UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 9
75 Hawthorne Street
San Francisco, CA 94105

Environmental Assessment for the Town of Patagonia Wastewater Treatment and Collection Facilities

Patagonia, Arizona

October, 1999

Table of Contents

Executive Summary 1

I. Purpose and Need 2

II. Present Facilities 2

III. Alternatives 6

IV. Present Environment 7

V. Environmental Inventory 9
- A. Wetlands 9
- B. Ground Water 9
- C. Floodplains 9
- D. Important/Significant Agricultural Lands 10
- E. Vegetation 10
- F. Wildlife 10
- G. Endangered Species 11
- H. Historic, Prehistoric, Architectural, Archaeological, and Cultural Sites 11
- I. Aesthetic Resources 12
- J. Hazardous and Solid Waste 12
- K. Receiving Water Quality 12
- L. Air Quality/Odors 14
- M. Socioeconomic 14
- N. Environmental Justice 15

VI. Impact Evaluation 16
- A. Wetlands 16
- B. Groundwater 16
- C. Floodplains 16
- D. Air Quality/Odors 17
- E. Important Vegetation Types 17
- F. Wildlife/Endangered Species 17
- G. Solid Waste 18
- H. Receiving Water 18
- I. Historic, Prehistoric, Architectural, Archaeological, and Cultural Sites 19
- J. Aesthetic Resources 19
- K. Socioeconomic 19
- L. Utilities 19
- M. Noise 19

Table of Contents (cont.)

N. Environmental Justice 19

VII. Cumulative Impacts 20

VIII. Summary of Impacts and Mitigation for the Proposed Alternative 20

IX. References 22

Appendix 25

Executive Summary

The Town of Patagonia proposes to upgrade their existing wastewater treatment facilities and rehabilitate their collection system. While several sub-alternatives were considered, three main alternatives are presented in this assessment: A) No-Project, B) Treatment Plant Upgrade and Expansion at the Existing Site, C) Treatment Plant Improvements Plus Constructed Wetlands. Alternatives B and C also include rehabilitation of the existing collection system. Patagonia chose Alternative B.

Alternative B includes an oxidation ditch on the site of the current treatment facilities plus rehabilitation and/or replacement of deteriorated sections of approximately 5,500 linear feet [lf] out of 21,000 lf of existing collection lines using either open trench replacement or in situ repair. The treatment plant would be sized large enough to ensure that the Town could consistently meet permit limits and upgraded to accommodate upcoming nitrogen removal requirements.

The proposal would have positive impacts on both groundwater and surface water quality.

I. Purpose and Need

The following measures are proposed improvements to the Town of Patagonia's existing wastewater collection and treatment system:

- Upgrade of the wastewater treatment facilities to improve treatment reliability and ease of operation and to allow for nitrogen removal. Improvements would also be made to the existing sludge management process.

- Expansion of the wastewater treatment facilities to accommodate current flows and anticipated future flows.

- Rehabilitation and/or replacement of deteriorated sections of the wastewater collection system (approximately 5,500 linear feet [lf] out of 21,000 lf of existing collection lines) using either open trench replacement or in situ repair.

The above improvements will help the town meet existing and upcoming discharge permit limits (including EPA's National Pollutant Discharge Elimination System [NPDES] and Arizona's Aquifer Protection permit [APP]). The proposed treatment plant upgrade and expansion are necessary to accommodate current and future wastewater flows and remove nitrogen. The improvements to the collection system are necessary to minimize sewage losses and to reduce infiltration and inflow (I/I - groundwater and stormwater flows that are inadvertently collected and conveyed to the treatment plant).

The proposed treatment plant will discharge treated effluent to Sonoita Creek at the same location as the existing facilities. Sludge will be dried on-site and hauled to a landfill for final disposal. In the future, sludge may be further conditioned and used for land application (Pentacore May 1999).

