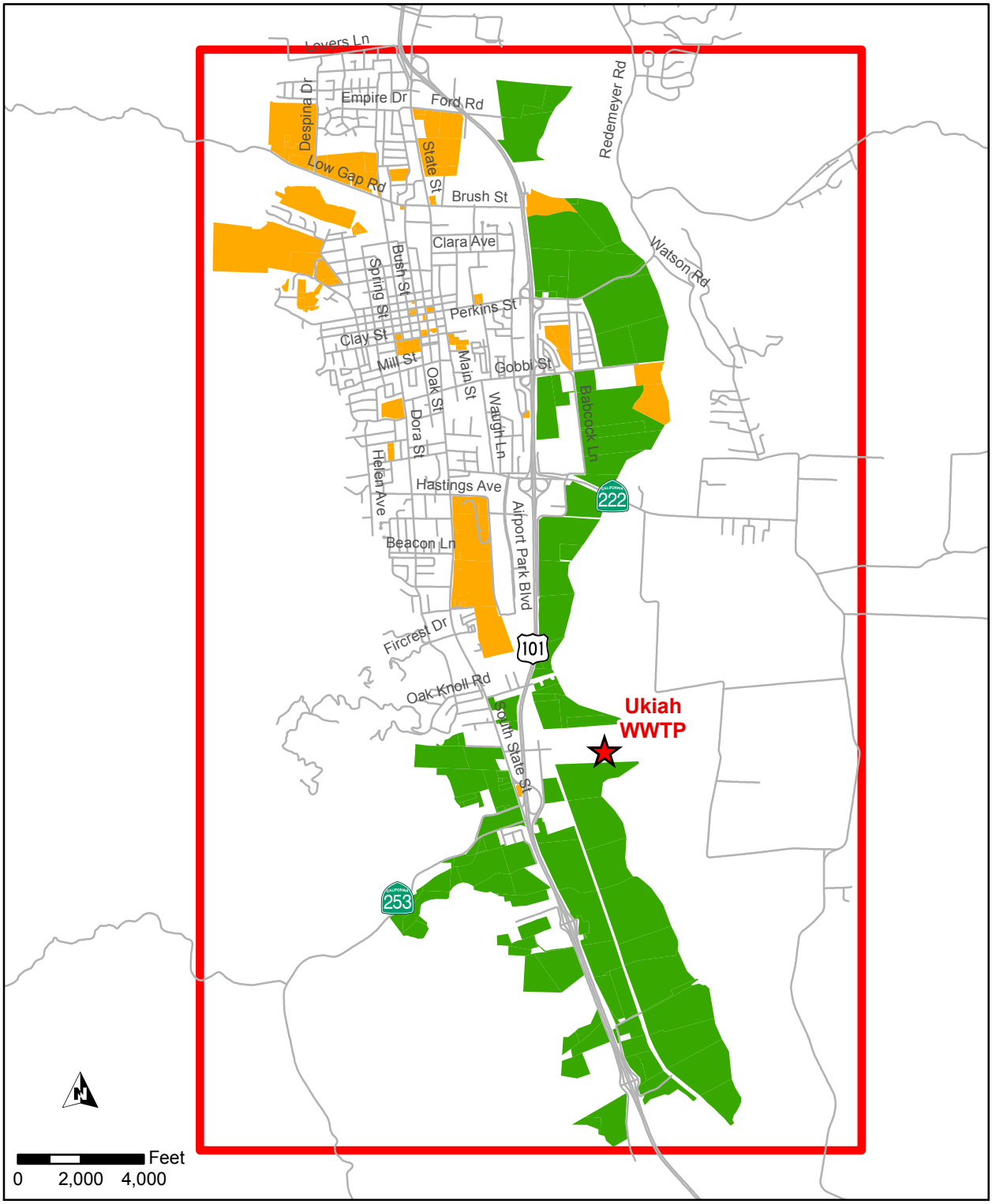
The potential recycled water use sites are shown on Figure 5.1 and listed in Appendix B.

5.1.1 Recycled Water Questionnaire

A recycled water questionnaire was delivered to approximately 20 key potential recycled water users in the area surrounding the wastewater treatment plant and the City to determine local interest in using recycled water and to assess current water use practices. These key potential recycled water users account for approximately 144 irrigable or agricultural parcels (about 1,180 acres) within the City of Ukiah and surrounding area. The questionnaire and summaries of the questionnaire responses are located in Appendix A.

The following information was requested on the questionnaires:

- Irrigation type (e.g. vines, orchard, grass/landscaping, pasture).
- Existing and planned additional irrigated acreage.
- Water source for irrigation and frost protection.



Legend

Streets

Recycled Water Master Plan Study Area

Potential Recycled Water Use Sites

Agricultural

Urban Landscaping

Figure 5.1
POTENTIAL RECYCLED WATER USE SITES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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- Existing and planned storage for irrigation.
- Interest in using recycled water.
- Concerns and comments.

5.1.1.1 Questionnaire responses

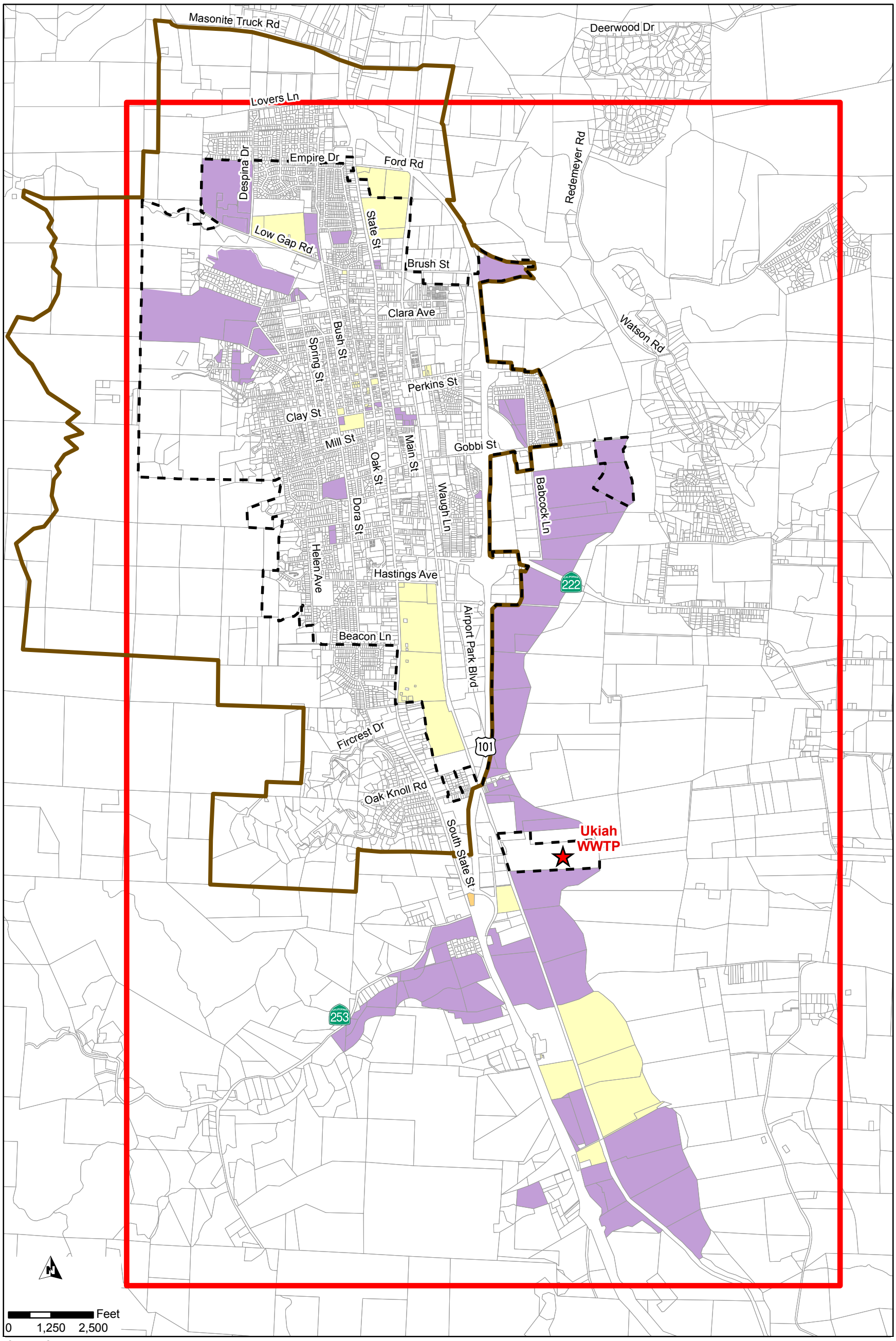
The questionnaire responses are illustrated in Figure 5.2 and summarized by irrigation type in Table 5.1. The Study Area is comprised of mostly vineyards and orchards, urban landscaping and some row crops and pasture irrigation. For properties where a questionnaire response was not received, GIS data was used to estimate irrigable acreage and type of irrigable acreage.

As can be surmised from Table 5.1, 80 percent of the questionnaires were returned, which represented over 66 percent of the parcels and 76 percent of the land area considered in the study. Of the questionnaires returned, owners and managers of 99 percent of the parcels were interested in using recycled water to meet their irrigation needs. These parcels account for 100 percent of the acreage reported in the returned questionnaires. Appendix A provides further analysis of the questionnaire responses.

5.1.1.2 Frequent Responses

Many of the questionnaire responses contained similar feedback and formed overall trends. The most frequent concerns/comments were:

- They are interested in using recycled water.
- How much will recycled water and a recycled water delivery system cost.
- How will the use of recycled water impact their water rights.
- Uncertainty about the recycled water quality (i.e. salts, nutrients).
- Pressure and daily/seasonal timing of supply (i.e.: main need is in spring for frost protection).
- Will recycled water use be compatible with fresh fruit and cannery markets, and wineries.
- Compatibility with organic certification requirements.
- Will a recycled water program be feasible based on recycled water programs implemented in the region (e.g., Sonoma).



Legend

- Interested in RW
- Not Interested in RW
- Did Not Respond
- Parcels
- Recycled Water Master Plan Study Area
- City Limits
- Sphere of Influence

Figure 5.2
RECYCLED WATER (RW)
QUESTIONNAIRE RESPONSES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Table 5.1 Summary of Questionnaire Responses by Irrigable Area
Recycled Water Master Plan
City of Ukiah

Irrigation Type	Questionnaires			Corresponding Number of Parcels			Corresponding Irrigable Acreage[1]			Percent of Respondents Interested in Using Recycled Water	
	Total Number Sent	Number Responded	% Responded	Total Number Sent	Number Responded	% Responded	Total Acres Sent	Acres Responded	% Responded	Parcels	Acreage
Agriculture	13	11	85%	60	52	87%	860	730	85%	100%	100%
Landscaping[2]	7	5	71%	84	43	51%	320	170	53%	98%	100%
Total	**20**	**16**	**80%**	**144**	**95**	**66%**	**1180**	**900**	**76%**	**99%**	**100%**

Notes:

(1) GIS data was use to approximate the parcels, irrigable acreage and type of irrigable acreage corresponding to land owners for which a questionnaire was not received.

(2) Landscaping includes grass, gardens and other non-agricultural irrigation.

5.2 MARKET QUANTIFICATION

The potential recycled water demand was quantified for each of the recycled water customer sites indentified through the market assessment based on irrigable acreage and crop type. To estimate the annual and peak water requirements of each site, the total irrigable acreage of each site was multiplied by assumed water use parameters (included in Table 5.2). The irrigable acreage and type of irrigable acreage of each site was determined using both GIS mapping and the questionnaire responses. Expected landscape irrigation demands were estimated using landscape irrigation requirements for the Ukiah Valley area based on evapotranspiration and rainfall data. Expected agricultural irrigation and frost protection demands were developed based on water use data included in regional agricultural publications and discussions with local agricultural and water agencies and industries.

Crop types for evaluated agricultural parcels within the study area are shown on Figure 5.3. The estimated annual water use and peak water use of the identified potential customers are summarized in Appendix B.

5.2.1 Agricultural Water Demands

Irrigation and frost protection are the two primary agricultural water demands in Ukiah Valley. Agricultural irrigation requirements are subject to numerous variables, including crop selection, irrigation method (i.e. flood, drip, etc), field rotation, planting season, planting date, and other farmer-specific factors.

In addition to meeting irrigation demands, farmers in the Ukiah Valley apply water to their crops to protect them from damage during frost events. During typical frost conditions, known as radiant frost conditions, heavier cold air settles in the lower parts of the landscape and can potentially damage crops grown in these areas. During adjective frost conditions, which occur infrequently, the entire Ukiah Valley is impacted regardless of elevation. While radiant frost conditions are more typical of the area, frost protection is typically implemented on crops that are in the lower parts of the landscape - below about 700 feet in elevation. (Mendocino Irrigated Agricultural Water Needs and Management, 2008)

Table 5.2 summarizes the parameters that were used to quantify agricultural water demands. Several discussions were held with local agricultural and water supply agencies and industries including Mendocino County Farm Bureau, Mendocino County Russian River Flood Control and Water Conservation Improvement District, and AG Unlimited, to determine agricultural water use parameters that were representative of most agricultural practices in the Ukiah Valley. In addition to this, several agricultural publications were referenced as sited in Table 5.2.

Table 5.2 Assumed Water Use Parameters
Recycled Water Master Plan
City of Ukiah

Water Use Parameter	Vineyard[1,2]	Orchard (Pears)[1,3]	PTL (Pasture)[4]	Row Crops[4]	Grass[5]
Frost Protection					
Frost Months	Mar – May	Apr – May	NA	NA	NA
Duration of Frost Season, months	3	3	NA	NA	NA
Average frost events per max month	2	2	NA	NA	NA
Frost event duration, days	3	3	NA	NA	NA
Frost event duration, hrs. per day	8	6.5	NA	NA	NA
Rate of application, gal/min/acre	55	65	NA	NA	NA
Max Month Frost Demand, af/acre/month	0.5	0.5	NA	NA	NA
Max Day Frost Demand, af/acre/day	0.08	0.08	NA	NA	NA
Average Total Demand During Frost Season	0.50	0.50	NA	NA	NA
Irrigation					
Irrigation Months	Jun – Oct	May - Sep	May – Sep	May – Sep	Apr – Oct
Duration of irrigation season, months	5	5	5	5	7
Avg. annual demand[1], af/acre/yr	0.75	2.0	2	2	2.03
Avg. monthly demand, af/acre/mo	0.15	0.45	0.40	0.40	0.29
Avg. daily demand, af/acre/day	0.02	0.22	0.01	0.01	0.01
Total Demand[5] (afy)	**1.3**	**2.5**	**2.0**	**2.0**	**2.0**

Notes:

(1) Vineyard and pear frost and irrigation requirements from local farmers and Lewis, David et.al., Irrigated Water Needs and Management in the Mendocino County Portion of the Russian River Watershed, July 2008, Tables 1, 2 and 9. http://ucanr.org/sites/Mendocino/files/17223.pdf

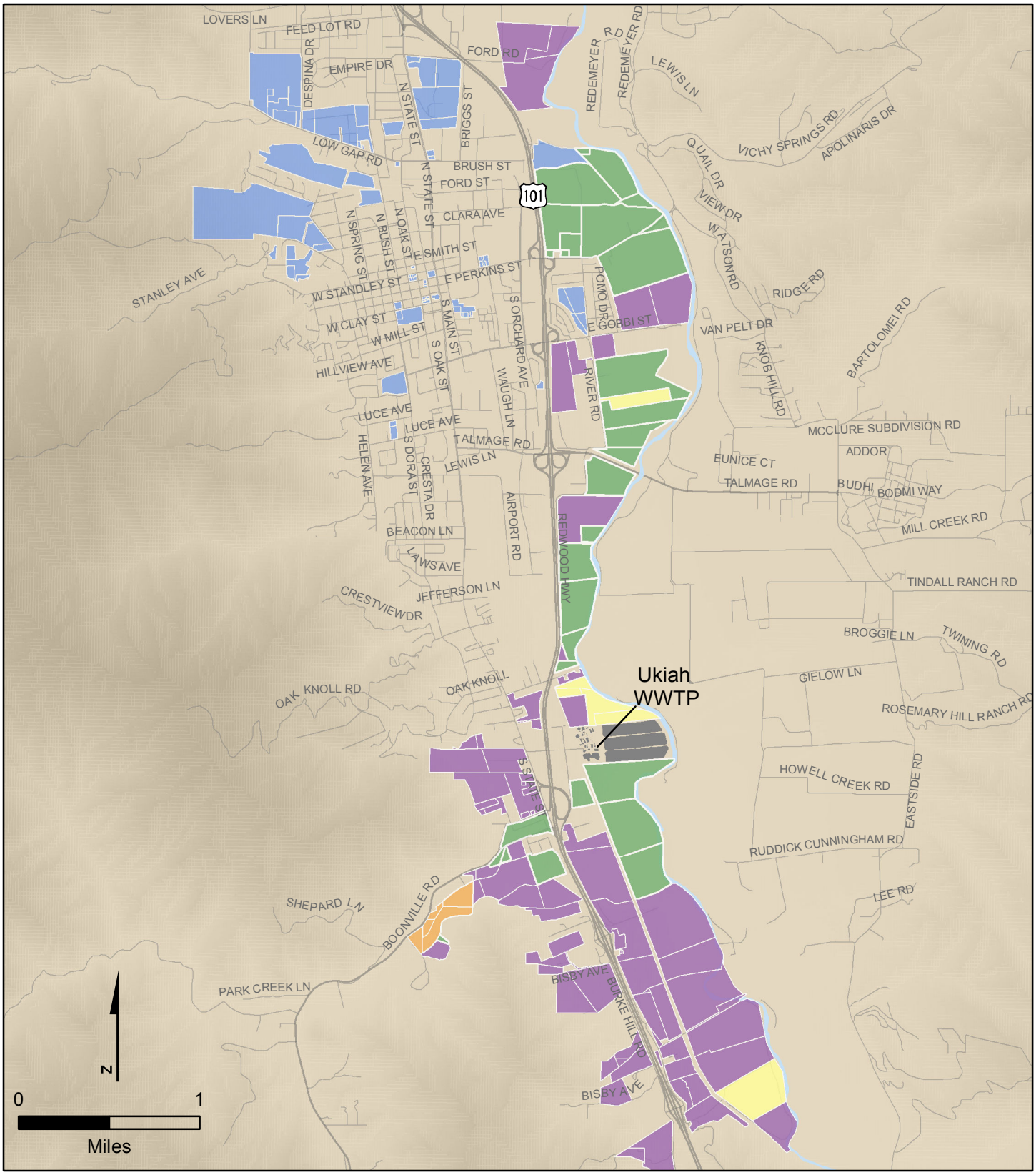
(2) Rate of application for frost protection of vineyards from Mendocino County Farm Bureau and Mendocino County Russian River Flood Control and Water Conservation Improvement District.

(3) Rate of application for frost protection of pears from UC Cooperative Extension, 2006 Sample Costs to Establish and Produce Pears, 2006, pg. 4. http://coststudies.ucdavis.edu/files/pearnc2006.pdf

(4) Pasture and row crop irrigation requirements from Lewis, David et. al., Irrigated Water Needs and Management in the Mendocino County Portion of the Russian River Watershed, July 2008, Tables 5. http://ucanr.org/sites/Mendocino/files/17223.pdf

(5) Grass irrigation requirement calculated using temperature, rainfall, and evapotranspiration data obtained from the Western Regional Climate Center and the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources.

(6) Annual water use for vineyards and pears from Mendocino County Farm Bureau and Mendocino County Russian River Flood Control and Water Conservation Improvement District and local agricultural industries.



Legend

- Other Row Crop Parcels
- Pasture Parcels
- Orchard Parcels
- Vineyard Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 5.3
AGRICULTURAL PARCELS BY CROP TYPE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_5_3-Ag_Parcels_by_Crop.mxd

5.2.2 Landscape Irrigation Requirements

In many cases, landscape irrigation customers use less water than necessary because of conservation practices and cost considerations. Conversely, some customers over-irrigate because of uneven sprinkler coverage or overly conservative watering practices. Therefore, expected landscape irrigation requirements for the Ukiah Valley area were calculated based on evapotranspiration and rainfall data. Calculated irrigation requirements, as defined below, were used to estimate irrigation use at the sites. Calculated irrigation requirements were also used to estimate peak month demand, peak day demand, and peak hour demand for distribution considerations.

The amount of irrigation required for the potential irrigation customers is directly dependent on precipitation quantities in the region. The amount of precipitation, evapotranspiration, and irrigation required for the potential irrigation customers are listed in Table 5.3. To calculate the amount of evapotranspiration occurring in the study area, the following formula was used:

$$ET_L = K_L * ET_o$$

Where: ET_L = Evapotranspiration of landscaped areas (in inches)

K_L = Landscaped area crop coefficient

ET_o = Reference evapotranspiration (in inches)

The reference Evapotranspiration was obtained from the California Irrigation Management Information System (CIMIS) Evapotranspiration zoning map. The City is located in Zone 8: Inland San Francisco Bay Area characterized as inland areas near San Francisco with some marine influence.

To calculate the landscape evapotranspiration, the landscaped area crop coefficient was estimated using information contained in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources. The landscaped area crop coefficient is the product of an average species factor (k_s), density factor (k_d), and microclimate factor (k_{mc}). These were estimated to be 0.6, 1, and 1, respectively. The landscape coefficient was then multiplied by the reference evapotranspiration to determine the average landscape evapotranspiration for the study area.

Therefore, the net annual average landscape irrigation requirement in the study area is approximately 24.3 inches per year or 2.0 feet per year. The irrigation season is roughly April through October, a period of 214 days. Landscape irrigation demand peaks in the month of July at 6 inches, 25 percent of the annual total.

Table 5.3 Average Annual Landscape Irrigation Requirements
Recycled Water Master Plan
City of Ukiah

Month	Landscape Area Evapotranspiration[1] (Inches)	Average Rainfall[2] (Inches)	Net Irrigation Requirement[3] (Inches)	Percent of Annual Net Irrigation Requirement[4] (%)
January	0.74	4.75	0.0	0%
February	1.01	6.52	0.0	0%
March	2.05	4.75	0.0	0%
April	2.88	2.35	0.7	3%
May	3.72	1.05	3.6	15%
June	4.14	0.35	5.1	21%
July	4.46	0.04	6.0	25%
August	3.91	0.08	5.2	21%
September	3.06	0.46	3.5	14%
October	2.05	1.9	0.2	1%
November	1.08	4.69	0.0	0%
December	0.56	7.22	0.0	0%
Total	**29.65**	**34.16**	**24.3**	**100%**
			2.0 feet	

Notes:

(1) Evapotranspiration (ETL) = Reference Evapotranspiration (ETo) x Landscaped Crop Area Coefficient (KL). Reference evapotranspiration values obtained from the California Irrigation Management Information System Reference Evapotranspiration Zone Map and rates included in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources (Guide). The City of Ukiah is located in Zone 8 (Inland San Francisco Bay Area). Landscaped crop coefficient (KL) = Average Species Factor (Ks) x Density Factor (Kd) x Microclimate Factor (Kmc). Ks, Kd, Kmc estimated using data in the Guide.

(2) Source: Ukiah Station #049122 Data from the Western Regional Climate Center Precipitation Gauges, 1893-2010.

(3) Net Irrigation Requirement = (Evapotranspiration - Rainfall)*1.15/0.85. Where 0.85 = 85% Irrigation Factor (Average Value from Carlos and Guitijens, University of Nevada) and 1.15 = 15% Leaching Fraction (Average value from Ayers and Westcot, "Water Quality for Agriculture", Food and Agriculture Organization of the United Nations).

(4) Current month net irrigation requirement divided by total net irrigation requirement.

5.2.3 Potential Customer Storage

As discussed in Section 5.1.1, several agricultural parcels have existing storage ponds or plans to construct storage ponds. Since frost protection is a significant demand, it is anticipated that storage at the site of potential customers will extend the potential coverage of frost protection supply from the Ukiah WWTP.

Agricultural parcels with storage ponds are presented in Figure 5.4. Whether a parcel has a storage pond was determined based on the results of the questionnaire and discussions with City and RRFCD staff. It should be noted that some of the responses on questionnaires did not seem feasible and were thus revised accordingly. While the sizing of individual storage ponds was considered the responsibility of the farmer and was not evaluated within this study, the aggregate size of the storage ponds were used to determine the potential seasonal storage available. This will be discussed in detail in Chapter 6.

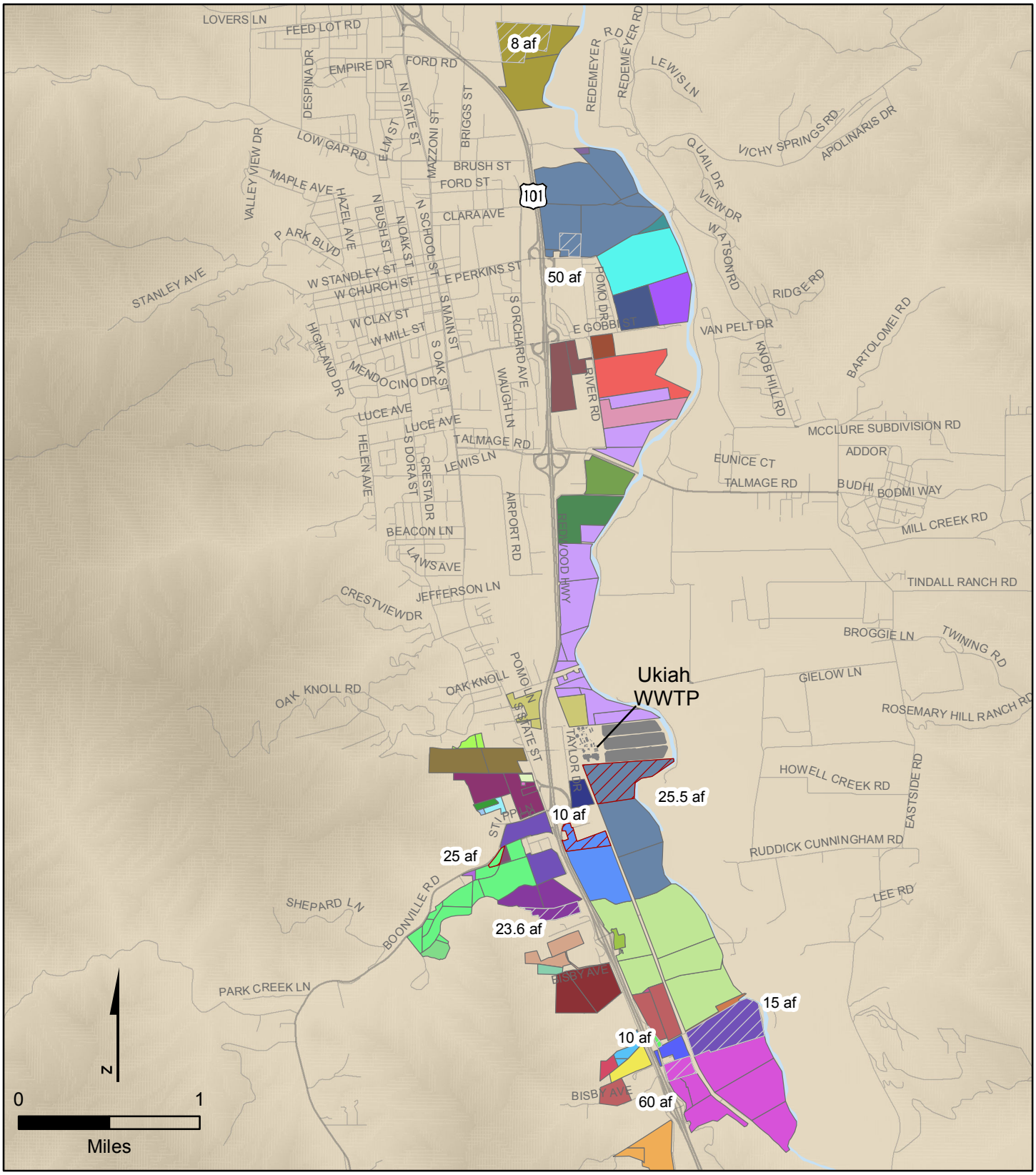
5.3 STAKEHOLDER OUTREACH

In addition to the mailing of questionnaires to larger and local possible users, two Stakeholder Workshops were held to inform the public of the project and obtain feedback. The Stakeholder Workshops were used to describe the project and the process, present recycled water alternatives, and obtain feedback. The workshops were held at key milestones during the planning process and had approximately 10 to 20 attendees at each. Besides the potential users, attendees from the City also participated.

The first Stakeholder Workshop was held on June 8, 2011 and presented a recycled water overview, project timeline, description of the master plan and its focus, discussion of expected irrigation water quality, brief review of funding options, and closed with the next steps in the process. Numerous questions were asked and as the meeting closed, the attendees were highly considering using the recycled water. The purpose of this meeting was to introduce the project to the attendees and describe the process being conducted.

Stakeholder Workshop No. 2 was held on October 6, 2011. The goals were to present the background information, schedule, and work-to-date, present the alternatives analyzed, review the recommended project and costs, review possible funding options, and again close with the next steps in the process. Five alternatives were presented along with their screening and ranking based on the criteria established at the Visioning Workshop at the beginning of the Plan. Based on input from the stakeholders, a six alternative was added that combined serving the agricultural interests as well as serving the large urban irrigation sites like the sports park and golf club.

A presentation to the City Council was conducted on December 7, 2011 to present the project status, the recommended alternative, and associated costs (capital and O&M).



Legend

- Parcels w/ Existing Storage Pond
- Parcels w/ Future Storage Pond
- Agricultural Parcels Colored by Grower or Owner Name (Adjacent parcels with the same color are likely able to share storage)
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Figure 5.4
EXISTING AND PLANNED AGRICULTURAL STORAGE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_5_4-Existing_and_Planned_Agricultural_Storage.mxd

PROJECT ALTERNATIVE ANALYSIS

6.1 WATER RECYCLING ALTERNATIVES EVALUATED

A total of six alternatives were evaluated in this study. The alternatives were selected based on providing recycled water along different alignments and prioritization of different use types. The alternatives vary by area/acreage served, use types served, and storage configuration. Pipelines for each alternative was routed and sized in Innovyze's H_2OMap Water hydraulic modeling software.

First, Alternatives 1 through 3 (a total of 5 different alternatives) were preliminarily developed and presented to City staff and potential agricultural users at a workshop. Through input at the workshop, the alternatives were refined and Alternative 4 was developed to prioritize supplying recycled water to urban sites, including City parks, schools, and the golf course. A complete description of the alternatives follows. Planning level cost estimates for each alternative are presented and discussed following the alternative descriptions. Planning assumptions are discussed in more detail in Section 6.2.

6.1.1 Alternative 1

The Baseline Alternative, Alternative 1, was routed to the south and west to maximize use of the existing off-site storage while minimizing length and size of pipelines. It was considered as the minimum pipeline alternative that could be constructed while utilizing the full dry weather recycled water supply of 4 mgd. This alternative maximized supplying recycled water to meet frost protection demands. This alternative serves only agricultural needs.

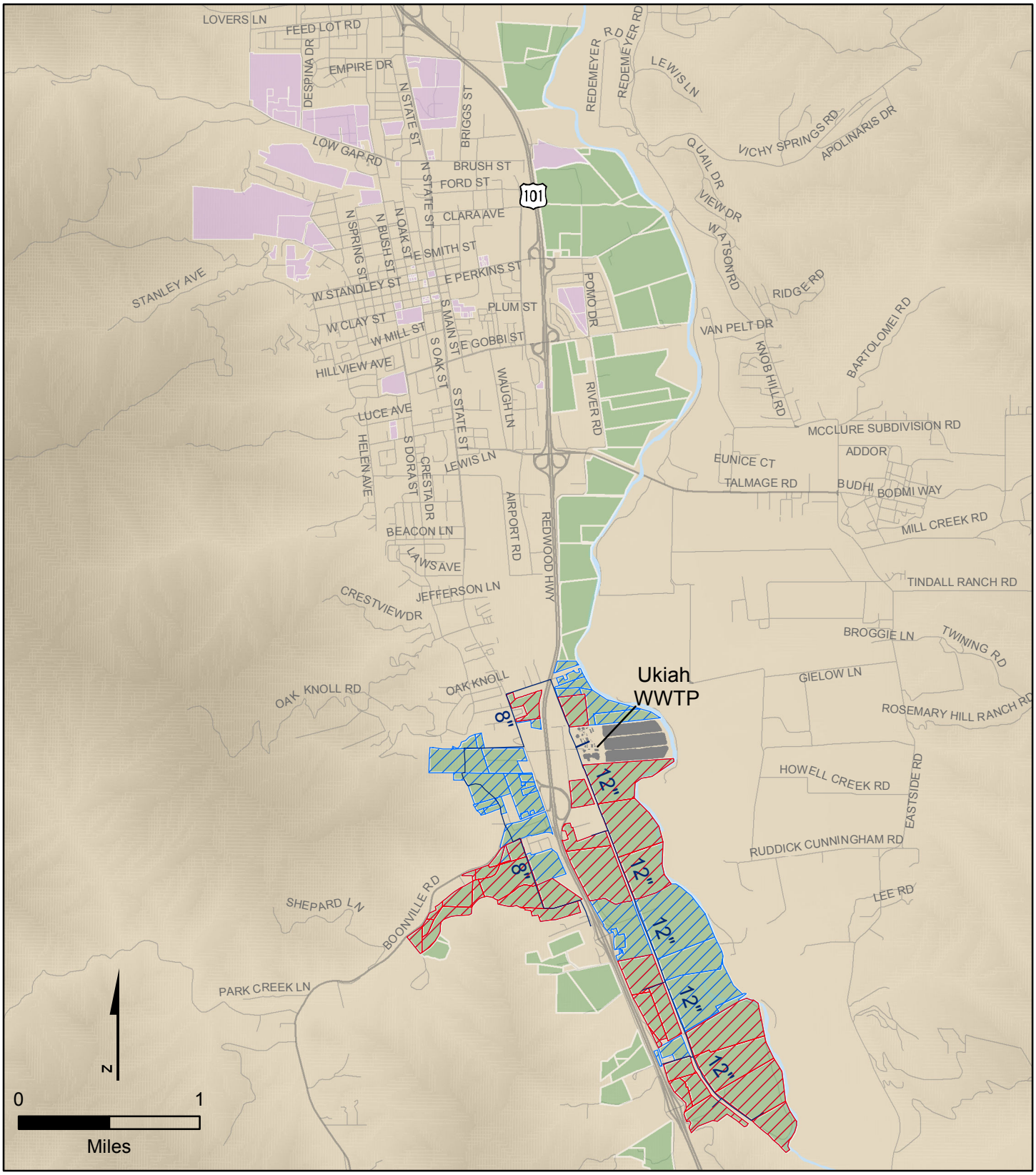
A total of 68 parcels covering 793 acres would be supplied with irrigation in this alternative with an irrigation demand of 830 AFY. About 483 acres representing 35 parcels (corresponding to about 10 farmers) would be supplied with frost protection water, with an estimated annual frost protection demand of 242 AFY. This alternative includes just under 6 miles of pipeline, with diameters ranging between 8 and 16 inches.

This alternative would utilize 5 farmer owned storage ponds, totaling 99 af in size. In addition, 19 parcels representing about 5 farmers not having ponds, covering 134 acre (ac) of land, are provided frost protection during frost events.

Figure 6.1 illustrates the pipeline routing and properties served by Alternative 1.

6.1.2 Alternative 1B

Alternative 1B follows a similar alignment to Alternative 1, but extends north to supply irrigation to additional parcels. This alternative prioritizes supplying agricultural parcels with recycled water for irrigation. This alternative serves only agricultural needs.



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.1
ALTERNATIVE 1
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_1-Alternative_1.mxd

A total of 75 parcels covering 915 acres, representing about 12 farmers, would be supplied with irrigation in this alternative with an irrigation demand of 1,027 AFY. Similar to Alternative 1, 483 acres would be supplied with frost protection water, with an estimated annual frost protection annual demand of 242 AFY.

This alternative includes just over 7 miles of pipeline, with diameters ranging between 8 and 16 inches. Similar to Alternative 1, this alternative would utilize 5 farmer based storage ponds, totaling 99 af in size. Figure 6.2 illustrates the pipeline routing and properties served by Alternative 1B.

6.1.3 Alternative 2

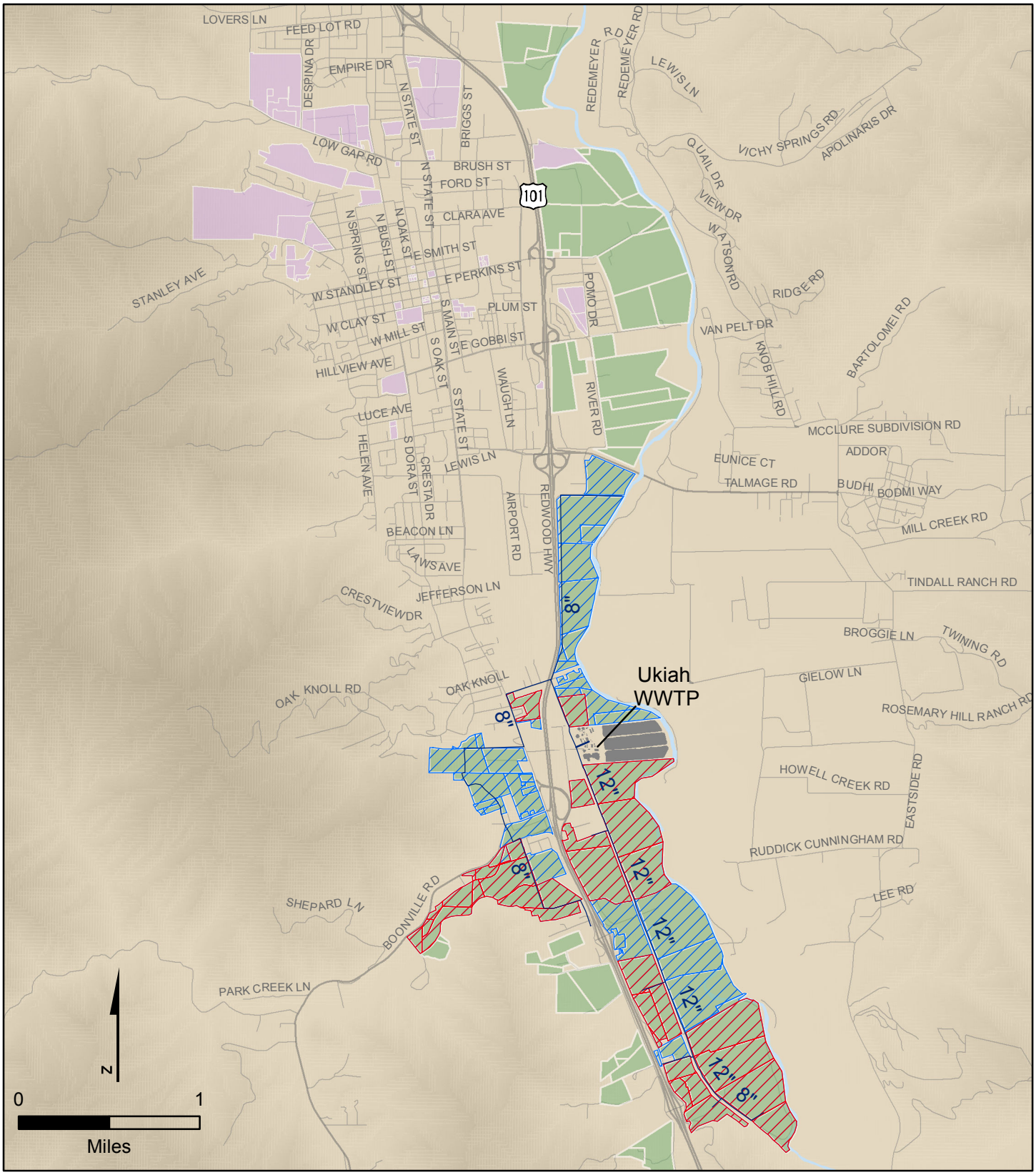
Alternative 2 investigates the feasibility of farmers constructing their own storage ponds with which to provide their own peaking for frost protection.

Based on discussions with Russian River Flood Control District (RRFCD), many farmers are considering adding storage due to the new possible State Board river withdrawal schedule, making this alternative likely. This would save the WWTP money in storage facilities, but would cost the farmers more and it would rely on the farmers being proactive in building storage facilities. This alternative serves only agricultural needs.

While Alternative 1 focused on supplying frost protection water to farmers with existing or planned storage ponds, Alternative 2 was developed to determine the effective maximum extent of acreage provided frost protection assuming farmers built a typical amount of storage.

The limiting factor for this alternative is the recharging of farmer ponds between frost events. Based on results of the questionnaire, a typical storage factor of 0.3 af/ac was applied to all the parcels to determine the minimum volume of storage each farmer would construct. The recycled water distribution system was sized assuming that the ponds could be refilled during the non-frost hours of each day during a frost protection event and over a period of seven days between frost events (as discussed in Chapter 5, frost events are assumed to last three days). Based on the assumptions discussed in Chapter 5, a single frost event (occurring over 3 days) will require between 0.23 and 0.24 af/ac of storage. In this scenario, recharge demands between frost events are calculated as 2,982 gallons per minute (gpm). A storage pond sized for 0.3 af/ac would include sufficient storage to make up for the difference between the recharge flows and the projected flow from the Ukiah WWTP.

A total of 35 parcels covering 494 acres, representing about 10 farmers, would be supplied with frost protection in this alternative with an estimated frost protection demand of 247 AFY. About 619 acres would be supplied with irrigation water, with an estimated annual annual irrigation demand of 699 AFY. This alternative includes about 4 miles of pipeline, with diameters ranging between 8 and 16 inches. Figure 6.3 illustrates the pipeline routing and properties served by Alternative 2.



Legend

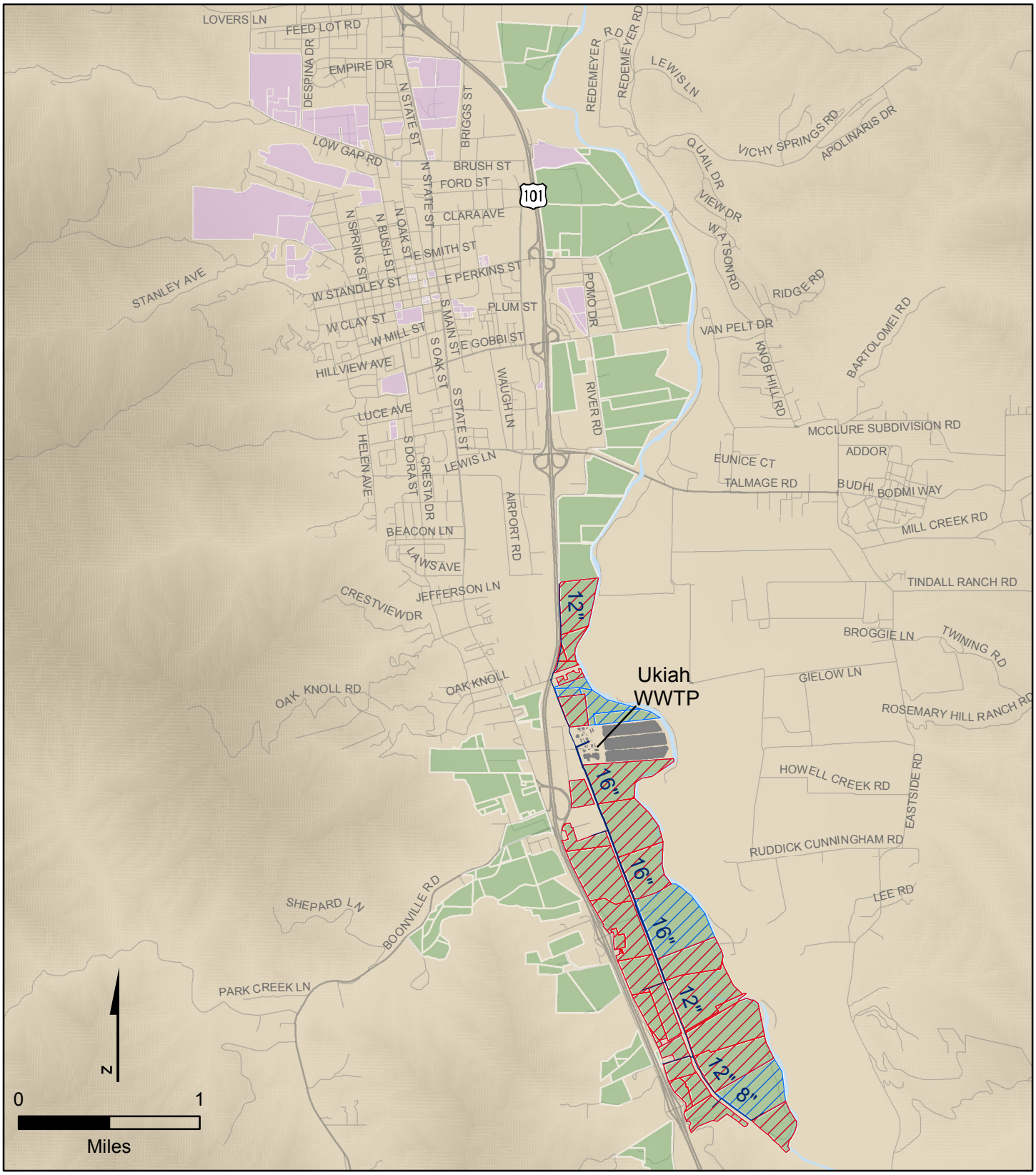
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.2
ALTERNATIVE 1B
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_2-Alternative_1B.mxd



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.3
ALTERNATIVE 2
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_3-Alternative_2.mxd

It should be noted that if the storage ponds were sized for the average annual frost protection demand of 0.5 af/ac (as discussed in Chapter 5) plus evaporation or other losses, and filled at the start of the frost season, the farmers could theoretically require no recharge during frost events. While it was assumed that this level of storage may be too large for most farmers, this strategy could potentially be used to provide frost protection to any farmers not supplied frost protection in any of the alternatives.

6.1.4 Alternative 3

Alternative 3 investigates the feasibility of supplying frost protection through centralized storage. In this alternative, a large centralized storage facility would be constructed at the WWTP. This reservoir would then feed the demands as needed to meet frost protection and some irrigation needs. This would allow instantaneous supply of demands much larger than the 4-mgd dry weather tertiary capacity. The main issue with this alternative is that the infrastructure required to convey instantaneous frost protection demands is very substantial.

A total of 54 parcels covering 891 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,081 AFY. A total of 50 parcels, representing about 11 farmers and covering 837 acres would be supplied with frost protection water, with an estimated annual frost protection annual demand of 419 AFY.

The centralized storage at the Ukiah WWTP was assumed as a 200 af pond. Since this alternative includes centralized storage at the Ukiah WWTP, the infrastructure is sized to supply the full frost protection demand instantaneously to all farmers. Thus, this alternative includes about 6 miles of pipeline, with diameters ranging between 8 and 48 inches. Instantaneous demand supplied to farmers without storage during the frost event is estimated as 28,600 gpm, representing 489 acres of land provided frost protection. In addition, recycled water could be supplied between frost events to farmers with storage ponds. This would enable an additional instantaneous supply of about 20,200 gpm from farmer ponds, protecting another 348 acres. Accounting for the hours of frost protection required for each type of crop, the effective supply to the system from storage and the WWTP would be 21.8 mgd for each of the three days of a frost protection event.

As with Alternative 2, the limiting factor for this alternative regarding the number of parcels supplied with frost protection is the recharge time between frost events of both the centralized storage pond and the individual farmer ponds. While the limiting effect of this recharge time could be reduced by increasing the size of the storage, a larger storage pond was assumed not to be feasible within this study.

An additional benefit of this alternative is the large storage pond, in that the Ukiah WWTP could use the pond to increase its operational flexibility when discharge to the Russian River is limited.

This alternative would utilize 4 farmer owned storage ponds, totaling over 50 af in size (size for one is unknown). In addition, 35 parcels representing 7 farmers not having ponds, covering 489 acres of land, are provided frost protection during frost events.

Figure 6.4 illustrates the pipeline routing and properties served by Alternative 3. This alternative serves mainly agricultural needs and two small urban sites, Oak Manor Park and Oak Manor School.

6.1.5 Alternative 3B

Alternative 3B follows a similar alignment as Alternative 3, but extends the recycled water distributions system to supply irrigation to additional parcels. This alternative prioritizes supplying agricultural parcels with recycled water for irrigation. The benefits and issues are primarily the same for this alternative as with Alternative 3.

A total of 69 parcels representing about 11 farmers and 2 urban users covering a total of 1,210 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,598 AFY. Substantially more irrigation water is available in this scenario as the centralized storage can be used for seasonal storage in the summer, when the Ukiah WWTP's capacity constrains the available irrigation water.

While slightly more acreage could be provided frost protection due to the additional existing or planned storage ponds that can be reached based on the irrigation driven pipeline alignment, the flow from the Ukiah WWTP is not sufficient to recharge the centralized storage pond in addition to the additional farmer storage ponds. Thus, the frost protection acreage and demand are the same as Alternative 3. This alternative includes over 8 miles of pipeline, with diameters ranging between 8 and 48 inches.

Figure 6.5 illustrates the pipeline routing and properties served by Alternative 3B. This alternative serves mainly agricultural needs and three small urban sites. When compared with Alternative 3B, an additional urban site, the Ukiah Sports Complex, can be supplied with recycled water since the pipeline extends further north in Alternative 3B.

6.1.6 Alternative 4

Alternative 4 was developed following input from the community at the second Stakeholder Workshop. This alternative is intended to supply a combined set of agricultural and urban landscape irrigation demands. The alignment is routed to the northeast, then extends west to supply urban landscape irrigation demands at several City parks and schools.

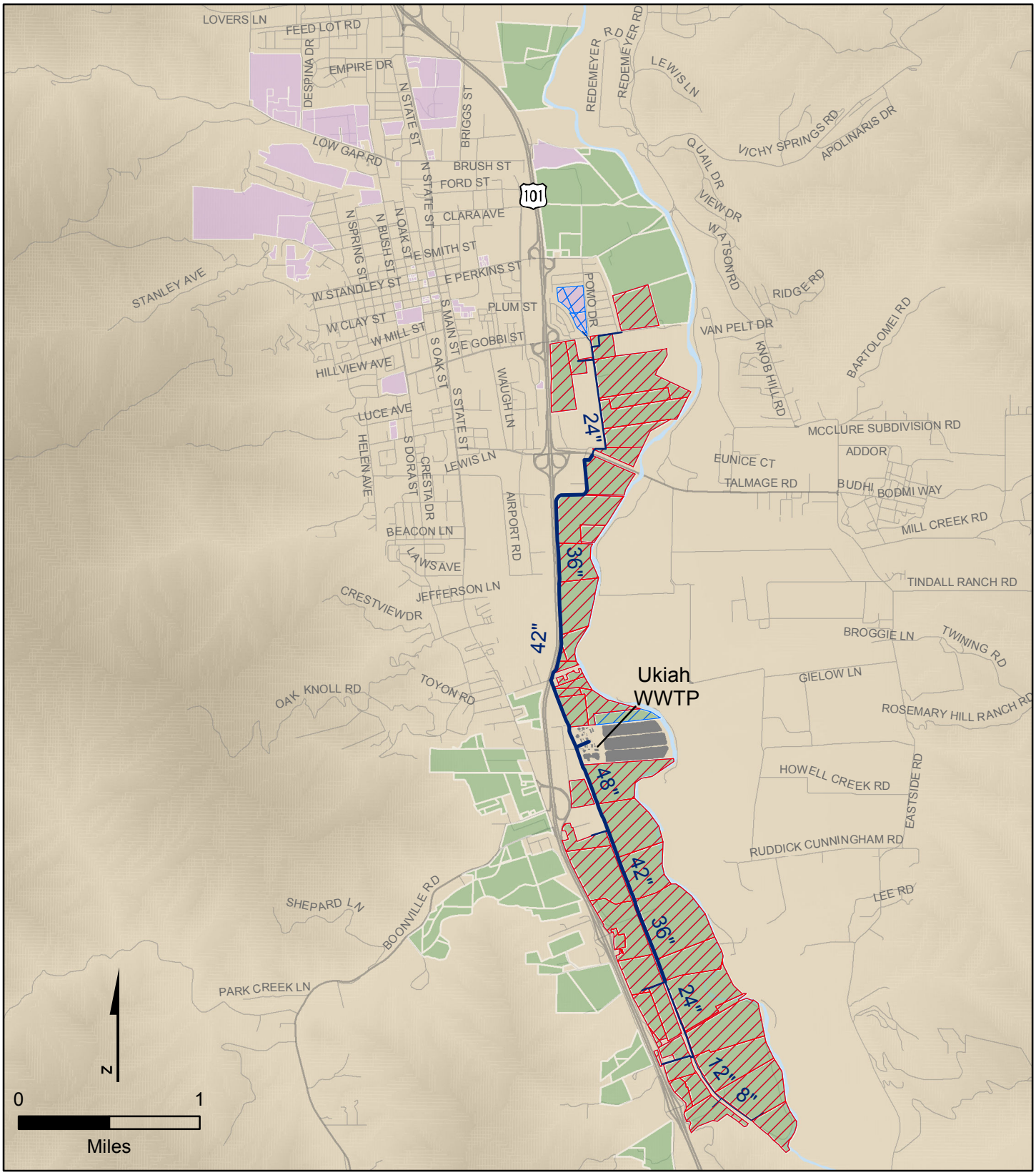
A total of 60 parcels covering 703 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,234 AFY. About 284 acres would be supplied with frost protection water, with an estimated annual frost protection demand of 142 AFY. This alternative includes 9 miles of pipeline, with diameters ranging between 8 and 16 inches.

This alternative would utilize 2 farmer based storage ponds, totaling approximately 75 af in size. In addition, 9 parcels representing 3 farmers not having ponds, covering 50 acres of land, are provided frost protection during frost events.

Figure 6.6 illustrates the pipeline routing and properties served by Alternative 4.

Table 6.1 Alternative Parameter Summary
Recycled Water Master Plan
City of Ukiah

Parameter	Alternative 1	Alternative 1B	Alternative 2	Alternative 3	Alternative 3B	Alternative 4
Irrigation Demand (AFY)	830	1,027	699	1,081	1,598	1,234
Irrigated Area Served[1] (Acres)	793	915	619	891	1,210	703
Parcels Provided Irrigation (Number)	68	75	37	54	69	60
Frost Protection Demand (AFY)	242	242	247	419	419	142
Frost Protected Land (Acres)	483	483	494	837	837	284
Parcels Provided Frost Protection (Number)	35	35	35	50	50	17
Pipeline (Miles)	5.8	7.3	3.9	6.0	8.4	9.4
Diameter (Inches)	8 – 16	8 – 16	8 – 16	8 – 48	8 – 48	8 – 16
Pump Stations (Number)	1	1	1	1	1	1



Legend

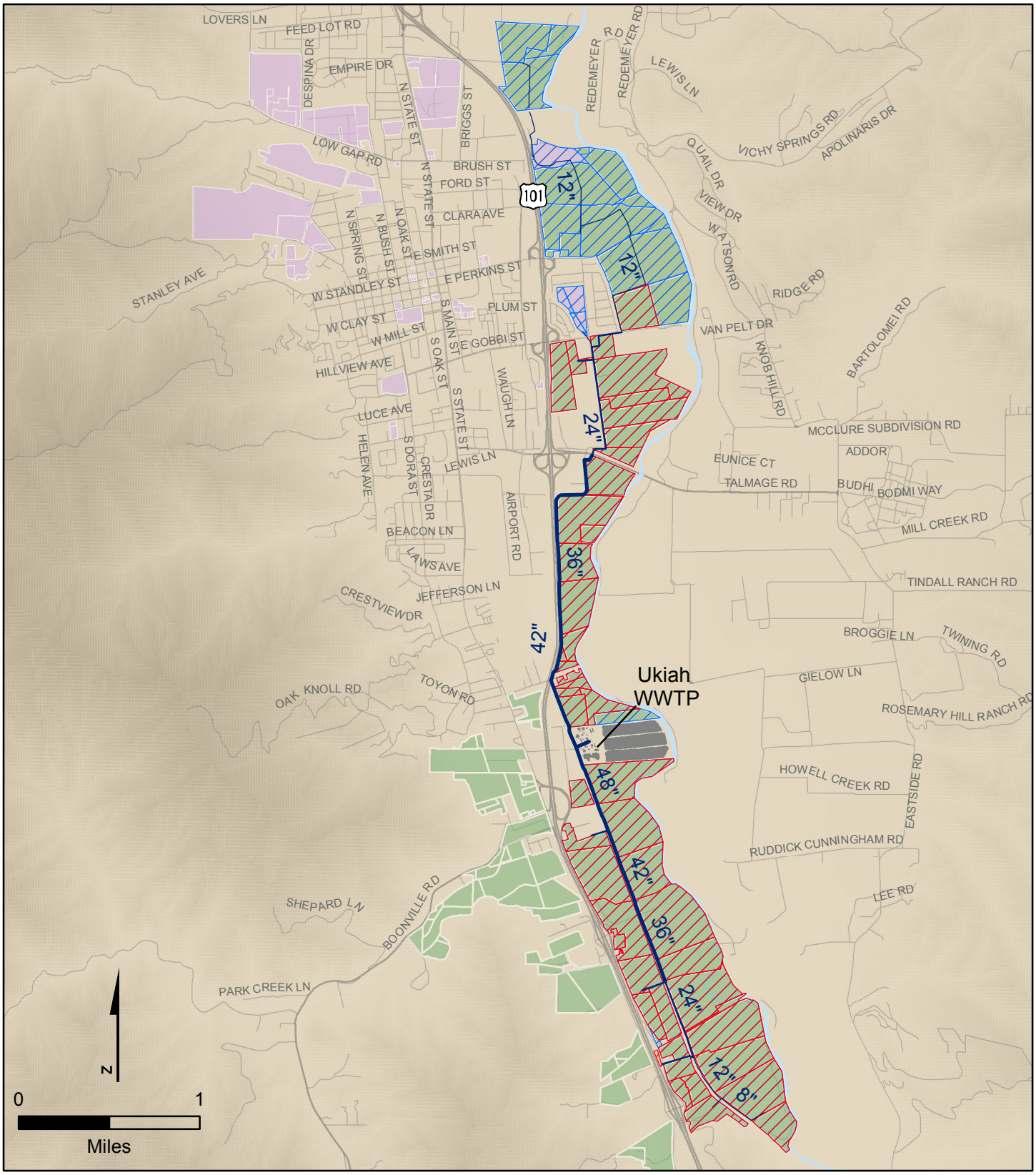
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.4
ALTERNATIVE 3
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_4-Alternative_3.mxd



Legend

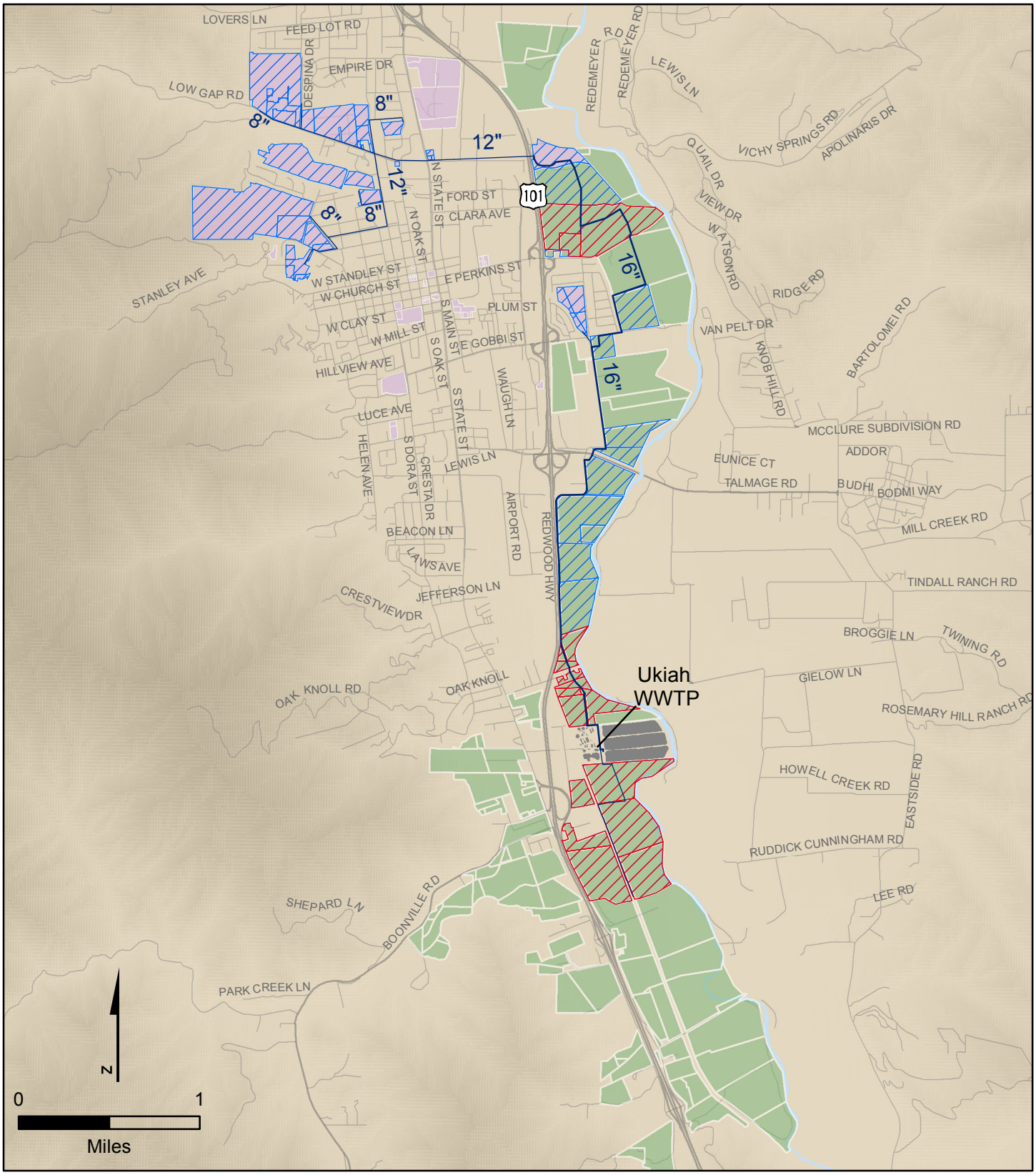
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.5
ALTERNATIVE 3B
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_5-Alternative_3B.mxd



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.6
ALTERNATIVE 4
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_6-Alternative_4.mxd

6.2 PLANNING LEVEL COST ESTIMATES

Planning level cost estimates were developed for each of the alternatives discussed above. Assumptions regarding costs are discussed, followed by a presentation of the costs for each alternative.

6.2.1 Assumptions

Several assumptions were used in the development of cost estimates. Scope and anticipated range of accuracy are discussed, followed by a discussion of the markups and contingencies and a presentation of the unit costs used in this study.

6.2.1.1 Scope and Accuracy Range

The cost estimating criteria presented herein develop a consistent methodology for comparing alternatives. This methodology allows for different alternatives to be evaluated on the same cost basis.

Cost estimates presented in this master plan are based on the Engineering and News Record (ENR) San Francisco cost index of 10,199 published in October 2011. Future adjustments of cost estimates presented in this report can be estimated by increasing the estimated capital cost by the ratio of the future ENR to 10,199.

The cost estimates presented in the CIP have been prepared for general master planning purposes and for guidance in project evaluation and implementation. The actual costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, detailed utility surveys, and environmental and local considerations.

The Association for the Advancement of Cost Engineering (AACE) defines an order-of-magnitude estimate for master plan studies as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type would be accurate within +100 percent to -50 percent. This section presents the assumptions used in developing order of magnitude cost estimates for recommended facilities.

The AACE International defines five different class estimate categories as summarized in Table 6.2.

The budgeting level estimates needed for planning purposes and CIPs are usually based on Class 5, and as such, the costs developed in this master plan shall be considered Class 5 estimates, unless noted otherwise. A definition of the Class 5 estimate is described below.

Table 6.2	Class Estimates Recycled Water Master Plan City of Ukiah		
		Accuracy Range	
Class	**Status of Design**	**Low Side**	**High Side**
5	N/A	-20% to -50%	+30% to +100%
4	1% to 5%	-15% to -30%	+20% to +50%
3	10% to 40%	-10% to -20%	+10% to +30%
2	30% to 70%	-5% to -15%	+5% to +20%
1	80% to 110%	-3% to -10%	+3% to +15%
5	Rough Order-of-Magnitude Planning Estimate		
4	Detailed Planning Level Estimate		
3	Project Budget Estimate		
2	Detailed Project Control Estimate		
1	Bid Check Estimate		

Note:
Percentages are based on the construction cost value and not on an incremental subtotal after each percentage category

Class 5. This estimate is considered as rough order-of-magnitude estimate. It is usually prepared based on limited information, where little more than proposed facility type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location, and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would be cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Little time is expended in the development of this estimate. The typical expected accuracy range for this class estimate is -20 to -50 percent on the low side and +30 to +100 percent on the high side.

All classes of cost estimates described, and any resulting conclusions on project financial or economic feasibility or funding requirements, are prepared for guidance in project evaluation and implementation. The final costs of the project, and resulting feasibility, will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate developed using the information in this master plan. Because of these factors, project feasibility, cost-benefit ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

This evaluation is concerned only with estimates at the planning and conceptual phase of the projects for the City. Therefore, only Class 5 estimates have been developed. For the development of the project costs, a construction cost contingency, estimating contingency, and other markups will be applied consistent with Table 6.3. The markups are intended to account for costs of engineering, design, administration, and legal efforts associated with implementing the project. It should be noted that construction contingency, estimating contingency, and markups are applied incrementally; that is, the percentage for each component is applied to the previous subtotal.

Table 6.3 General Cost Estimating Assumptions
Recycled Water Master Plan
City of Ukiah

Description	Percent of Construction Cost[1]
Construction Cost	100.0%
Construction Cost Contingency	20.0%
Subtotal: Construction Cost + Construction Contingency	**120.0%**
Estimating Contingency	20.0%
Subtotal of Estimating Contingency	20.0%
Subtotal w/ Estimating Contingency[2]	**144.0%**
Engineering and Design	21.0%
Project Administration	5.0%
Legal	5.0%
Subtotal of Total Markups	31.0%
Total Project Cost	**188.6%**

Note:
(1) Percentages are based on the construction cost value and an incremental subtotal after each category for contingencies and total markup cost. Total Project Cost = Construction Cost x (1 + (Construction Cost Contingency x Estimating Contingency)) x (1 + Total Markups).
(2) Estimating Contingency multiplied by Subtotal of Construction Cost plus Construction Contingency.

6.2.1.2 Markups and Contingency

The cost estimates are based on current perceptions of conditions at the project locations. These estimates reflect Carollo's professional opinion of costs at this time and are subject to change as the project details are defined. Carollo has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding, or market conditions, practices, or bidding strategies. Carollo cannot, and does not, warrant or guarantee that proposals, bids, or actual construction costs will not vary for the costs presented as shown.

6.2.1.3 Unit Construction Costs

The construction cost estimates presented in this report are based on the unit construction costs listed in Table 6.4. Construction costs for recycled water system pipelines include pipe material, valves, appurtenances, excavation, installation, bedding material, backfill material, transport, and paving where applicable. The costs of acquiring easements for pipeline construction are not included in the estimates presented in this report.

For booster pumping stations (PS), unit costs are included based on the required horsepower assuming the project involves a new PS requiring new piping and all associated appurtenances. If a PS project only requires the replacement or addition of a pump to an existing PS, the unit costs will be evaluated on a per site basis at that time. Unit costs for PSs are estimated per horsepower of design size.

6.2.1.4 Excluded Costs

There are several other components that may be needed to support the development of major water supply facilities. Since most of these items are unique and project specific, they should be applied on a project-by-project basis. Therefore, no unit costs were included in Table 6.4 for the following items:

- **Land acquisition.** Cost for purchasing land or right of way are not included due to variability of real estate market conditions.
- **Power transmission lines.** The cost of these to support a major pumping or treatment is often on a shared cost basis with the power utility.
- **Maintenance roads.** If pipelines are installed in remote areas, maintenance roads are sometimes required to access the facilities.
- **Overall program management.** If the sheer magnitude of the capital cost program exceeds the capacity of City of Ukiah staff to manage all of the work, then the services of a program management team may be required.
- **Public information program.** Depending on the relative public acceptability of a major water facility or a group of facilities, there may be a need for a public information program, which could take many different shapes.
- **Customer retrofits.** Retrofit costs are associated with separating the customer's existing potable water system from a new recycled water system. An example would be a park where restroom and drinking fountain water supply pipes would need to be isolated from an existing irrigation system. Additional costs include posting signage, which identifies where recycled water is being used. Customer retrofits are one-time costs and are dependent upon the complexity of existing irrigation systems at each individual site. This cost estimate excludes cost of customer retrofits.

Table 6.4 Unit Construction Cost Recycled Water Master Plan City of Ukiah	
Category	**Unit Construction Cost**
Pipelines – Paved Streets	**$/lineal ft**
8-inch diameter	136
12-inch diameter	204
16-inch diameter	272
20-inch diameter	340
24-inch diameter	408
30-inch diameter	510
36-inch diameter	612
42-inch diameter	714
48-inch diameter	816
54-inch diameter	918
60-inch diameter	1,020
72-inch diameter	1,224
Pipelines – Unpaved Easements (Agricultural Land, Site Piping)	**$/lineal ft**
8-inch diameter	109
12-inch diameter	163
16-inch diameter	218
20-inch diameter	272
24-inch diameter	326
30-inch diameter	408
36-inch diameter	490
42-inch diameter	571
48-inch diameter	653
54-inch diameter	734
60-inch diameter	816
72-inch diameter	979
Special Pipeline Construction	**Markup (%) or $/lineal ft**
Jack and Bore	$1,200 /lineal ft
Booster Pumping Stations – New Construction	**$/hp**
Less than 100 hp	9,800
100 to 500 hp	7,400
500 to 3,000 hp	6,400
3,000 to 5,000 hp	3,100
Greater than 5,000 hp	3,000
Storage	**$/gallon**
Pond	$0.10
Steel Tank	$0.70

- **Foundation requirements.** Foundation reinforcement or support requirements are very site specific with regard to necessary method and type, and a geotechnical study is typically needed to determine such requirements. These costs, therefore, have not been included in any of the unit cost curves.
- **Other costs.** These costs may be necessary on some projects and could include environmental mitigation and permitting costs; special legal, administrative, or financial assistance; easements or rights-of-way and land acquisition costs; and expediting costs, such as separate material procurement contracts. These *other* costs typically range from 5 to 15 percent of construction cost.

6.2.2 Cost Estimates for Alternatives

Preliminary capital cost estimates for each of the alternatives discussed in Section 6.1 were developed for relative comparison between the alternatives. Components included in the cost estimates for each alternative include pipelines, storage provided by the City, and pump stations. The sizing of the components is presented in Table 6.5.

Table 6.5 Summary of Project Components
Recycled Water Master Plan
City of Ukiah

Alternative	Irrigation Acreage	Frost Protection Acreage	Pipeline Length (mi.)	Pump Station (hp)	Storage Pond(1) (MG)
1	793	483	5.8	150	0.65
1B	915	483	7.3	150	0.65
2	619	494	3.9	75	1.60
3	891	837	6.0	1,400	200.00
3B	1,210	837	8.4	1,400	200.00
4	703	284	9.4	400	1.60

Note:

(1) Costs for farmer provided storage were not included in this analysis. While all alternatives utilize farmer provided storage, Alternative 2 relies the most heavily on farmer provided storage. Based on discussions during the Stakeholder Workshops, farmers may be able to construct frost protection storage ponds more economically than the unit costs used within this study. However, it is important to recognize this unseen cost. For Alternative 2, based on the unit costs used in this study of $0.10 per gallon, the estimated project cost for the 58.8 af of farmer provided storage would be $3.6 M.

Preliminary cost estimates for capital costs for each alternative are presented in Table 6.6. Cost estimates do not account for operations and maintenance costs. Some operations and maintenance costs will be included in the financial analysis of the recommended alternative in Chapter 8.

Table 6.6	Preliminary Cost Estimates Recycled Water Master Plan City of Ukiah			
Alternative	**Capital Cost ($M)**	**Annual Demand[1] (AFY)**	**Annual Cost[2] ($ per year)**	**Estimated Unit Cost[1] ($ per AF)**
1	$10.3	1,071	$680,000	$635
1B	$12.3	1,268	$810,000	$639
2	$8.0	946	$530,000	$560
3	$58.4	1,499	$3,800,000	$2,535
3B	$67.0	2,017	$4,360,000	$2,162
4	$25.3	1,376	$1,650,000	$1,199

Notes:
(1) Annual demand is based on the combined demand of landscape irrigation, agricultural irrigation, and frost protection. It should be noted that the value associated with the frost protection demand is whether or not frost protection is provided rather than the quantity of actual demand.
(2) Amortization assumes interest rate of 6% and 30-year payback period.

Capital costs were amortized to compare the relative advantages on a unit cost basis assuming an interest rate of 6 percent and a payback period of 30 years. It should be noted that, although the frost protection demand is included in the annual demands used to develop the unit costs, the unit costs do not reflect the value of frost protection, as whether or not frost protection is provided is much more critical than the actual quantity of frost protection demand supplied.

As shown in Table 6.6, Alternative 2 is the least costly, on both a capital and unit cost basis. However, the cost to the individual farmers of on-site storage is not included in this estimate. Alternative 1 and 1B are the next least expensive on both a capital and unit cost basis. The additional pipeline length included in Alternative 1B is offset by the increase in demand, making the two alternatives comparable on a unit cost basis. Alternative 3 and 3B are predicted to be the most expensive, with unit costs exceeding $2,000 per af. Estimated costs for Alternative 4 fall between the centralized storage costs and the lower cost alternatives. Detailed cost estimates are included in Appendix C.

6.3 PLANNING AND DESIGN ASSUMPTIONS

The alternatives for the City's recycled water system are planned based on the project flows and planning and design criteria defined in this chapter. The developed criteria addressed the recycled water system capacity, pipe roughness, maximum velocity, minimum velocity, maximum headloss, and demand factors.

Demand factors and other customer specific factors were discussed in detail in Chapter 5, and will only be summarized here.

The planning and design criteria are presented in Table 6.7. A discussion of several of these criteria follows.

Table 6.7 Planning and Design Criteria
Recycled Water Master Plan
City of Ukiah

Description	Criteria
Delivery Pressure – Agricultural Irrigation	20 psi
Delivery Pressure – Landscape Irrigation	40 psi
Minimum System Pressure	5 psi
Maximum Pipeline Velocity(1)	5 ft/sec
Maximum Pipeline Headloss (Diameter <= 12-inches)	10 ft/1,000 ft (ft/kft)
Maximum Pipeline Headloss (Diameter > 12-inches)	3 ft/kft(2)
Pipeline Roughness (C Factor)	130
Seasonal Peaking for Irrigation	1.00
Agricultural Irrigation Schedule	Continuous
Landscaping Irrigation Schedule	6 pm to 5 am (Continuous)
Customers with Storage Frost Protection Schedule	Recharge for 16 hours a day for 3 days, then continuous for 7 days
Customers without Storage Frost Protection Schedule	8 hours a day for 3 days

Notes:
(1) A higher pipeline velocity criteria of 10 ft/sec was used to accommodate the significant frost protection demands. A pipeline velocity criteria of 5 ft/sec was used for irrigation scenarios.
(2) Under frost protection scenarios, headloss of up to 5 ft/kft was considered acceptable in pipelines over 12-inches in diameter.

6.3.1 Supply Availability

As discussed in Chapter 3, the projected wastewater available for use as recycled water is projected to grow by about 550 AFY over the next 25 years. The wastewater flow varies seasonally, with minimum flows occurring during the summer months. Since the minimum flow coincides with peak irrigation demands (due to evapotranspiration, as discussed in Chapter 5), the irrigation demands supplied by the recycled water system will be limited by the available flow during summer months. Table 6.8 presents projected available supplies for both average annual and August conditions.

Table 6.8	Projected Wastewater Flow Recycled Water Master Plan City of Ukiah				
	Average Annual Wastewater Flow		Projected August Flow[1]	Ukiah WWTP Demand	Available Recycled Water Supply[2]
Year	(AFY)	(mgd)	(mgd)	(mgd)	(mgd)
2010	4,650	4.15	1.99	0.14	1.85
2015	4,650	4.15	2.25	0.16	2.09
2020	4,780	4.27	2.31	0.16	2.15
2025	4,910	4.39	2.38	0.17	2.21
2030	5,060	4.51	2.45	0.17	2.28
2035	5,200	4.65	2.52	0.18	2.34

Notes:

(1) Predicted minimum monthly flow based on the month of August, the minimum month for the period 2001 through 2010. Average seasonal flow pattern for August when compared with average flows was 0.54. Actual flow for the month of September 2010, the minimum flow month for 2010, was 1.99 mgd.

(2) During month of August (predicted to have the minimum available wastewater flow).

As discussed in Chapter 3, the Ukiah WWTP is the only existing recycled water user. Based on discussions with City staff, annual usage by the Ukiah WWTP is estimated at 323 AFY or about 0.3 mgd. Assuming the demand of the treatment plant varies according to the plant flow, the projected August flow is included in Table 6.8 and deducted from the plant flow in order to calculate the available supply.

As shown in Table 6.8, estimated available supply is projected to increase from 1.85 mgd to 2.34 mgd by 2035. The alternatives developed in this chapter will be constrained by this available recycled water supply.

6.3.2 Alignments

Routing of pipelines was assumed through agricultural land and along the railroad easement to minimize the cost associated with laying pipeline in paved streets. Pipelines routed within agricultural land were aligned to farmers' access paths from aerial photographs.

6.3.3 Seasonal Demand Variation

While irrigation is expected to vary by season, based on discussions with City staff, the farm bureau, and the RRFCD, irrigation demands are assumed to be relatively flat seasonally. This is believed to be partially due to the limited number of months for which irrigation is used. As discussed in Chapter 5, vineyards are typically irrigated between June

and October and Orchards are typically irrigated between May and September. When compared to irrigation occurring year round, the seasonal peaking during this irrigation season may appear relatively flat. Thus, a seasonal peaking factor of 1.0 will be used for development of the alternatives in this chapter. However, irrigation will be assumed to occur for only a limited number of months out of the year.

6.3.4 Daily Demand Variation

Based on discussions with City staff, the farm bureau, and the RRFCD, irrigation demands for agricultural crops vary significantly by crop type and individual farmer. It was noted that farmers would most likely be accustom to irrigating for a few days continuously every couple weeks. For the purposes of developing alternatives, the assumption was made that agricultural irrigation would be continuous and relatively flat, with no hourly fluctuation.

Demands for urban landscape irrigation are assumed to occur between 6 p.m. and 5 a.m. It is assumed that demand will be evenly distributed over this period. It should be noted that if irrigation is concentrated simultaneously within a couple hours, the sizing of the distribution system would need to be increased. This can be averted by staggering the scheduling of irrigation timers, especially those within the City's control, such as those for City parks. Based on discussions with City staff, potential urban landscape irrigation users, such as the golf course, do not have on-site storage capabilities, and thus could not accept water during daytime hours (golf courses often can use on-site ponds to accept irrigation water during off-peak hours, reducing the required sizing of the recycled water distribution system).

6.3.5 Frost Protection Demands

As discussed in Section 6.1, the limiting factor for many of the alternatives is the plant flow and corresponding recharge time for replenishing storage, whether farmer provided storage or centralized storage. As discussed in Chapter 5, typical frost event durations are estimated as three days, with two frost events occurring during a typical peak month of the frost season. It is assumed that the two frost events occurring during a typical month occur at least one week apart, allowing time for the plant to recharge the applicable storage. While some frost events in a worst case scenario are anticipated to occur for more than three consecutive days, or occur less than a week apart, sizing of the storage for such events is anticipated to be prohibitively expensive or reach too few farmers to be justified.

6.4 NO PROJECT ALTERNATIVE

Since this project has multiple beneficiaries, the effect of a "No-Project" Alternative is discussed separately for each. The beneficiaries for the various alternatives in this study include the wastewater users (since Ukiah WWTP is restricted from discharging to the Russian River during specific times), agricultural farmers (for frost protection and irrigation), and landscape irrigation users (as a lower cost alternative to potable water).

For the wastewater users, a “No-Project” Alternative would necessitate the Ukiah WWTP to build additional percolation ponds to accommodate effluent flow during periods in which discharge is restricted.

For agricultural farmers, based on recent developments regarding restrictions on use of water from the Russian River for frost protection, without recycled water as an alternative source for water for frost protection demands, agricultural parcels in the area may not be provided frost protection using water. The farmers are outside of the City service area to receive potable water supplied by the City, and the City currently has no plans to expand their service area in order to serve them. And it is highly unlikely any of the other water purveyors in the area have additional supplies to serve the farmers. It is anticipated that potable or groundwater sources for frost protection water would be economically unfeasible. While not evaluated within the scope of this study, without water for frost protection, agricultural farmers may be forced to utilize alternative methods of frost protection, such as heaters or wind machines (Snyder, 2001), which may not be economically viable or feasible due to the type of frost situations the Valley is accustomed to. Effects of the “No-Project” Alternative on farmer irrigation use is assumed to be minimal.

For landscape irrigation uses, effects of the “No-Project” Alternative include continuing to use potable water for landscape irrigation at potable water rates. It is not anticipated that the City will face shortages of water supplies within the planning horizon of this study.

6.5 COMPARISON OF ALTERNATIVES

The six alternatives were compared on their technical and non-technical merits.

Screening criteria were developed at the Visioning Workshop held at the beginning of the master planning process. Both quantitative and qualitative criteria were used to compare and rank the alternatives. A summary of the criteria is show in Table 6.9.

The quantitative parameters were straightforward in their ranking. As shown in Table 6.10, Alternatives 1B and 4 rank best in the quantitative scoring, while Alternative 3 ranks worst.

Table 6.11 presents the comparison of alternatives on a qualitative basis, with the associated scoring results in Table 6.12. For the qualitative parameters, a description was provided and then a general ranking of minimum, moderate, or maximum was provided depending on how the alternative met the criteria relative to the other alternatives. A discussion of the specific qualitative rankings and scores follows.

A matrix showing the quantitative scoring was developed and is presented in Table 6.10.

As shown in Table 6.12, Alternatives 1 and 1B have the lowest qualitative scores, while Alternatives 3B and 4 have the highest qualitative scores. Overall scores are presented in Table 6.13.

Table 6.9 Screening Criteria
Recycled Water Master Plan
City of Ukiah

Criteria	Definition	Quantitative Measure	Qualitative Measure
Cost	Planning-level estimate of capital cost	$ and $/af	-
Water Offsets	Reduction in water use: - Potable* - River/groundwater*	AFY	-
System Flexibility	Variety and quantity of benefits and uses	Ac (irrigation) and Ac (frost)	-
Implementation Considerations	Political will, project phasing, and timing	-	Description
Public Acceptance	Public support of project (aesthetics and social benefits)	-	Description
Funding	State and Federal funding	-	Description
Environmental Considerations	Improves environment, CEQA requirements	-	Description
Regulatory Implications	Meets regulatory requirements	-	Description

Table 6.10 Quantitative Scoring
Recycled Water Master Plan
City of Ukiah

	System Flexibility		Water Offsets		Costs		
Alternative	Irrigated Area	Frost Protected Area	Potable	River or GW	Capital	Unit	Overall Quantitative Score
1	1.7	2.1	5.0	2.3	0.8	1.2	13.0
1B	1.2	2.1	5.0	1.8	0.9	1.2	12.0
2	2.4	2.1	5.0	2.6	0.6	1.1	14.0
3	1.3	0.0	4.5	1.3	4.4	5.0	16.0
3B	0.0	0.0	4.0	0.0	5.0	4.3	13.0
4	2.1	3.3	0.0	2.0	1.9	2.4	12.0

Note:
(1) Scores are weighted based on the relative quantities for each criteria. A score of 0 meets the criteria best of the alternatives, while a score of 5 meets the criteria worst out of the alternatives.

Table 6.11 Qualitative Comparison
Recycled Water Master Plan
City of Ukiah

Alternative	Difficulty of Implementation	Public Acceptance	Funding	Environmental Considerations	Regulatory Impacts
1	Min	Max	Mod	Min	Min
1B	Min-Mod	Max	Mod	Min	Min
2	Max	Max	Max	Mod	Mod
3	Mod	Max	Min	Max	Mod
3B	Mod	Max	Min	Max	Mod
4	Mod-Max	Max	Mod	Min	Mod

Note:
(1) Assessment based on discussion above. Min = minimal, Mod = moderate, Max = maximal.

Table 6.12 Qualitative Scoring
Recycled Water Master Plan
City of Ukiah

Alternative	Ease of Implementation	Public Acceptance	Funding	Environmental Considerations	Regulatory Impacts	Overall Score
1	1	1	3	1	1	**7**
1B	2	1	3	1	1	**8**
2	5	1	1	3	5	**15**
3	3	1	5	5	3	**17**
3B	3	1	5	5	3	**17**
4	4	1	3	1	3	**12**

Table 6.13 Total Scoring
Recycled Water Master Plan
City of Ukiah

Alternative	Quantitative Score	Qualitative Score	Overall Score	Rank
1	14	7	21	1
1B	13	8	21	1
2	14	15	29	4
3	17	17	34	6
3B	14	17	31	5
4	12	12	24	2

6.5.1 Difficulty of Implementation

Difficulty of implementation accounts for difficulty of design and construction, as well as effort required to coordinate construction and implementation between parties.

Alternative 1 was ranked minimal, meaning that relative to the other alternatives, Alternative 1 represents the least effort with implementation, due to its smaller footprint. Alternative 1B requires slightly more effort to implement, due to increased length of pipeline. Alternatives 3 and 3B were ranked as moderate difficulty to implement, since these projects would require extensive design and construction. Difficulty of implementation was scored moderate to maximal for Alternative 4, due to construction considerations in the urban areas and coordination between agricultural and landscape irrigation. Alternative 2 was considered to have the least ease of implementation due to the necessity of individual farmers constructing their own individual storage.

6.5.2 Public Acceptance

Since each of the alternatives assists with providing a point of discharge while the wastewater discharge limitations are in effect and helps to preserve agricultural character of the City and Valley, all alternatives were scored maximal.