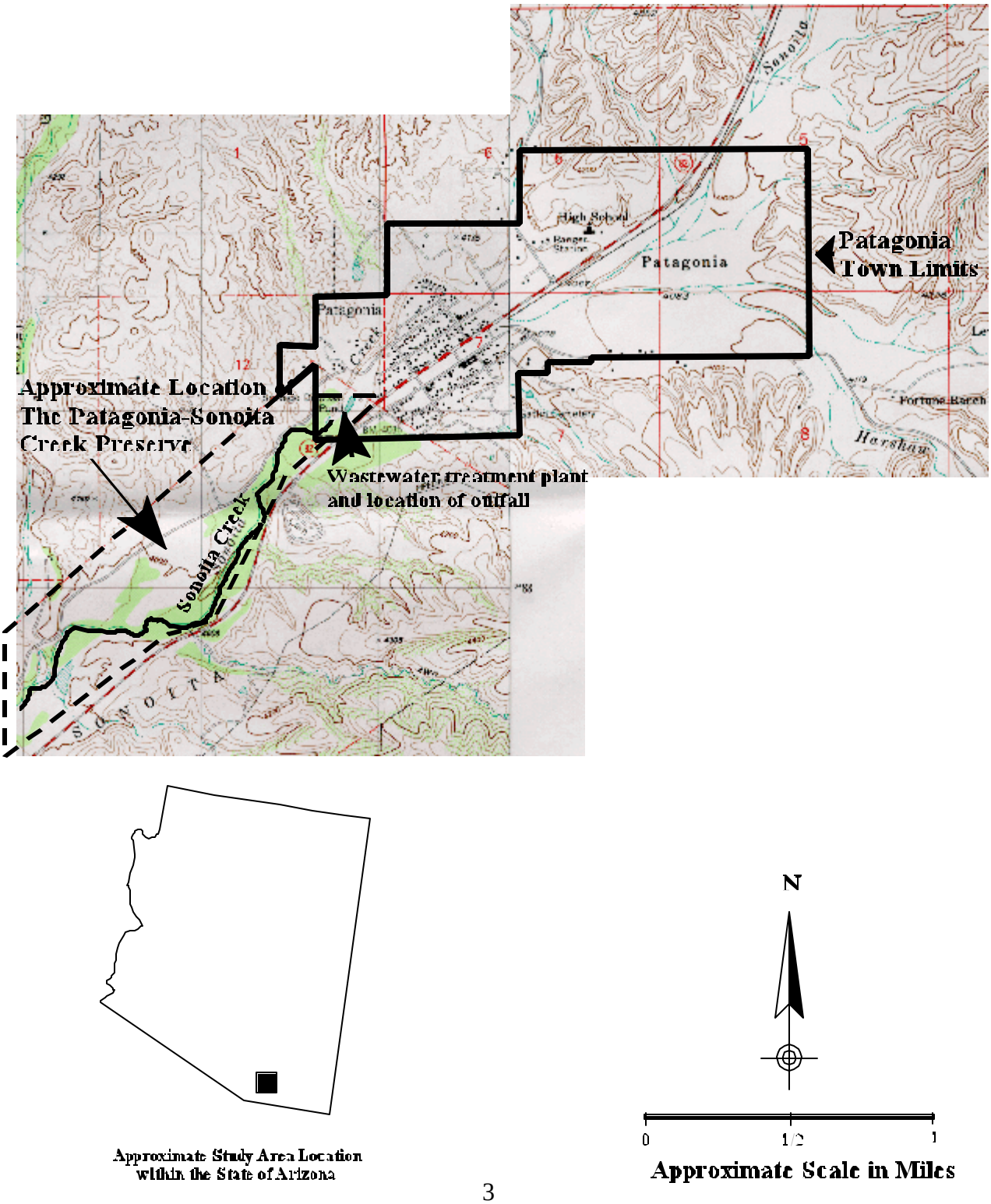
Population estimates used for sizing the facilities were based on projections from the Arizona Department on Economic Security. They estimate that 1033 people will live in the town in 2020, slightly up from the current population of 968. The existing treatment facilities were sized for a population of 889. The proposed facility will be designed based on a per capita flow contribution of 106 gallons per person per day (112 gallons less a 5% reduction anticipated as a result of collection system improvements). This results in a design capacity of 110,000 gallons per day.

II. Present Facilities

Patagonia's existing wastewater treatment plant is situated on 9.5 acres of private land in the southwest corner of town, adjacent to Sonoita Creek (Figure 1) (Pentacore April 1999). Patagonia has a 100-year lease for this land from a private landowner (VanNest *pers. Comm.* 1999). The current lease expires in April 2064 (Pentacore May 1999). The facility is located at an elevation of approximately

4,027 feet above mean sea level. The ground water table at the

Figure 1 Patagonia, Arizona Proposed Project Area (SAIC March 1999)



treatment plant occurs at an elevation of approximately 4,024 feet above mean sea level and the facility is located within the 100-year flood plain. Patagonia's wastewater treatment plant has not been subject to flooding according to town records; however, the facility offices and workshop have been subject to occasional flooding (Kale *pers. Comm.* 1999). The facility discharges treated effluent to Sonoita Creek on the northern edge of the site. The Nature Conservancy's Patagonia-Sonoita Creek Preserve borders the facility's southwestern edge and residential properties are located on the northeast edge of the facility.

Patagonia's sewer collection system was installed in 1965 with few additions and modifications in subsequent years (Pentacore April 1999). Sewage is collected in a gravity system, with approximately 19,500 feet of lines, before being conveyed to the treatment facility through a 10-inch interceptor line (Pentacore April 1999). The sewer system has 414 connections and serves the entire town of Patagonia with the exception of one property that currently uses a septic system (Kale *pers. Comm.* 1999). The Town does not currently have any significant industrial dischargers to the public wastewater system (Pentacore April 1999).

The existing wastewater treatment facility was installed in 1978 and designed to accommodate a population of 889, 61 fewer than the current estimated population of 950 people. The design average flow rate is 0.080 million gallons per day (MGD) with the capacity to handle peak daily flows of 0.24 MGD (Pentacore April 1999). Wastewater treatment plant influent during dry weather is approximately 0.071 MGD (Pentacore April 1999). Influent increases to approximately 0.081 MGD during the rainy season and 0.109 MGD during extreme precipitation events (Pentacore April 1999). Increased influent volume during wet weather is generally attributed to Infiltration and Inflow (I/I) to the collection system from the high water table and surface runoff. Infiltration is water that enters the collection system from the ground through defective pipes, damaged connections, or manhole walls (Pentacore April 1999). Inflow is stormwater that enters the collection system through roof leaders, cleanouts, sump pumps, foundation, cellar, yard, and other drains (Pentacore April 1999). Patagonia's wastewater collection system is estimated to have 5,000 gallons per day (gpd) of excessive I/I contributed by inflow or rainfall induced infiltration (Pentacore April 1999). Deteriorated shallow lines and service laterals were identified as major sources of rainfall induced infiltration and the primary cause of increased wastewater influent during wet weather (Pentacore April 1999).

The existing wastewater treatment process is contained within a 42-foot diameter circular steel tank containing two 50,000 gallon aeration compartments, an 18.5-foot diameter circular clarifier at the center of the unit, an aerobic digester, a chlorine contact basin, and dechlorination equipment (Pentacore April 1999). Two unlined lagoons are located adjacent to the existing wastewater treatment facility. The lagoons have been used to store excess sewage influent when high inflows exceeded plant capacity (Pentacore April 1999). The lagoons are in direct hydrologic contact with the floodplain aquifer and were observed to contain water during a March 8, 1999 site visit (SAIC March 1999).