6.5.3 Funding

Assessment of funding was based on the anticipated ease of obtaining funding for the alternative. Alternative 2 was considered to have the least difficulty with funding, as some grants are available to individual farmers for construction of ponds. Alternatives 3 and 3B are ranked minimal since they have the greatest cost, and are anticipated to have the greatest difficulty with financing out of the alternatives.

6.5.4 Environmental Considerations

Alternatives 1 and 1B are anticipated to encounter the least environmental issues when compared to the other alternatives. Alternatives 3 and 3B include construction of a 200 af pond, with associated environmental considerations, and were thus ranked maximal.

6.5.5 Regulatory Impacts

Because of their smaller footprint, Alternatives 1 and 1B are anticipated to have the least difficulty with regulatory impacts out of the alternatives. The remaining alternatives are anticipated to have fairly similar regulatory impacts.

6.5.6 Qualitative Scoring

Based on the qualitative issues described, scores were assigned to each alternative, as presented in Table 6.12.

6.5.7 Overall Scoring

The combined scoring, incorporating both the quantitative and qualitative scores, is presented in Table 6.13. As shown in Table 6.13, Alternatives 1 and 1B rank the best out of the alternatives, while Alternatives 3 and 3B ranked the least favorable. Alternative 4 ranked just after Alternatives 1 and 1B.

6.5.8 Recommended Alternative

The preferred alternative was selected using the screening and ranking outcome as a basis, but also considered relative importance of each criteria. During the ranking process, each criteria was considered to be equal and hold the same level of importance as the others. This however, was not the case when a bigger picture view was considered, such as the importance of off setting potable water demands. Alternatives 1 and 1B met most of the screening criteria the best, but did not contain any potable water offsets. Alternative 2 had the most implementation concerns and regulatory concerns as its success relies on the farmers developing storage. Alternatives 3 and 3B were the least desirable with the highest costs, highest operations and maintenance due to the large pump station required, and very minimal potable water offsets. Alternative 4 had a relatively higher cost since it serves the most users, and also has the most potential for potable water offsets. Therefore, based on the ranking process and discussions with City staff, Alternative 4 was selected as the preferred alternative.

RECOMMENDED FACILITIES PROJECT PLAN

7.1 RECOMMENDED ALTERNATIVE

After reviewing the draft outcome of the projects screening and ranking, discussions with City staff, and a presentation to the City Council, it was decided to select Alternative 4 as the recommended recycled water project alternative for the City. This alternative is presented in Figure 7.1. This alternative combines agricultural frost protection and irrigation usage with urban landscape irrigation. The recycled water would be pumped from Ukiah Wastewater Treatment Plant (WWTP) to those landowners with storage, and would also be available up to the WWTP and pump station capacity to those landowners without storage facilities. Optimization in this analysis will be focused on further development of alternative details and phasing of the recommended alternative. This alternative is recommended because it provides a greater number of benefits, including the option for eventual urban landscape irrigation, at a lower cost than many of the other alternatives.

7.1.1 Preliminary Design

The design conditions and criteria for the recommended alternative are summarized in Table 7.1. The pipeline routing and potential customers and parcels served are discussed in the sections that follow.

7.1.1.1 Planning and Evaluation Criteria

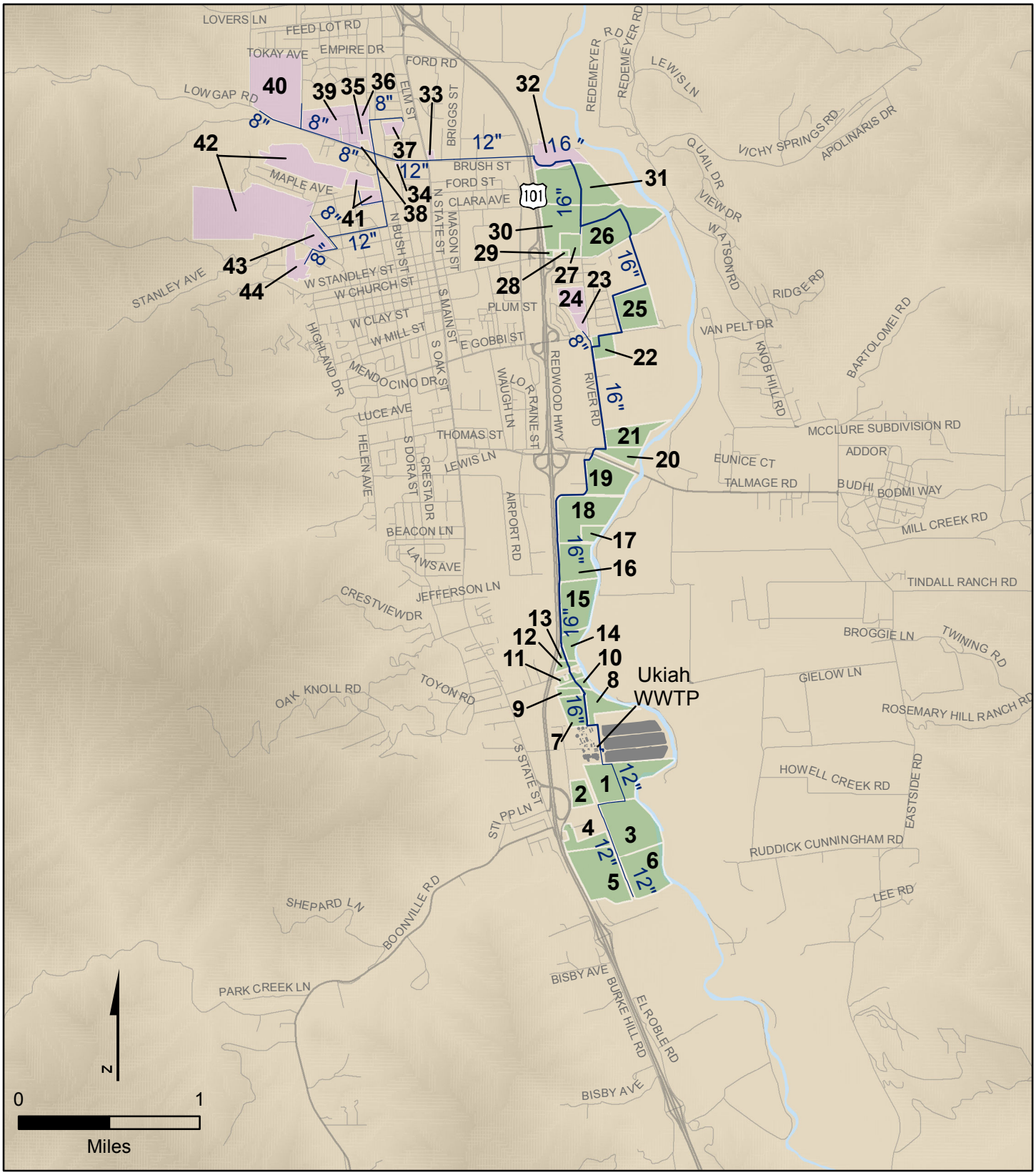
Planning and evaluation criteria were used to develop the preliminary design in the following sections. This criteria is listed in Table 7.1. In addition, the criteria discussed in Chapter 6 was used to develop demands.

Several of the criteria listed in Table 7.1 represent conservative planning assumptions. During more detailed design, and as the commitment of potential customers becomes more certain, these planning and evaluation criteria may be further refined.

As in the preliminary alternatives analysis, it is assumed that the individual potential customers are responsible for their customer laterals. It is also assumed that the farmer's are individually responsible for sizing of their frost protection ponds and pumping and pipelines from their ponds.

7.1.1.2 Pipeline Route

The proposed recycled water system includes 9.4 miles of recycled water pipelines ranging between 8 and 16-inches in diameter. The preliminary pipeline alignment for the recommended alternative is presented in Figure 7.1. In order to reduce construction costs, the pipeline is planned to be constructed partially within the right-of-way of some of the agricultural land that it provides frost protection to. Major transmission pipelines are routed



Legend

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

- WWTP Ponds and Buildings
- Landscape Parcels
- Agricultural Parcels
- River
- Major Roads
- Local Streets

Figure 7.1
RECOMMENDED ALTERNATIVE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_7_1-Recommended_Alternative.mxd

Table 7.1 Planning and Evaluation Criteria Recycled Water Master Plan City of Ukiah	
Description	**Criteria**
Delivery Pressure – Agricultural Irrigation	20 psi
Delivery Pressure – Landscape Irrigation	40 psi
Minimum System Pressure	5 psi
Maximum Pipeline Velocity(1)	5 ft/sec
Maximum Pipeline Headloss (Diameter <= 12-inches)	10 ft/kft(1)
Maximum Pipeline Headloss (Diameter > 12-inches)	3 ft/kft(2)
Pipeline Roughness (C Factor)	130
Storage	5 af (1.6 MG) at Ukiah WWTP
Seasonal Peaking for Agricultural Irrigation	1.00
Seasonal Peaking for Landscape Irrigation	1.73
Agricultural Irrigation Schedule	Continuous
Landscaping Irrigation Schedule	6 pm to 5 am (Continuous)
Customers with Storage Frost Protection Schedule	Recharge for 16 hours a day for 3 days, then continuous for 7 days
Customers without Storage Frost Protection Schedule	8 hours a day for 3 days

Notes:
(1) A higher pipeline velocity criteria of 10 ft/sec was used to accommodate the significant frost protection demands. A pipeline velocity criteria of 5 ft/sec was used for irrigation scenarios.
(2) Under frost protection scenarios, headloss of up to 5 ft/kft was considered acceptable in pipelines over 12-inches in diameter.

north through the east part of the City along Hastings Road and through agricultural right of way. Assuming the optional urban landscape irrigation would be developed, Highway 101 would be crossed using trenchless construction techniques at Brush Street to serve urban landscape irrigation demands on the west side of the City.

A previous recycled water study evaluated the feasibility of a recycled water pipeline installed through the City downtown along State Street. At the time of that study, other utilities were being constructed along the State Street alignment, minimizing the disruption and cost associated with constructing a recycled water pipeline along that alignment. However, that route focused on offsetting urban irrigation, and did not maximize agricultural uses. The alignment shown in Figure 7.1 is routed to the east of the City to maximize the potential for agricultural benefit AND minimize costs associated with construction through the developed downtown area.

A summary of the pipeline lengths associated with the alignment shown in Figure 7.1 are presented in Table 7.2.

Table 7.2 Pipeline Length
Recycled Water Master Plan
City of Ukiah

Type of Alignment[1]	Diameter (in)	Length (ft)
Agricultural Land / Site Piping	16	14,500
Agricultural Land / Site Piping	12	6,000
Paved Public Street	16	9,600
Paved Public Street	12	8,600
Paved Public Street	8	10,900
	Total	**49,600**

Note:
(1) Laterals to individual agricultural parcels are assumed to be the responsibility of the farmer or landowner and are not included in the lengths presented here.

As shown in Table 7.2, a total of approximately 49,600 feet, or 9.4 miles, of pipeline is included in the alignment shown in Figure 7.1.

7.1.1.3 Potential Users

There are two categories of potential users, agricultural and landscape irrigation. Based on discussions with City staff, it is anticipated that the City will pursue a phased approach to implement the recommended recycled water system. Total estimated demand by phase and type is presented in Table 7.3. Table 7.4 lists the agricultural users by irrigable area, annual irrigation and frost protection demands, and instantaneous demand. Table 7.5 lists landscape irrigation demands by parcel, and includes the estimated instantaneous irrigation demand, annual irrigation demand, and name. The Map IDs in Table 7.4 and Table 7.5 correspond to Figure 7.2.

Table 7.3 Annual Demand Summary
Recycled Water Master Plan
City of Ukiah

	Estimated Annual Demand (afy)				
	Irrigation				
Phase	Agricultural	Urban Landscape	Frost Protection	Total for Phase	Cumulative Total
1	309.2	0.0	94.6	403.8	403.8
2	210.4	0.0	4.8	215.1	618.9
3	311.8	22.2	42.3	376.3	995.2
4	0.0	380.6	0.0	380.6	1,375.8
Total	**831.4**	**402.8**	**141.7**	**1,375.8**	

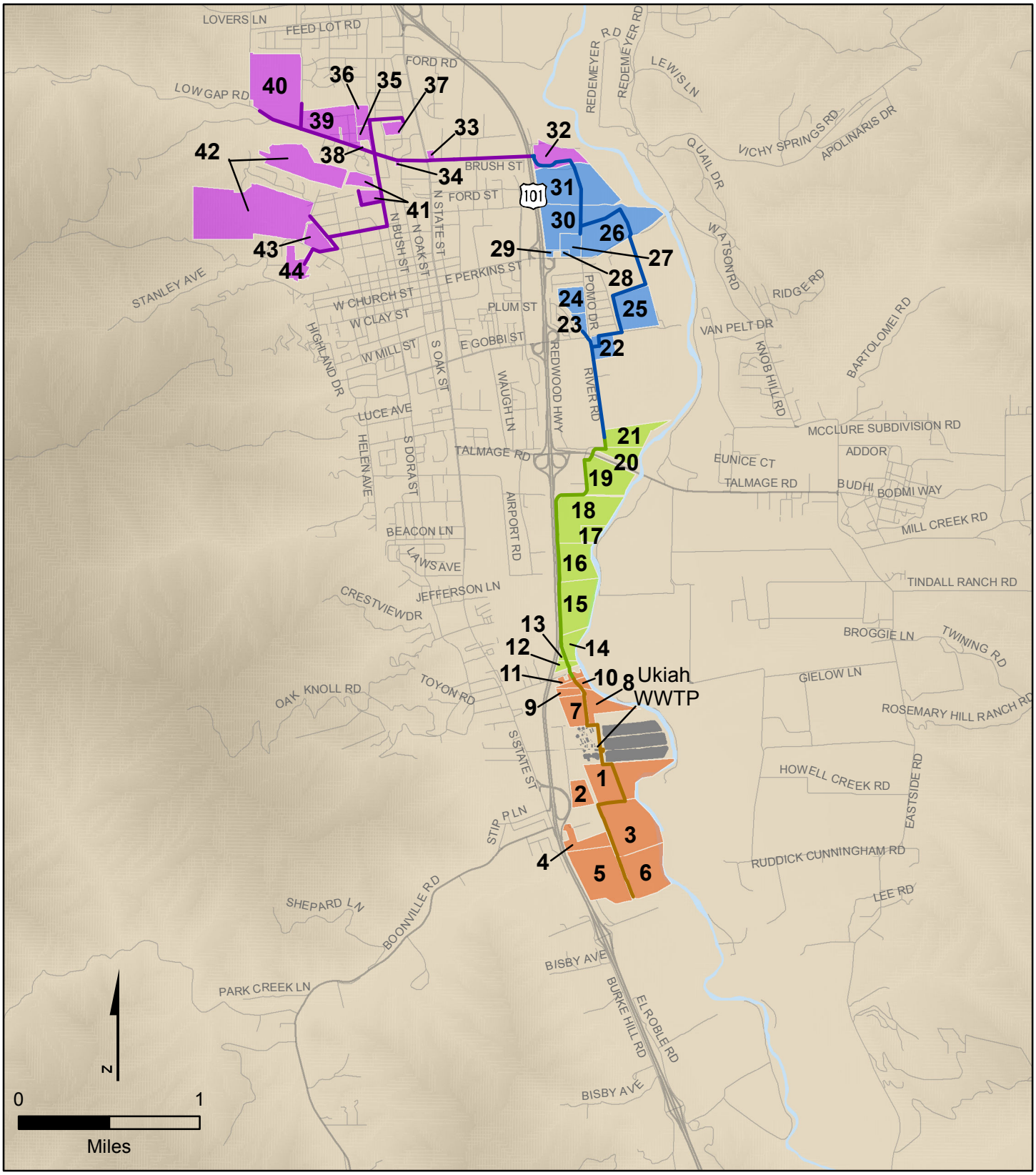
Table 7.4 Potential Agricultural Customers
Recycled Water Master Plan
City of Ukiah

Map ID	Name	Provided Irrigation Water	Provided Frost Protection	Storage Pond	Estimated Demand (afy)		Irrigable Acreage by Crop			
					Irrigation	Frost Protection	Vineyard	Orchard	Pasture	Other Row Crop
Phase 1										
1	Koball	Y	Y	Y	70.5	17.6	0.0	35.2	0.0	0.0
2	Gannon	Y	Y	N	18.5	4.6	0.0	9.2	0.0	0.0
3	Koball	Y	Y	Y	81.3	20.3	0.0	40.5	0.0	0.0
4	Milovina	Y	Y	Y	7.9	5.2	10.5	0.0	0.0	0.0
5	Milovina	Y	Y	Y	33.0	22.0	44.0	0.0	0.0	0.0
6	Koball	Y	Y	Y	57.0	14.2	0.0	28.4	0.0	0.0
7	City	Y	Y	N	10.3	6.9	13.8	0.0	0.0	0.0
8	Norgard	Y	Y	N	21.7	1.5	0.0	3.0	7.8	0.0
9	Norgard	Y	Y	N	4.4	1.5	2.0	0.9	0.6	0.0
10	Norgard	Y	Y	N	4.6	0.8	1.4	0.2	1.5	0.0
Phase 2										
11	Norgard	Y	Y	N	0.5	0.3	0.6	0.0	0.0	0.0
12	Norgard	Y	Y	N	2.0	1	1.5	0.5	0.0	0.0
13	Norgard	Y	Y	N	0.7	0.5	1.0	0.0	0.0	0.0
14	Norgard	Y	Y	N	12.1	3	0.0	6.0	0.0	0.0
15	Norgard	Y	N	N	54.4	0	0.0	27.1	0.0	0.0
16	Norgard	Y	N	N	43.4	0	0.0	21.6	0.0	0.0
17	Norgard	Y	N	N	10.2	0	0.0	5.1	0.0	0.0
18	Hildreth	Y	N	N	27.6	0	36.8	0.0	0.0	0.0
19	Hildreth	Y	N	N	48.4	0	0.0	24.1	0.0	0.0
20		Y	N	N	11.0	0	0.0	5.5	0.0	0.0
Phase 3										
21		Y	N	N	26.9	0	0.0	13.4	0.0	0.0
22		Y	N	N	4.5	0	6.1	0.0	0.0	0.0
25		Y	N	N	19.2	0	25.5	0.0	0.0	0.0
26		Y	Y	Y	98.9	24.7	0.0	49.3	0.0	0.0
27		Y	Y	Y	15.8	3.9	0.0	7.9	0.0	0.0
28		Y	N	Y	0.9	0	0.0	0.4	0.0	0.0
29		Y	N	N	2.2	0	0.0	1.1	0.0	0.0
30		Y	Y	Y	55.0	13.7	0.0	27.4	0.0	0.0
31		Y	N	N	88.4	0	0.0	44.1	0.0	0.0
Total					**831.4**	**141.7**	**143.3**	**351.2**	**9.9**	**0.00**

Table 7.5 Potential Landscape Irrigation Customers
Recycled Water Master Plan
City of Ukiah

Map ID	Name	Type	Irrigated Acreage	Estimated Annual Irrigation Demand[1] (afy)	Peak Demand[2] (gpm)	Current Potable Demand[3] (afy)
Phase 3						
23	Oak Manor Park	Park	3.4	6.9	27.9	10.4
24	Oak Manor School	School	7.5	15.3	61.2	9.6
Phase 4						
32	Ukiah Sports Complex[4]	Park	11.5	23.4	93.8	19.7
33	UUSD District Office	School	0.3	0.6	2.3	1.5
34	Brush Street Fountain	Park	0.3	0.7	2.8	
35	Ukiah Adult School	School	0.9	1.8	7.1	0.6
36	Frank Zeek School	School	3.5	7.0	28.1	2.3
37	Vinewood Park	Park	4.4	8.9	35.6	15.1
38	UUSD Special Education and Preschool	School	0.1	0.1	0.6	0.9
39	Russian River Cemetery	Other	26.6	53.9	216.3	18.5
40	Ukiah High School	School	39.6	80.4	322.4	62.4
41	Track and Baseball Fields (near Bus Barn)	Park	12.4	25.2	100.9	
42	City Golf Course	Golf Course	73.5	149.0	597.8	139.4
43	Todd Grove Park	Park	7.2	14.7	58.8	14.2
44	Anton Stadium	Park	7.4	14.9	59.9	12.8
Total			**198.6**	**402.7**	**1,615.4**	**307.4**

Notes:
(1) Based on irrigable acreage estimated from aerial photograph and water demand factors discussed in Chapter 5.
(2) Instantaneous demand based on seasonal peaking of 1.73, seven months of irrigation annually, and irrigation demands distributed evenly over 11 hours each night.
(3) Based on average usage from 2008 to 2010 billing data. Provided for reference; it should be noted that some potential customers, such as smaller schools, may not have dedicated irrigation meters, thus potential demand may be lower than that shown here.
(4) Ukiah Sports Complex is located at the north end of the pipeline proposed for Phase 3 and could be included in Phase 3 or Phase 4 depending on whether the City intends to implement Phase 4.



Legend

Pipelines by Phase	Potential Parcels by Phase	
1	1	WWTP Ponds and Buildings
2	2	River
3	3	Major Roads
4	4	Local Streets

Figure 7.2
PHASING OF
RECOMMENDED ALTERNATIVE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_7_2-Phasing_of_Recommended_Alternative.mxd

As shown in Table 7.4, the annual irrigation demand associated with irrigation of agricultural land for the recommended alternative is 831 acre-feet per year (AFY). Peak demand is estimated as 2,284 gpm based on flat seasonal peaking of irrigation demands and a 13-hour irrigation cycle in order to coordinate with the landscape irrigation schedule. If a 24-hour irrigation schedule were used, the peak demand is estimated at 1,237 gpm. Based on discussions with farmers, it is anticipated that scheduling of irrigation demands would be feasible.

As discussed in Chapter 6, an estimated supply of 2.34 mgd is projected to be available from the Ukiah WWTP during the month of August under 2035 conditions. Adding the landscape and agricultural irrigation demands results in peak seasonal demand of 2.85 mgd, anticipated to occur in July. By comparing the available monthly supply to the monthly demand variation (based on monthly irrigation requirements from evapotranspiration as discussed in Chapter 5), it is estimated that 18.6 MG (57 af) of seasonal storage would be required. In order to maximize the amount of irrigable land, it is anticipated that the City could coordinate irrigation of agricultural parcels with frost protection ponds to store irrigation water for their parcels in lieu of irrigation water from the distribution system for these peak periods. Alternatively, the City could construct a storage pond at the Ukiah WWTP to be used for seasonal irrigation storage, or fewer irrigation customers would need to be served.

It should be noted that the total number of customers listed in Table 7.4 and Table 7.5 differs slightly from the number of parcels listed in Alternative 4 in Chapter 6. Landscape irrigation customers with the same owner name for adjacent parcels were combined into a single customer, reducing the number from 60 parcels to 44 customers.

As shown in Table 7.5, the annual irrigation demand associated with landscape irrigation for the recommended alternative is 403 acre-feet per year (AFY). Peak demand for the landscape irrigation is estimated as 1,615 gpm, based on an assumed seasonal peaking factor of 1.73 and scheduling of landscape irrigation from 6 pm to 5 am. It should be noted that if demand management is not applied, landscape irrigation demands could be significantly higher (e.g., if City park sprinklers are set by timer to irrigate between 10 pm and 11 pm, demands would be significantly higher than if City park irrigation timer setpoints are evenly distributed between 6 pm and 5 am).

As will be discussed later, it is anticipated that landscape irrigation and agricultural demand schedules will be coordinated to maximize use of the pipeline network such that agricultural demands will be supplied between 5 am and 6 pm and landscape irrigation demands will be supplied between 6 pm and 5 am. If this coordination is not realized, additional storage may be required to buffer irrigation demands.

Instantaneous frost demand for the acreage provided frost protection would be estimated as 17,700 gpm. However, the majority of provided frost protection will be through farmer

provided frost protection storage ponds. Assuming recharge of farmer provided storage ponds during non-frost protection hours during the three days of a peak frost protection event and during a seven day recharge period between peak frost protection events is estimated as 520 gpm. Instantaneous frost protection demand for the parcels provided frost protection without storage ponds is estimated as 2,410 gpm. It should be noted that the sizing of individual farmer's frost protection ponds is assumed the responsibility of the individual agricultural parcel and was not evaluated as a part of this study.

Sizing of pipelines included in the pipeline alignment was based on the design criteria presented in Table 7.1. Pipeline length by phase, diameter, and construction condition is presented in Table 7.6.

Table 7.6 Pipeline Length by Phase
Recycled Water Master Plan
City of Ukiah

Phase	Type of Alignment[1]	Diameter (in)	Length (ft)
1	Ukiah WWTP Site Piping	16	1,300
1	Agricultural / Railroad Easements	12	5,600
2	Paved Street	16	5,600
2	Agricultural / Railroad Easements	16	4,200
3	Agricultural / Railroad Easements	16	9,000
3	Paved Street	16	4,000
3	Agricultural / Railroad Easements	12	400
3	Paved Street	8	1,000
4	Paved Street	12	4,700
4	Paved Street	8	13,800
Total			**49,600**

Note:
(1) Laterals to individual agricultural parcels are assumed to be the responsibility of the farmer or landowner and are not included in the lengths presented here.

As shown in Table 7.6, pipelines installed in the first phase are anticipated to be entirely within the treatment plant or along agricultural or railroad easements and would not be along paved roads. Phases 2 and 3 would be along both agricultural easements where possible, or along paved roads, primarily River Road, Babcock Lane, and Hastings Frontage Road. Pipelines installed as a part of the optional Phase 4 would be along paved streets, and are routed to enter the urban area from the east to minimize the total length of pipeline along paved streets.

7.1.1.4 Pump Station

A single pump station is included in the alignment shown in Figure 7.1 at the Ukiah WWTP. Recommended sizing for this pump station based on the criteria outlined in Table 7.1 is presented in Table 7.7.

Table 7.7 Pump Station Units by Phase
Recycled Water Master Plan
City of Ukiah

Phase	New Units	Elevation Served (ft-msl)	Head (ft)	Flow (gpm)	Power (hp)
1	2	560 - 580	310	800	200
2	2	580 - 590	310	800	200
3	-	600 - 610	-	-	-
4	-	610 - 710	-	-	-

Initially, it is planned that two pump units be installed in the pump station, with spare bays for two additional units, which would be installed in Phase 2. Phase 3 and 4 are not anticipated to require additional pump units, since the demands for frost protection are significantly higher than what would be required for urban landscape irrigation.

It should be noted that the recommended pump sizing is based on ultimately serving the urban uses in Phase 4, which are about 100 feet higher in elevation than the potential agricultural parcels. If only Phases 1 through 3 are implemented, the pump head could be reduced. Alternatively, a smaller booster pumping station could be implemented along with Phase 4 near the freeway crossing.

The elevation at the Ukiah WWTP is approximately 580 feet above mean seal level (ft-msl).

7.1.1.5 Storage

Storage is anticipated to include individual storage ponds at specific farmers, as well as a single storage pond at the wastewater treatment plant sized at 5 af (1.6 MG). The storage pond at the wastewater treatment plant is recommended both to accommodate the variation in potential customer demand patterns and as an equalization basin to buffer the potential variation in effluent flow at the WWTP.

It should be noted that as hourly flow data from the Ukiah WWTP was not available, sizing is estimated based on one third of the projected 2035 average annual wastewater flow volume of 4.65 mgd.

Increasing the size of the storage pond at the Ukiah WWTP beyond 5 af would allow additional users to be provided frost protection and increase operational flexibility related to the discharge limitations on Ukiah WWTP. If a sufficiently large pond is built, increasing the

size could also allow additional recycled water users to be supplied irrigation water during the summer, as the peak irrigation demand coincides with the minimal plant flows as discussed in Chapter 6.

7.1.1.6 Scheduling of Demands

In order to maximize use of the pipeline network, it is recommended that coordinated scheduling between landscape irrigation users and agricultural irrigation users be used. For the analyses included in this study, it was assumed that landscape irrigation users would schedule their demands between 6 p.m. and 5 a.m., and that the irrigation for all users would be spread out over this entire period. Agricultural irrigation users were scheduled between 5 a.m. and 6 p.m. While agricultural irrigation users were assumed within this study to continuously irrigate simultaneously, it is likely that the agricultural irrigation users would coordinate irrigation schedules to irrigate at different times for several days in a row. The scheduling of individual users would need to consider pipeline sizing and geographic distribution.

If irrigation times are reduced, increasing peak demands, larger pipeline sizes may be required (at increased capital cost).

7.2 COST ESTIMATE

The construction cost of the recommended recycled water system is summarized in Table 7.8 by phase. The total construction cost, including a construction contingency of 20 percent and an estimating contingency of 20 percent of the entire system, is estimated to be $18.7 million. As discussed in Chapter 6, project costs were estimated using an engineering/legal/administrative markup of 31 percent. The total project cost including contingency is estimated at $24.5 million (ENR of 10,199, October 2011, San Francisco).

Table 7.8 Cost Summary
Recycled Water Master Plan
City of Ukiah

Phase	Construction Cost (w/ Contingency)	Project Cost[1]
1	$3,797,300	$4,975,300
2	$5,353,120	$7,013,120
3	$4,677,680	$6,128,680
4	$4,897,800	$6,416,800
Total	**$18,725,900**	**$24,533,900**

Note:
(1) Includes markups for legal, administration, engineering, and design. Assumptions regarding costs are included in Chapter 6.

It should be noted that the total cost shown for the recommended alternative differs slightly from the cost shown in Chapter 6. This difference is due to the breakdown of construction into multiple phases.

Cost estimate details for each phase are included in Appendix D.

7.3 IMPLEMENTATION PLAN

The City will need to address the following project components in implementing the recycled water project (listed in no specific order):

- Design and construct the recommended alternative.
- Receive firm commitments and Agreements from landowners to use recycled water.
- Obtain permits and clearances from applicable regulatory agencies (RWQCB, CDPH, etc). Also includes the RW Policy Salt/Nutrient Management Plan development (defined in section 4.1.3).
- Conduct environmental process (CEQA) and develop compliance documents.
- Conduct a Proposition 218 process.
- Adopt a resolution for recycled water use.
- Prepare a cost of service rate study.

An implementation schedule is shown in Figure 7.3.

7.3.1 Recycled Water State Policy

The SWRCB recognizes that a burdensome and inconsistent permitting process can impede the implementation of recycled water projects. The SWRCB adopted a Recycled Water Policy (RW Policy) in 2009 to establish more uniform requirements for water recycling throughout the State and to streamline the permit application process in most instances.

The newly adopted RW Policy includes a mandate that the State increase the use of recycled water over 2002 levels by at least 200,000 AFY by 2020, and by at least 300,000 AFY by 2030. Also included are goals for stormwater reuse, conservation and potable water offsets by recycled water. The onus for achieving these mandates and goals is placed both on recycled water purveyors and potential users.

Absent unusual circumstances, the RW Policy puts forth that recycled water irrigation projects that meet CDPH requirements and other State or Local regulations, be adopted by Regional Boards within 120 days. These streamlined projects will not be required to include a monitoring component.

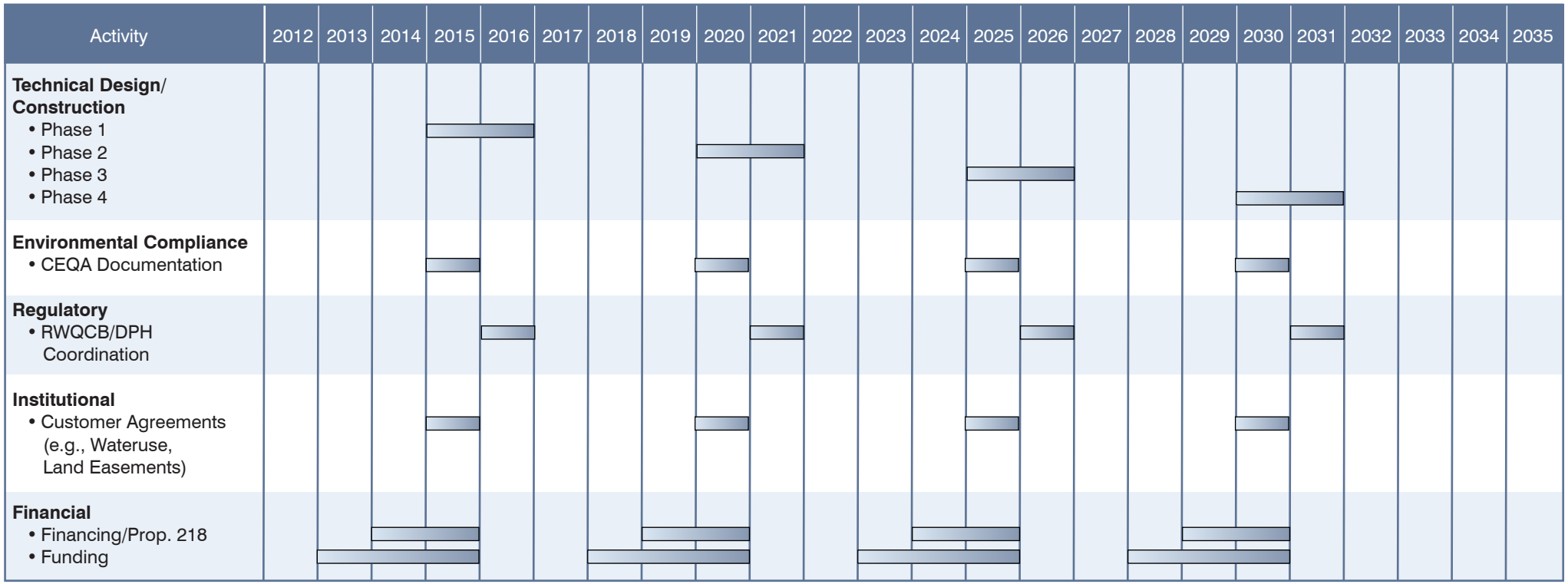


Figure 7.3
IMPLEMENTATION SCHEDULE
RECYCLED WATER FEASIBILITY STUDY
CITY OF UKIAH

uk112s1-8660.ai

CONSTRUCTION FINANCING PLAN AND REVENUE PROGRAM

8.1 FUNDING SOURCES AND CONSIDERATIONS

The adequate funding of capital costs is a primary constraint in implementing any construction project, especially water recycling projects. Recycled water projects have several State, Federal, and local funding sources available. Some are available directly to the City of Ukiah while others are available to individual water users.

This chapter describes potential funding opportunities and financing mechanisms for capital and operations costs, including an outline of current applicable grants and loan opportunities. The term “funding” refers to the method of collecting funds; the term “financing” refers to methods of addressing cash flow needs.

The recommended recycled water project is attractive for funding agencies for two primary reasons.

1. The project provides integrated benefits and meets various objectives:
    a. Helps meet State recycled water objectives.
    b. Improves environmental habitat.
    c. Protects surface water resources.
    d. Reduces cost associated with wastewater discharge management.
    e. Promotes a vibrant agricultural region.
    f. Demonstrates regional cooperation.
2. The project involves regional partnerships and provides benefits to numerous stakeholders:
    a. Calpella County Water District.
    b. Hopland Public Utility District.
    c. Millview County Water District.
    d. Redwood Valley Water District.
    e. Rogina Water Company.
    f. Willow County Water District.
    g. Agricultural Users.
    h. Ukiah Valley Sanitation District.
    i. Mendocino County Russian River Flood Control and Water Conservation Improvement District.

The pursuance of alternate funding is highly competitive. Competitive funding programs require enhanced recycled water programs to meet as many of the following objectives as possible:

- Regional partnerships.
- Integrated project benefits.
- Water conservation.
- Renewable energy improvements.
- Economic stimulus:
  - Job creation.
  - Job preservation.

Of the above objectives, the recommended City project meets all but the renewable energy improvement objectives.

8.2 FUNDING SOURCE IDENTIFICATION

Costs of the City's recycled water project consist of two components – capital cost for construction of distribution facilities and operation and maintenance (O&M) costs of the treatment and distribution systems.

The funding sources available range from traditional funding options such as pay-as-you go funding and bond funding to non-traditional funding sources such as grants and loans and market based programs. The sections that follow outline the mechanisms available to recover both capital and O&M costs.

The main instruments available for funding the capital costs include:

- Pay-as-you-go financing or upfront collection of project costs from existing and new users for future capital improvement projects.
- Debt financing or the acquisition of funds through borrowing mechanisms.
- Grants and loans or alternate source of funds at no or minimal interest cost. Examples include federal, state, and local programs that provide funding at zero interest for projects that meet select criteria.
- Market based programs that refer to financing through funds obtained from tax credits, purchase agreements, voluntary programs, and trading and offset programs.

All of these funding sources are discussed in additional detail in the following sections.

8.2.1 Pay-As-You-Go Financing

Pay-as-you-go financing involves periodic collection of capital charges or assessments from customers within the utilities jurisdiction for funding future capital improvements. These revenues are accumulated in a capital reserve fund and are used for capital projects in future years. Pay-as-you-go financing can be used to finance 100 percent or only a portion of a given project.

One of the primary advantages of pay-as-you-go financing is that it avoids the transaction costs (e.g., legal fees, underwriters' discounts, etc.) associated with debt financing alternatives, such as revenue bonds. However, there are two common disadvantages associated with this method. First, it is difficult to raise the required capital within the allowable time without charging existing users elevated rates. Second, it may result in inequities in that existing residents would be paying for facilities that would be utilized by, and benefit, future residents.

8.2.1.1 Utility Fees and Benefit Assessment Fees

Utility fees or benefit assessments, sometimes called service fees or user fees, consist of a fee imposed on each property in proportion to the service provided to that property. They are inherently flexible in that the City can select any assessment method that equitably relates the amount charged to the service provided. Benefit assessment fees are usually included as a separate line item on the annual property tax bill sent to each property owner.

Utility fees are usually billed on a monthly or bi-monthly interval. In all other respects, benefit assessments, utility fees and service charges are essentially identical. A utility has the authority to collect a benefit assessment fee, but only after approval by a majority of the voters, affected property owners, or ratepayers.

8.2.1.2 Development Charges/Connection Fees

The system development charges/connection fees/impact fees represent the cost of providing regional conveyance and treatment facilities to serve new recycled water customers. They are one-time fees charged to customers at the time of system connection approval or permit/contract issuance. The charges for individual properties may be based on whatever assessment measures the City desires for equity.

A disadvantage to utilizing impact fees is that the fees cannot be collected until the system constructions permit stage at the earliest. The amount collected each year depends solely on the rate of growth of the recycled water system. Consequently, funds may not be available to construct new facilities at the time it is needed.

8.2.2 Debt Financing

There are several different options for debt financing of recycled water projects, ranging from issuance of short- or long-term bonds.

8.2.2.1 Revenue Bonds

Revenue bonds are historically the principal method of incurring long-term debt. This method of debt obligation requires specific non-tax revenues such as user charges, facility income, and other funds, pledged to guarantee repayment. There is often no legal limitation on the amount of authorized revenue bonds that may be issued, but from a practical standpoint, the size of the issue must be limited to an amount where annual interest and

principal payments are well within the revenues available for debt service on the bonds. Revenue bond covenants generally include coverage provisions, which require that revenue from fees minus operating expenses be greater than debt service costs.

In the case of this project, based on policy decisions made regarding cost of service, any revenue bonds obtained would require proof of financial capacity to repay, using the City revenue sources that do not inequitably burden customers.

8.2.2.2 Certificates of Participation

Certificates of participation provide long-term financing through a lease agreement that does not require voter approval. The legislative body of the issuing agency is required to approve the lease arrangement by a resolution. The lessee (City), is required to make payments typically from revenues derived from the operation of the facilities. The amount financed may include reserves and capitalized interest for the period that facilities will be under construction. One disadvantage with certificates of participation, as compared with revenue bonds, is that interest rates can be slightly higher due to the insecurity associated with the obligation to make lease payments.

8.2.2.3 General Obligation Bonds

General obligation (GO) bonds are municipal securities secured by the issuer's pledge of its full faith, credit, and taxing power. GO bonds are backed by the general taxing authority of local governments and are often repaid using utility revenues when issued in support of a sewer or water enterprise fund. In the event that GO bonds are issued for this project, the City of Ukiah or Mendocino County tax revenue will need to be used to back the bonds.

8.2.2.4 Assessment District Bonds

Financing by this method involves initiating assessment proceedings. Assessment proceedings are documents in "Assessment Acts" and "Bond Acts." An assessment act specifies a procedure for the formation of a district (boundaries), the ordering, and making of an acquisition or improvement, and the levy and confirmation of an assessment secured by liens on land. A bond act provides the procedure for issuance of bonds to represent liens resulting from proceedings taken under an assessment act. Procedural acts include the Municipal Improvements Acts of 1911 and 1913. The commonly used bond acts are the 1911 Act and the Improvement Bond Act of 1915. The procedure most prevalent currently is a combination of the 1913 Improvement Act with the 1915 Bond Act. Charges for debt service can be included as a special assessment on the annual property tax bill. The procedure necessary to establish an assessment district may vary depending on the acts under which it is established and the district size.

8.2.3 Grants and Loans

Several grant and loan programs can be utilized to finance the recommended recycled water project alternative. These grants and loans are further discussed as state and federal

funding sources in the succeeding sections. Table 8.1 provides a summary of the available state and federal funding sources. The grant and loan options presented herein are accurate as of June 2010. Please refer to the contact or website for the most up to date information for each of these grants and loans.

There are numerous factors that should be considered in the pursuance of grant funding. Several factors that should be noted in pursuance of grant funding include:

- Grant applications require demonstration of the ability to construct, operate, and maintain the project without grant funding.
- Grant award or funding authorization is NOT a promise of grant reimbursement:
  - Most grants are reimbursements and not cash up front. This requires that a source of funding be available for the construction of the project.
  - Grant reimbursements are subject to annual budget and appropriations process and thus disbursement of grant funds on schedule is not guaranteed.
  - It may take several years after project completion to receive reimbursements, especially in difficult economic times.
  - Most grants require a minimum cost share by project sponsor.
  - Federal grants typically require investment of additional resources to obtain lobbying support.

Despite the competitive nature of alternate funding, available funding sources should be considered to minimize ratepayer impacts. The following sections summarize available state and federal funding options.

8.2.3.1 State Funding

Several state funding sources are applicable to the recycled water project alternatives. Due to the California state budget crisis, some of these programs may be suspended or not have funding available when the City of Ukiah is ready to move to construction.

8.2.3.1.1 *Water Recycling Funding Program*

One option for financing the Recycled Water Project is the Water Recycling Funding Program administered by the State Water Resources Control Board. The program offers funding for research, feasibility studies, planning, and construction. The program is financed through Propositions 13, 50, and the State Revolving Fund (SRF).

Recycling projects are categorized by their potential benefits to state and local communities, which in turn determine which funding sources are applicable.

Table 8.1 Funding Summary
Recycled Water Master Plan
City of Ukiah

Program	Agency	Type	Description
State			
Water Recycling Funding Program	State Water Resources and Control Board	Grant/Loan	Funding is available for projects in the following categories: 1. Category I projects will offset state water supplies and increase water to the Delta. 2. Category II projects will offset state water use, but do not provide benefits to the Delta. 3. Category III projects use recycled water to supplement local water supplies but have no impact on the state water supply or the Delta. 4. Category IV projects will treat and reuse groundwater contaminated by human activity. 5. Category V projects will treat and dispose wastewater to meet waste discharge regulations. 6. Category VI captures miscellaneous projects that do not fall into other categories and have no benefits to state or local water supplies. The maximum award for construction grants for Category I through IV projects is the lesser value of $5 million per project or 25 percent of construction costs. Category V and VI projects are only eligible for SRF loans. Loans are capped at $50 million per agency per year.
Integrated Regional Water Management Grants Program (Prop 84)	Department of Water Resources	Grants	Grants are available for projects that support IRWM Plans and are related to water supply reliability, groundwater recharge, water quality enhancement etc.
Specialty Crop Block Grant	California Department of Food and Agriculture	Grant	Eligible projects include those that will enhance the competitiveness of California specialty crops. Specialty crops include fruits, vegetables, tree nuts, dried fruits, horticulture, and nursery crops. Awards range from $75,000 to $500,000 per project.
Federal			
Title XVI	U.S. Bureau of Reclamation	Grants	Eligible projects include recycled water feasibility, demonstration, and construction projects. The program provides as much as 25 percent of construction costs with a maximum of $20 million. To meet eligibility requirements a project must have a Bureau of Reclamation approved feasibility study, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs.
USDA Agricultural Water Enhancement Program	U.S. Department of Agriculture (USDA)	Grants	Several grant programs awards to projects or programs that support sustainable agriculture and the conservation of water resources. • The Sustainable Agriculture Research and Education Program (SARE) provide grants of up to $60,000 for projects within a single state that promotes sustainable agriculture through outreach, education, training, and technical support. • The Environmental Quality Incentive Program grant program awards incentive payments, up to $50,000 per year, directly to agricultural producers who conserve soil, water, and air resources on their land. • The Agricultural Water Enhancement Program offers local units of government that work with EQIP participants the option to receive multi-million dollar grants for capital and non-capital projects that improve agricultural water quality or quantity.
Organic Farming Research Foundation	Organic Farming Research Foundation	Grants	Grants are available for research or public outreach projects related to organic farming. Grant awards have averaged approximately $5,000 to $12,000.

- Category I projects will offset state water supplies and increase water to the Delta.
- Category II projects will offset state water use, but do not provide benefits to the Delta.
- Category III projects use recycled water to supplement local water supplies but have no impact on the state water supply or the Delta.
- Category IV projects will treat and reuse groundwater contaminated by human activity.
- Category V projects will treat and dispose wastewater to meet waste discharge regulations.

Category VI captures miscellaneous projects that do not fall into other categories and have no benefits to state or local water supplies.

The recycled water alternatives will likely fall into Category II as it should offset state water use, will use recycled water to supplement local water supplies, but will have no impact on the Delta.

The source of available funding varies with the category in which the project is classified. The maximum award for construction grants for Category I through IV projects is the lesser value of $5 million per project or 25 percent of construction costs.

Category V and VI projects are only eligible for SRF loans. Loans are capped at $50 million per agency per year. The SRF interest rate is set at one-half of the state general obligation bond rate and has historically averaged around 2.5 percent.

The SWRCB provides one application package for both construction grants and SRF recycled water loans. The application package consists of:

- Financial Assistance Application.
- Facilities Plan composed of:
  - Project report.
  - Environmental documents including CEQA documents.
  - Construction Financing Plan.
  - Recycled Water Market Assurances documenting user participation in the project.
  - Authorized Representative Resolution (Legal Authority).

- Water Conservation Plan demonstrating that the applicant has a water conservation program in effect or has signed onto the California Urban Water Conservation Council's Memorandum of Understanding.

The SWRCB will review the application package and assess eligibility. Once the SWRCB receives and reviews the final plans and specs, it will issue project performance standards. Once performance standards are agreed to and the applicant chooses a contractor, the parties sign a funding agreement. The applicant must also have an Urban Water Management Plan filed with the Department of Water Resources to receive funds.

8.2.3.1.2 *Integrated Regional Water Management Implementation Grant Program*

Grants are available for projects that support IRWM Plans and are related to water supply reliability, groundwater recharge, water quality enhancement etc.

In transitioning from Prop 50 funding to Prop 84 funding, the DWR altered several of the standards it uses to evaluate regions including governance requirements, acknowledgement of water conflicts, and potential climate change requirements. To facilitate this change, DWR has allowed regions with standing IRWM plans to also receive funds under Prop 84 to comply with the new standards and to develop new projects. Projects seeking funding through this grant process generally submit a project summary to the respective local IRWM management group to review and assess the merits of a project and its ability to fulfill the intent of the IRWM plan. Once approved through this process, a project may be included in the region's implementation grant application.

8.2.3.1.3 *Specialty Crop Block Grant*

Since the project will supply water to agricultural irrigation, the City has the option of utilizing grant programs targeted at conservation within agricultural lands. At the state level, the California Department of Food and Agriculture awards grants annually to projects that will enhance the competitiveness of California specialty crops. Specialty crops include fruits, vegetables, tree nuts, dried fruits, horticulture, and nursery crops. Awards range from $75,000 to $500,000 per project. Eligible projects include the development of best management practices, conservation practices, special studies and research, education and outreach, and training and technical assistance. Past grant awards have not typically included funding for capital projects. However, the City could utilize Specialty Crop Block Grant Funds for outreach, education, training or the development of recycled water best management practices for its customers.

8.2.3.2 <u>Federal Funding</u>

In addition to local and State grants and loans, there are several highly competitive Federal grant and loan programs that provide financial resources to recycled water projects.

8.2.3.2.1 *Title XVI*

The U.S. Bureau of Reclamation administers funds for recycled water feasibility, demonstration, and construction projects through the Water Reclamation and Reuse Program authorized by the Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 (Title XVI) and its amendments. The program provides as much as 25 percent of construction costs with a maximum of $20 million. To meet eligibility requirements a project must have a feasibility study, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs. Projects are authorized by Congress and recommended in the President's annual budget request by the Bureau of Reclamation. Congress then appropriates funds and the Bureau ranks and prioritizes projects and disburses the money on a competitive grant basis each year. Prioritized projects are those that postpone the development of new water supplies, reduce diversions from natural watercourses, reduce demand on federal water supply facilities, or that have a regional or watershed perspective.

8.2.3.2.2 *USDA Agricultural Water Enhancement Program*

The U.S. Department of Agriculture (USDA) offers several grant programs that give awards to projects or programs that support sustainable agriculture and the conservation of water resources. These programs are detailed below.

- The Sustainable Agriculture Research and Education Program (SARE) is administered by the USDA's Cooperative State Research, Education and Extension Service (CSREES) and universities nationwide to provide support for sustainable agriculture. SARE provides grants of up to $60,000 for projects within a single state that promote sustainable agriculture through outreach, education, training, and technical support. Applications are accepted throughout the year.

- Environmental Quality Incentive Program is grant program offered through the Environmental Quality Incentive Program (EQIP). This program awards incentive payments directly to agricultural producers who conserve soil, water, and air resources on their land. To participate, agricultural producers sign six-year commitments to conserve resources and the USDA provides payments of up to $50,000 per year. Well decommissioning and irrigation water pipelines, storage, and management are eligible uses of funds.

- The Agricultural Water Enhancement Program offers local units of government that work with EQIP participants the option to receive multi-million dollar grants for capital and non-capital projects that improve agricultural water quality or quantity.

8.2.3.2.3 *Organic Farming Research Foundation*

The Organic Farming Research Foundation offers small grants for research or public outreach projects related to organic farming. This grant program cannot provide funding to

offset the capital costs of the recycled water alternative, but funding could be used to garner support for recycled water use within the City service area for any customers utilizing organic farming practices. Past grant awards have averaged approximately $5,000 to $12,000. Applications are accepted in May and November of each year.

8.2.4 Funding Source and Timing Summary

The City proposes to utilize a combination of funding sources to construct the recycled water project. The priority of the funding will be to secure grants where available, pursue low interest loans such as the SRF loans, and then finally obtain debt financing in the form of GO or revenue bonds for the cost of the project not covered by grants and low interest loans. These funding options are summarized in Table 8.2. Typically, the anticipated sources of repayment for any loans consist of water, wastewater, and recycled water revenues.

Table 8.2 Funding Source Summary
Recycled Water Master Plan
City of Ukiah

Funding Source	Use	Amount	Timing
SRF Grants and Loans	Design/Construction	Up To $20.2 million(1)	2011
Other Federal and State Grants and Loans	Construction	TBD	2011
Debt	Construction	Cost not recovered by alternate supplies up to $20.2 million	2011

Note:
(1) Although SRF funding and grants have not yet been secured, the City plans to pursue grants and low interest loans for the construction of the recycled water facilities to the maximum extent possible.

8.3 RECYCLED WATER PRICING POLICY

Typically, the cost of recycled water projects is recovered through a combination of methods where costs are shared amongst recycled water customers, potable water customers, and wastewater customers.

Several recycled water cost recovery alternatives were considered relative to capital, O&M, and repair and replacement (R&R) costs. Dependent on the preferred cost recovery strategy, the corresponding pricing alternatives were developed.

8.3.1 Capital Cost Recovery

The capital costs associated with the recycled water system will consist of distribution system components – pump station, storage, and pipelines. No new treatment infrastructure is required as the City wastewater treatment plant has sufficient capacity to produce tertiary treated recycled water.

Implementation of expansive recycled water projects requires large up-front capital. The current project implementation plan proposes to finance the construction of the recommended project through a combination of SRF and other grants and loans, as well as the issuance of debt. There are several alternatives by which the associated debt service can be recovered. These include:

- Land based assessments where all parcels in the City service area are assessed a dollars per acre or dollars per parcel fee.
- Consumption based service charges where water, wastewater and recycled water users are assessed their fair share of the annual debt service of the recycled water project based on their quantity of potable or recycled water used.
- A combination of land based assessments and consumption based service charges where a portion of the debt service is recovered using both methods.
- System connection fees where users connecting to the water, wastewater, and recycled water systems pay a one-time fee for the system capacity utilized.

The construction of the recycled water distribution system reduces reliance on use of increasingly regulated Russian River water, reduces the need for perhaps more costly future water supplies, and facilitates City compliance with its wastewater discharge permit, which requires increased reuse of the tertiary treated effluent. Because the City currently has adequate potable water supplies to meet its water demands, and compliance with the City wastewater permit requirements is needed in the near term, the pricing policy for the capital cost component of the recycled water project consists of recovery through wastewater customers.

8.3.2 Operations and Maintenance Cost Recovery

The O&M costs associated with the recycled water system will consist of treatment and distribution components.

The City's wastewater permit requires tertiary treatment of its wastewater to meet specified effluent limits from October through May each year. During this period, no additional treatment is incurred to produce tertiary quality recycled water. The City is prohibited from discharging treated effluent to the Russian River from June through September and thus discharge secondary treated effluent to recharge ponds. Implementation of the recycled water program will now require tertiary treatment during the summer months for urban and

agricultural reuse, increasing O&M costs at the wastewater treatment facility. In addition to increased treatment cost during the summer, the City will incur recycled water distribution costs year-round.

O&M costs are most typically recovered using user charges. Similar to capital costs, it is possible for the City to recover its O&M costs using land based, consumption based, or combination methods. As the causation of the City's O&M costs are directly correlated to compliance with its wastewater permit and delivery of recycled water to specific recycled water users, the pricing policy proposes to recover the O&M costs on a consumption basis from wastewater and recycled water customers.

At this time, no purchase agreements are in place between the City and the recycled water users. As these agreements are further developed, the O&M pricing strategy will be modified to appropriately allocate and recover fixed and variable costs amongst users.

8.3.3 Repair and Replacement Cost Recovery

Similar to O&M costs, the R&R costs can also be recovered using land based, consumption based, or combination methods. The currently proposed recycled water pricing policy will recover annual R&R costs from its users through a consumption based fee with the assumption that any R&R required is a result of system use.

8.3.4 Costs Allocated to Water Pollution Control

The implementation of the recycled water project reduces reliance on use of increasingly regulated Russian River water, reduces the need for perhaps more costly future water supplies, and facilitates City compliance with its wastewater discharge permit, which requires increased reuse of the tertiary treated effluent. The project also extends the use of existing discharge ponds by reducing the need for construction of additional wastewater discharge ponds to meet future discharge needs.

As the primary drivers of this project are related to compliance with the City's wastewater discharge permit, much of the capital and O&M costs of the project are allocated to wastewater pollution control. Similarly, much of the capital repair and replacement cost is allocated to water pollution control as a fully functional and reliable system is required to comply with discharge regulations.

8.3.5 Costs Allocated to Potable Water

Implementation of the recycled water project may facilitate compliance with the 2009 CA Water Conservation Act to reduce 20% urban water use by 2020. Additionally, the project may help reduce the need for and the size of future, perhaps more costly, water supplies.

The recommended alternative will not result in sizable potable water offsets until the final, optional phase of the project is constructed. The City's Urban Water Management Plan projects the baseline water demand in 2035 to equal 5,217 AFY. The preferred recycled

water alternative is projected to offset approximately 400 AFY, or approximately 10 percent of the City's average potable water demands between 1995 to 2008 if the optional phase is implemented (demands have decreased by about 25 percent in 2009 and 2010) . Currently, the City has sufficient water supplies to meet water demand and has already achieved the conservation targets set by the State. Therefore, the City does not intend to recover cost associated with the initial phases of the recycled water project from water ratepayers. THe City does however, plan to evaluate allocation of a portion of the capital costs associated with construction of this portion of the system to water ratepayers or private developers benefitting from potable offsets at the time of construction of Phase 4.

8.3.6 Recycled Water Pricing Summary

The recycled water pricing summary for the various project cost elements is summarized in Table 8.4. The City plans to conduct a cost of service study in the future to appropriately and equitably determine the impacts to water, wastewater, and recycled water rates.

Table 8.4 Funding Source Summary
Recycled Water Master Plan
City of Ukiah

Cost Description	Allocation	Cost Unit(1)
Capital Cost	Wastewater	$ per hcf or af(1)
O&M and R&R Cost	Treatment – Recycled Water Distribution - Wastewater	$ per hcf or af(1)

Note:
(1) Cost recovery strategy of consumptive based charges was determined to be most appropriate at this stage of the recycled water project. Rates would be set to recover the annual debt service, O&M, and R&R costs from water, wastewater, and recycled water users as appropriate.

8.4 ANNUAL COST PROJECTIONS

8.4.1 Capital Costs

The total project cost for the recommended alternative is estimated to be approximately $24.5 million for construction of all phases of the project (including the optional phase). The estimated costs do not include retrofit costs or costs associated with piping required within the individual users' property lines.

It was assumed for planning purposes that the project would be funded through a 30-year loan. Annual debt service was calculated using a 5 percent interest rate over a 30-year period for each project phase.

The annual cash flow projections for assuming debt financing is presented in Appendix G. It was assumed that the annual payments collected from wastewater and recycled water revenues will be equal to the annual debt service.

8.4.1.1 Sunk Costs

In the last three years, the City has spent approximately $150,000 on this engineering feasibility report, public outreach, CEQA review, and preliminary engineering to promote recycled water use within its service area.

The estimated indebtedness for construction of necessary facilities is $24.5 million. The costs associated with project planning and construction will also be sunk costs upon project completion.

8.4.1.2 Salvage Value

The salvage value of the system at the end of the debt period was calculated assuming an average useful life of 50 years for the system. Engineering, legal, and administrative costs were assumed to have no salvage value. The salvage value of the distribution system is estimated at $112,731.

8.4.2 Operations and Maintenance Costs

The O&M costs associated with the recycled water program will be dependent upon the volume of recycled water production. Potential O&M costs include:

- Recycled water pumping costs.
- Inspections costs.
- Metering and meter reading costs.
- Billing costs.
- System cleaning and maintenance costs.
- Public outreach costs.

Table 8.5 summarizes the estimated annual O&M costs of the system.

Table 8.5 Operations and Maintenance Cost Summary
Recycled Water Master Plan
City of Ukiah

Description	Annual Cost (2010 Dollars)
Recycled Water Pumping	$150,000
Inspection Personnel (0.25 FTE)	$25,000
Metering and Meter Reading (0.25 FTE)	$25,000
System Cleaning and Maintenance (0.25 FTE)	$25,000
Billing Support	$5,000
Public Outreach	$5,000
Total	**$235,000**

Note:
(1) Assumes Full Time Equivalent (FTE) = $100,000 per year for salary and benefits.

8.4.3 Repair and Rehabilitation Costs

The City currently replaces its tertiary filter media approximately every five years. The media replacement costs approximately $500,000; the City plans to allocate 50 percent of the media replacement cost to the recycled water system operation, resulting in an estimated annual R&R need of $50,000.

8.4.4 Total Annual Project Expenses

Table 8.6 presents a summary of the estimated project costs for the recommended project and the allocation of costs to water, wastewater, and recycled water customers. Since project implementation helps reduce the capacity of future water supply needs, the City water enterprise may opt to recover the costs allocated to the water system from future water customers. Similarly, the City's wastewater enterprise may opt to allocate costs to both existing and future customers. For the purposes of this study, it is assumed that annual debt service allocated to water and wastewater will be recovered from existing customers. As there are no existing recycled water users, 100 percent of the costs are allocated to future users.

Table 8.6 Recommended Project Annual Cost Summary and Allocation
Recycled Water Master Plan
City of Ukiah

Expense Type	Total Annual Expense	Water Customers[1]	Wastewater Customers[1]	Recycled Water Customers[2]
Capital (Debt Service/Loan Repayment)[3]				
Existing	$1,179,000	$0	$1,179,000	$0
Future	$0	$0	$0	$0
Operating Expense				
Treatment O&M	$352,500	$0	$352,500	$0
Distribution O&M	$12,311	$0	$0	$12,311
Capital Replacement				
Annual R&R	$50,000	$0	$50,000	$0
Total Annual Revenue Requirement	**$1,593,811**	**$0**	**$1,581,500**	**$12,311**

Notes:

(1) The City's water and wastewater enterprise may opt to allocate costs to both existing and future customers. For the purposes of this study, it is assumed that annual costs allocated to water and wastewater will be recovered from existing customers.

(2) Only customers who use recycled water are allocated distribution system O&M costs.

(3) The debt service presented is the debt service associated with a 30-year term and 5 percent interest.

A cash flow forecast was developed over a 30 year period for the recycled water project assuming that the first phase of project will start design in fiscal year (FY) 2015 and complete construction in FY 2016. Each subsequent phase of the project was assumed to be initiated in five-year increments with phase construction requiring two years. A summary of the cash flows for these scenarios is presented in Appendix G. It was assumed that the annual payments collected from property owners would be equal to the annual debt service and operations costs.

8.4.5 Recycled Water Use Projections and Unit Costs

The projected recycled water use for the recommended alternative (based on acreage and land use) is 1,376 acre-feet per year. All projected recycled water use is anticipated to be for irrigation and frost protection.

Preliminary unit costs for each user category were developed using the proposed cost recovery strategy. These costs assume that only Phases 1 through 3 of the project will be constructed. Phase 4 is considered as optional. Table 8.7 presents a summary of the unit costs. These unit costs are preliminary and are not based on a detailed cost of service study. The allocation of costs, unit costs, and rates for water, wastewater and recycled will be developed to recover the cost of construction and operation through the cost of service study. The City plans to pursue a detailed cost of service and assessment study prior to the initiation of a Proposition 218 process and adoption of rates.

Table 8.7 Summary of Unit Costs
Recycled Water Master Plan
City of Ukiah

Expense Type	Total Annual Expense	Unit Cost(1)		
		Water(1)	Wastewater(2)	Recycled Water(3)
Capital Costs		0		
Annual Debt Service(4)	$1,179,000	$0.00	$0.81 per hcf ($263.17 per acre-foot)	$0.00
Operating Costs				
Treatment and Distribution O&M	$364,811	$0.00	$0.24 per hcf ($78.68 per acre-foot)	$0.03 per hcf ($12.37 per acre-foot)
Capital Repair and Replacement Costs				
Annual R&R	$50,000	$0.00	$0.15 per hcf ($50.24 per acre-foot)	$0.00

Notes:
(1) Costs associated with Phases 1 through 3 of the recommended project are not expected to be allocated to water ratepayers.
(2) Unit costs based on estimated average annual wastewater flow of 4 mgd or 4,480 AFY.
(3) Unit costs presented are based on use of 1,376 acre-feet per year for the total annual cost.
(4) Assumes a 30-year term with an interest rate of 5 percent.

Data Report:
Stream Flow Monitoring in Tributaries to the Russian River (Sonoma and Southern Mendocino Counties) 2010 and 2011.

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Habitat Conservation Division
Southwest Region

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Acknowledgements

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I. Introduction

The use of water in the Russian River basin peaks during spring when the highest demand for agricultural water is for frost protection of sensitive crops during cold weather episodes (temperatures ≤ 35˚F) that generally occur from March to May. This time of year is when juvenile salmonids are particularly vulnerable as they emerge from gravel redds, adapt to riverine habitat and migrate to suitable summer rearing locales.

The most common frost sensitive crop is wine grapes and the typical application of water to manage frost is 50-55 gallons per minute (gpm), per acre, or 0.11-0.12 cubic feet per second, per acre. Low temperature events generally last for 6 hours, but water use may last longer depending on many human factors. Deitch *et al.,* 2007 and Lewis *et al.,* 2008 document that existing agricultural water development in the Russian River watershed has depleted stream flow, at least temporarily, in several locations during critical life stages for native salmonids. NMFS has also documented stream flow depletions resulting in stranding of juvenile Coho and steelhead on the mainstem Russian River near Ukiah, and in basin tributaries (Felta Creek) in addition to locations identified by Deitch *et al.,* 2007. Demand for frost-management water can be a watershed-wide synchronized demand, thus NMFS's emphasis in monitoring the spring period of the year.

Flow recession during spring is a natural process as the wet winter months give way to dry summer months in this Mediterranean climate, where summer rains are rare. The rate of recession as influenced by water use, the chronic effect, is an area requiring more information and study.

This report presents data from 5 sites for 2010 and 17 sites for 2011 from two sources; 5 SWRCB gauges, and 12 NMFS gauges (see Table 1). It makes available the NMFS and SWRCB flow records and instantaneous flow measurements that are relevant to the acute effects of relatively rapid, short duration changes in instantaneous stream depth and flow in occupied salmonid habitat, with emphasis on spring.

[1] Dr. Matthew Deitch did not visit SWRCB gauge sites in his review of this monitoring program.

Table 1. NMFS & SWRCB Monitoring sites for 2010 & 2011. Mark West at Slusser Road, monitored in 2010, was discontinued in 2011.

Stream Gauge Locations	Agency	County	Monitoring Year(s) Included
*Atascadero at Water Trough Rd	NMFS	Sonoma	2011
*Atascadero at Mill Station Rd	NMFS	Sonoma	2011
*Bidwell Creek	NMFS	Sonoma	2010/2011
Feliz Creek	NMFS	Mendocino	2011
Franz Creek	NMFS	Sonoma	2011
Mark West at Calistoga Rd	NMFS	Sonoma	2010/2011
*Mark West at River Rd	NMFS	Sonoma	2011
Mark West at Slusser Rd	NMFS	Sonoma	2010
Pena Creek	NMFS	Sonoma	2010/2011
**Pieta Creek	NMFS	Mendocino	2011
Redwood Creek	NMFS	Sonoma	2010/2011
*Sausal Creek	NMFS	Sonoma	2011
**Russian River (West Branch)	NMFS	Mendocino	2011
Dooley Creek	SWRCB	Mendocino	2011
Green Valley Creek	SWRCB	Sonoma	2011
McNab Creek	SWRCB	Sonoma	2011
Mill Creek	SWRCB	Sonoma	2011
York Creek	SWRCB	Mendocino	2011

* Due to temperature related effects on the barometric record, the signal to noise ratio was insufficient to identify small (0.10 feet) changes in stream depth related to frost protection diversions.
** These two sites experienced sensor malfunctions and depth data is not included in this report. Cluer (2011) simulated data for the Russian River (West Branch) from the downstream USGS gauge flow record.

II. Methods

Site Selection:

Exploring the geographic scope and temporal scale of streamflow fluctuations related to agricultural frost water use was the primary goal of the NMFS monitoring effort. In collaboration with Alan Fox we estimated the spatial scope of water demand for temperature management in the Russian River basin (Fox, 2010). With this information and limited resources for stream monitoring, NMFS established water level monitoring stations in twelve tributaries to the Russian River Watershed in southern Mendocino and Sonoma Counties during the 2011 water year to monitor flow over a range of micro climates and vineyard acreage densities (see Table 2 for watershed characteristics). In 2010, five tributaries were monitored by NMFS.

Stream gauge locations were chosen based on proximity to low-lying frost prone areas and frost risk (as defined by Fox, 2010), and stream access. During the 2010 water year, depth was monitored at Bidwell Creek, Mark West Creek at Calistoga and Slusser Roads, Redwood Creek, and Pena Creek. During the 2011 water year, depth was monitored in Sonoma and southern Mendocino Counties at 12 locations; Atascadero Creek at Water Trough and Mill Station Roads, Bidwell Creek, Feliz Creek, Franz Creek, Mark West Creek at Calistoga and River Roads, Pena Creek, Pieta Creek, Redwood Creek, Sausal Creek, and the Russian River near East School Road in Redwood Valley (also known as the West Branch of the Russian River). See Maps 1 & 2 for gauge locations in Mendocino and Sonoma Counties.

Table 2. Watershed and agricultural areas associated with the NMFS and SWRCB stream monitoring sites in Sonoma and southern Mendocino Counties (source for vineyard acreage: Russian River GIS Vineyard Layer, UC Hopland Research and Extension Center, 2008).

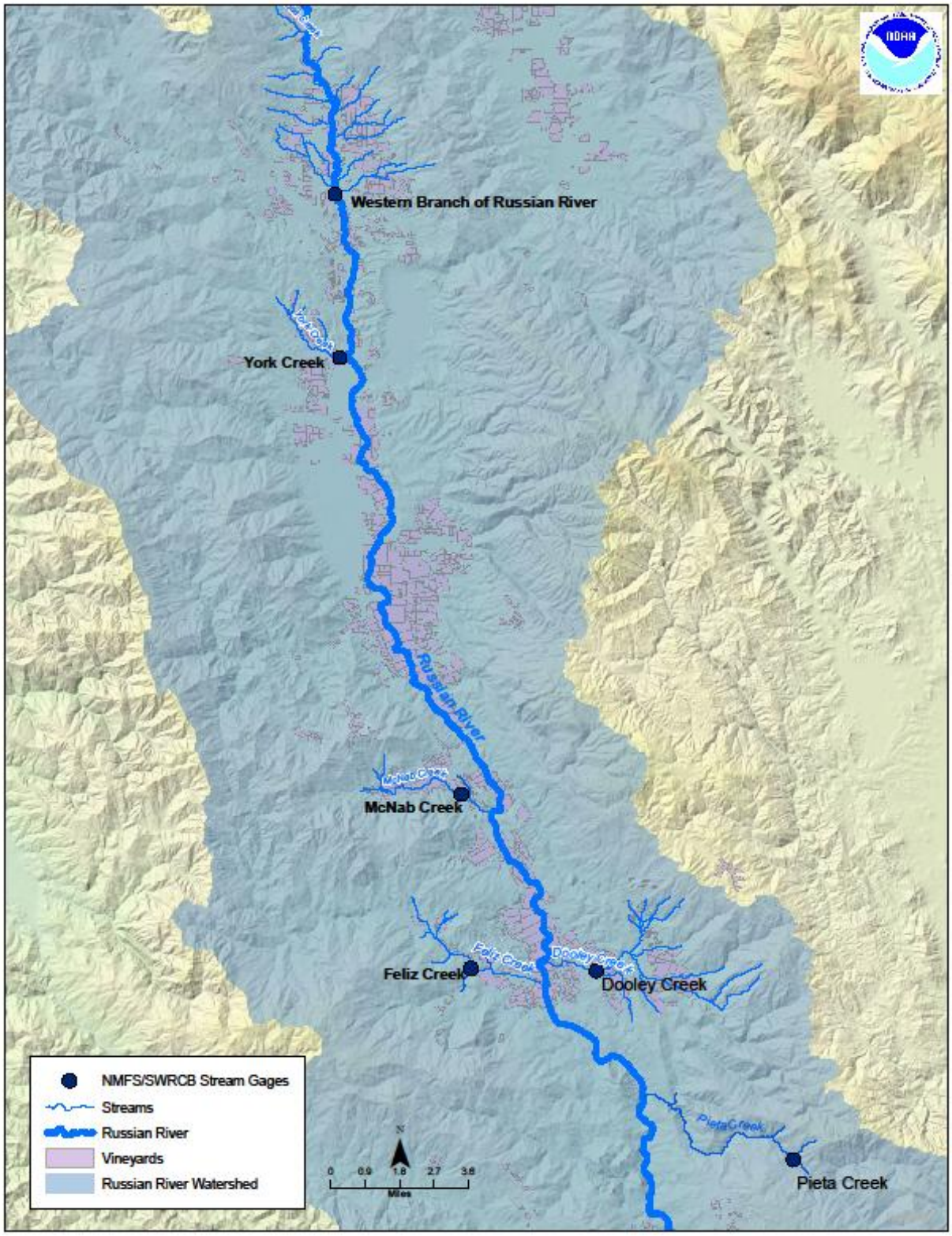
Gauge Location/Creek	Total Area Above Gauge (square miles)	Total Area Above Gauge (acres)	Total Vineyard Area (acres) Within Watershed Above Gauge	Vineyard Acreage Percentage
Atascadero at Mill Station	13.6	8704	576	6.6
Atascadero at Water Trough	4.8	3072	256	8.3
Bidwell Creek	4.6	2944	467	15.9
Feliz Creek	31.2	19968	147	0.7
Franz Creek	23.0	14720	1330	9.0
Mark West at Calistoga	13.7	8768	182	2.1
Mark West at River Road	50.2	32128	2458	7.7
McNab Creek	8.3	5312	457	8.6
Redwood Creek	14.0	8960	1362	15.2
Sausal Creek	12.6	8064	1122	13.9
York Creek	11.7	7488	332	4.4
Dooley Creek	14.9	9536	1135	11.9
Mill Creek	3.5	2240	31	1.4
Green Valley Creek	37.4	23936	2742	11.5
Pieta Creek	17.0	10880	0	0.0
Pena Creek	22.7	14528	266	1.8
West Branch Russian River	30.1	19264	2240	11.6

Equipment Selection[2] and Installation:

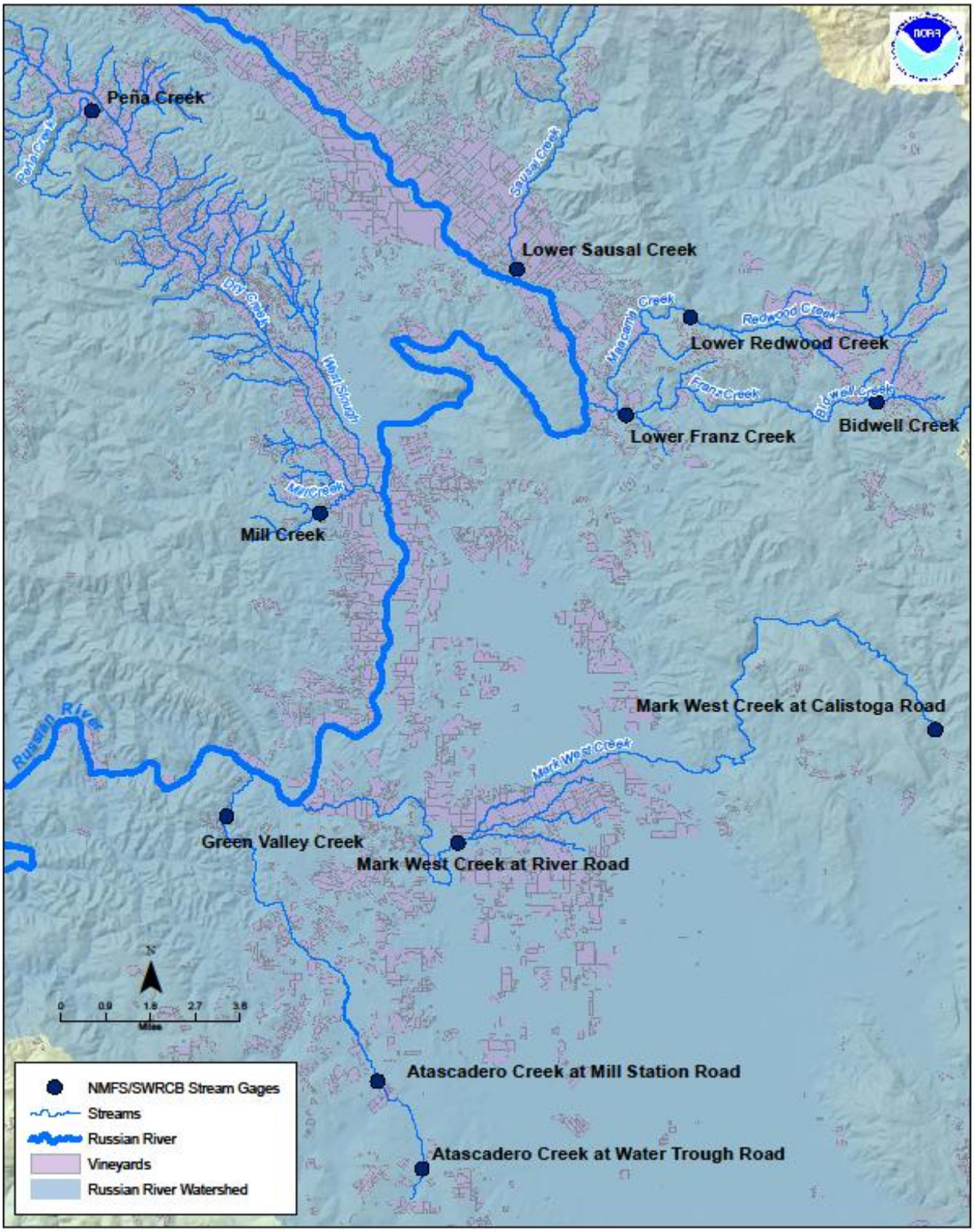
NMFS assisted the State Water Resources Control Board (SWRCB) staff in their installation of three Global Water SIT 65 Satellite Telemetry units with WL400 pressure transducers on Dooley, McNab, and York Creeks in Mendocino County, and two Azonde 2220 pressure transducers on Green Valley and Mill Creeks in Sonoma County. NMFS also uses data generated through other efforts including the Coho Partnership and USGS stream gauges. The NMFS and SWRCB monitoring sites are listed in Table 1.

[2] The use of brand names is only for the convenience of discussion. NMFS does not endorse any particular brand of monitoring equipment.

Map 1. NMFS & SWRCB Monitoring Sites in Mendocino County



Map 2. NMFS & SWRCB Monitoring Sites in Sonoma County



Two NMFS sites were equipped with real-time monitoring equipment; Lower Franz Creek with an Azonde 2220 pressure transducer and cellular modem, and Feliz Creek with a Global Water SIT65 Satellite Telemetry unit and WL400 pressure transducer. The Franz Creek pressure transducer was attached to an 8 ft. construction stake driven 7 ft. into the gravel. At Feliz Creek the Global Water WL400 pressure transducer was encased in flexible PVC hose and anchored to solid substrate near the toe of the bank. The remaining sites were all instrumented with unvented Solinst Levelogger pressure transducers and barometric loggers (Levelogger Gold #3001). Level loggers were fitted into a 1 ft. section of perforated PVC with caps tightly secured on each end, eye hooks screwed into each end-cap, and each hook secured to the stream bed with rebar. The level loggers were pushed down onto the surface of the gravel and stainless steel hose clamps were attached to the rebar to prevent the PVC encased loggers from dislodging. Longer pieces of rebar were used in locations with fine substrate to secure the loggers to the streambed during peak flow events. The loggers were programmed to record data at 15-min intervals, except the McNab and York Creek gauges which recorded at 30-min intervals, and Dooley Creek at 1-hr intervals.

Discharge Measurements:

Water depth over the pressure sensors and stream discharge were measured weekly to bimonthly at both NMFS and SWRCB monitoring sites. Instantaneous discharge was measured using a Swoffer 3000 current meter following protocols according to standard USGS methods (Rantz, 1982). These data are listed in Table 3.

Data QC: Field Depth Verification and Initial Screening;

Field measurements of water depth over pressure sensors were used to verify pressure records, and adjust those records if needed. Adjustment of depth logs was done manually when the field measurement and the logged pressure reading disagreed by more than 0.2 feet. Depth adjustment was performed on Atascadero Creek at Water Trough Road and Mark West Creek at Calistoga Road sites for the months of November 2010 thru June 2011.

Additionally, two SWRCB sensors were dislodged during the March 24th, 2011 storm at Dooley and McNab Creeks in Mendocino County. SWRCB staff reinstalled the sensors to their original positions on April 6th and the necessary corrections were made to the data to compensate for the depth shifts.

Water depth over riffles was also measured in 2011 at all of the monitoring sites that had existing pool tail-outs/riffle crests within our area of property access (except for Feliz Creek and the SWRCB gauges). Depths were measured in the thalweg of the riffle crest near installed gauges during the receding limb of the season's hydrograph.

The water depth logs were then shifted to correspond to riffle crest depths measured in the thalweg by subtracting the shallowest riffle crest depth from the corresponding pool depth in which the pressure transducer was located. Once shifted to match field measured water depth,

and to correspond to nearby riffle crest depth, the data were screened for ghost signals. These are obvious excursions from the pattern made up of only one or two data points. These points were deleted from the record so that any further screening or analysis would not incorporate erroneous data points.

Table 3. NMFS and SWRCB Discharge Estimates.

NMFS Discharge Estimates	Date	Depth Over Sensor (ft)	Depth Over Riffle (ft)	Q (ft^3/sec)
Atascadero at Mill Station Rd.	01/19/11	2.13	1.38	11
	03/30/11	2.45	1.70	36
	04/14/11	1.86	1.11	7
	04/25/11	2.06	1.31	13
	05/05/11	1.65	0.90	3.4
Atascadero at Water Trough Rd.	01/19/11	2.15	0.64	3.2
	03/02/11	3.24	1.73	51
	03/30/11	2.31	0.80	11
	04/14/11	1.91	0.40	2.1
	04/25/11	2.02	0.51	4.6
	05/05/11	1.79	0.28	0.9
	05/10/11	1.82	0.31	1
Bidwell Creek	01/14/11	1.43	0.53	3.1
	02/25/11	1.90	1.00	22
	03/17/11	1.95	1.05	30
	03/24/11	3.16	2.26	160
	04/28/11	1.33	0.43	2.2
	05/03/11	1.29	0.39	1.4
Feliz Creek	01/03/11	2.24	-	88
	02/14/11	1.93	-	43
	03/02/11	3.29	-	229
	04/08/11	1.64	-	41
	04/21/11	1.48	-	21
	05/04/11	1.30	-	7
Franz Creek	01/04/11	1.34	0.85	41
	02/25/11	2.17	1.68	186
	03/15/11	2.60	2.11	273
	04/07/11	1.07	0.58	24
	04/19/11	0.91	0.42	11
	05/03/11	0.84	0.35	5.3
	05/13/11	0.79	0.30	3.8

Table 3 Continued.

NMFS Discharge Estimates	Date	Depth Over Sensor (ft)	Depth Over Riffle (ft)	Q (ft^3/sec)
Mark West at Calistoga Rd.	01/07/11	1.39	1.17	22
	03/03/11	1.61	1.39	52
	03/16/11	2.26	2.04	170
	04/15/11	1.06	0.84	10
	04/28/11	0.98	0.76	7
	06/21/11	0.80	0.58	1.4
Mark West at River Road	02/10/11	2.37	0.79	12
	02/14/11	2.64	1.06	41
	03/01/11	2.94	1.36	96
	03/30/11	3.57	1.99	180
	04/27/11	2.28	0.70	20
	05/06/11	2.18	0.60	12
Pena Creek	03/04/11	1.89	-	121
	03/08/11	1.73	-	88
	03/31/11	2.35	-	124
	04/20/11	0.86	-	32
	04/28/11	0.78	-	13
	05/15/11	0.65	-	8
Pieta Creek	03/04/11	2.05	-	93
Redwood Creek	01/13/11	2.95	1.41	20
	02/18/11	3.42	1.88	154
	03/01/11	2.73	1.19	31
	03/15/11	3.26	1.72	109
	04/19/11	2.40	0.86	16
	05/03/11	2.23	0.69	8
Sausal Creek	02/10/11	1.93	0.51	3.6
	02/23/11	2.43	1.01	29
	03/17/11	2.84	1.42	87
	04/15/11	2.24	0.82	14
	04/21/11	2.20	0.78	13
	05/04/11	1.97	0.55	5.3
	05/13/11	1.90	0.48	3.2
	06/15/11	1.78	0.36	1.1

Table 3 Continued.

NMFS Discharge Estimates	Date	Depth Over Sensor (ft)	Q (ft^3/sec)
Russian River (West Branch)	01/10/11	2.55	49
	02/13/11	2.60	52
	03/09/11	3.05	83
	04/21/11	2.25	26
	05/04/11	2.10	14
	05/09/11	1.70	10
	05/16/11	1.80	12
	06/21/11	1.53	3.7
SWRCB Discharge Estimates			
Dooley Creek	04/20/11	2.07	11
	05/05/11	1.84	3.5
	07/14/11	1.44	0.5
	08/03/11	1.30	0
Green Valley Creek	04/14/11	1.36	27
	04/21/11	1.14	21
	04/27/11	1.03	16
	07/01/11	0.49	2.8
	08/03/11	0.37	1.7
	08/17/11	0.27	0.6
McNab Creek	04/20/11	2.31	6
	04/28/11	2.22	4.4
	05/19/11	2.14	2.7
	05/13/11	2.04	1.7
	07/07/11	1.64	0.5
Mill Creek	04/14/11	1.40	24
	04/21/11	1.32	18
	04/27/11	1.21	15
	05/11/11	1.06	8
	07/01/11	0.89	2.4
	07/14/11	0.81	1.6
	08/03/11	0.70	0.7
	08/17/11	0.61	0.2
York Creek	03/09/11	2.34	23
	04/13/11	2.10	8
	04/20/11	1.90	5
	04/28/11	1.80	3.3
	05/11/11	1.70	1.4

Signal Definition and Detection:

The corrected water depth records were screened in five steps.

1. Scan water depth for abrupt changes (≥ 0.09 feet), persisting for at least two hours.
2. These signals were further screened with a scatterplot of temperature and depth to determine if the detection corresponded to air temperatures less than or equal to 35˚ F.
3. If a signal correlated with temperature less than or equal to 35˚ F it was considered a response to water withdrawal for frost management, and was isolated and recorded separately.
4. Signal information recorded separately included the;
    a. start time of depth reduction,
    b. amount of reduction,
    c. duration of reduction,
    d. percentage of original depth recovered,
    e. end time, time at which the water depth ceased recovery.

Following the above procedure, all of the monitoring data were screened for each day of the 2010 & 2011 frost protection seasons.

Cold Morning Habitat Surveys:

Widespread frost can be predicted and this information is available from common weather services. On predicted frost mornings during the spring of 2011, NMFS staff performed salmonid stranding surveys near gauge locations in the early morning hours. Low gradient gravel bars and riffles were inspected for stranded juvenile salmonids and dewatered redds.