Patagonia's wastewater treatment facility discharges to Sonoita Creek under NPDES permit number AZ0021679. Table 1 summarizes Patagonia's NPDES permit limits and effluent statistics from Discharge Monitoring Reports (DMRs) submitted to Arizona Department of Environmental Quality (ADEQ) covering the period from January 1997 through October 1998. Table 1 reports the range of report concentrations for constituents identified on the Town's NPDES permit. Table 1 also reports the number of months the Town did not meet its NPDES permit limits for each constituent. Patagonia violated its phosphate limit 21 months of the 22 for which DMRs were available from ADEQ. (Note that phosphorous limits are not expected to be included in future discharge permits). For other parameters, exceedences of limits occurred only once or twice during the 22 month period (Table 1). The facility discharges an average of 0.08 MGD (89 acre-feet per year) of treated effluent to Sonoita Creek.

Table 1. Characterization of Effluent from Patagonia's Wastewater Treatment System (January 1997 - October 1998)

Parameter	NPDES Permit Limit	Average Reported Value	Range of Reported Values	Number of Months Exceeding NPDES Limits
BOD (5 day, mg/l)	30.00	7.96	0.00 - 76.00	1
pH (s.u.)	6.5-9.0	N/A	6.60 - 8.11	0
Suspended Solids (mg/l)	30.00	17.19	0.10 - 156.00	2
Settleable Solids (mg/l)	1.00	2.41	0.00 - 50.00	2
Phosphate (mg/l as PO4, total)	0.50	5.70	0.85 - 14.70	21
Flow (MGD)	no limit	0.08	0.06 - 0.12	no limit
Fecal Coliform (No. per 100 ml)	200.00	158.37	2.00 - 1,600.00	1
Chlorine Residual (ug/l)	5.00	89.38	0.00 - 1,000.00	2

SOURCE: Pentacore 1999a, Patagonia DMRs 1997-1998.
N/A = not applicable

The existing treatment plant is beyond its design life and operates below treatment demands during high flow periods (Pentacore May 1999). This has resulted in the NPDES discharge violations discussed in the previous paragraph. The existing treatment process is incapable of achieving total nitrogen removal as currently required by the Town's pending Aquifer Protection Permit and anticipated new NPDES permit limits (Pentacore May 1999). The existing system also has limited sludge digester capacity, limited sludge wasting ability, and is incapable of withstanding shock loads (Pentacore May 1999). The chlorination/dechlorination unit is inadequate resulting in occasional violations of the NPDES chlorine residual limit. These treatment limitations result in repeated NPDES permit violations and unacceptable

levels of contaminants being discharged to Sonoita Creek. Furthermore, the treatment plant capacity is often exceeded during major storm events, and high peak flows must be diverted into the unlined holding ponds located adjacent to the plant (Pentacore April 1999). It is possible, given the locally high water table, that sewage stored in these holding ponds may seep into the aquifer.

III. Alternatives

The following alternatives are discussed in this environmental assessment:

Alternative A - No Project Alternative: assumes no improvements are made to the current treatment and collection system. Under this alternative, sewage flows would continue to surpass the capacity of the facility and would increase slightly with time. There would continue to be violations of the NPDES permit and the upcoming APP requirement to reduce nitrogen levels. In addition, the collection system would continue to leak sewage and have infiltration and inflow problems.

Alternative B (Proposed Alternative) - Treatment Plant Upgrade and Expansion at the Existing Site: assumes the treatment plant is upgraded on the site of the existing plant and improvements are made to the collection system. While the designer evaluated five different treatment technologies (sequencing batch reactor, phased isolation ditch, conventional oxidation ditch, extended aeration, and retrofit existing unit), the impacts associated with each of these sub-alternatives are roughly equivalent. Therefore, these sub-alternatives are all addressed under this category. Effluent would be discharged at the same location as the existing facilities. Patagonia chose the conventional oxidation ditch sub-alternative since it accomplishes the effluent improvement requirements at the least cost with a high degree of reliability, relative ease of operation, and a relatively low sludge yield (Pentacore May 1999).

Alternative C - Treatment Plant Improvements Plus Constructed Wetlands: assumes sewage is either treated or partially treated at the existing plant site and then conveyed to a constructed wetland. In one sub-alternative, the constructed wetland would be used to remove nitrogen and in another sub-alternative, the wetlands would be used to polish the treated effluent. Three sites were evaluated by the designer, one across the highway from the existing facility, another downstream adjacent to the freeway, and the third further downstream and on the other side of Sonoita Creek. This alternative also assumes that improvements will be made to the existing collection system. Effluent would be discharged to the Sonoita Creek, either at the existing location (for the first site), or at the wetland locations (for the other two sites). These sub-alternatives were not chosen because of their significant cost increase over the Alternative B oxidation ditch.

In both Alternatives B and C, improvements would be made to the collection system. As mentioned earlier, these improvements would reduce sewage losses from the system and reduce I/I contributions

to the system. These improvements may lead to a decrease in flows during wet weather periods. However, it is unlikely that flows during dry periods would be substantially altered from historic levels. Currently, dry weather flows average 67,000 gal/day (Pentacore May 1999). This translates into a per capita flow rate of 69 gallons per person, a typical flow rate for residential areas (Metcalf & Eddy 1991). Therefore, while the quality of the wastewater reaching the treatment plant would be affected by a reduction in sewage loss and a reduction in I/I gains, it appears that the quantity will not be significantly changed. The flow losses resulting from the improvements should be roughly balanced by the flow gains. In addition, the low growth expected in Patagonia indicates that flows should increase only slightly over the next 20 years.

In both Alternatives B and C, the effluent quality would be improved. The new facilities would be sized to accommodate current and future flows and would therefore consistently meet permit limits throughout the year. In addition, the facilities would include nitrogen removal processes (nitrification and denitrification), unlike the current treatment plant.

IV. Present Environment

The proposed project area is in Santa Cruz County, Arizona and is defined by (Figure 1):

- The incorporated limits for the Town of Patagonia, Arizona (T22S R16E SW1/4 section 5, S1/2 section 6, N1/2 section 7, NW1/4 section 8; T22S R15E SE1/4 section 1, NW1/4 section 12).

- Proposed sites for wastewater treatment plant expansion either on the existing property owned by Patagonia or on property owned by The Nature Conservancy (T22S R15E SW1/4 NW1/4 section 12).

- The discharge area for the wastewater treatment plant and a 1 mile reach of Sonoita Creek below the discharge point (T22S R15E SE1/4 section 12, NW1/4 section 13).

The climate is semi-arid with hot summer days, moderate winter days, and low humidity. Average monthly high temperatures range from 63.4 ºF in January to 94.9 ºF in June. Average monthly low temperatures range from 26.8 ºF in January to 63.4 ºF in June. Most of the precipitation occurs as rainfall. Very small amounts of snow occur from November through March, with December receiving the maximum monthly average of 0.2 inches. Precipitation ranges from 10 to 30 inches per year with an average of 18.63 inches per year. More than half of the annual rainfall occurs during the July through mid-September “monsoon” season. The prevailing wind direction around Patagonia is from the southeast with mean wind speeds from 7 to 9 miles per hour.

The proposed project area is located in Santa Cruz County, Arizona. Land ownership in Santa Cruz

County is split between individual and corporate ownership (37.5 percent), the state of Arizona (7.8 percent), and U.S. Forest Service and Bureau of Land Management (54.6 percent) (ADC 1998a). Land ownership in the Project Area is entirely private (USFS 1991). Coronado National Forest borders the Project Area on both the northwest and southeastern sides (USFS 1991).

Principle land uses in Santa Cruz County are farming, ranching, and tourism (ADC 1998a). The Town of Patagonia comprises approximately 1,280 acres within its jurisdictional boundaries. Residential developments occupy the largest portion of the developed land. Commercial development is concentrated along Arizona Highway 82 as it passes through the town. Industrial land uses are not significant in or around Patagonia.

The Nature Conservancy's Patagonia-Sonoita Creek Preserve (Preserve) covers 309 acres (TNC 1999) adjacent to and southwest of Patagonia's wastewater treatment plant (Figure 1). The Preserve is located along 1½ miles of the Sonoita Creek floodplain (TNC 1999) downstream of Patagonia's wastewater treatment plant discharge point. The preserve is known world-wide for its prime birding opportunities and draws more than 25,000 visitors each year (TNC 1999).

The Project Area is located in the 605 square mile Cienega Creek basin of southern Arizona's Basin and Range physiographic province. The Project Area is underlain by older surficial deposits from the middle Pleistocene to the latest Pliocene period (AGS 1988). Downstream from Patagonia, Sonoita Creek flows over late Cretaceous volcanic rock (AGS 1988). The hills west of Patagonia consist of early Cretaceous Bisbee Group sedimentary rocks with local volcanic units (AGS 1988).

Soil characteristics reflect their position within the landscape. Broad alluvial plains (fans) form the intermediate landscape between the highest points and the bottoms of the basins. Coarser, shallow soils tend to be located higher on the alluvial fans and particle size decreases and soil depth increases from the top to the bottom of the fans. Parent materials range from alluvium to granitic and volcanic rock in the surrounding mountains (NRCS 1971). Soils underlying the Town of Patagonia are generally from the Pima soil series (NRCS 1971). The Pima series consists of well-drained soils 60 inches or more in depth found on flood plains and are formed in recent alluvium weathered from mixed rock (NRCS 1971). Sonoita Creek, in the Project Area, flows over flood plains consisting of Grabe-Comoro complex soils (NRCS 1971). The surface layers of these soils are dominantly sandy loam but can be locally gravelly sandy loam, loam, and gravelly loam (NRCS 1971). This soil series is found on long, narrow ridge remnants of old dissected fans (NRCS 1971). The 1979 Soil Survey of Santa Cruz and Parts of Cochise and Pima Counties, Arizona did not identify any hydric (i.e., wetland) soils occurring in the Project Area (NRCS 1971).

Patagonia is located at approximately 4,044 feet above mean sea level in the arid and semi-arid Basin and Range physiographic province of the southwestern United States. This physiographic province is characterized by mountains rising above broad alluvial plains (Bloom 1991). Mountains in the desert are islands of non-desert climate maintained by orographic precipitation and occasional snowmelt

(Bloom 1991). Streams begin in the mountains before discharging onto the dry pediment slopes located at the base of the mountain range (Bloom 1991). Pediments disappear downslope under the thick alluvial fill found at the center of the basin (Bloom 1991). The Project Area occurs along, and in, the Sonoita Creek flood plain and on the toes of pediment areas extending from the Patagonia and Santa Rita Mountains.

V. Environmental Inventory

Following is an inventory of environmental features that are in the project area and may be affected by the proposed project (SAIC May 1999):

A. Wetlands - The intermittent nature of streams and drainages limits the distribution of wetlands within the Project Area. Small palustrine wetlands may occur along drainages and stream courses that flow perennially or nearly so. Scrub-shrub wetlands consisting of cottonwood, willow, saltcedar, horsetails, and sedges may occur along Sonoita Creek (Brown 1994). These wetlands are restricted to areas of adequate moisture immediately adjacent to the river.