In the event of observed stranding events, individual fish would be counted within habitat units in the vicinity of the stream gauge or other stream reaches prone to stranding. Wetted perimeter widths would be measured and flagged before and after surveying to determine the change of wetted area, and to determine streamflow recovery during surveying. The only location where dewatered stream habitat was observed in the field was the West Branch Russian River; those results were documented by Cluer (2011).

Data Limitations:

Reliably detecting relatively small amplitude water depth changes is technically demanding. Equipment selection plays a role along with site selection and time interval between measurements. Site selection and time interval can be managed, but we found that sealed, or unvented, water level loggers present inherent problems for precision measurement. The basic problem is that sealed sensor monitoring of water depth is a two-sensor installation; the barometric pressure must be monitored as a correction for the total pressure sensor submerged in water. Two sensors generate two signals, and also two sources of signal noise. Signal noise proved to be impossible to resolve in some of our installations (see note to Table 1) because some of the barometric sensors were influenced more by changes in air temperature than the

built-in temperature compensation algorithm corrected; the barometric pressure oscillated as temperatures increased and decreased when we knew that water depth was remaining steady. These variations in the barometric record were transferred to the water depth data when performing the barometric correction, indicating diurnal depth fluctuations of up to 0.10 feet throughout the springtime depth record that were not real. This temperature/pressure error became worse as the daily temperature range increased. This equipment limitation affected 5 sites; Atascadero Creek at Mill Station and Water Trough Roads, Bidwell Creek, Mark West Creek at River Road and Sausal Creek. Consequently, we did no further analysis for diversion signals for those stations.

Although there are installation advantages, another disadvantage of integrated level loggers is difficulty with data retrieval, especially when stream flow is up. In order to download data from the logger it has to be removed from its housing which is attached to the streambed. Water depths and velocities are at times too great to safely remove and replace the sensor from the streambed, so it is often several months between downloads; malfunctions cannot be identified until data are retrieved, so malfunctions persist for long periods of time. This type of malfunction occurred shortly after installation of a level logger on the Russian River (West Branch) in Redwood Valley, resulting in an absence of data for the entire spring season. Additionally, the barometric logger for Pieta Creek was faulty, so we could not make the necessary correction for total pressure at that station. For these reasons NMFS replaced unvented sensors with vented sensors and separate temperature loggers for the 2012 water year.

III. Results

The data collection, data QC, and data screening methods described above resulted in continuous water depth records adjusted to correspond to the flow depth over the nearby hydraulic control, or the riffle depth. These records were screened for water diversion signals associated with cold weather.

These stream hydrographs for NMFS and SWRCB monitoring sites are as follows; Atascadero Creek at Mill Station and Water Trough Roads (Figures 3-6), Bidwell Creek (Figures 7-9), Dooley Creek (Figure 31), Feliz Creek (Figure 10), Franz Creek (Figures 11-12), Green Valley Creek (Figure 32), Mark West Creek at Calistoga, Slusser, and River Roads (Figures 13-16 & 22-23), McNab Creek (Figure 37), Mill Creek (Figure 43), Pena Creek (Figures 24-25), Redwood Creek (Figures 26-28), Sausal Creek (Figures 29-30), and York Creek (Figure 44).

Graphical representation of diversion signals and corresponding air temperatures are as follows; Green Valley Creek (Figures 33-36), Mark West Creek at Calistoga Road (Figures 17-21), McNab Creek (Figures 38-42), and York Creek (Figure 45). See Cluer (2011) for details regarding the depth reduction at the NMFS monitoring site on the West Branch of the Russian River (Figure 1 displays the diversion signal at the USGS Gauge #11461000 near Ukiah, CA). Table 4 lists the timing, depth reduction amount and duration of diversion signal, percentage of recovery to pre-diversion depth, and lowest daily temperature for all of the NMFS and SWRCB sites.

Green Valley Creek:

Frost Protection signals were recorded during the 2011 water year at the Green Valley gauge on April 7th, 9th, 12th - 13th, 26th, May 1st- 2nd, & May 12th-13th. Three of these listed diversion signals on Green Valley Creek produced depth reductions that were greater than or equal to 0.09 feet. The first event occurred on April 12th at 9:44am and caused a depth reduction of 0.10 feet (1.20 to 1.10 ft). Depth returned to near pre-event levels on April 13th at 12:22pm, a total of 26.6 hours. The second event occurred on May 1st at 8:24am and caused a depth reduction of 0.13 feet (0.87 to 0.74 ft). Depth returned to 85% of the original depth on May 2nd at 8:31 pm, a total of 36.1 hours. The third event occurred on May 12th at 9:09am and caused a depth reduction of 0.12 feet (0.70 to 0.58 ft). Depth returned to pre-event levels on May 13th at 11:30am, a total of 26.4 hours. All diversion signals correspond to air temperatures approaching, or dipping below the 35˚F threshold.

Mark West Creek at Calistoga Road:

During the 2011 frost protection season, diversion signals on Mark West Creek at Calistoga Road were recorded on March 31st, April 3rd, 4th, 5th, 7th, 8th, 9th, 10th, 23rd, & 26th. Five of these listed diversion signals caused a depth reduction greater than or equal to 0.09 feet. The first of these diversions occurred on March 31st at 5:16am causing a depth reduction of 0.09 feet (1.45 to 1.36 ft). Depth returned to pre-event levels at 11:31am, a total of 6.3 hours. The second event was recorded on April 3rd at 8:01am and caused a depth reduction of 0.09 feet (1.18 to 1.09 ft). Depth returned to pre-event levels at 3:16pm, a total of 7.3 hours. The third event occurred on April 8th at 7:01am and caused a depth reduction of 0.10 feet (0.99 to 0.89 ft). Depth returned to pre-event levels at 9:31pm, a total of 2.5 hours. The fourth event occurred on April 23rd at 11:31am and caused a depth reduction of 0.10 feet (0.80 to 0.70 ft). Depth returned to pre-event levels at 3:16pm, a total of 3.8 hours. The final event was recorded on April 26th at 4:00pm and caused a depth reduction of 0.09 feet (0.82 to 0.73 ft). Depth returned to near pre-event levels at 7:00pm, a total of three hours. All diversion signals correspond to air temperatures approaching or dipping below the 35˚F threshold except for the two late April signals, which occurred well above the temperature threshold, and the April 26th signal occurred in the afternoon.

McNab Creek:

Frost protections signals were recorded during the 2011 water year at the McNab Creek gauge on April 5th, 6th, 7th - 8th - 9th, 12th, 14th, May 12th, 13th, & 21st - 23rd. Seven of these listed diversion signals at McNab Creek produced depth reductions that were ≥ 0.09 feet. The first event occurred on April 5th at 2:01pm and caused a depth reduction of 0.43 feet (2.68 to 2.25 ft). Depth returned to pre-event levels on the same day at 5:31pm, a total of 3.5 hours. The second event occurred on April 7th at 10:30pm and caused a depth reduction of 0.28 feet (2.55 to 2.27 ft). Depth returned to near pre-event levels on April 8th at 8:30pm, a total of 22 hours. The third depth reduction occurs 3 hours later on April 8th at 11:30pm, reducing depth by 0.24 feet (2.53 to 2.29 ft). Depth returned to near pre-event levels on April 9th at 7:30pm, a total of 20 hours. The fourth event occurred on April 12th at 3:30am and caused a depth reduction of 0.18 feet (2.43 to

2.25 ft). Depth returned to pre-event levels at 11:00 am that same morning, a total of 7.5 hours. The fifth event occurred on April 14th at 3:30am and caused a depth reduction of 0.14 feet (2.37 to 2.23 ft). Depth returned to pre-event levels at 9:00am that same morning, a total of 5.5 hours. The sixth event occurred on May 13th at 5:30am and caused a depth reduction of 0.16 feet (2.14 to 1.98 ft). Depth returned to near pre-event levels at 7:30pm that evening, a total of 14 hours. The final frost event occurred on May 21st at 7:30am and caused a depth reduction of 0.23 feet (2.12 to 1.89 ft). Depth returned to near pre-event levels on May 23rd at 12:00am, a total of 40.5 hours. All diversion signals, except for the signals produced on April 5th & May 12th, correspond to air temperatures approaching, or dipping below the 35˚F threshold.

York Creek:

One frost protection signal was recorded on April 8th at 7:17am and caused a depth reduction of 0.18 feet (2.22 to 2.04). Depth returned to near pre-event levels at 11:17am, a total of 4 hours. The diversion signal corresponds to temperatures approaching, or dipping below the 35˚F threshold.

Figure 1. Diversion signals downstream from the NMFS monitoring site on the Russian River (West Branch). Air temperature from the NMFS barometric pressure logger was plotted with sensor depth from the USGS gauge.

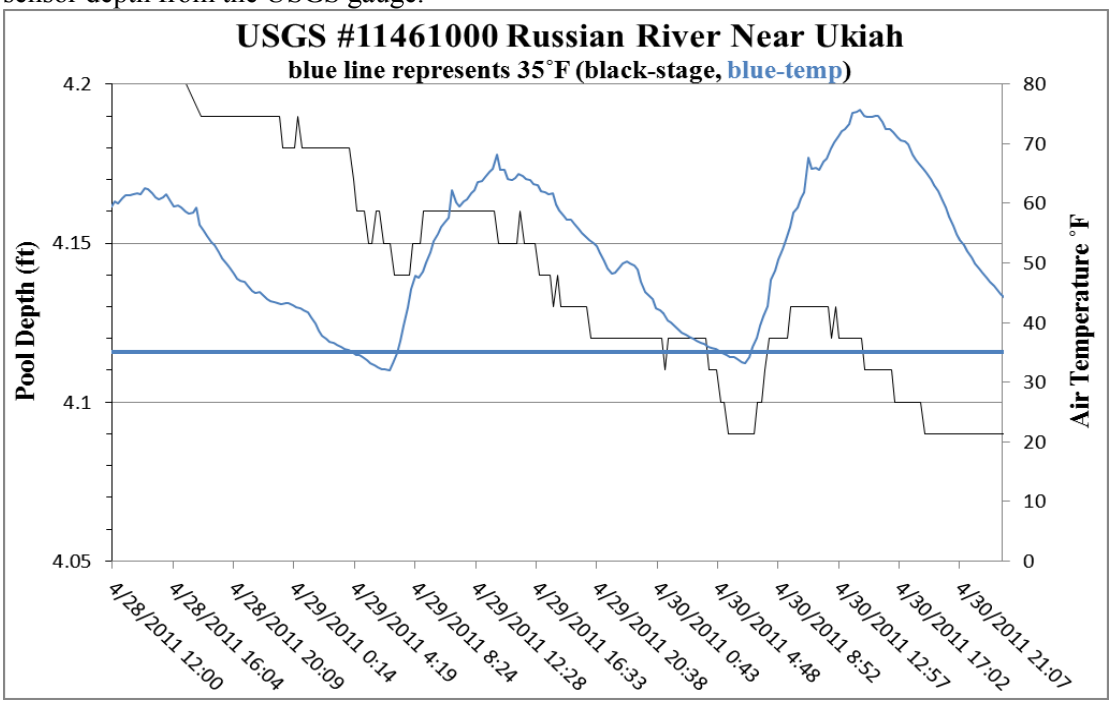


Table 4. Diversion signals at NMFS & SWRCB monitoring sites, start and end times, water depth reduction, signal duration, the percentage of depth recovered, and associated low temperatures.

Russian River Tributary	Signal Start Date	Signal End Date	Depth Reduction (ft)	Signal Duration (hrs)	% Recovery	Daily Lows (°F)
Green Valley	4/12/11 9:44am	4/13/11 12:22pm	0.10	26.6	98.2	37.2, 41.7
Green Valley	5/1/11 8:24am	5/2/11 8:31pm	0.13	36.1	85.5	39.7, 41.2
Green Valley	5/12/11 9:09am	5/13/11 11:30am	0.12	26.4	99.1	42.8, 41.2
Mark West at Calistoga	3/31/11 5:16am	3/31/11 11:31am	0.09	6.3	100.0	42.2
Mark West at Calistoga	4/3/11 8:01am	4/3/11 3:16pm	0.09	7.3	99.3	33
Mark West at Calistoga	4/8/11 7:01am	4/8/11 9:31am	0.10	2.5	97.5	30.5
Mark West at Calistoga	4/23/11 11:31am	4/23/11 3:16pm	0.10	3.8	100.0	45.2
Mark West at Calistoga	4/26/11 4:00pm	4/26/11 7:00pm	0.09	3.0	100.0	34.5
McNab	4/5/11 2:01pm	4/5/11 5:31pm	0.43	3.5	100.0	43.3
McNab	4/7/11 10:30pm	4/8/11 8:30pm	0.28	22.0	99.3	34.8, 30.1
McNab	4/8/11 11:30pm	4/9/2011 7:30pm	0.24	20.0	99.2	30.1, 34.4
McNab	4/12/11 3:30am	4/12/11 11:00am	0.18	7.5	100.0	34.5
McNab	4/14/11 3:30am	4/14/11 9:00am	0.14	5.5	100.0	34.9
McNab	5/13/11 5:30am	5/13/11 7:30pm	0.16	14.0	99.1	41.4
McNab	5/21/11 7:30am	5/23/11 12:00am	0.23	40.5	98.2	43.8, 43.1, 37.7
York	4/8/11 7:17am	4/8/11 11:17am	0.18	4.0	99.1	29.7
*Russian River (West Branch)	4/29/11 4:00am	4/29/11 9:00am	0.10	5.0	99.5	32.1

* Spring discharge in the Russian River (West Branch) and the corresponding depth reduction was simulated by Cluer (2011) using data from the USGS #11461000 Near Ukiah, CA. weighted against watershed area and vineyard densities upstream of the NMFS monitoring site at East School Road.

IV. Discussion

Hydrologic Context for the 2011 Signals:

During the 2011 water year the California Data Exchange Center (CDEC) reported 43.85 & 38.98 inches of precipitation from their Ukiah (UKH) and Santa Rosa (SRO) stations, respectively. The 2011 water year ranks 6th wettest in the last 28 years at Santa Rosa, and 8th wettest at Ukiah (Table 5), with the largest storm occurring on March 24th, making spring flows abnormally high during the 2011 frost protection season (March 15th thru May 15th). This is supported by observing monthly stream flow totals at the long-term USGS gauge near Guerneville (USGS # 11467000) for March-May, which show that spring 2011 was the 5th wettest since 1980 (Table 6).

Climatic Context for 2011 Signals:

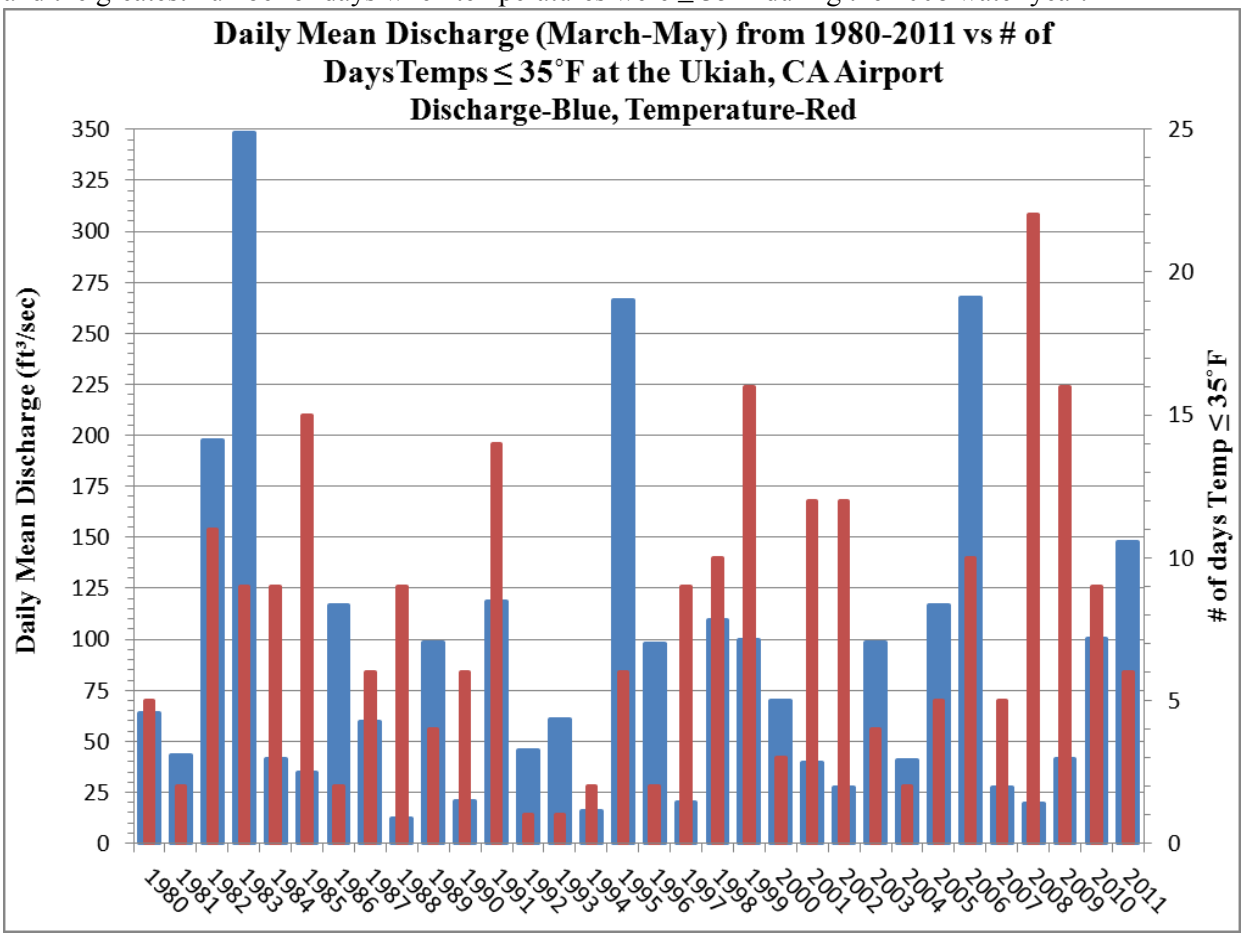
In addition to supplementing stream flow, increased rainfall in spring also reduces the risk of frost events by decreasing the potential for radiation frost. Radiation frost events are caused by clear skies and calm winds in the evening and early morning hours and will occur with greater frequency during years of lesser rainfall or drought, resulting in a greater demand for frost protection water.

These conditions were observed in 2008, when the weather station at the Ukiah airport recorded 22 days of temperatures ≤ 35˚F, 8 of which were days of temperatures ≤ 32˚F, during the frost protection season. There were potentially 22 days of frost protection pumping occurring on the upper Russian River in 2008, while Russian River stream flow conveyed the third lowest daily mean discharge rate in 32 years, (see Table 6 & Figure 2).

Table 5. Precipitation totals for Water Years 1984-2011 (SRO & UKH CDEC Stations, 2011). Incomplete precipitation data was not included in yearly calculations and all of the data is considered provisional. A rank of 1 indicates the largest recorded precipitation and 28 the smallest.

Water Year	Rainfall Totals SRO (in)	SRO Rank	Rainfall Totals UKH (in)	UKH Rank
2011	38.98	6	43.85	8
2010	31.35	13	38.39	14
2009	21.18	25	26.18	23
2008	23.11	20	32.53	17
2007	20.25	27	25.37	25
2006	45.72	3	60.31	3
2005	37.82	7	40.31	12
2004	29.2	16	40.32	11
2003	34.14	11	49.93	5
2002	37.46	8	31.58	18
2001	20.63	26	26.57	22
2000	30.3	15	37.62	15
1999	33.1	12	38.66	13
1998	53.83	1	71.15	1
1997	34.29	10	42.14	9
1996	39.29	5	49.39	6
1995	52.24	2	63.8	2
1994	22.38	22	24.33	27
1993	37.28	9	50.49	4
1992	24.29	19	30.87	19
1991	22.67	21	24.46	26
1990	21.38	24	25.93	24
1989	26.62	18	33.23	16
1988	22.09	23	29.8	21
1987	18.67	28	23.05	28
1986	39.79	4	49.06	7
1985	26.7	17	29.94	20
1984	30.77	14	41.71	10

Figure 2. Daily mean discharge from USGS Gauge # 11467000 on the Russian River near Guerneville, CA plotted against the number of days temperatures dipped below the frost protection threshold (Ukiah Airport) between water years1980 & 2011 (Table 6). We observed the third lowest mean discharge rates and the greatest number of days when temperatures were ≤ 35˚F during the 2008 water year.



Water Withdrawal Signals:

Water diversion signals were observed in five of the monitored streams (Green Valley, Mark West at Calistoga Road, McNab, York, and the Russian River[3]) during the spring of 2011, indicating that measurable stream flow reductions exist even during years of plentiful rainfall, and relatively little demand for frost protection.

[3] See report by Cluer 2011.

Table 6. Monthly and daily mean stream flow (ft³/sec) during frost protection seasons from 1980 to 2011 for USGS Gauge # 11467000 on the Russian River near Guerneville, CA. A Ranking of 1 indicates the largest amount of spring runoff and 32 the smallest. Data used to calculate daily mean stream flow for March-May 2011 is considered provisional. Temperature data is from the Ukiah airport weather station.

Water Year	March Mean Q	April Mean Q	May Mean Q	Σ March-May Mean Q	Daily Mean Q (March-May)	Rank	# of Days Temp ≤ 32°F	# of Days Temp ≤ 35°F
1980	4030	1291	564	5885	64	16	0	5
1981	2881	855	239	3975	43	20	0	2
1982	5484	11700	1019	18203	198	4	1	11
1983	23290	5956	2798	32044	348	1	0	9
1984	2231	1145	456	3832	42	21	0	9
1985	2047	905	231	3182	35	25	5	15
1986	9277	1031	437	10745	117	7	1	2
1987	4572	611	309	5492	60	18	2	6
1988	448	384	298	1130	12	32	3	9
1989	7337	1324	429	9090	99	12	1	4
1990	937	231	760	1928	21	28	3	6
1991	9291	1242	394	10927	119	6	7	14
1992	3041	899	283	4223	46	19	0	1
1993	3052	1689	871	5612	61	17	0	1
1994	870	359	223	1452	16	31	0	2
1995	18280	3865	2338	24483	266	3	0	6
1996	5898	1866	1256	9020	98	14	1	2
1997	1014	539	315	1868	20	29	1	9
1998	4872	3231	1964	10067	109	9	1	10
1999	5645	2911	621	9177	100	11	3	16
2000	4851	1076	528	6455	70	15	0	3
2001	3012	385	217	3614	39	24	4	12
2002	1475	667	387	2529	27	27	4	12
2003	2569	3710	2796	9075	99	13	0	4
2004	2697	686	353	3736	41	23	0	2
2005	5482	2586	2675	10743	117	8	0	5
2006	12100	11300	1196	24596	267	2	3	10
2007	1729	553	264	2545	28	26	0	5
2008	1159	408	252	1819	20	30	8	22
2009	2783	417	592	3792	41	22	8	16
2010	3464	4582	1200	9246	101	10	2	9
2011	*10622*	*2366*	*623*	*13611*	*148*	*5*	1	6

Russian River tributaries are particularly susceptible to instream diversions during the early spring months because the natural flow recession signaling the end of the rainy season occurs at the same time that agricultural demand for water increases (Deitch *et al.*, 2009). Diversions that reduce spring base flow may desiccate portions of riffles containing redds, or strand juvenile salmonids on low gradient benches adjacent to riffles/runs (Spina *et al.*, 2006). Reductions in spring base flow, especially during dry years, can also cause streams to become intermittent, not

only shrinking salmonid spawning and rearing habitat, but potentially decreasing salmonid growth rates and reducing invertebrate drift (Harvey *et al.,* 2006).

Though winter base flows are mostly unimpaired by licensed diversions during abundantly wet years, diversions may have local impacts on spawning and rearing habitat in particularly dry years (Deitch *et al.*, 2009).

Ratio of Water Demand and Stream Flow:

The ratio between stream flow and water demand is an important information gap that will hopefully be closed in the next few years. Using available information on water demand from one watershed (Lewis *et al.,* 2008), we estimate here the potential water demand for crop frost protection at each of our gauges. That report takes a first look at water needs, including crop frost and heat protection near the NMFS West Branch Russian River gauge. NMFS mapping (source for vineyard acreage: Russian River GIS Vineyard Layer, UC Hopland Research and Extension Center, 2008) shows approximately 3.5 mi^2 of prime agricultural land upstream from our gauge, and Lewis *et al.* (2008) reports that 591 acres of crops use water for frost protection. They assumed a water application rate of 50-55 gpm, per acre, for an average of 6.5 hours per frost day, and between 8 and 14 days per year depending on grapes or pears, respectively. That is an instantaneous water demand of approximately 67 cubic feet per second. Their estimated acreage managed for frost with water is approximately 26% of the agricultural acreage in the Redwood Valley.

In Table 7 we assumed that the other watersheds in our study area have the same ratio of crop acreage to acreage using water for frost protection, to get a first order estimate of the risk posed by crop frost protection on those streams. This is clearly not the thorough and watershed specific analysis that the water demand/streamflow problem deserves. Watersheds will differ depending on climate, hydrology, frost protection practices, and the extent of watershed area in vineyard development. We present these data here as 1) a framework for refinement in subsequent annual editions, 2) to illustrate the potential problem across the landscape and 3) highlight the need for more information regarding water demand to develop water supply/demand relationships in order to effectively manage streamflow for listed salmonids during the spring.

Summary:

Late in the frost pumping season (May) as stream flows decline asymptotically to low summer rates is when the greatest stranding risk occurs, corresponding to the greatest changes in depth caused by large diversions. It is common sense that as flow declines, a given water diversion can have relatively greater effect and create a larger signal in flow records. Diversion signals were still apparent in many of the monitored streams in 2011 even though the Russian River basin yielded the fifth largest mean daily discharge (March-May) in 32 years during the frost protection season (see Table 6). The duration and magnitude of depth reductions caused by diversions during years of drought or average rainfall would be significantly higher as compared to years of abundant precipitation. A dry winter/spring in combination with an increasing

demand for frost protection water may produce a persistent low-flow condition during sensitive developmental stages (incubating eggs, developing larvae, foraging juveniles, and migrating smolts) of ESA listed salmonids in Sonoma and Mendocino Counties, limiting their successful production in the Russian River watershed, and contribution to the population.

Table 7. Cumulative potential demand for water during frost events for each gauge site. The potential demand is based on vineyard acreage upstream from the respective gauge and the ratio of 26% of those acres using water at the rate of 50-55 (gpm) per acre. Discharge estimates are shown at each NMFS & SWRCB monitoring location for the frost protection season and summer of 2011. The ratio of demand vs. mid-May discharge illustrates the difference between the potential demand for water and the measured flow in the stream when the demand would likely have greatest risk to streamflow. Source for vineyard acreage: Russian River GIS Vineyard Layer, UC Hopland Research and Extension Center, 2008.

Stream/Gauge Location	Potential Water Demand (ft^3/sec)	Demand Defined by Existing Water Rights	Dishcharge Estimates Taken on the Following Dates	Corresponding Discharge Estimates (ft^3/sec)	Ratio: Demand vs May Q (ft^3/sec)
Atascadero at Mill Station	17.2	--	3/30, 4/14, 4/25, 5/5	36, 7, 13, 4	4.3
Atascadero at Watertrough	7.7	--	3/2, 3/30, 4/14, 4/25, 5/5	51, 11, 2, 5, 1	7.7
Bidwell Creek	14.0	--	3/17, 3/24, 4/28, 5/3	30, 160, 2, 1.4	10.0
Feliz Creek	4.4	--	3/2, 4/8, 4/21, 5/4	229, 41, 21, 7	0.6
Franz Creek	39.8	--	3/15, 4/7, 4/19, 5/3, 5/13	273, 24, 11, 5, 4	10.0
Mark West at Calistoga	5.4	--	3/3, 3/16, 4/15, 4/28, 5/15	52, 170, 10, 7, 4.2	1.2
Mark West at River Road	73.5	--	3/1, 3/30, 4/27, 5/6	96, 180, 20, 12	6.1
Pena Creek	7.9	--	3/4, 3/8, 3/31, 4/20, 4/28, 5/15	121, 88, 124, 32, 13, 8	1.0
Pieta Creek	0.0	--	3/4	93	0.0
Redwood Creek	40.7	--	3/1, 3/15, 4/19, 5/3	31, 109, 16, 8	5.1
Sausal Creek	33.5	--	3/17, 4/15, 4/21, 5/4, 5/13	87, 14, 13, 5, 3	11.2
West Branch Russian River	67.0	--	3/9, 4/21, 5/4, 5/9, 5/16	83, 26, 10, 12, 4	16.8
Dooley Creek	34.0	--	4/20, 5/5, 7/14, 8/3	11.4, 3.5, 0.5, 0.0	9.7
Green Valley Creek	82.0	--	4/14, 4/21, 4/27, 7/1, 8/3, 8/17	27, 21, 16, 2.8, 1.7, 0.6	5.1
McNab Creek	13.8	--	4/20, 4/28, 5/13, 5/19, 7/7	6, 4.4, 1.7, 2.7, 0.5	8.1
Mill Creek	0.9	--	4/14, 4/21, 4/27, 5/11, 7/1, 7/14, 8/3, 8/17	24, 18, 15, 7.5, 2.4, 1.6, 0.7, 0.2	0.1
York Creek	10.0	--	3/9, 4/13, 4/20/ 4/28, 5/11	23, 8, 5, 3.3, 1.4	7.1

NMFS and SWRCB, exploring the scope and scale of habitat dewatering events and the connection to water diversion for frost management of crops in the Russian River basin, monitored 17 sites in 15 watersheds during winter/spring 2011 (Table 1 & 2). The sites selected represent a range of watershed sizes from 3.5 to 50.2 square miles with vineyard acreage density ranging from 0 to 15.9% of the watershed (Table 2). 2011 was an abnormally wet spring (5th wettest in 32 years, (Table 6) and the peak flow occurred in mid-March. Wet springs are associated with warmer weather and fewer frost events, therefore 2011 had low probability of risk to salmonids due to water withdrawals for frost management.

Frost related water level changes (≥ 0.09 ft) were detected on 17 occasions at 5 stations (Table 4). The earliest was on March 31st and the latest on May 23rd. Depth reductions ranged from 0.09 feet (the minimum defined in our screening process) to 0.43 feet, and signal durations ranged from 2.5 to 40.5 hours.

NMFS attempted to sum the diversion rates listed in water rights upstream from each gauge but found that this information requires compilation and additional organization before the analysis can be conducted. Lewis *et al.,* 2008 reported that the ratio of frost protected cropland acreage in the Redwood Valley is approximately 26% of the total farmed acreage, so we applied that ratio for a first approximation of the water demand for frost protection in the other monitored watersheds (Table 7). By that method, which deserves site specific analysis, the water demand versus supply ratio ranges from 0.10 to 16, where 1 is demand equal to supply during the low flow measured in early to mid-May. The highest demand/supply ratio is at the West Branch Russian River, where NMFS documented fish stranding on April 29th, 2011 (see Cluer, 2011) during a night-time drawdown of 0.10 feet, or 10% of discharge, lasting for approximately 5 hours. The next day on April 30th there was a similar signal (see Figure 1).

Conclusions:

2011 was a relatively warm and wet spring resulting in relatively few frosty nights and relatively high stream flows during the frost protection season. Nonetheless, water diversion signals were documented in 5 out of 17 sub-basins, one of which is known to have stranded hundreds of juvenile steelhead (Cluer, 2011). Because of climate patterns, the demand for frost protection water increases during years when water availability decreases, so the frequency and magnitude of water use signals would be amplified during average and drier water years.

The report touches on the water demand / water supply issue, which deserves more attention. The report does not address what may be another important issue, the cumulative effect of repeated high-volume water withdrawals during the natural spring hydrograph recession. The natural recession to very low summer flows may be accelerated, reducing stream flows during the period of time necessary for successful completion of early salmonid life stages. These issues deserve emphasis.

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Harvey, B.C., Nakamoto, R.J., White, J.C. 2006. Reduced streamflow lowers dry-season growth of rainbow trout in a small stream. *Transactions of the American Fisheries Society* 135: 4, 998-1005.

NMFS Stream Monitoring Sites

Figures 3-30. Stream hydrographs for the NMFS stream monitoring sites. The red X's represent a physical depth measurement that was performed while measuring stream discharge (Figures 3, 5, 8, 10, 11, 15, 22, 27 & 29).

Figure 3.

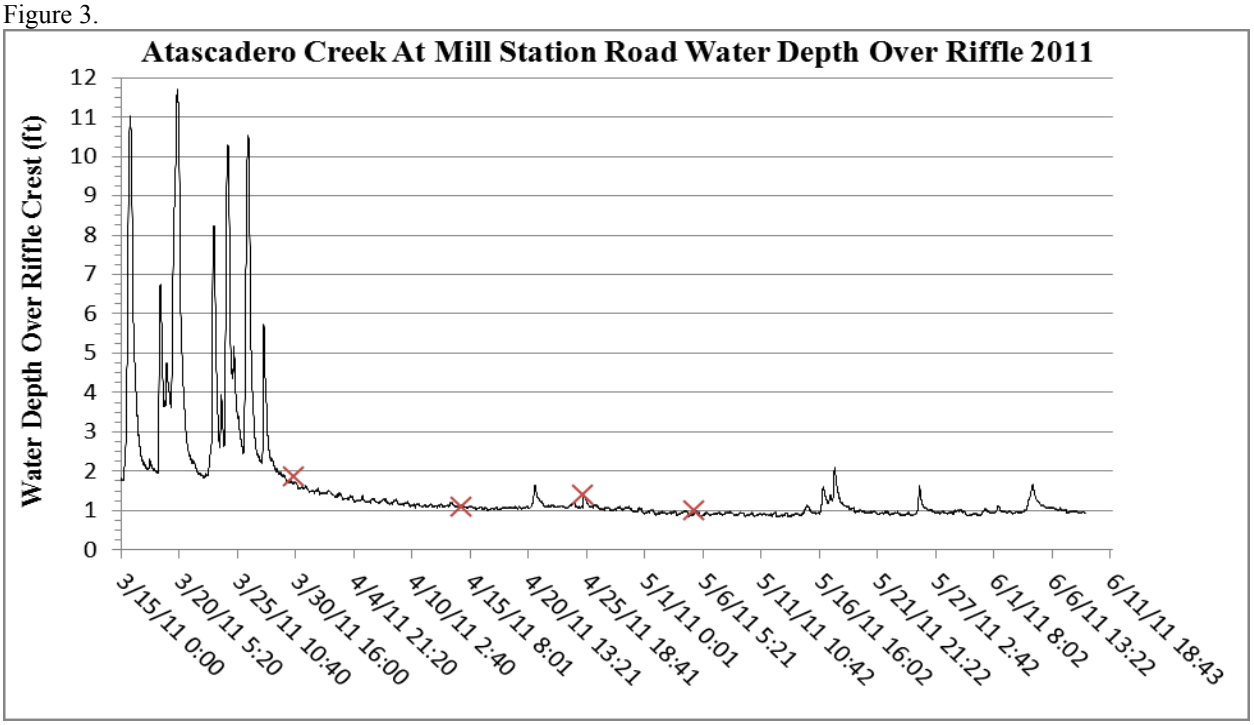
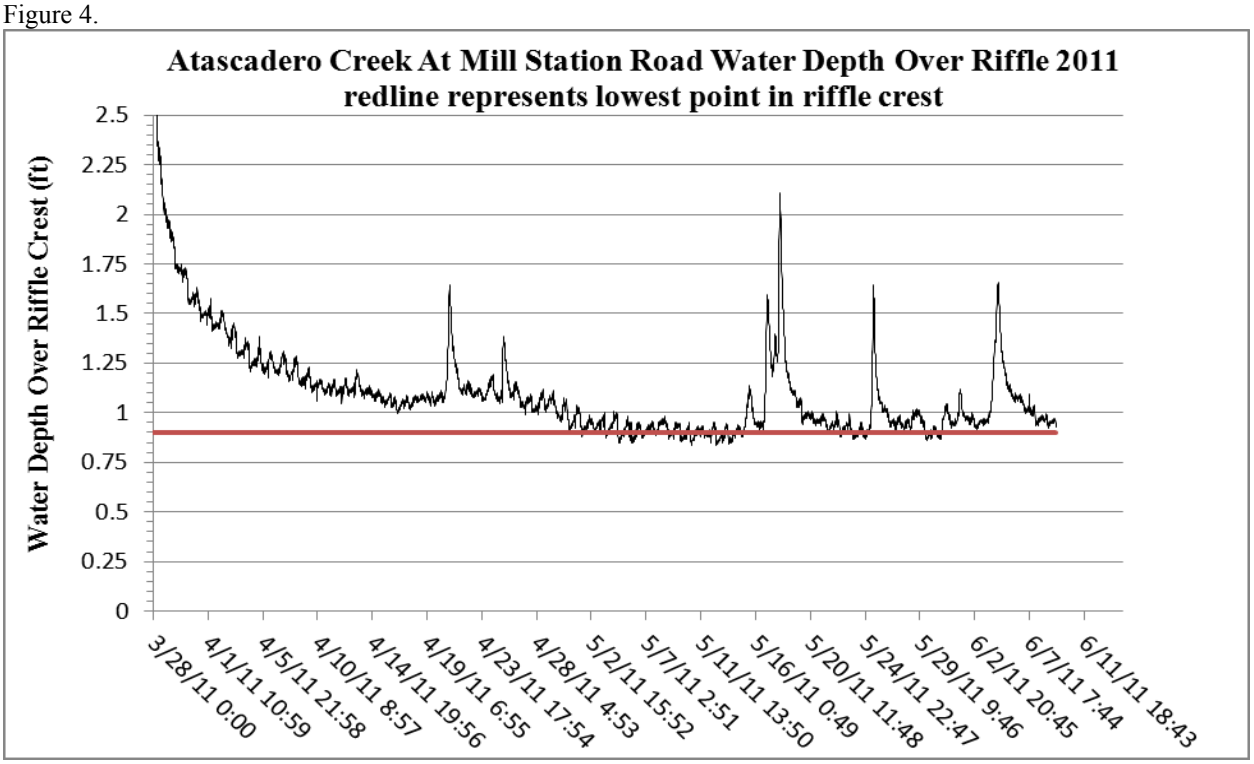


Figure 4.



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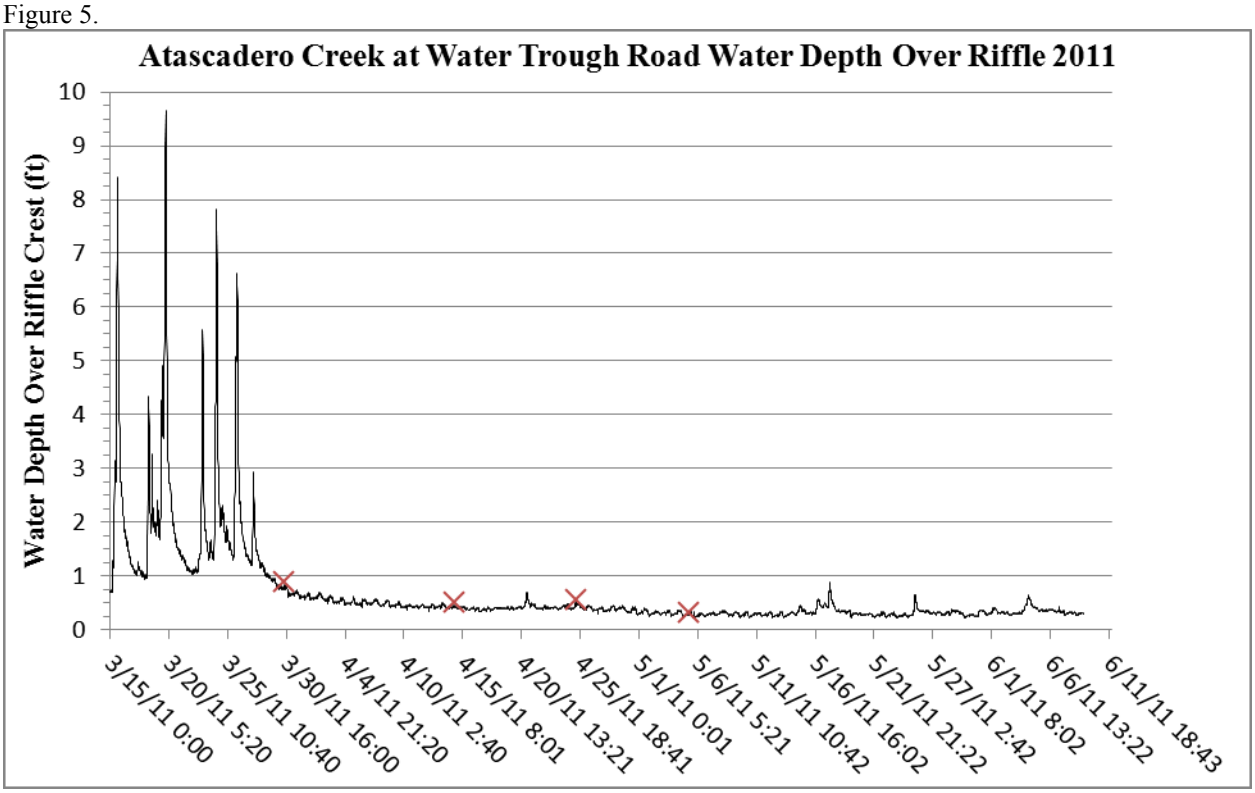
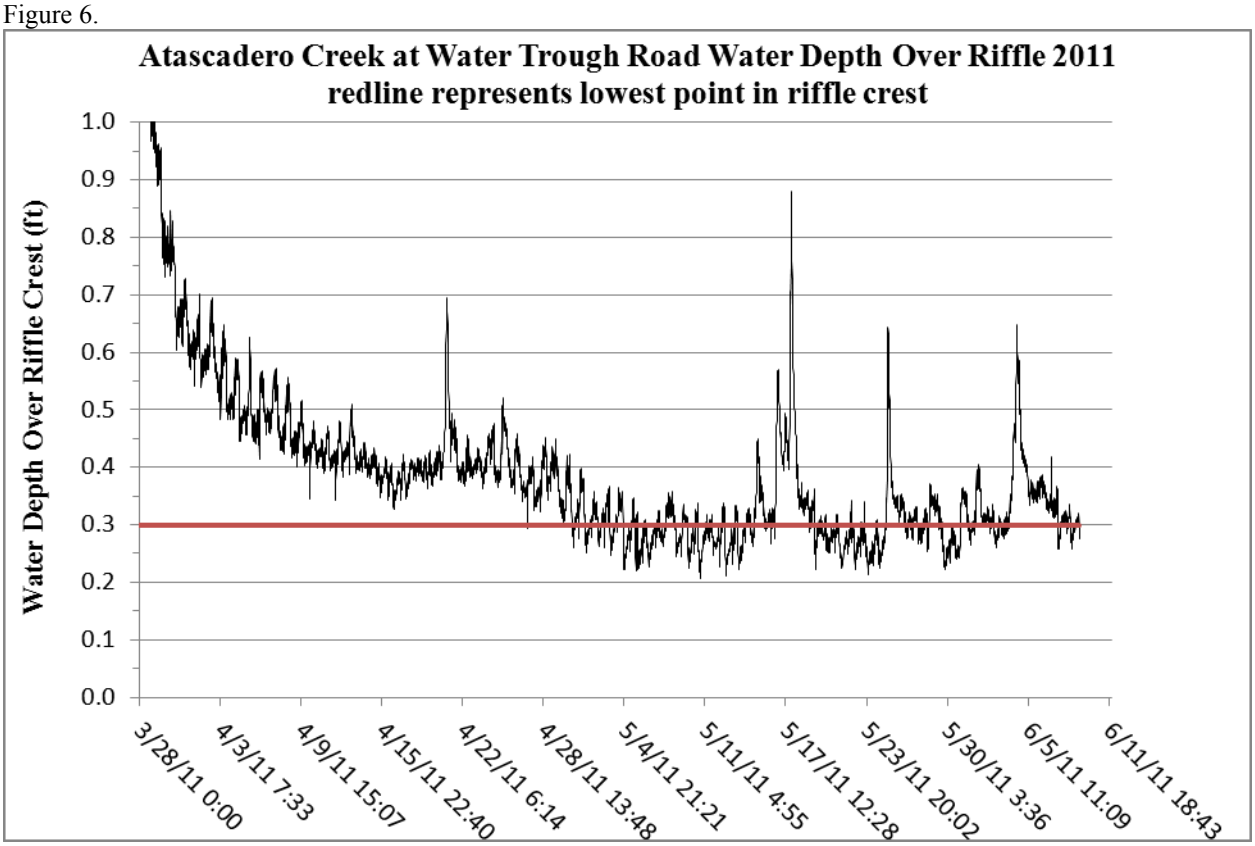


Figure 6.