B. Ground Water - Patagonia overlies the southwestern extension of the Cienega Creek ground water basin (ADWR 1997). The Cienega Creek Basin encompasses 605 square miles in southeastern Arizona (ADWR 1997). The basin is bordered by the Santa Rita and Empire Mountains to the west, the Rincon Mountains to the north, the Whetstone and Mustang Mountains to the east, and the Canello Hills and Patagonia Mountains to the south (ADWR 1997). Characteristics of the Cienega Creek Basin have not received extensive study primarily because the basin is not designated as an Active Management Area (AMA) by the Arizona Department of Water Resources. The Cienega Creek Basin is generally divided into two sub-basins which are thought to be hydrologically connected; the Cienega Creek ground water basin underlies the northern 305 square miles and the Sonoita Creek ground water basin underlies the southern 300 square miles, including the Project Area (Boggs 1980). The principal aquifer in the Sonoita Creek section of the Cienega Creek basin is the streambed alluvium that forms the Sonoita Creek floodplain (ADWR 1997). The streambed alluvium consists of sand, silt, and gravel deposits up to 90 feet thick (ADWR 1997).

Ground water levels in Patagonia range from 4,022 to 4,035 feet above mean sea level (Pentacore April 1999). Depth to ground water can be as little as 2 feet below the ground surface in low areas near Sonoita Creek (Pentacore April 1999). Ground water levels are typically highest during January and February when ground water levels can rise up to approximately two feet below the existing ground surface (Pentacore May 1999). Ground water in the regional aquifer flows in a southwesterly direction toward the Santa Cruz River.

C. Floodplains - Based on the 1980 U.S. Department of Housing and Urban Development (HUD)

Flood Insurance Rate Map (FIRM) for the Project Area, the existing wastewater treatment plant is located within the 100-year flood plain. In addition, a significant portion of the Town is situated in the 100-year floodplain (HUD 1980).

D. Important/Significant Agricultural Lands - The Project Area does not contain any farmlands designated as Prime and Unique by the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) (Robinett *pers. Comm.* 1999).

E. Vegetation - The Project Area consists of one natural biotic community, Semidesert Grassland (Brown 1994); however, most of the Project Area has been disturbed by residential and commercial development. The NRCS identified two range sites in the Project Area -- sandy loam upland and loamy bottom (NRCS 1971). Vegetation on sandy loam upland areas is dominated by warm season perennial grasses including sideoats grama, cane beardgrass, Arizona cottontop, plains lovegrass, and bottlebrush squirreltail (NRCS 1988a). The remainder of the Project Area is classified as loamy bottom (NRCS 1971). Dominant vegetation on loamy bottom areas consists of warm season perennial grasses including: vine mesquite; blue grama; sideoats grama; and cane beardgrass (NRCS 1988b). Occasional trees and shrubs occurring on loamy bottom sites may include sycamore, cottonwood, walnut, oak, desert willow, and hackberry (NRCS 1971).

The Patagonia-Sonoita Creek Preserve contains an old-growth cottonwood-willow riparian forest that includes some of the largest (taller than 100 feet) and oldest (130 years old) Fremont cottonwood trees in the world (TNC 1999). Micro-habitats and higher elevation sites within the preserve contain Arizona black walnut, velvet mesquite, velvet ash, canyon hackberry, and willow trees (TNC 1999). Remnant wetlands, also known as cienegas, occupy portions of the Sonoita Creek floodplain within the Preserve (TNC 1999). Cienegas were once a common feature along Sonoita Creek, and other perennial Arizona streams, but are now the most endangered natural community in Arizona (TNC 1999).

F. Wildlife - Loamy bottom sites within the Project Area provide forage for larger wildlife species -- desert mule deer and pronghorn antelope (NRCS 1988b). These sites also provide habitat for a variety of small herbivores (e.g., desert cottontail), birds (e.g., Gambels quail and scaled quail), and associated predators (NRCS 1988b). Sandy loam uplands provide habitat to many small herbivores (e.g., blacktail jackrabbit), birds (e.g., Gambels quail and scaled quail), and associated predators (NRCS 1988a). Large wildlife, with the exception of pronghorn antelope, use sandy loam upland sites primarily as foraging areas (NRCS 1988a).

The Patagonia-Sonoita Creek Preserve provides temporary and permanent habitat for more than 260 species of birds (TNC 1999). Unique, unusual, and rare bird species found on the Preserve include the gray hawk, green kingfisher, thick-billed kingbird, northern beardless tyrannulet, violet-crowned hummingbird, and rose-throated becard (TNC 1999). Other

wildlife using the Preserve includes mountain lion, bobcat, white-tailed deer, javelina, coatimundi, coyote, desert tortoise, rattlesnakes, and several species of frogs and toads (TNC 1999).

G. Endangered Species - The Gila top-minnow is present in Sonoita Creek upstream of Patagonia near Cottonwood Spring, between the town and Patagonia Lake, and below the lake (Duncan 1999). Cottonwood trees lining Sonoita Creek and the Project Area may provide habitat to the southwestern willow flycatcher (Newman *pers. Comm.* 1999). Flycatchers have been observed at Cottonwood Spring (Duncan 1999). The Huachuca water umbel, which grows around cienegas, perennial, low gradient streams, and wetlands, has not been observed near the Project Area (Cooper 1999). The lesser long-nosed bat, which roosts in the Santa Rita and Patagonia Mountains may feed on agave and columnar cacti in the area (Duncan 1999).

The appendix contains lists provided by U.S. Fish and Wildlife Service and USFS of federally listed threatened and endangered species, state sensitive species, and other special status species potentially occurring in the Project Area and Santa Cruz County, Arizona. The USFS list was generated by the Arizona Department of Game and Fish's Heritage Database (Newman *pers. Comm.* 1999).

H. Historic, Prehistoric, Architectural, Archaeological, and Cultural Sites - The Archaeological Site Files at the State Museum of Arizona (ASM) and the Arizona State Historic Preservation Office (ASHPO) were surveyed to identify cultural resources located within the Project Area. The Project Area and immediate vicinity contain numerous known historic, archaeological, and paleontological sites; however, very few archaeological survey projects have been conducted (Urban *pers. Comm.* 1999). Three historic buildings occur in the town of Patagonia: Patagonia Hotel and Cady Hall are National Register sites; and the Patagonia railroad depot is eligible for historic listing (ASHPO 1999). Additional sites identified in the ASM Archaeological Site Files include:

- A shard area, probably indicative of a buried village, located 1.5 west of Patagonia (AZ:EE:5:5).
- A site with dense scatter of shards and lithics, with some visible trash mounds (AZ:EE:5:14).
- A 30 acre site containing chipped and ground stones, and plainware from the Tanque Verde culture (AZ:EE:6:31).

Several cultural surveys have been conducted in the Project Area, two identified cultural remains (Urban *pers. Comm.* 1999). Survey 1992-134 identified one site with archaic remains in the NW1/4 of section 6, T22S R16E. Survey 1992-164 identified two isolated cultural finds but the ASM Survey Project Form was unclear as to whether these finds occurred within the Project Area.

Based on knowledge of the general area, the Project Area has a long history of occupation (Urban *pers. Comm*. 1999). This amounts to a high probability for potential recovery of historic, archaeological, and paleontological remains (Urban *pers. Comm*. 1999). Surveys to date have found no evidence of paleo-indian or proto-historic cultures. Most finds have been from the Hohokam culture (1,100 AD to 1,400 AD). The Project Area potentially contains significant historic sites dating back to the 1860s (Urban *pers. Comm*. 1999). The Project Area had a military presence in the 1800s related to Forts Crittenden and Buchanan, and Patagonia and vicinity were significant mining areas in the 1800s (Urban *pers. Comm*. 1999).

The Arizona State Museum recommends that, at a minimum, a monitoring program be established to coincide with all ground disturbing activities (Urban *pers. Comm*. 1999).

I. Aesthetic Resources - Significant aesthetic resources in and around the Project Area include The Nature Conservancy's Patagonia-Sonoita Creek Sanctuary, the Patagonia Mountains to the southeast, and the Santa Rita Mountains visible to the northwest. Currently, Patagonia's wastewater infrastructure does not adversely impact the aesthetics of the Project Area. All structures are constructed at ground level. The wastewater treatment plant is only visible from its access road; the facility is not visible from Patagonia or Arizona Highway 82.

J. Hazardous and Solid Waste - A search of EPA's Resource Conservation and Recovery Information System (RCRIS) did not identify any facilities generating hazardous wastes or handlers of hazardous waste within the Project Area. A search of EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) did not identify any Superfund sites in the Project Area.

The Town of Patagonia provides residents with weekly garbage collection service. Solid waste is disposed of at the Patagonia Municipal dump, located on 1st Street approximately one to two miles northwest of Arizona Highway 82 (Figure 1). The municipal landfill is owned and operated by the Town of Patagonia (Kale *pers. Comm*. 1999).

Dried sludge from Patagonia's wastewater treatment plant is also disposed of at the Town dump. Sludge is bagged and dried at the wastewater facility before being transported to the dump. Sludge composition meets EPA requirements for metals concentrations (Kale *pers. Comm*. 1999). Prior to installation of the DRAIMAD sludge bagging system in 1998, the Town used a certified contractor to apply digested liquid sludge to approved agricultural fields (Pentacore May 1999). The Town wasted 950.3 tons of liquid sludge, which yielded 11.2 tons of dry solids, to agricultural fields in 1997 (Pentacore May 1999). Patagonia switched to the DRAIMAD system because land application was too expensive and the availability of permitted agricultural fields was limited (Pentacore May 1999).

K. Receiving Water Quality - Sonoita Creek is the designated receiving water for effluent from

Patagonia's wastewater treatment plant; the Town of Patagonia does not divert any surface water from the Creek. Sonoita Creek could be classified as C5 under the Rosgen system -- a low gradient, meandering, alluvial channel with sand as the dominant bed material (Rosgen 1994). Sonoita Creek flows across the northern edge of the Project Area in a southwesterly direction. Sonoita Creek flows are ephemeral through town; however, Sonoita Creek flows are perennial downstream of the wastewater treatment plant. Perennial flows are maintained by discharges from the floodplain aquifer.

The U.S. Geological Survey (USGS) operated a stream gaging station on Sonoita Creek intermittently beginning in 1905 and then continuously from 1936 through September 1971 (Water Development Corporation 1997). The gage was located approximately 5 miles downstream from Patagonia in the bedrock-constricted zone of perennial flow (Water Development Corporation 1997). The annual mean flow recorded at this site was 5,750 acre-feet (Water Development Corporation 1997). Data obtained from the ADEQ shows average Sonoita Creek flow below the Patagonia wastewater treatment plant to be 3.41 cubic feet per second (cfs) (2,469 acre-feet per year) between October 1987 and September 1993 (ADEQ 1999).

Sonoita Creek is designated an effluent dependent water (EDW) from the Patagonia wastewater treatment plant to 750 feet downstream of outfall (AAC, Title 18, Ch. 11). Designated uses established by the State of Arizona's Water Quality Standards for this reach are: aquatic and wildlife effluent dependent water; partial body contact; and agricultural livestock watering (AAC, Title 18, Ch. 11). Sonoita Creek's designated uses upstream and downstream of the EDW designated reach are: aquatic and wildlife warmwater; full body contact; fish consumption; agricultural irrigation, and agricultural livestock watering (AAC, Title 18, Ch. 11).

ADEQ collected water quality data for Sonoita Creek below the Patagonia wastewater treatment plant from October 1987 through September 1993. Selected water quality data for Sonoita Creek are included in Table 2.