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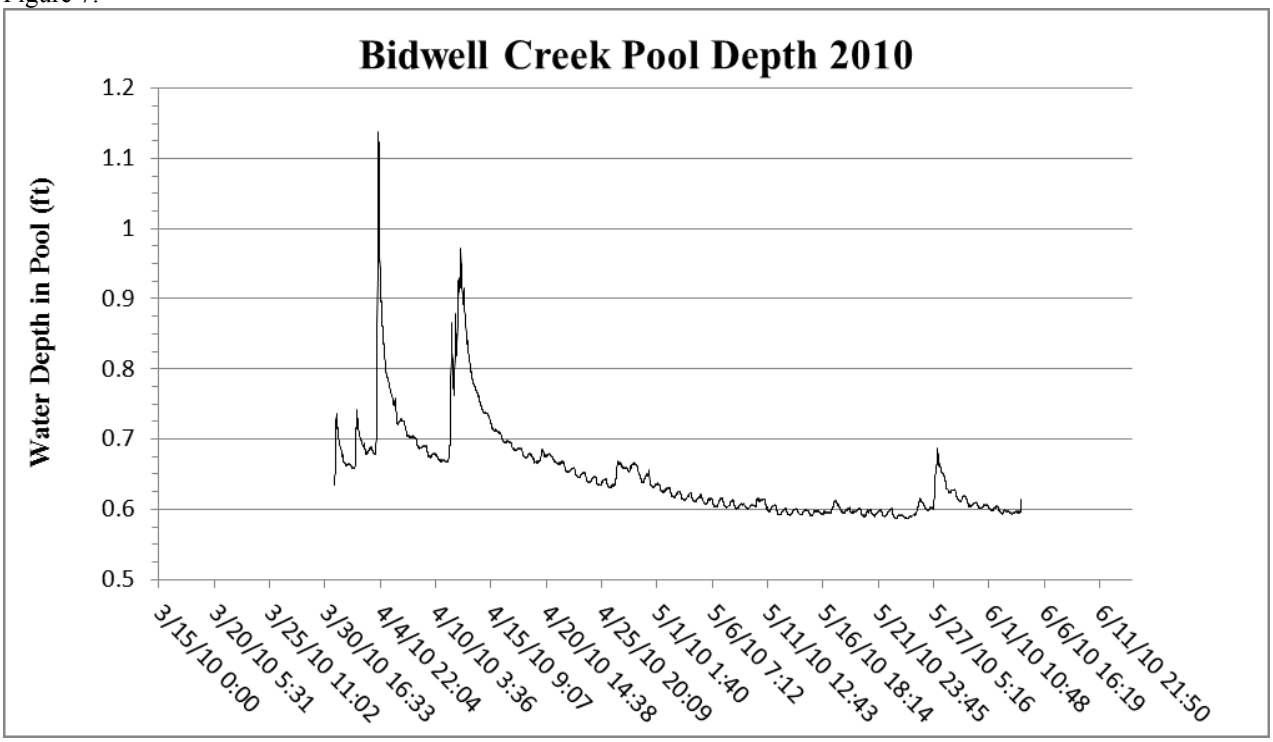

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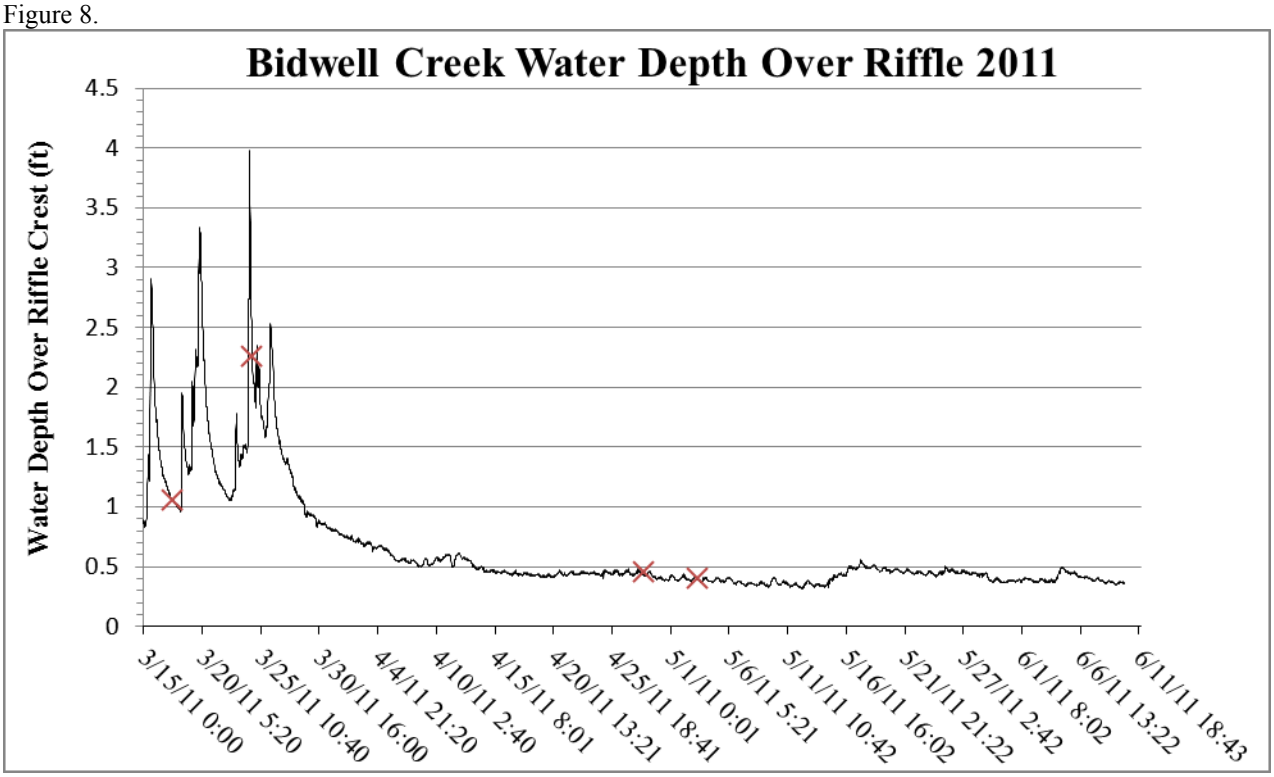


Figure 9.

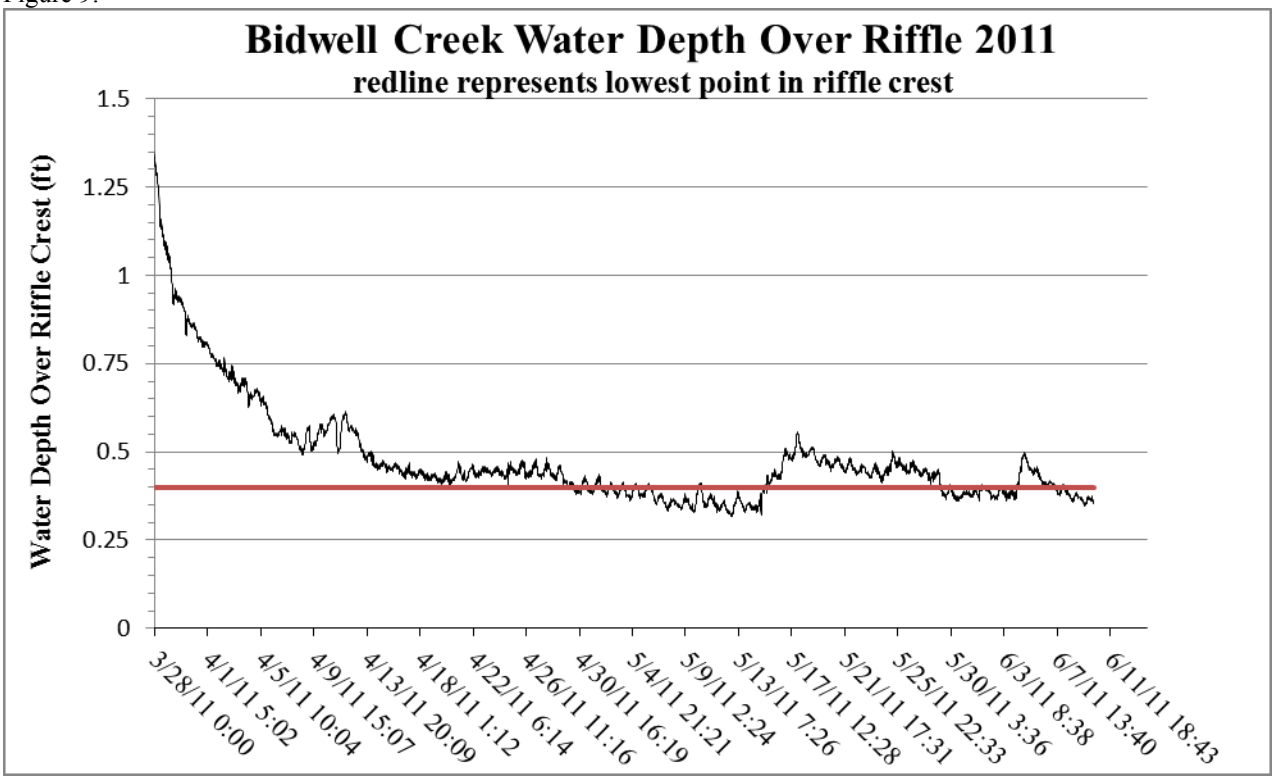


Figure 10.

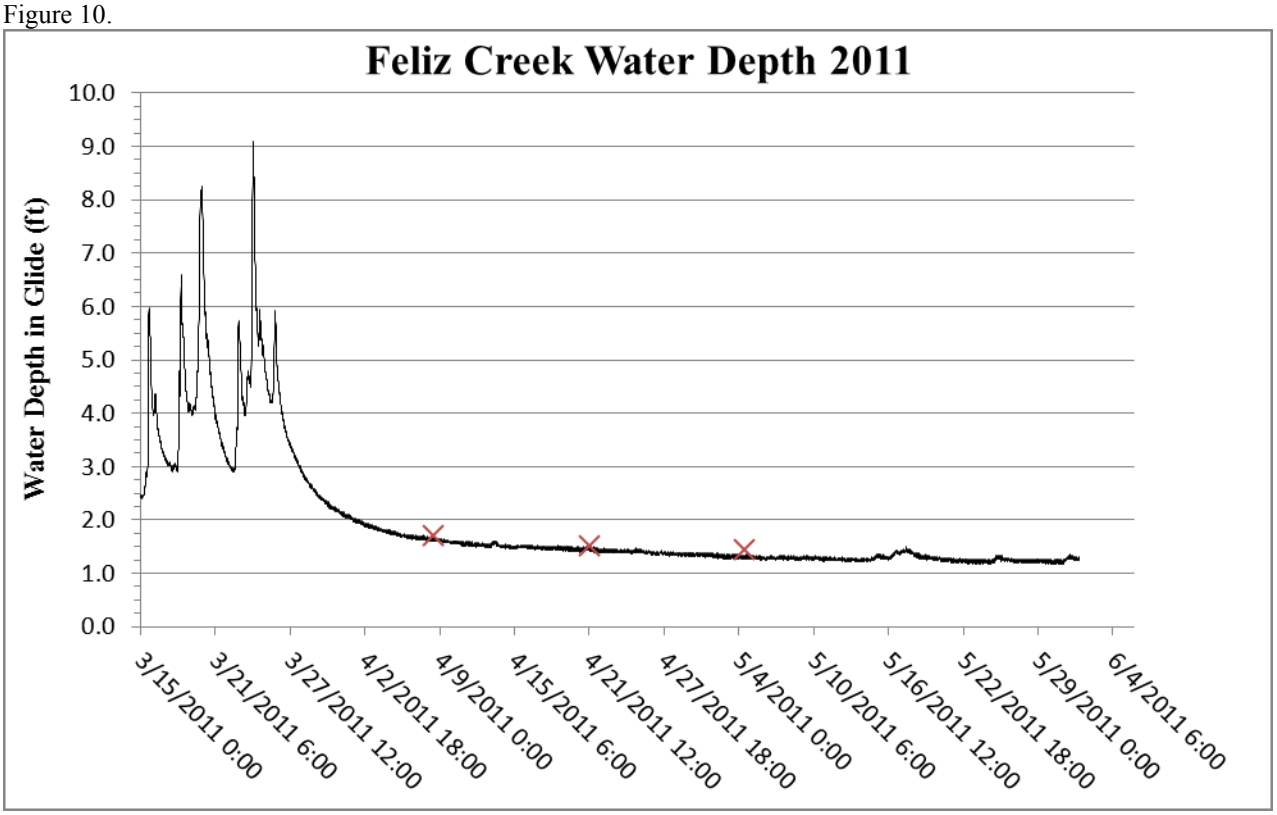
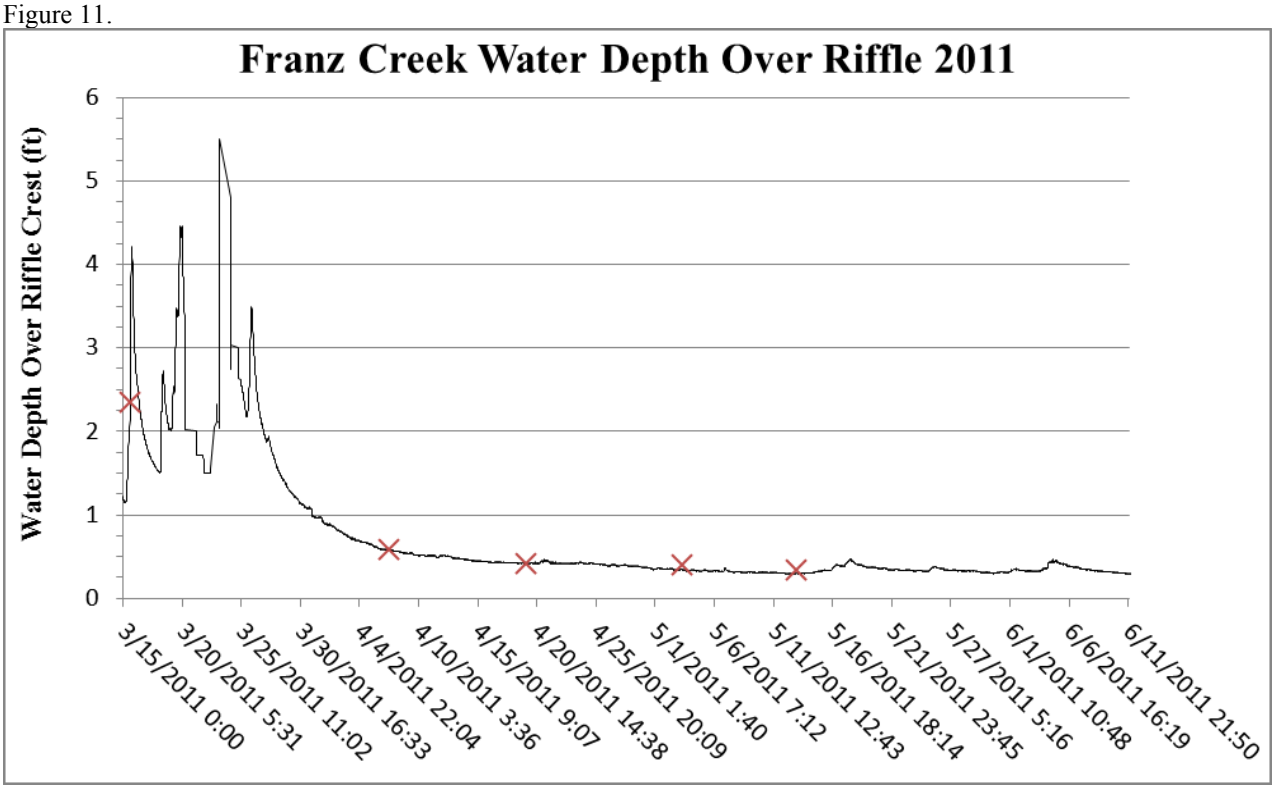


Figure 11.



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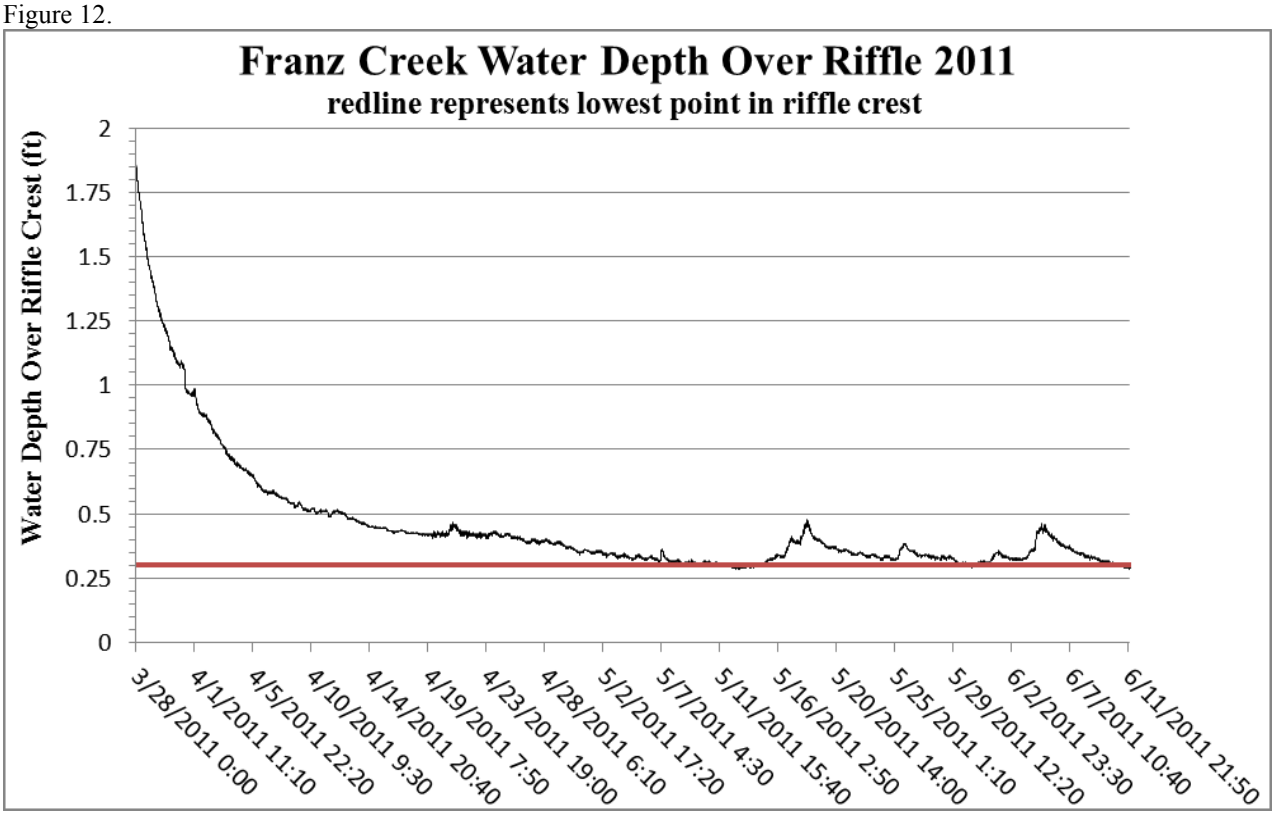

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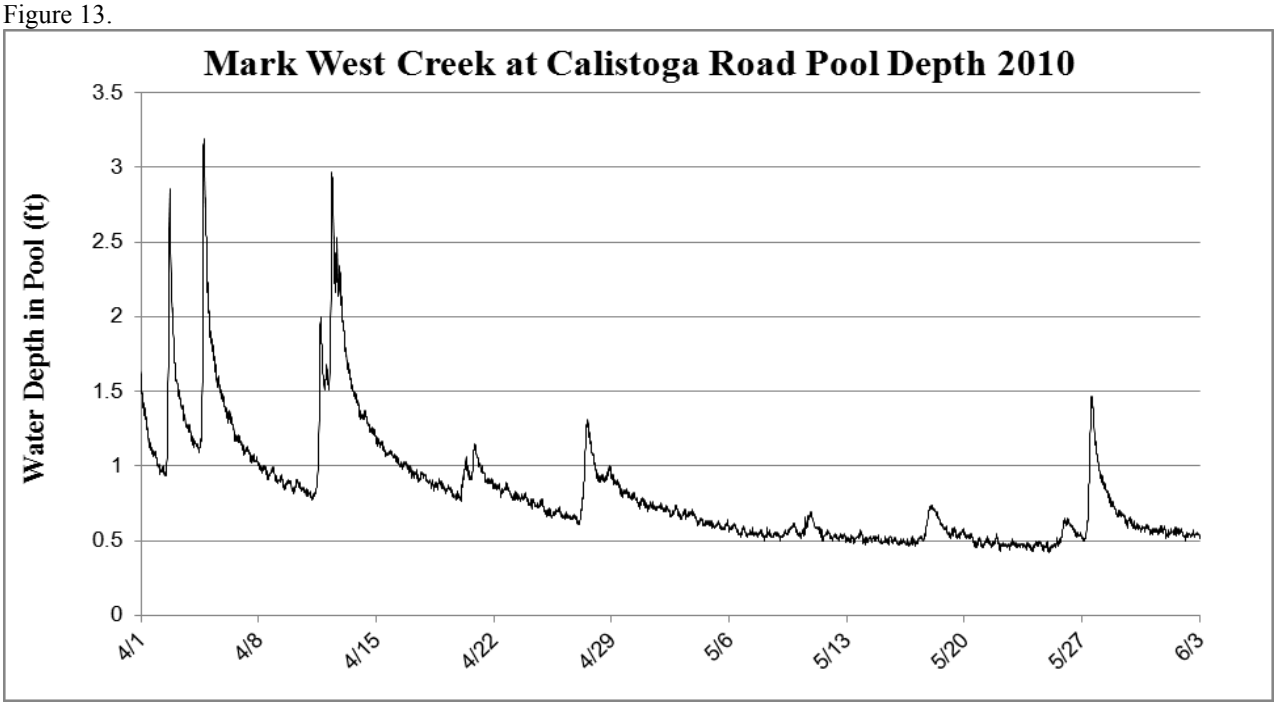

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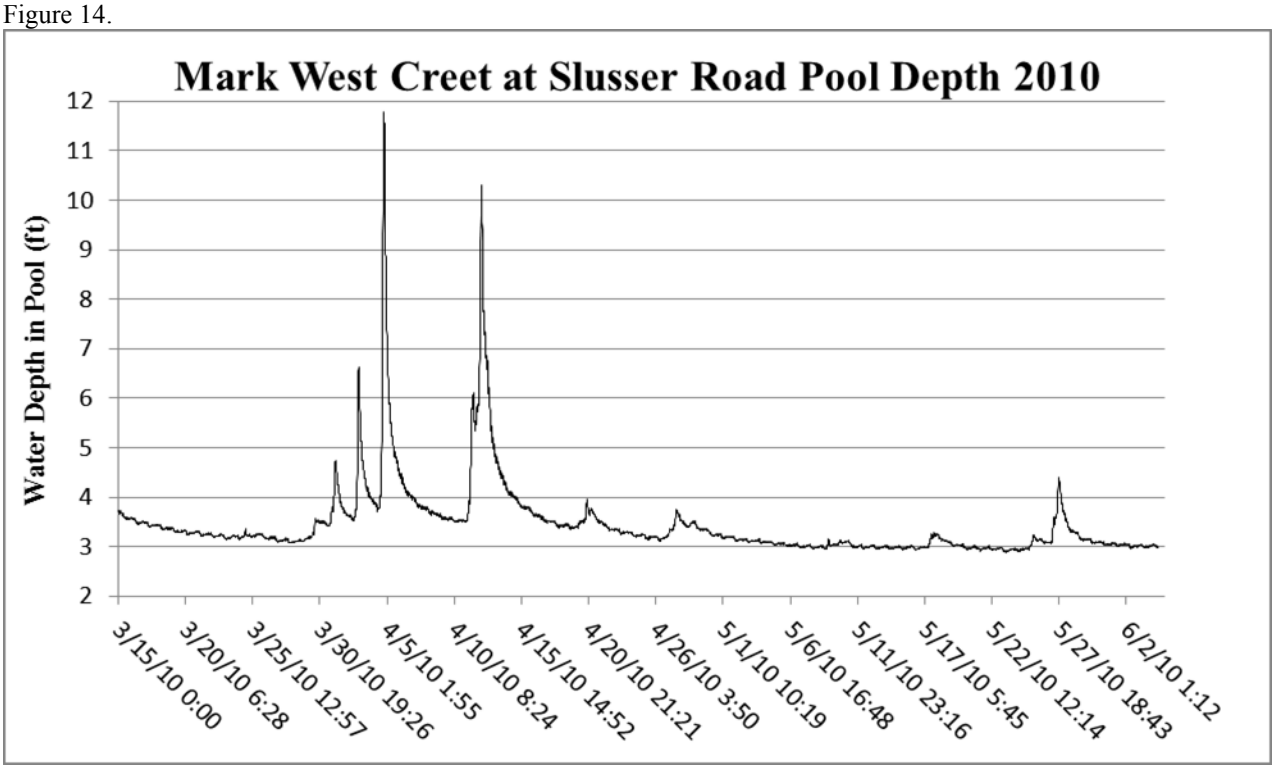

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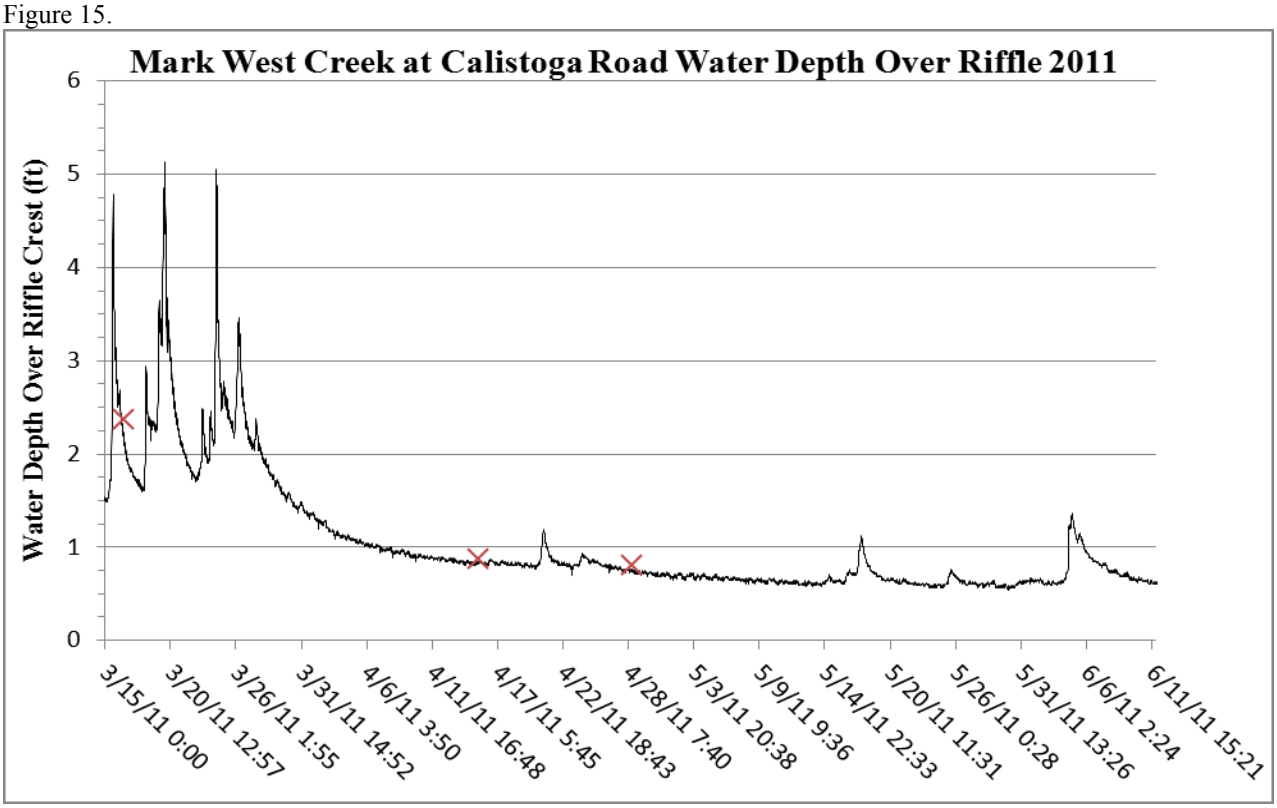

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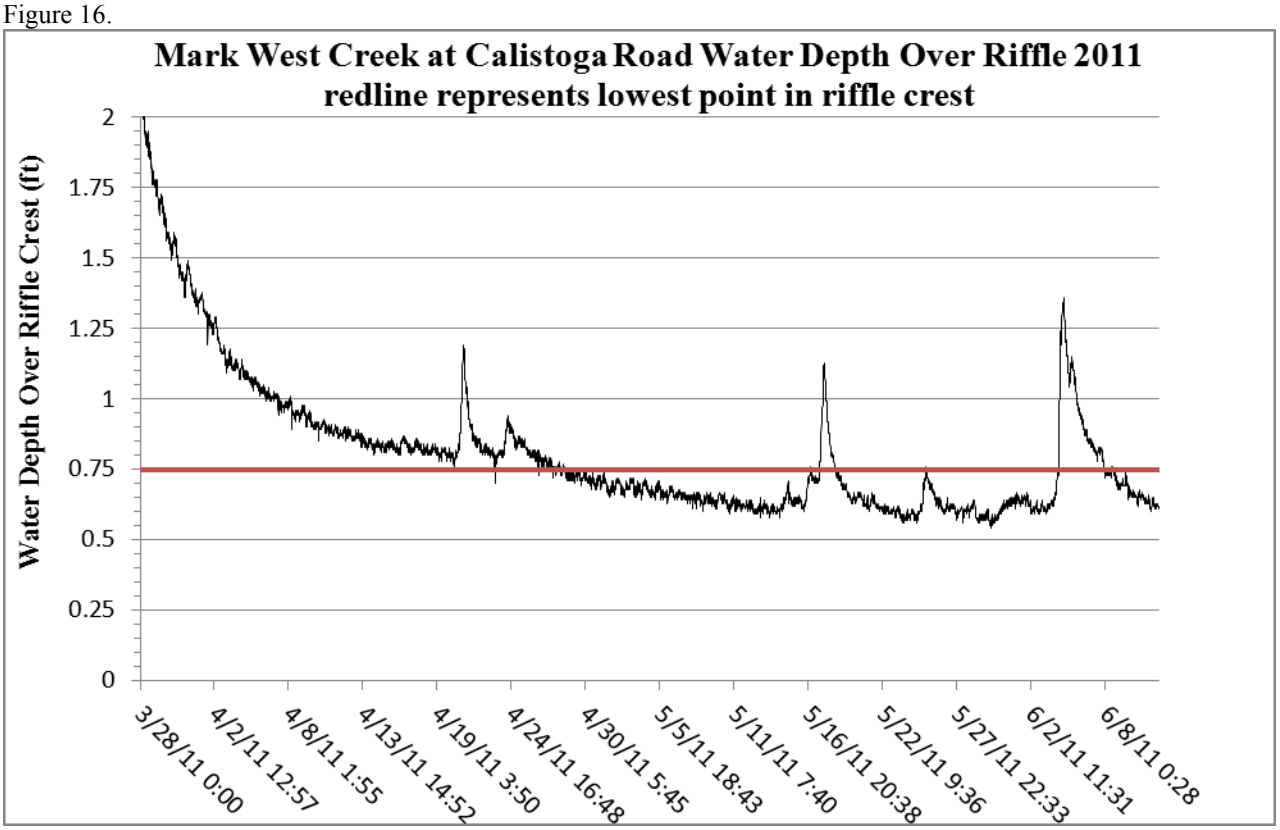


Figure 17. Showing the March 31st depth reduction of 0.09 feet beginning at 5:16am and ending at 11:31am. This diversion signal persisted for 6.3 hours before recovering.

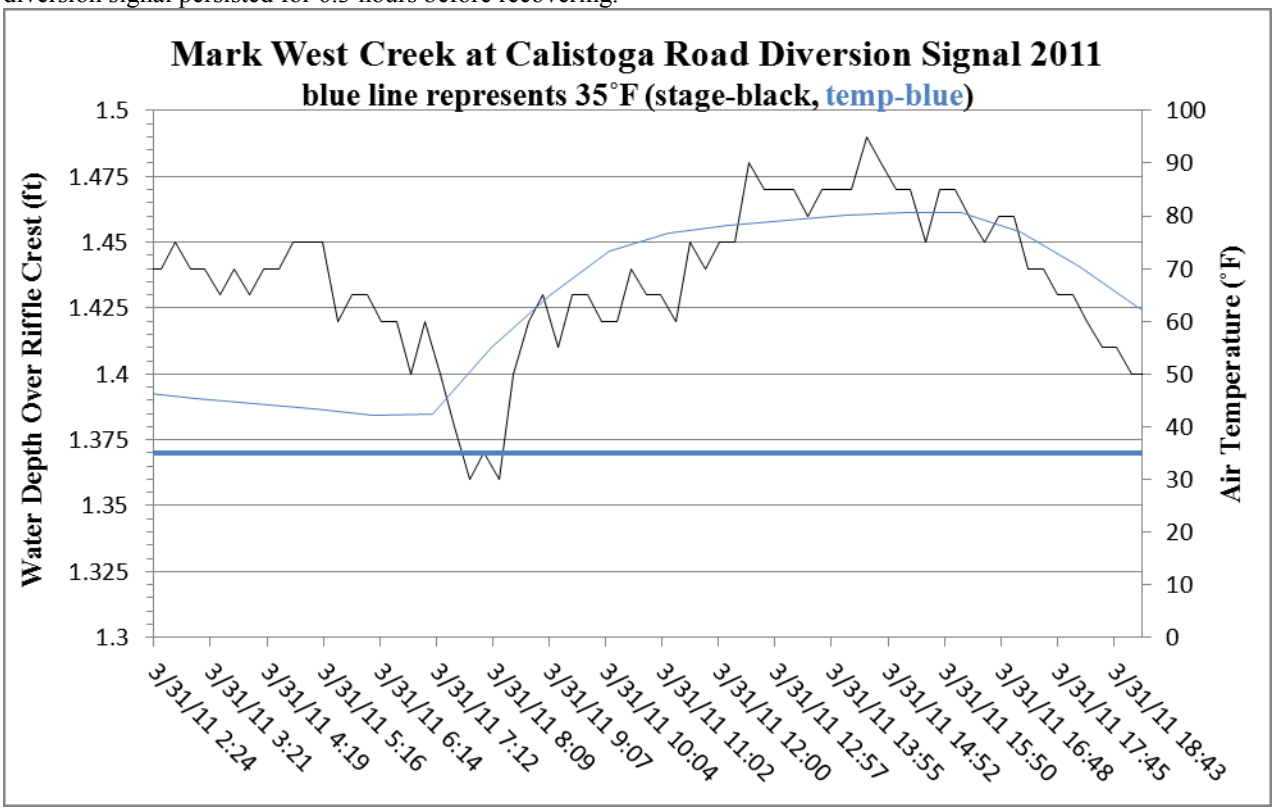


Figure 18. Showing the April 3rd depth reduction of 0.09 feet beginning at 8:01am and ending at 3:16pm. The diversion signal persisted for 7.3 hours before recovering. Depth reductions < 0.09 feet occurred on April 4th and 5th.

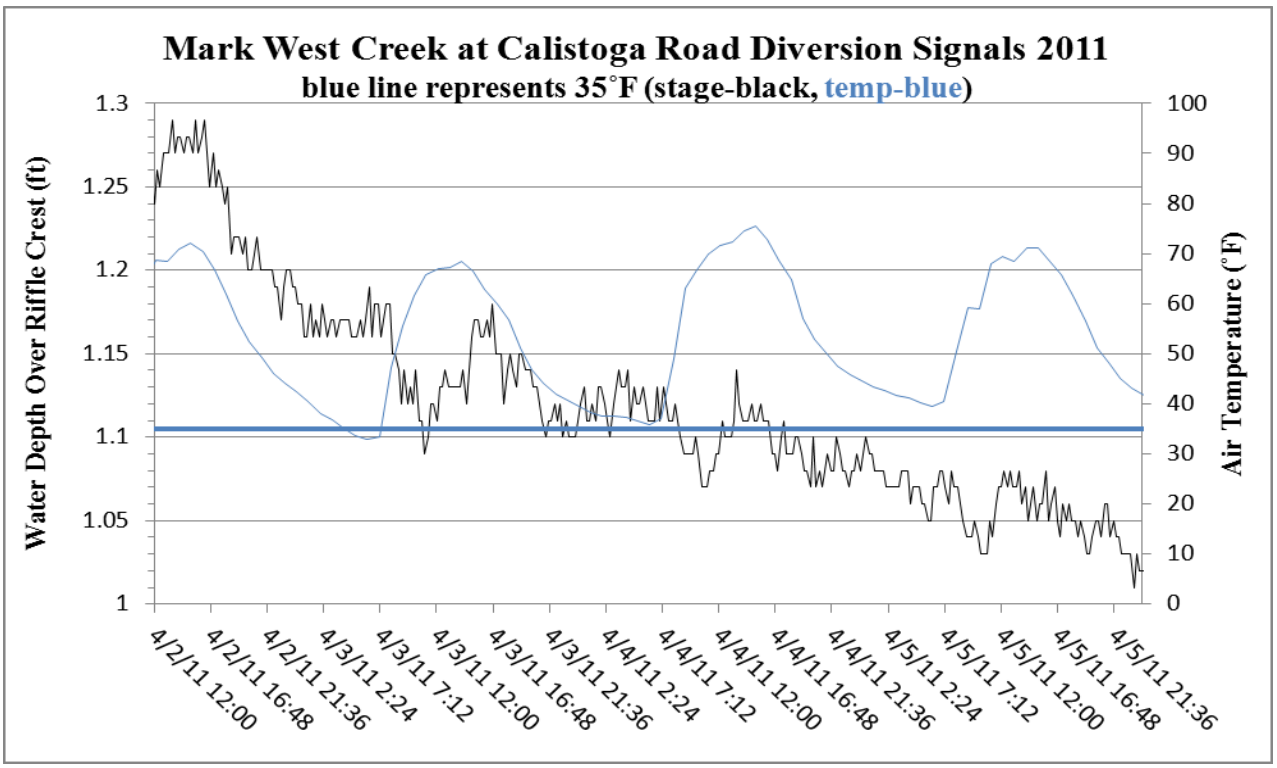


Figure 19. Showing the April 8th depth reduction of 0.09 feet beginning at 7:01am and ending at 9:31am. The diversion signal persisted for 2.5 hours before recovering. Depth reductions < 0.09 feet occurred on April 7th, 9th and 10th.

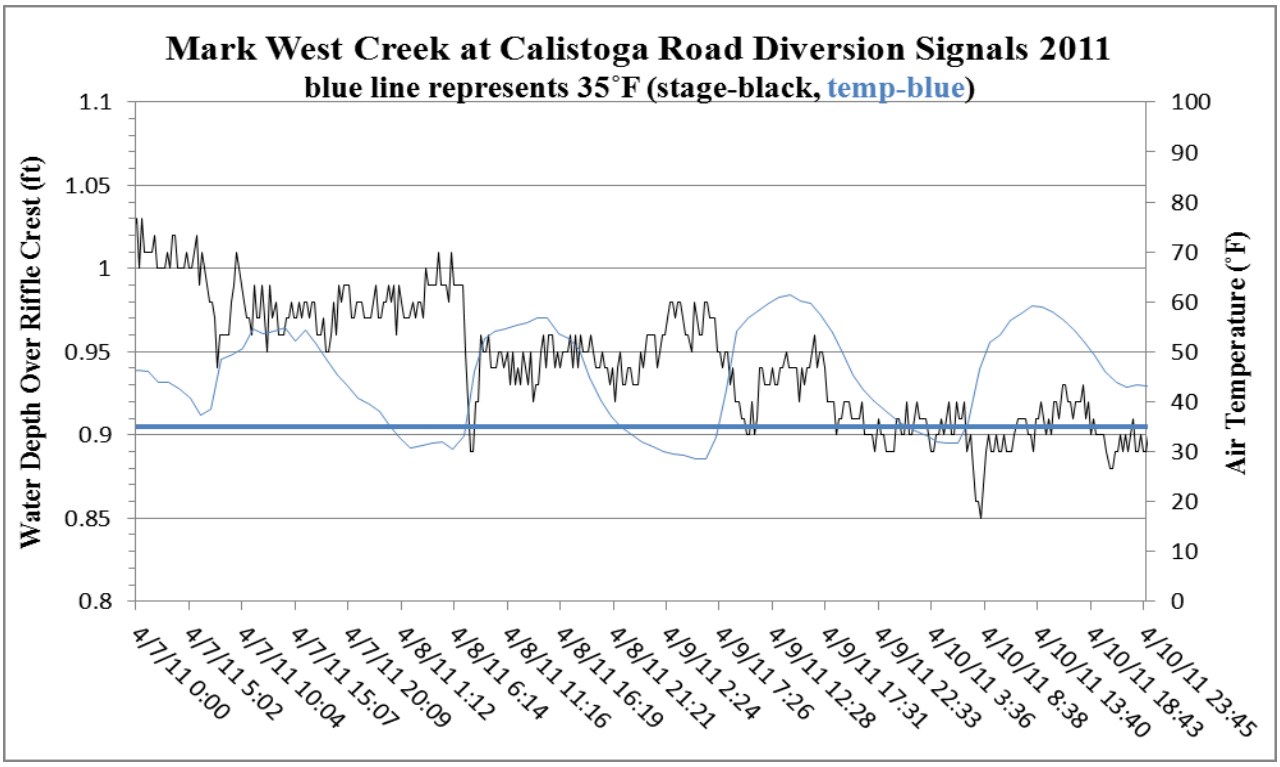


Figure 20. Showing the April 23rd depth reduction of 0.1 feet beginning at 11:31am and ending at 3:16pm. The diversion signal persisted for 3.8 hours before recovering.