Table 2. Selected water quality data for Sonoita Creek downstream of Patagonia's wastewater treatment plant (October 1987 - September 1993)

Parameter	Mean	Standard Deviation	Range (minimum - maximum)
Dissolved Oxygen (mg/l)	6.26	1.08	4.02 - 8.62
pH (s.u.)	N/A	N/A	6.40 - 7.88
Total Suspended Solids (mg/l)	8.20	13.77	0.00 - 67.00
Turbidity (NTUs)	5.07	14.86	0.13 - 67.00
Fecal Coliform (No. Per 100 ml)	74.33	96.66	1.00 - 300.00
Phosphorus (mg/l, total)	0.20	0.14	0.04 - 0.62
Chlorine (mg/l)	10.27	3.04	6.80 - 19.80
Alkalinity (mg/l, total)	222.55	16.86	182.00 - 252.00

SOURCE: ADEQ 1999
N/A = not applicable

L. Air Quality/Odors - The air quality in and around the Patagonia area is considered good. The pollution levels of the EPA criteria pollutants; sulphur dioxide (SO_2), nitrogen oxides (NO_X), volatile organic compounds (VOCs), carbon monoxide (CO), and particulate matter (PM_{10} or $PM_{2.5}$) are all below the ambient air quality concentration limits for each pollutant. The nearest area not within attainment of the ambient air quality standards is Nogales, Arizona near the Mexican/United States border, approximately 19 miles to the southwest. Nogales is in moderate non-attainment of the particulate matter standard which is primarily a localized issue.

There are no discernable odor producing sources in the Project Area other than the Patagonia wastewater treatment plant. Operation of the wastewater treatment facility has involved diversion of untreated wastewater into existing storage ponds when high flows exceeded plant capacity (Pentacore April 1999). These ponds are located less than 250 feet from adjoining residential properties and are not equipped with odor controlling devices; however, this practice did not result in odor complaints (Pentacore April 1999). This practice has since been curtailed (Kale *pers. Comm.* 1999) and review of the Patagonia Wastewater System records showed no recent odor complaints filed against the facility.

M. Socioeconomic - The predominant economic activities in Santa Cruz County are wholesale, retail trade, and service industries (ADC 1998a). The city of Nogales, 18 miles to the south, is an active produce shipping point and the economic center of Santa Cruz County (ADC 1998a). Retail trade and service industries are the largest private sector employers in Patagonia, employing 557 people in 1997 (ADC 1998b). Patagonia's business district is centered on

Arizona Highway 82 which passes through the center of town (ADC 1998b).

Extensive mineral exploration is being conducted in the vicinity of the Project Area (ADC 1998b). Construction in the Project Area is expected to increase with the development of numerous planned communities within 15 miles of Patagonia (ADC 1998b). The area is also known to have some of the finest ranches in the Southwest. These ranches breed specialty cattle and quarter horses (ADC 1998b).

Patagonia's population in 1997 was estimated at 950 people, up from 923 persons in 1990 but slightly down from the 1980 population of 980 (ADC 1998b, U.S. Census Bureau 1990). Patagonia's population increased by 3 percent between 1990 and 1997, significantly lower than Santa Cruz County's overall growth rate of 22 percent for the same period (ADC 1998b). Patagonia's growth rate is also lower than the overall 25 percent population increase between 1990 and 1997 estimated for the entire state (ADC 1998b). The Arizona Department of Economic Security (ADES) estimates that Patagonia's population will increase to 1,022 persons in 2010 and 1,246 persons in 2050 (ADES 1997).

The median family income in 1989 for the Town of Patagonia was $16,125 compared with $22,066 for Santa Cruz County as a whole (U.S. Census Bureau 1990).

N. Environmental Justice - The baseline environmental justice (EJ) screening process was used to identify minority or low-income communities within the Project Area. Preliminary screening for potential EJ issues is based on two general statistics. First, the screening process is used to ascertain whether the minority population percentage in the affected area is either greater than 50 percent or meaningfully greater than the minority population percentage in the general population (EPA 1997). The concept of race as used by the Census Bureau reflects self-identification and self-classification by people according to the race with which they most closely identify (U.S. Census Bureau 1990). Second, low-income populations are identified using either Department of Health and Human Services (HHS) poverty guidelines or the Department of Housing and Urban Development (HUD) statutory definition of very low-income for the purposes of housing benefits (EPA 1997). The percentage of impoverished people in the affected area is compared with the percentage of people living below the poverty limit in the general population to determine if a significant difference exists. Minority and impoverished population totals and percentages calculated using 1990 U.S. Census data are presented in Table 3 (U.S. Census Bureau 1990).

Patagonia does not appear to contain significantly higher percentages of minority populations than Santa Cruz County; however, the percentage of Patagonia's population classified as "other race" is more than twice that of Arizona (Table 3). Table 3 shows a higher percentage of impoverished people living in Patagonia compared with Arizona, but similar to Santa Cruz County. The EJ analysis is inconclusive as to whether environmental justice issues are present

in the Project Area. Given the significantly higher percentage of persons classified as "other race" and also persons with incomes below the poverty level in 1989 living in the Project Area, EJ should be addressed in conjunction with future projects to ensure that impoverished and minority populations are not disproportionately impacted.