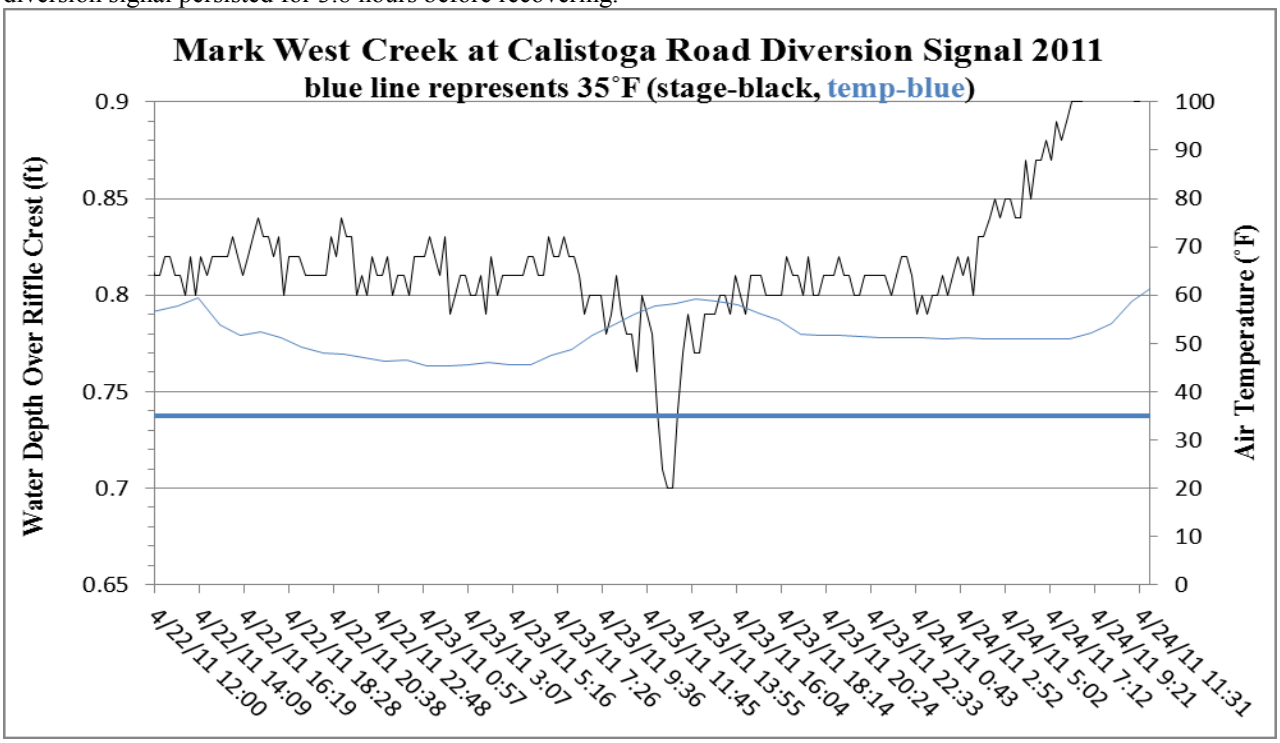
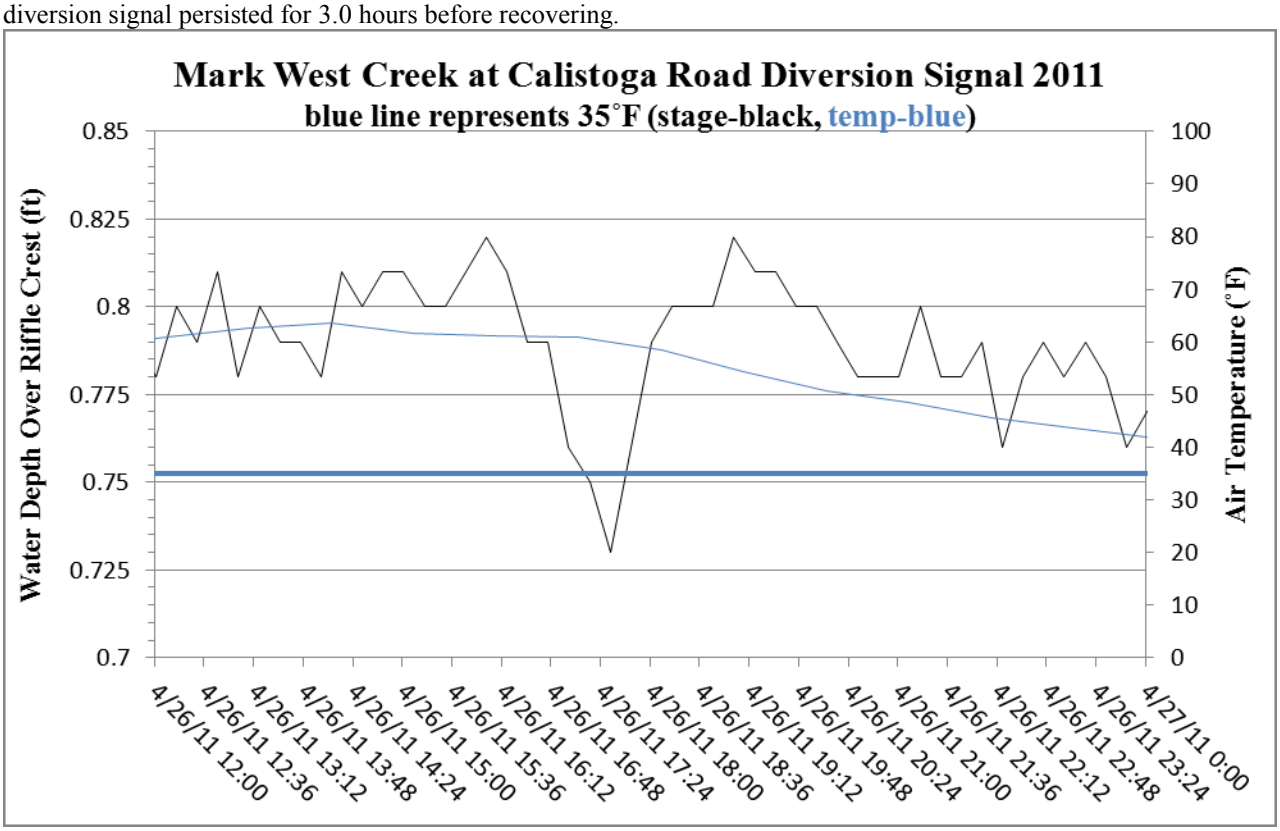


Figure 21. Showing the April 26th depth reduction of 0.09 feet beginning at 4:00pm and ending at 7:00 pm. The diversion signal persisted for 3.0 hours before recovering.



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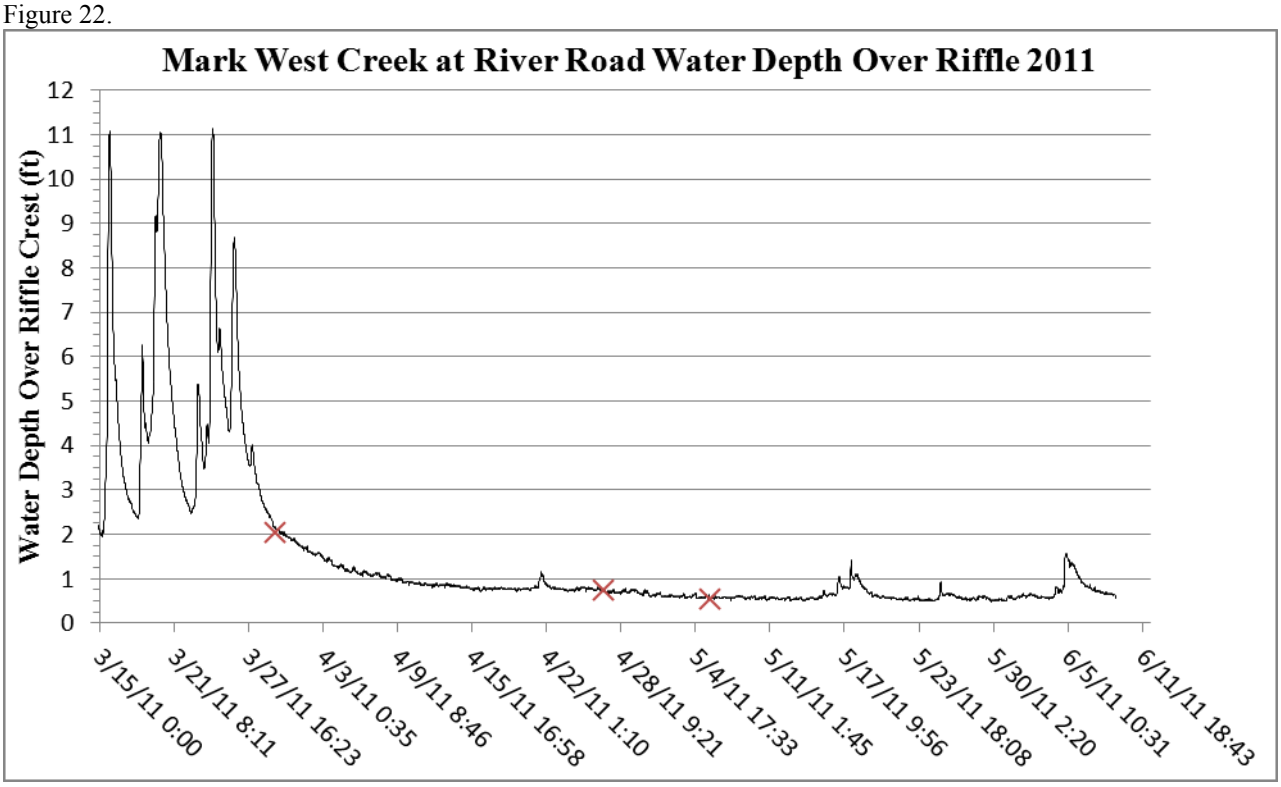

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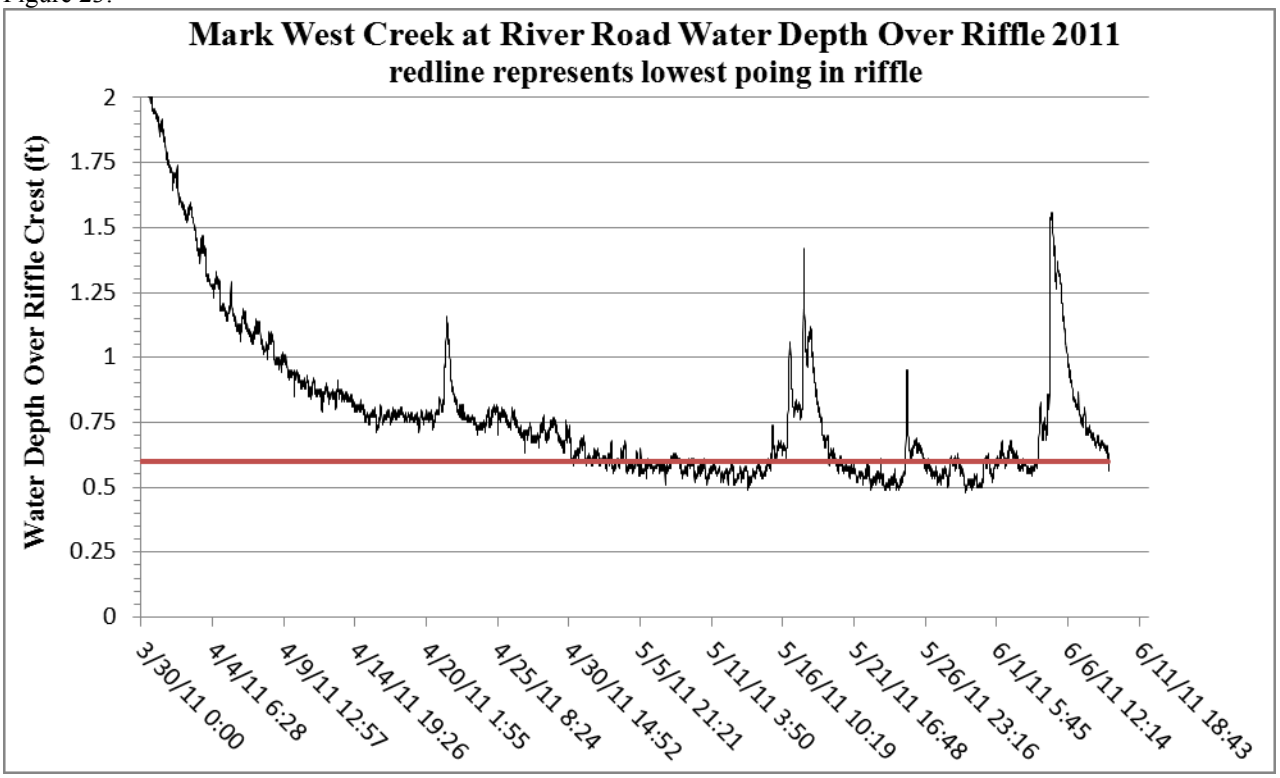

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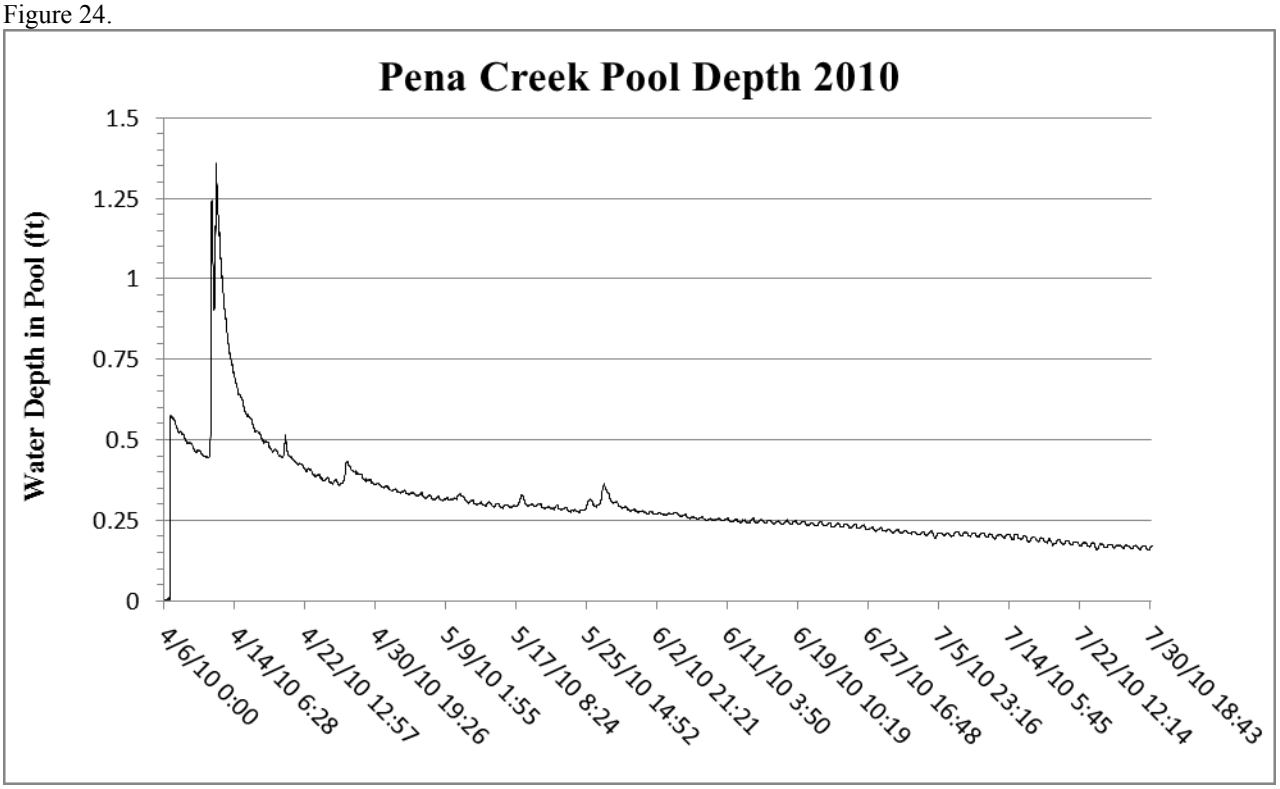

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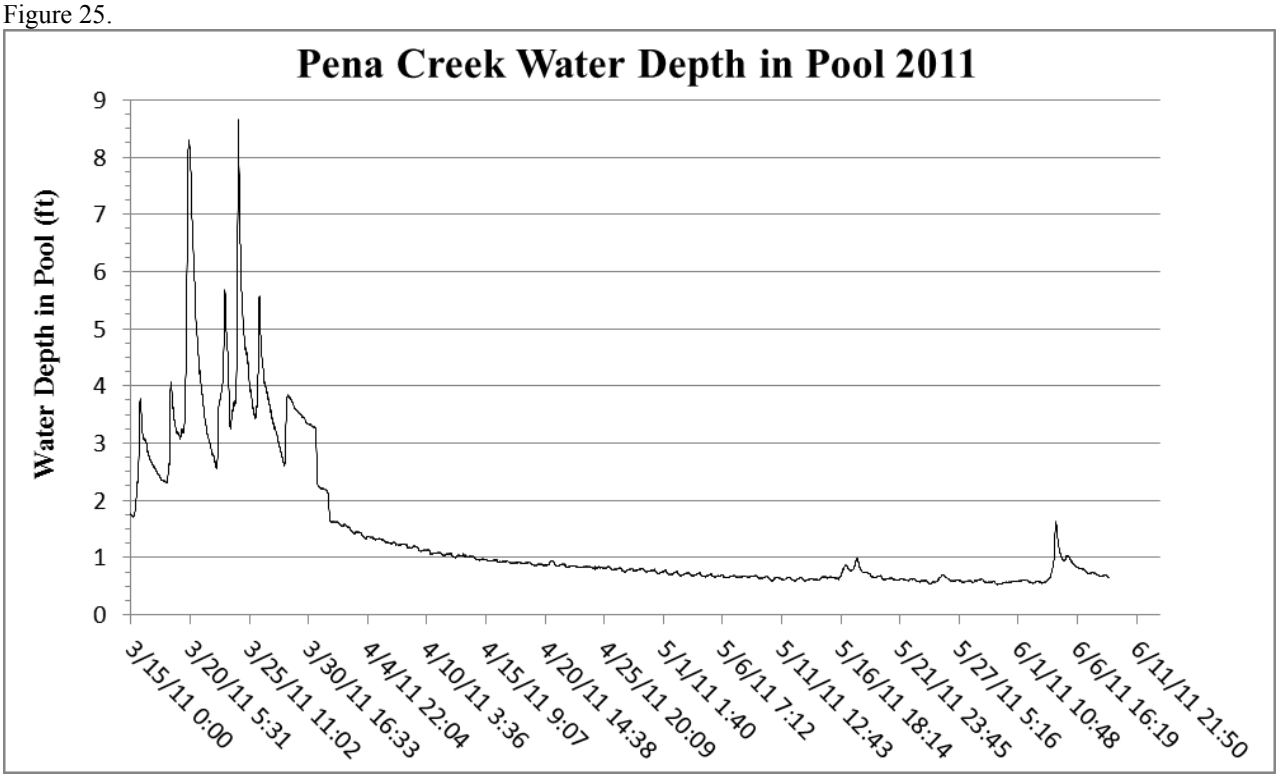

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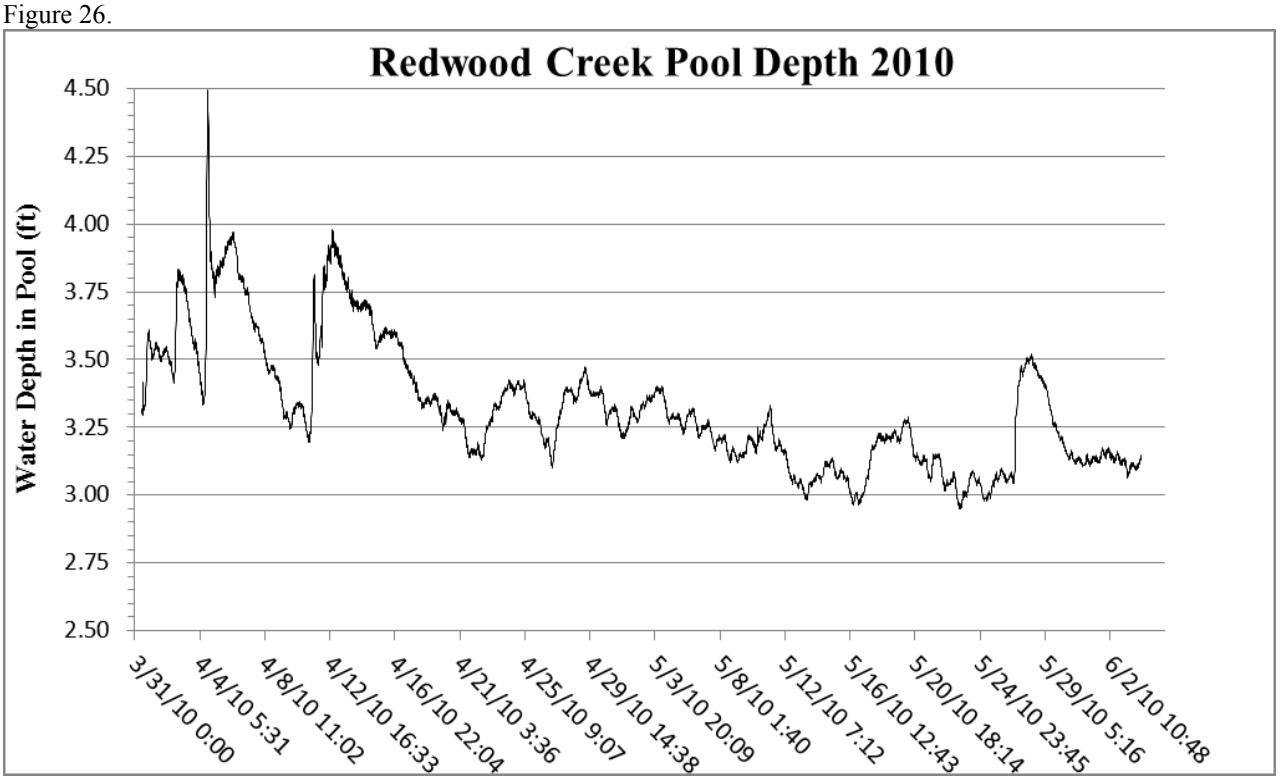

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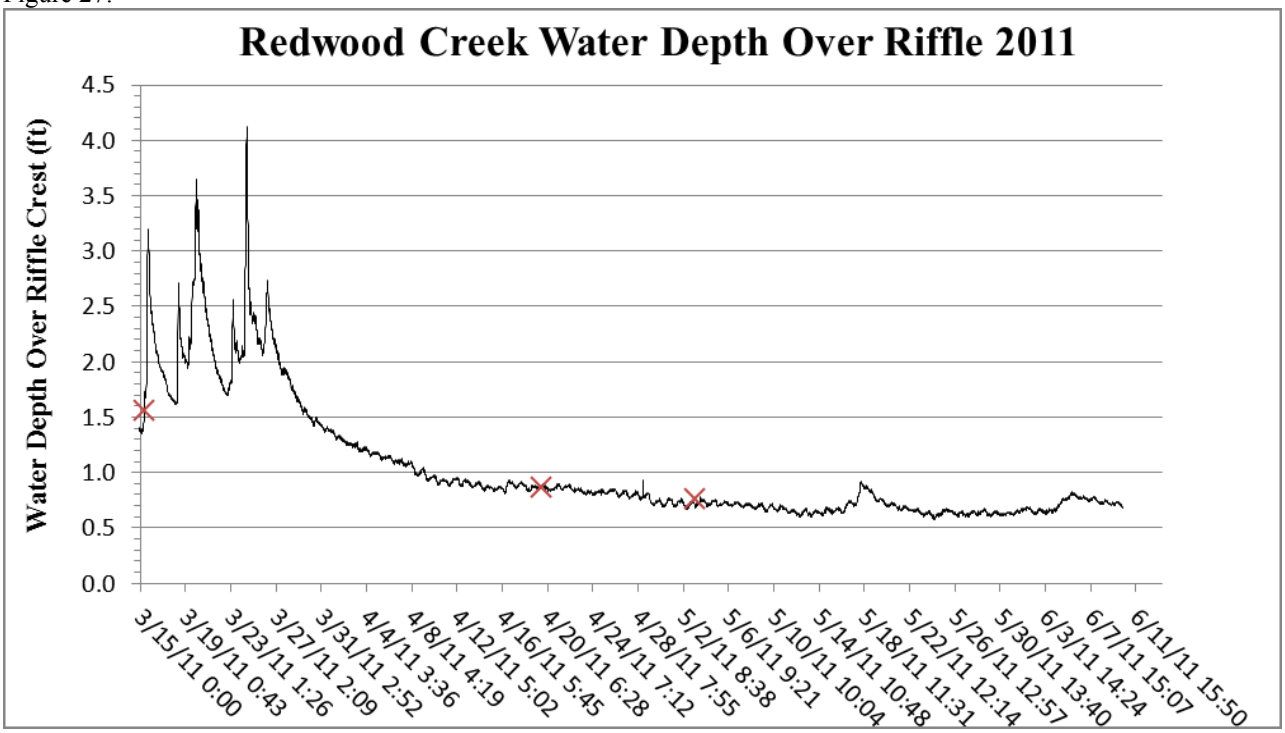

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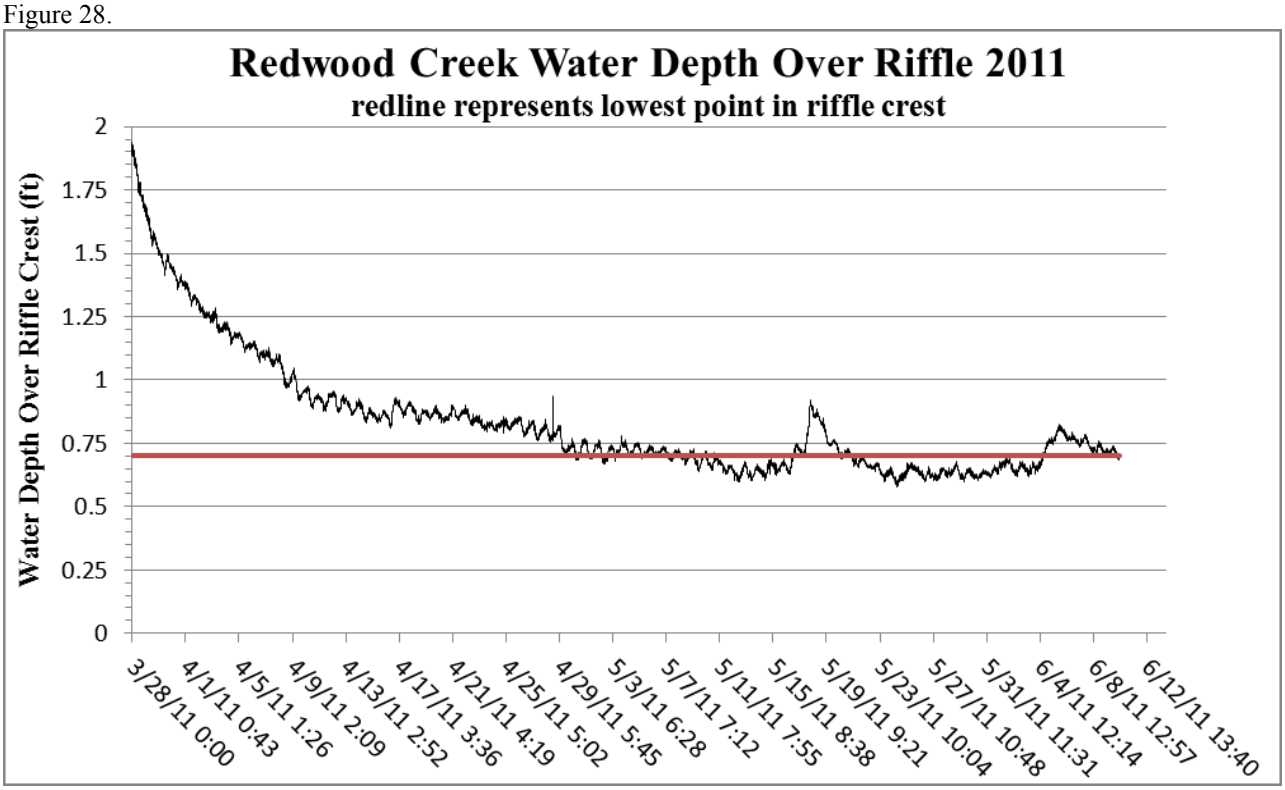

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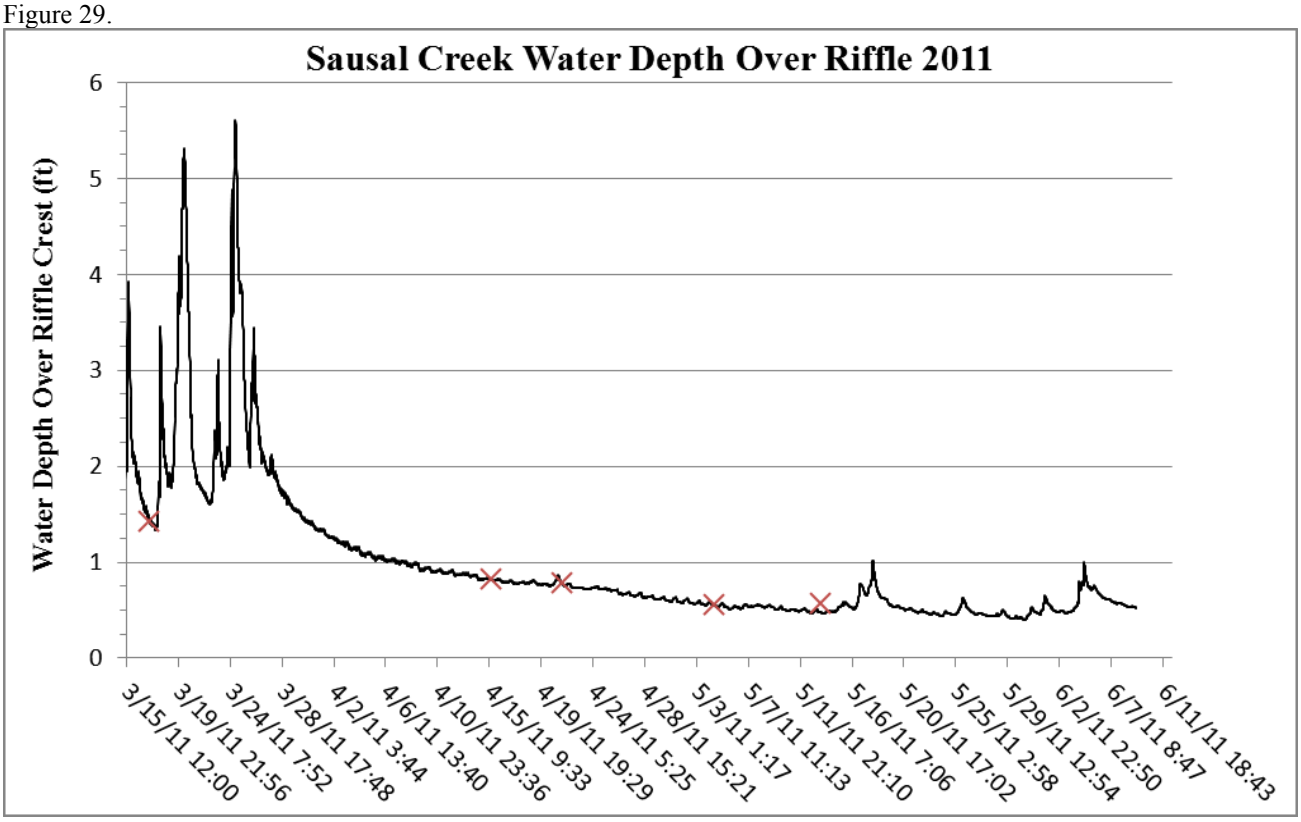

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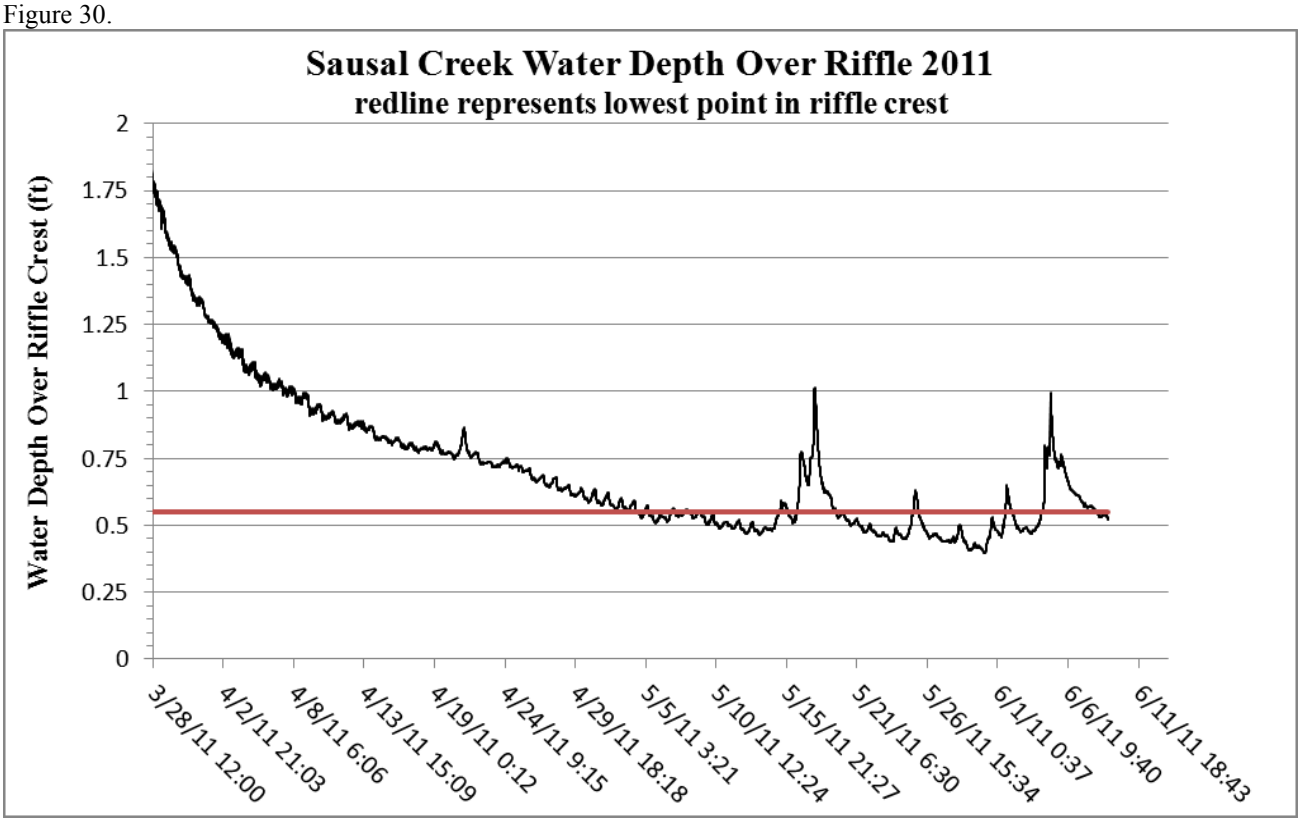
Sausal Creek Water Depth Over Riffle 2011
redline represents lowest point in riffle crest
Water Depth Over Riffle Crest (ft)
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
3/28/11 12:00
4/2/11 21:03
4/8/11 6:06
4/13/11 15:09
4/19/11 0:12
4/24/11 9:15
4/29/11 18:18
5/5/11 3:21
5/10/11 12:24
5/15/11 21:27
5/21/11 6:30
5/26/11 15:34
6/1/11 0:37
6/6/11 9:40
6/11/11 18:43

SWRCB Monitoring Sites

Figure 31. Stream hydrographs for SWRCB stream gauging locations (Figures 31-45). SWRCB data is provisional, though NMFS staff was aware of necessary depth shifts that were made in the data and has made the necessary corrections.

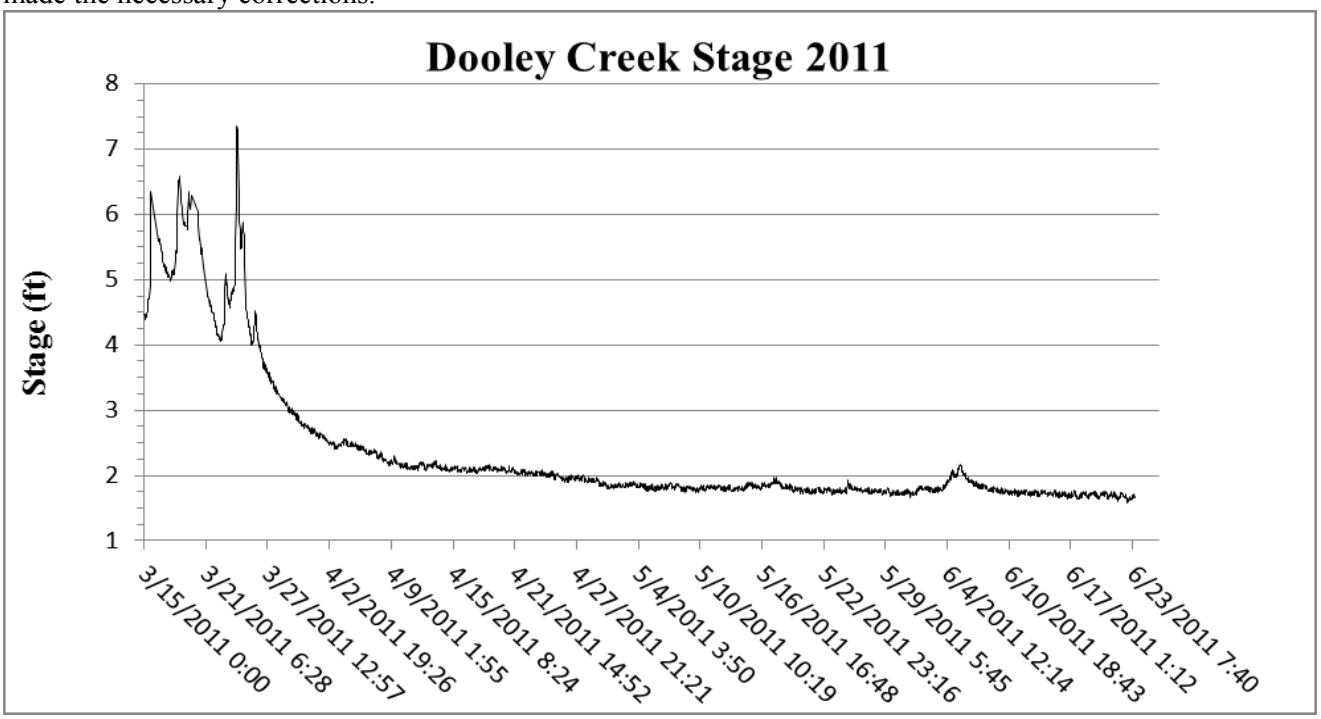

Figure 32.

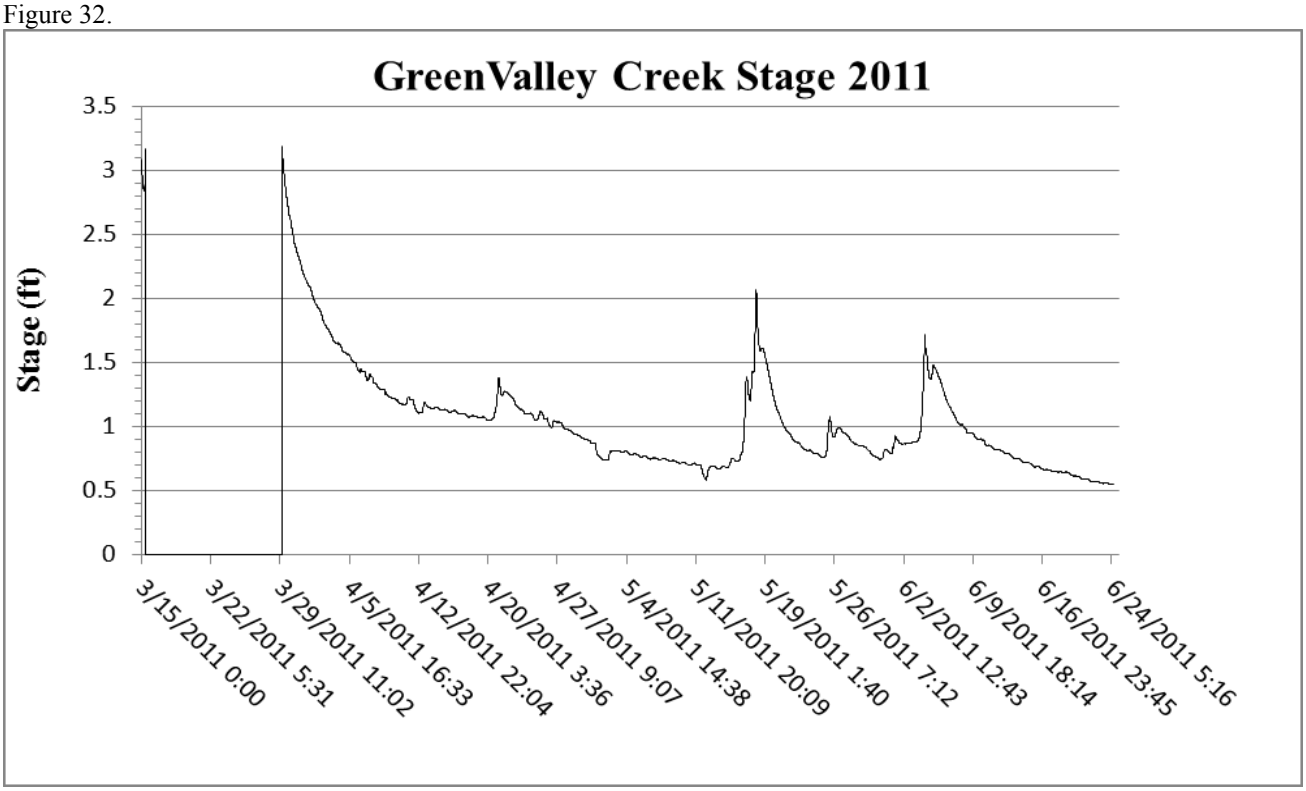

Figure 33. Showing the April 12th depth reduction of 0.10 feet beginning at 9:44am and ending April 13th at 12:22pm. The diversion signal persisted for 26.6 hours before recovering. Depth reductions < 0.09 feet occurred on April 7th & 9th.

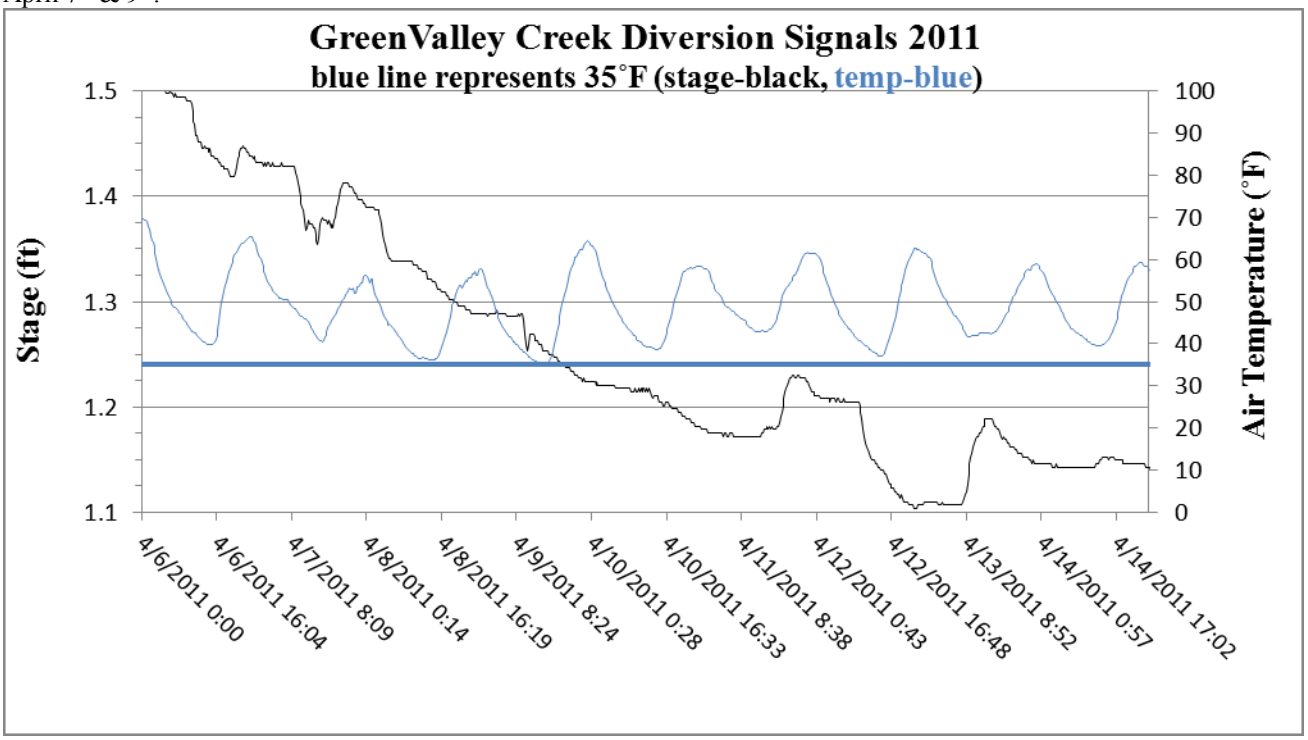

Figure 34. A depth reduction < 0.09 feet occurred on April 26th.

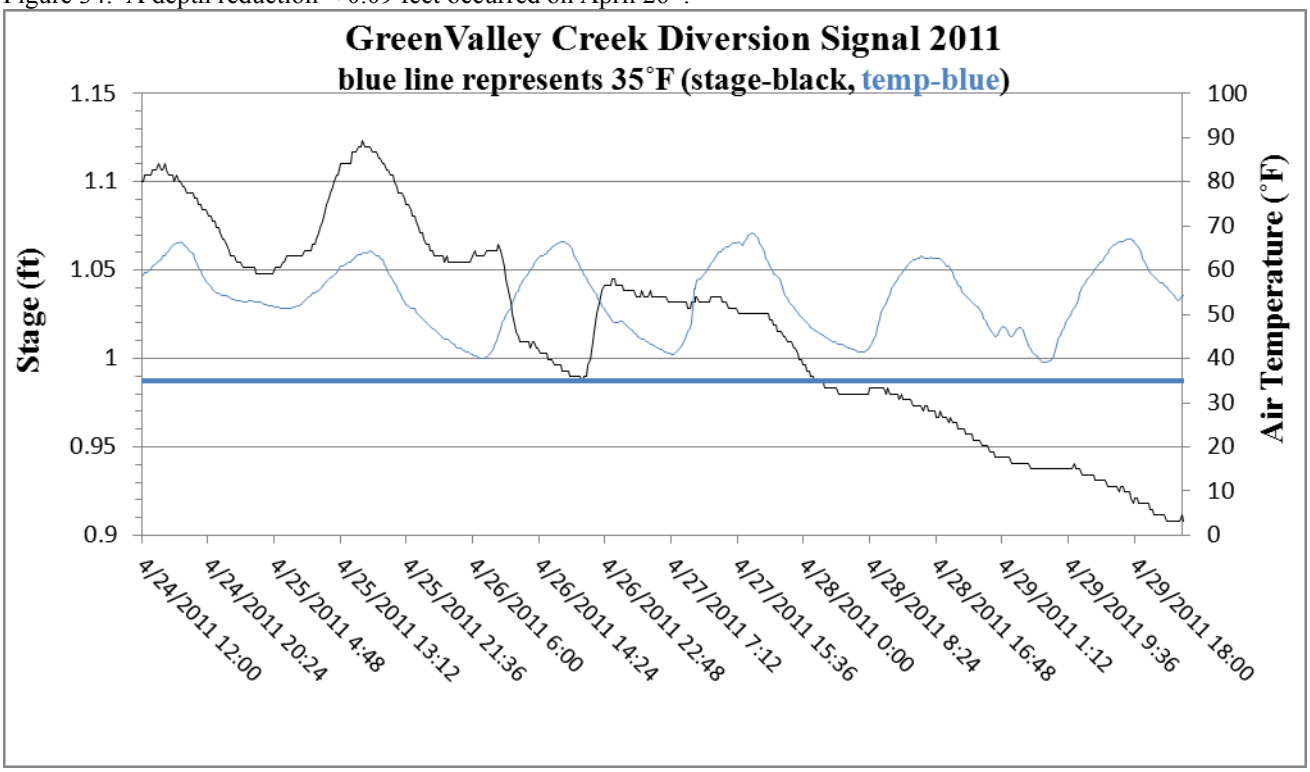

Figure 35. Showing the May 1st depth reduction of 0.13 feet beginning at 8:24am and ending May 2nd at 8:31pm. The diversion signal persisted for 36.1 hours before recovering. Depth recovery was the lowest of all sites at 85.5%.

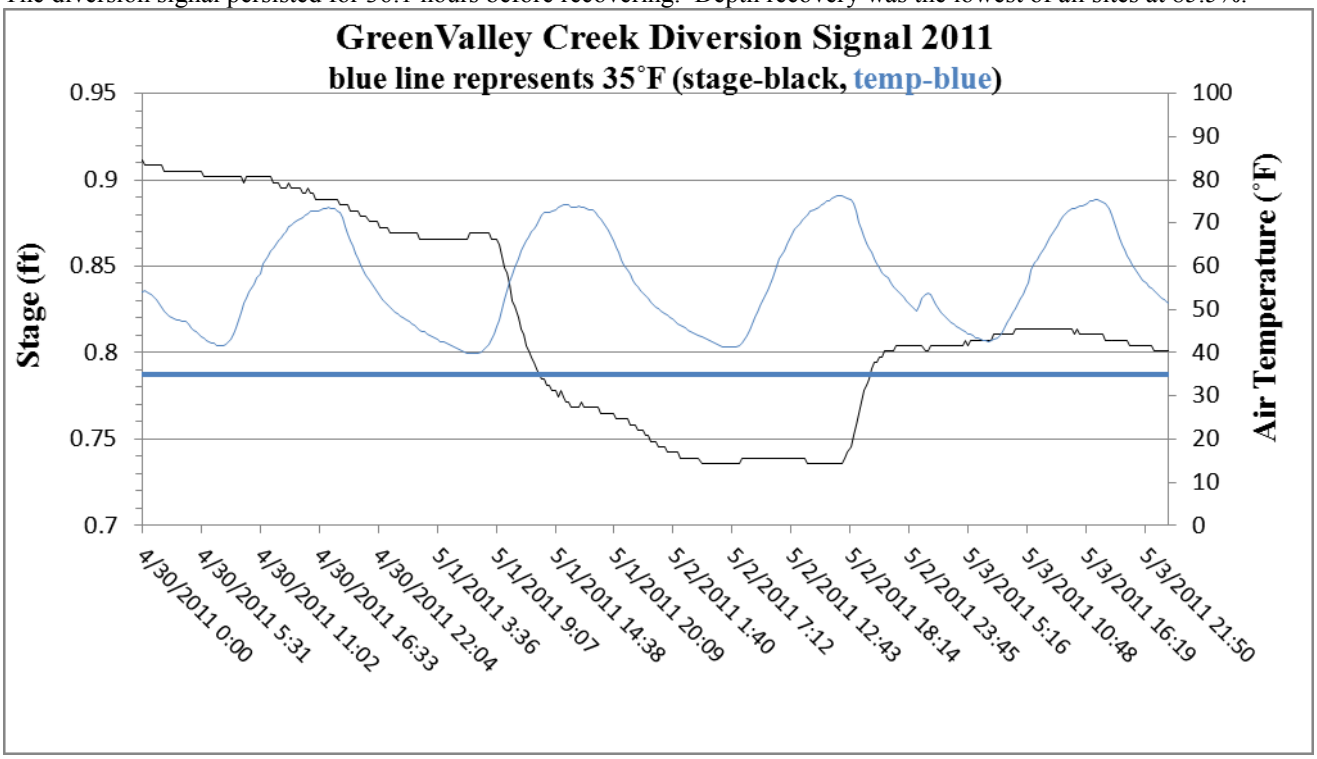

Figure 36. Showing the May 12th depth reduction of 0.12 feet beginning at 9:09am and ending May 13th at 11:30am. The diversion signal persisted for 26.4 hours before recovering.

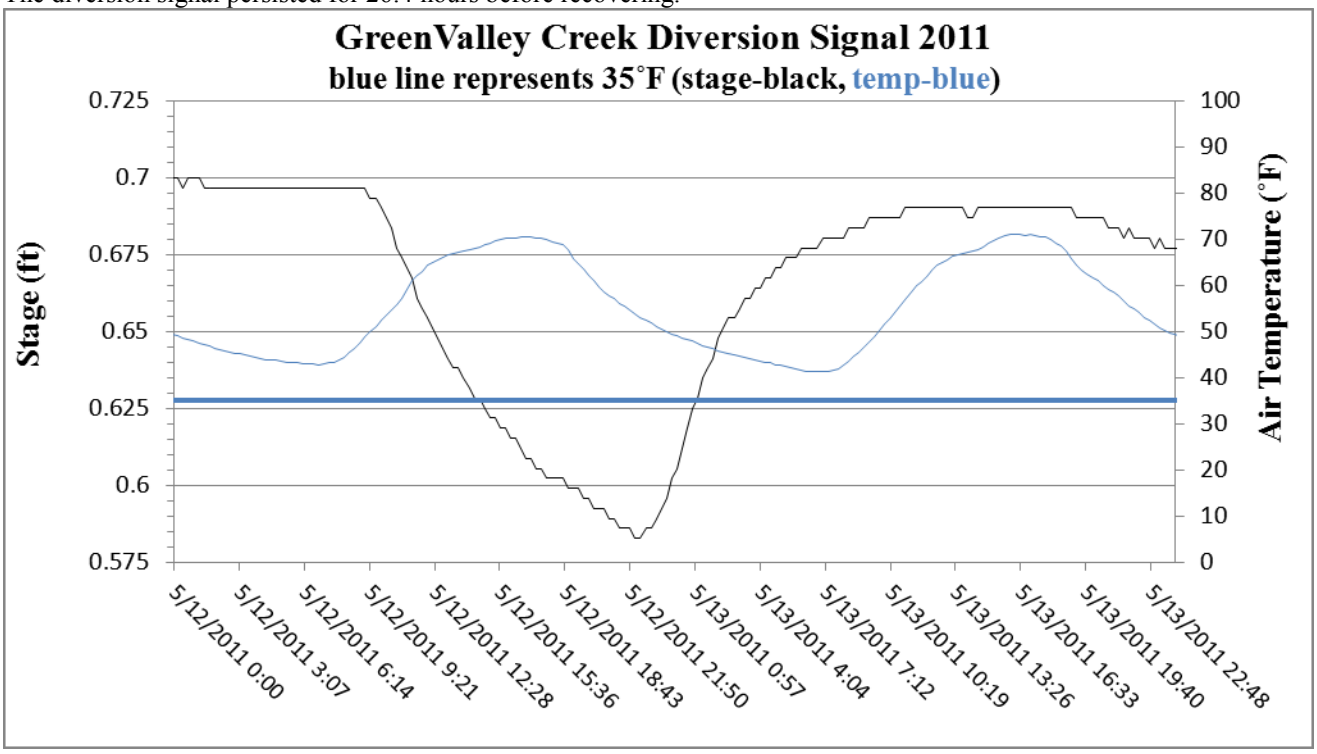

Figure 37.

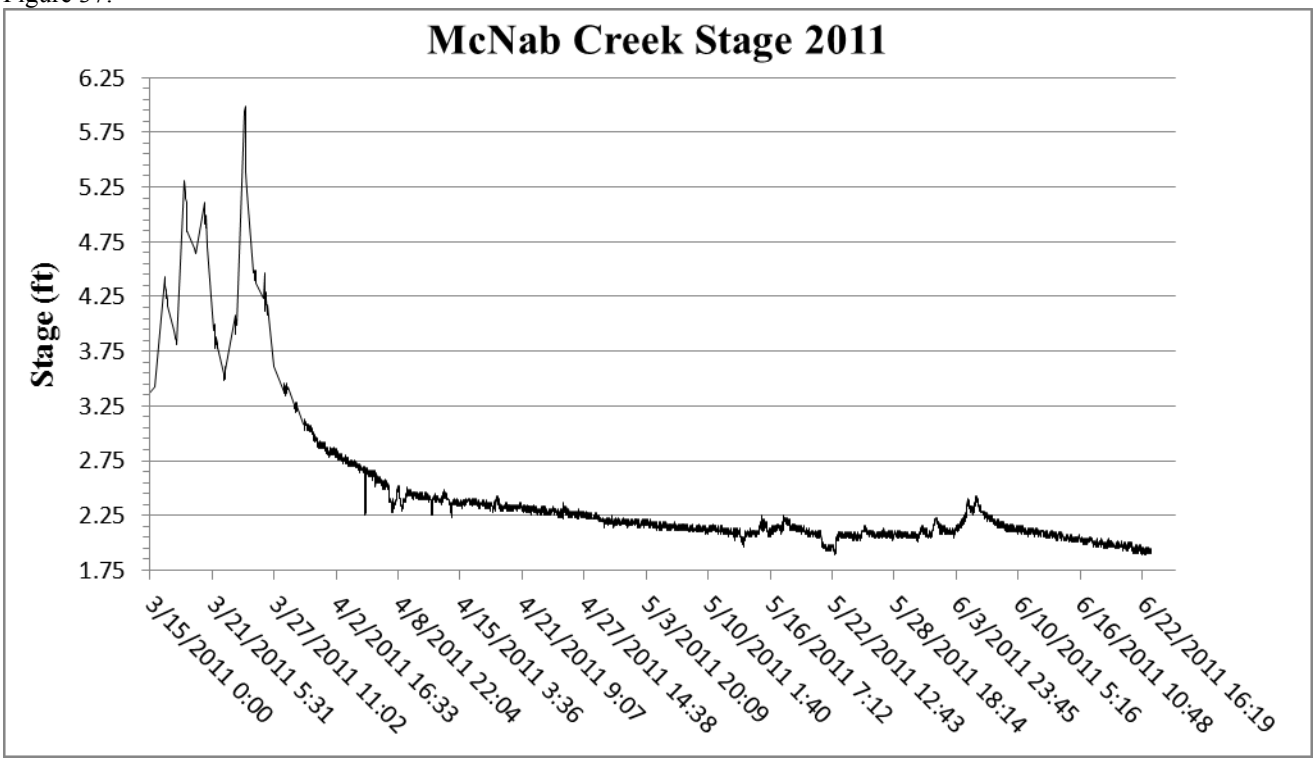

Figure 38. Showing the April 5th depth reduction of 0.43 feet beginning at 2:01pm and ending that evening at 5:31pm. The diversion signal persisted for 3.5 hours before recovering.

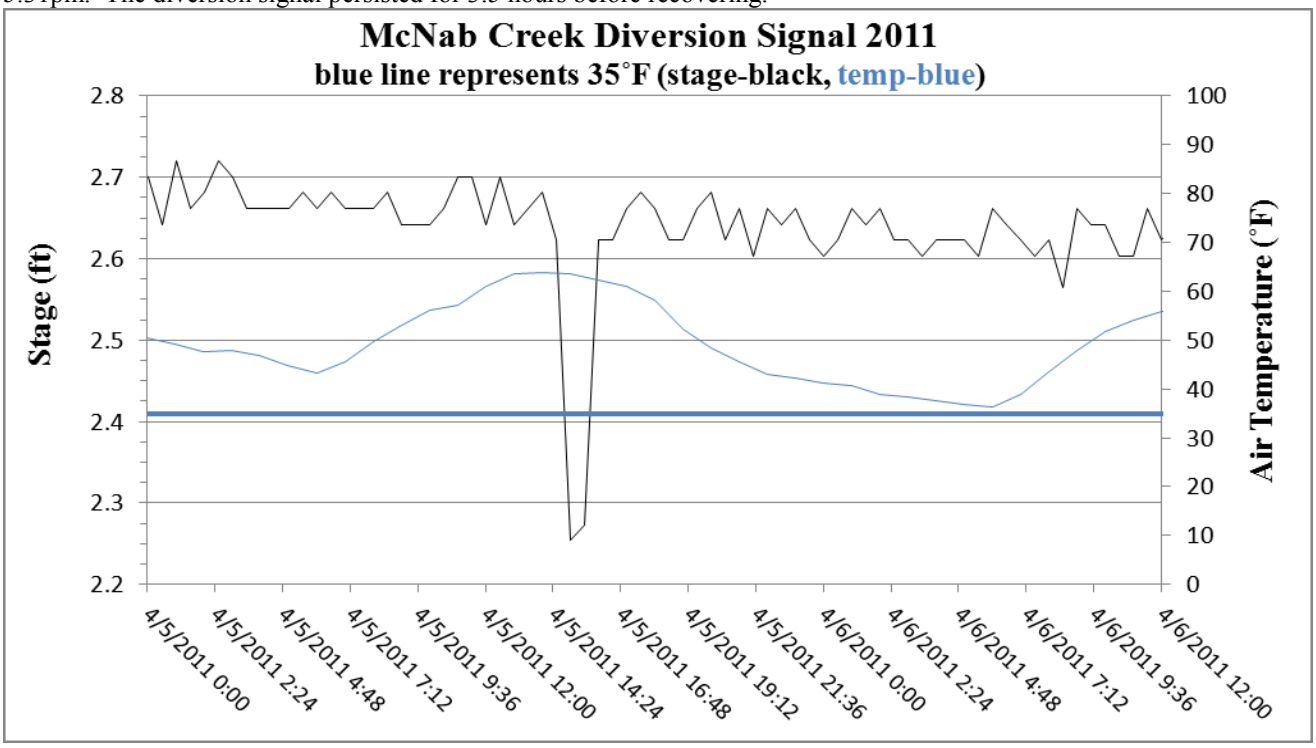

Figure 39. Showing the April 7th depth reduction of 0.28 feet beginning at 10:30pm and ending on April 8th at 8:30 pm. The diversion signal persisted for 22.0 hours before recovering. Three hours later at 11:30pm depth dropped again by 0.24 feet before recovering on April 9th at 7:30pm, a duration of 20.0 hours. Another depth reduction on April 12th reduced depth by 0.18 feet before recovering at 11:00am, a duration of 7.5 hours.

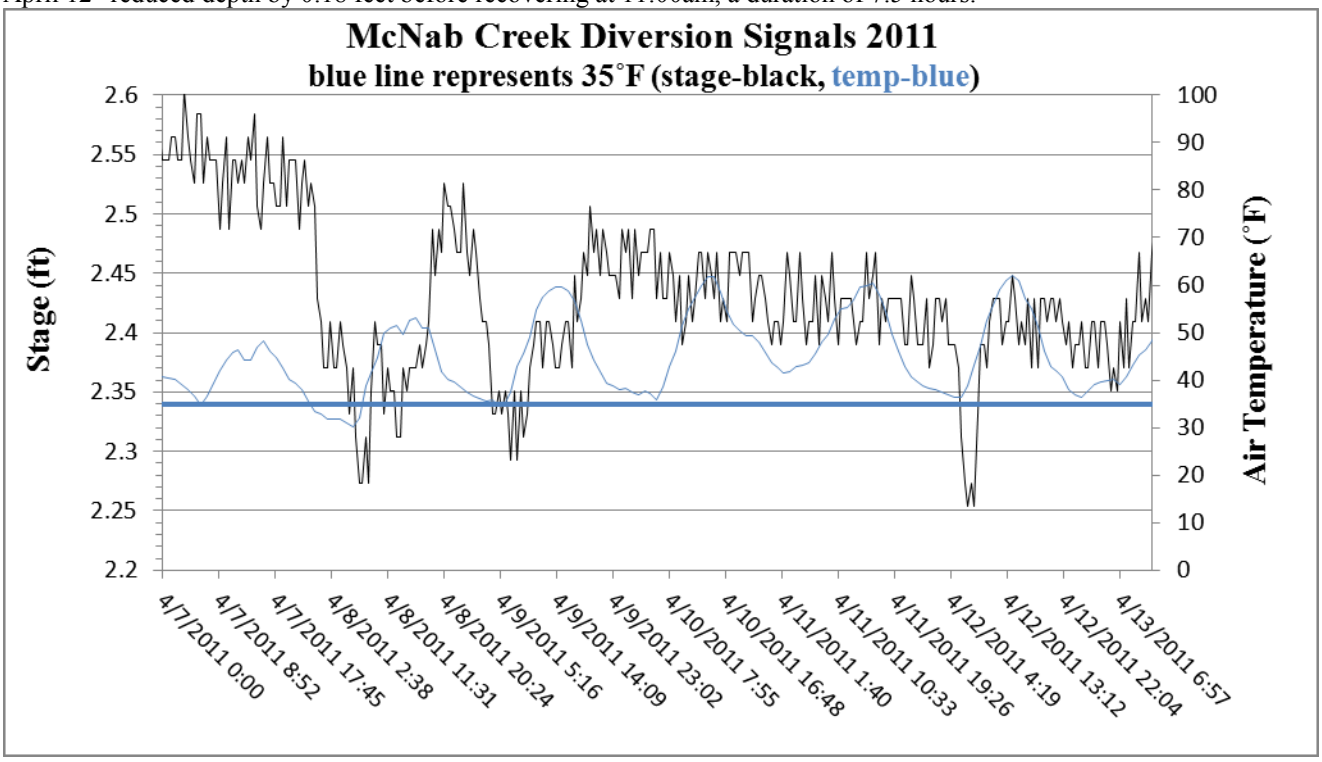

Figure 40. Showing the April 14th depth reduction of 0.14 feet beginning at 3:00am and ending that same morning at 9:00am. The diversion signal persisted for 5.5 hours before recovering.

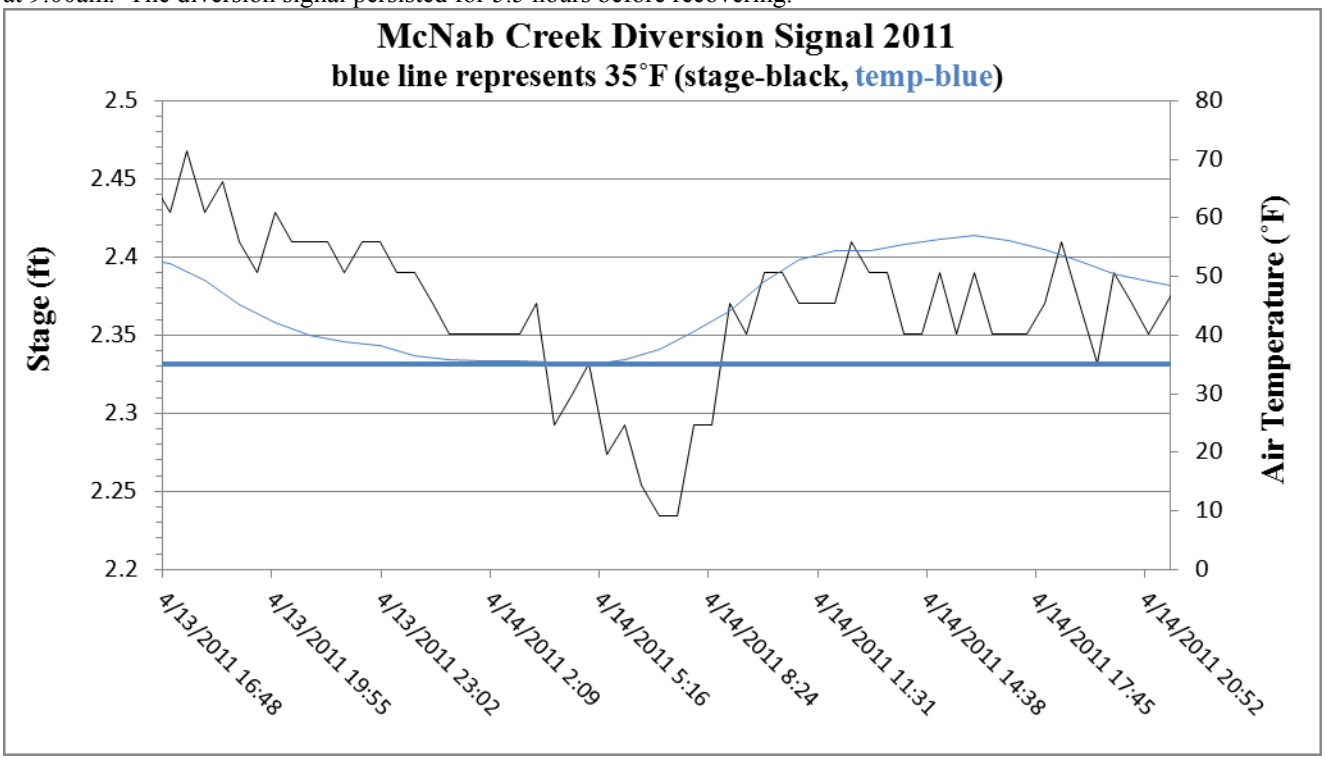

Figure 41. Showing the May 13th depth reduction of 0.16 feet beginning at 5:30am and ending that evening at 7:30pm. The diversion signal persisted for 14.0 hours before recovering.

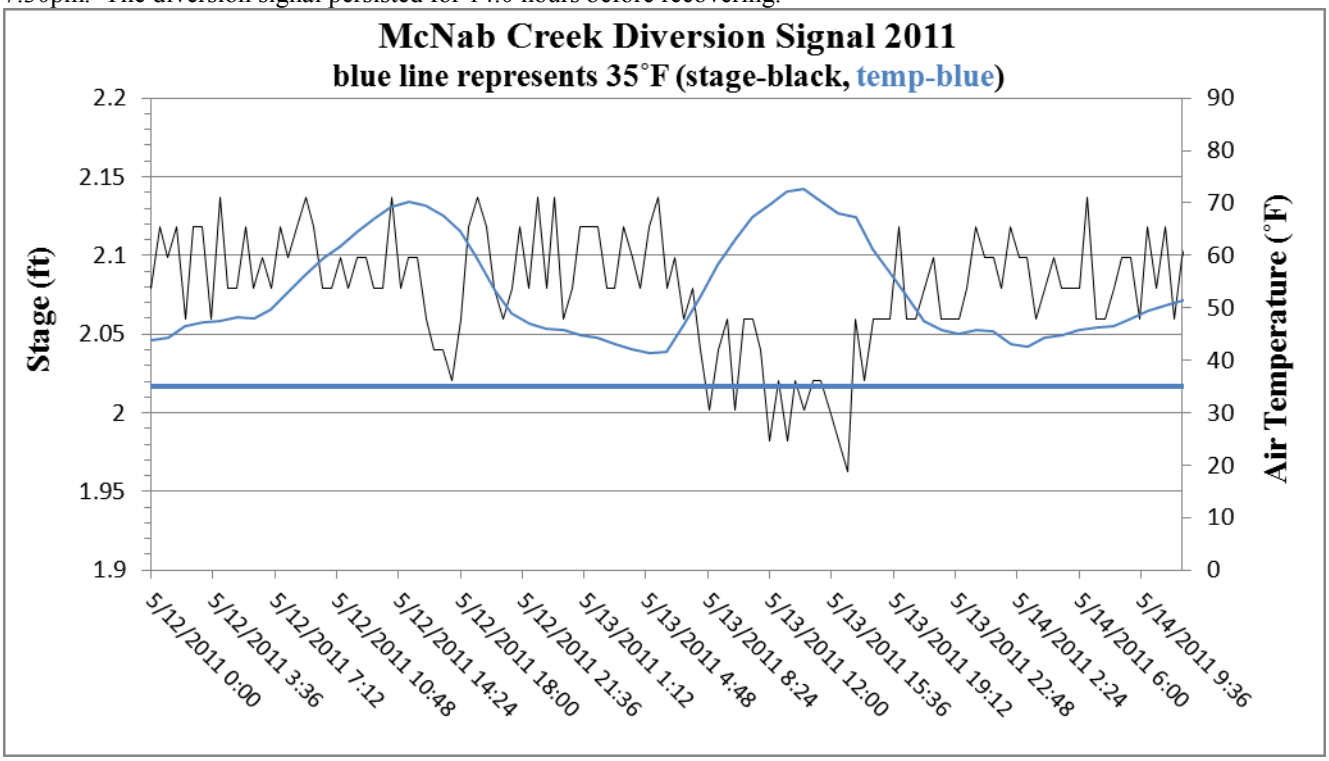

Figure 42. Showing the May21st depth reduction of 0.23 feet beginning at 7:30am and ending on May 23rd at 12:00am. The diversion signal persisted for 40.5 hours before recovering.

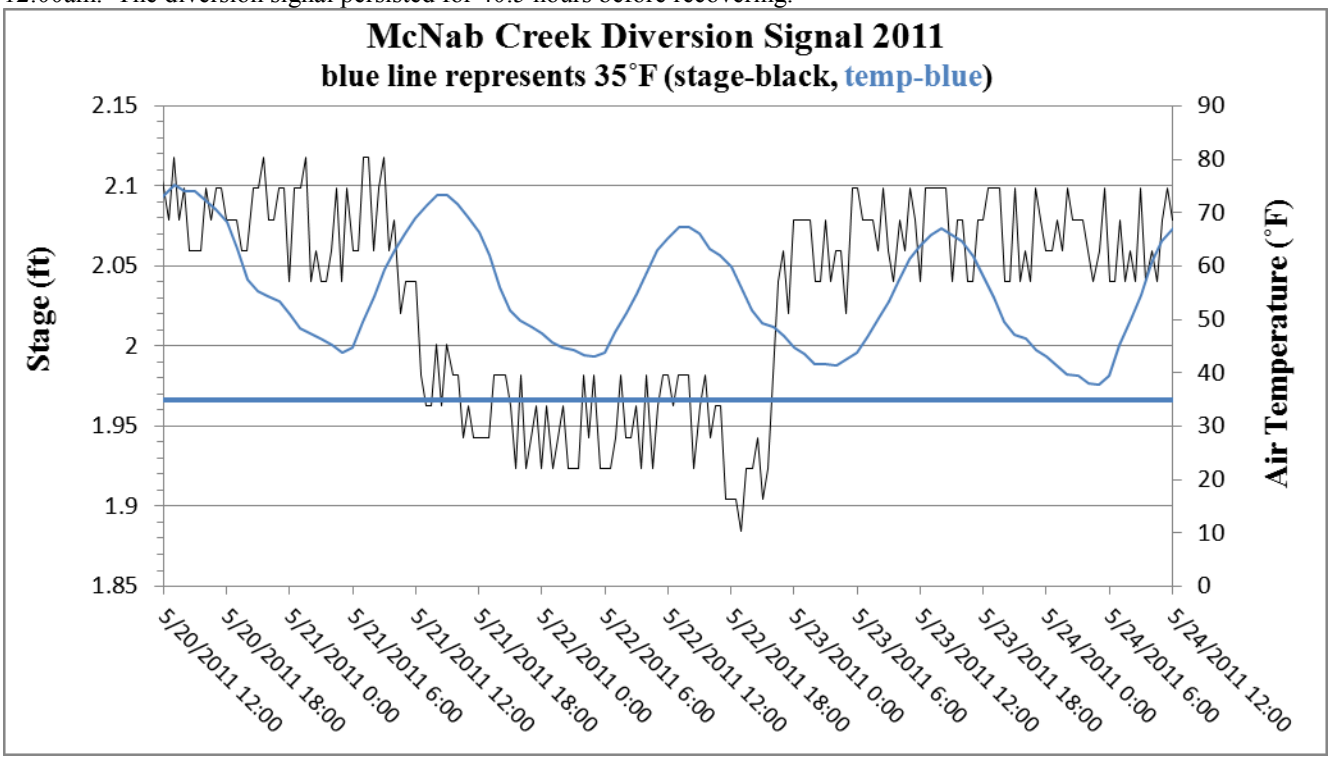

Figure 43.

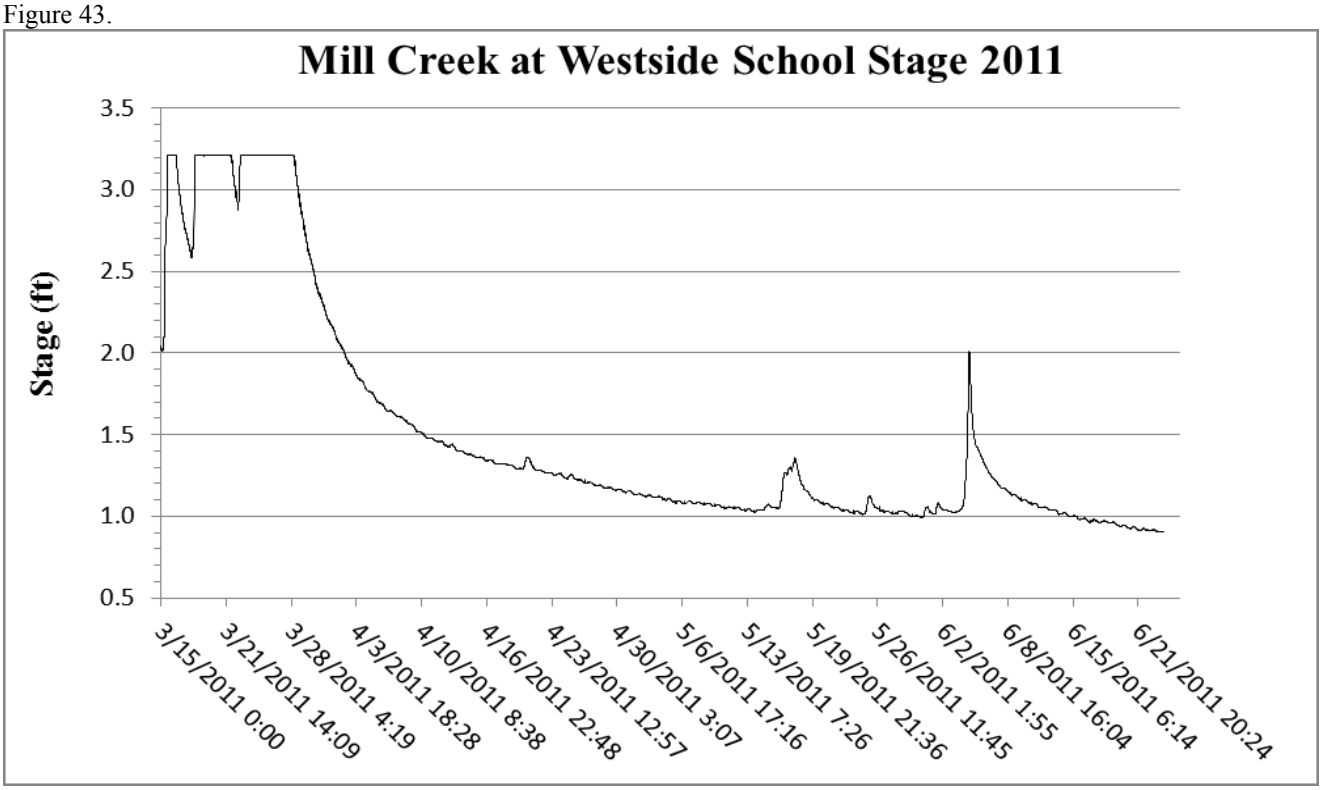

Figure 44.

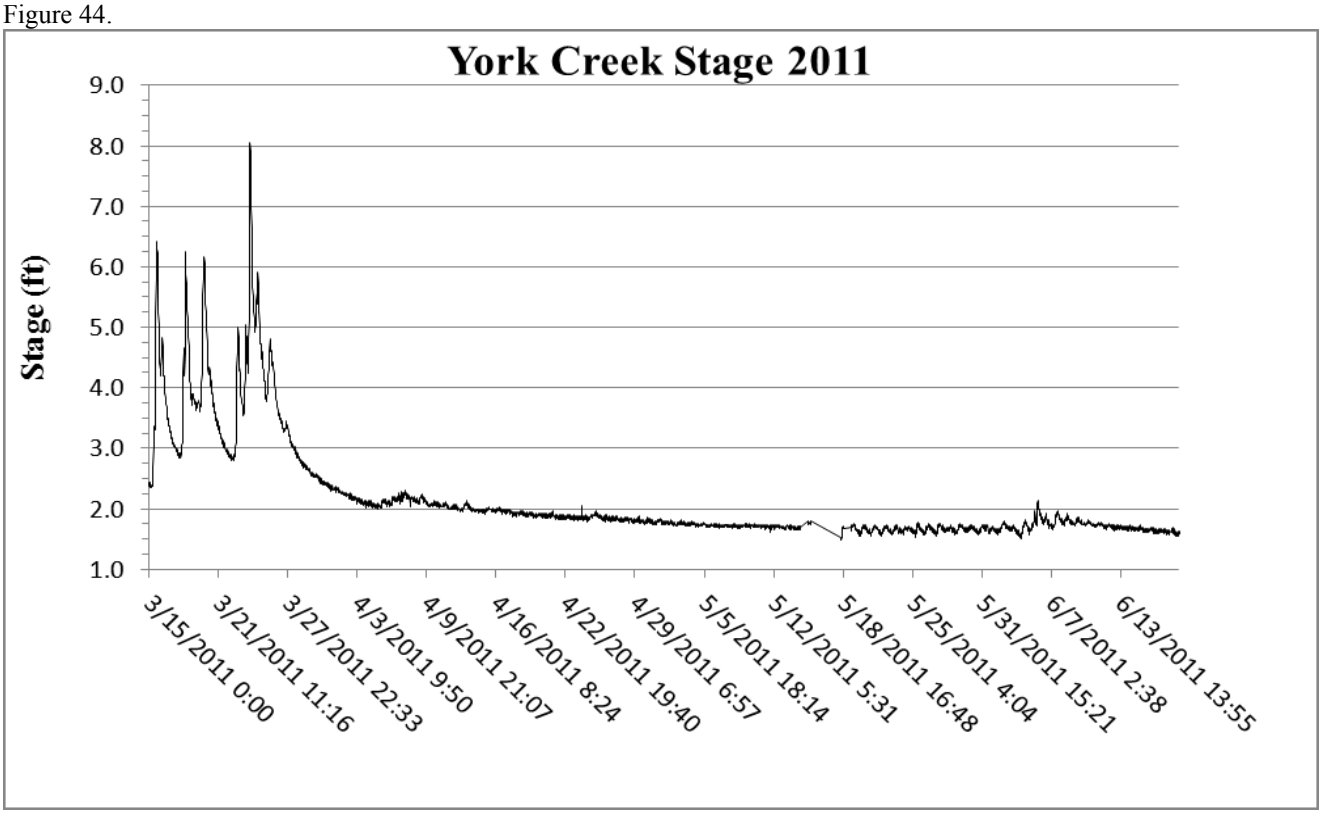
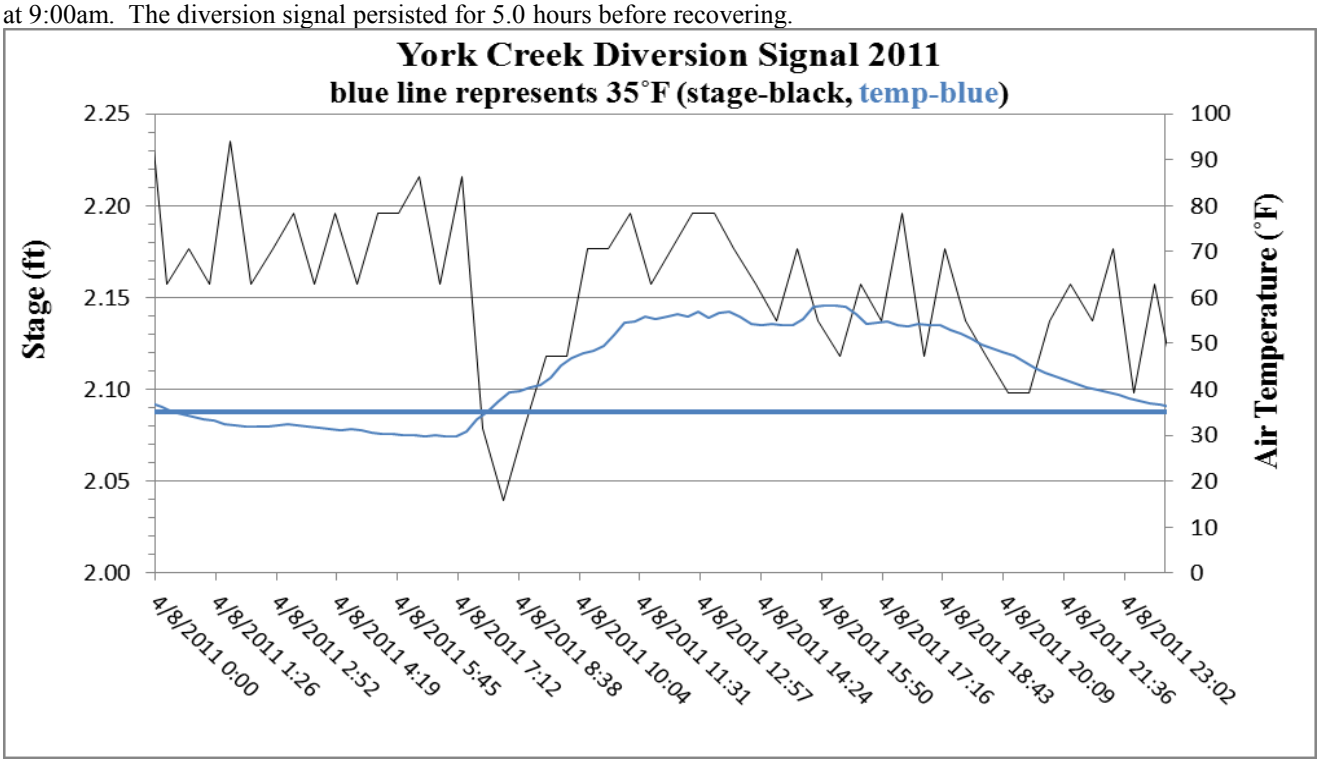
Figure 45. Showing the April 29th depth reduction of 0.10 feet beginning at 4:00am and ending that same morning at 9:00am. The diversion signal persisted for 5.0 hours before recovering.