Table 3. Minority and Impoverished Population Totals and Percentages for Patagonia, Santa Cruz County, and the state of Arizona, 1990

	Town of Patagonia	Santa Cruz County	State of Arizona
Total Population	923 (100%)	29,676 (100%)	3,665,228 (100%)
White	712 (77%)	22,218 (75%)	2,967,682 (81%)
Black	0 (0%)	66 (<1%)	110,062 (3%)
American Indian, Eskimo, or Aleut	4 (<1%)	70 (<1%)	204,589 (5%)
Asian or Pacific Islander	0 (0%)	110 (<1%)	54,127 (2%)
Other race	207 (22%)	7,212 (24%)	328,768 (9%)
Persons with 1989 Income below poverty level	285 (30%)	7,796 (26%)	564,362 (15%)

SOURCE: 1990 U.S. Census Data

VI. Impact Evaluation

A. Wetlands - As discussed in Section III, flows during dry weather periods wetlands should not be beneficially or adversely impacted by either Alternative A or B. Therefore, it is unlikely that downstream wetlands would be impacted by these alternatives. However, under Alternative C, wetlands would be beneficially affected, with the creation of new wetlands as part of the treatment process.

B. Groundwater - Under the No-Project alternative, the existing effluent would continue to negatively impact the groundwater by being a source of nitrate. Under Alternatives B and C, groundwater quality would be improved because of the treatment plant and collection system improvements. By removing nitrogen before discharge to Sonoita Creek, a significant source of nitrate to the groundwater would be removed. In addition, rehabilitation of the collection system would lead to a reduction in the amount of raw sewage contaminating local ground water supplies.

C. Floodplains - The current facility is within the 100-year floodplain. Therefore, under the no-project alternative (Alternative A), the existing facilities could be subject to occasional flooding.

The Alternative B facility improvements would be located at the existing site. To minimize the potential for flood damage (and the possibility that untreated or partially treated sewage could enter Sonoita Creek during floods), process units and equipment would be built above the 100-year floodplain elevation. However, there is a potential for flooding during the construction period. The potential for construction-related impacts should be minimal since the main part of construction is expected to occur outside of the monsoon season.

Alternative C would include construction at the existing site and the creation of constructed wetlands at one of three other sites. While Site 1 is at a higher elevation, Sites 2 and 3 are within the floodplain and could lose vegetation during flood events. Since vegetation is integral to treatment processes in constructed wetlands, effluent quality would be degraded during and after floods.

D. Air Quality/Odors - No new impacts would be expected from the No-Project Alternative (Alternative A). Air Quality impacts associated with Alternatives B and C would be limited to potential dust increases during facility construction. If dust is generated during the construction process dust control measures would be implemented (such as watering down the site).

The existing facilities and any new treatment plant construction on the existing site would occur within 1000 feet of the nearest property line. Under Alternatives B and C, property owners within 1000 feet of the treatment processes would give their consent prior to new construction.

E. Important Vegetation Types - No vegetation would be impacted by Alternative A, the no-project alternative. For Alternatives B and C, construction on the existing plant site and nearly all of the collection system would occur on disturbed or developed lands. There is one section of the existing collection system that crosses Sonoita Creek between Sonoita and Naugle Ave. There is only minor vegetation, and no trees, at this location (Kale October 1999).

Alternative C would also consist of the generation of new vegetation through the creation of new wetlands.

F. Wildlife/Endangered Species - as noted above, only one section of the collection system pipeline is in an area that is not either developed or disturbed. There is only minor vegetation, and no trees, at this location, the Sonoita Creek crossing (Kale October 1999). Therefore impacts to wildlife are expected to be negligible.

No new impacts are expected on endangered species under the no-project alternative (Alternative A). However, the treatment plant effluent would still contain ammonia, which degrades the aquatic habitat of the Gila Topminnow. Following is a discussion of the impacts of Alternatives B and C on endangered species that may be present in the Project Area:

Gila Topminnow: as discussed in subsection H (Receiving Water) below, there would not likely be any adverse construction impacts from the proposed project. However, after completion of construction, the effluent quality would be improved. Most important, nitrogen would be removed during treatment, leading to a nearly complete removal of ammonia in the effluent. Given the improvement in the effluent water quality, the proposed actions would have positive effects on topminnow habitat.

Southwestern Willow Flycatcher: Since no cottonwood trees are expected to be disturbed in any of the alternatives, the Southwestern Willow Flycatcher should not be affected.

Huachuca Water Umbel: Since no Huachuca water umbels have been observed in the Project Area, this species should not be affected by any of the alternatives.

Lesser Long-Nosed Bats: Since no agave or columnar cacti are expected to be disturbed in any of the alternatives, the lesser long-nosed bat should not be affected.

G. Solid Waste - Sludge quantities would remain unchanged in the No-Project Alternative (Alternative A) compared to the existing plant. Sludge would continue to be disposed of at the Town landfill. Under Alternative B, sludge would be processed in an aerobic digester and dried in a sludge drying bed. Sludge would be hauled to a landfill for final disposal, but in the future may be further conditioned and used for land application (Pentacore May 1999). Under Alternative C, much less sludge would be produced and disposed of than in Alternative B.

H. Receiving Water - Under the No-Project Alternative (Alternative A), effluent from the treatment plant would continue to violate permit limits. While phosphorous limits are not expected in future permits, new nitrogen limits would be included. The effluent would consistently violate the nitrogen limits.

For Alternatives B and C, the effluent would consistently meet discharge limits and would contain very low concentrations of ammonia. During construction, silt fences would be placed at the down stream end of the construction site to minimize siltation impacts on Sonoita Creek. The existing treatment facility would be used until such time as the proposed project is operational. Therefore, the effluent quality should not be degraded during the construction phase of the treatment facilities. The reductions in ammonia under Alternative B would benefit aquatic species living in Sonoita Creek.

The ammonia reductions would also occur in Alternative C. However, there would be a potentially negative impact under this alternative if the discharge location is moved further downstream. The move could impact riparian habitat and aquatic species between the existing and the new discharge location by removing a perennial water source.

Deteriorated sections of the wastewater collection system would be rehabilitated and/or replaced with either open trench replacement or in situ repair. While most of the collection system is under existing roads and alleys, one segment crosses Sonoita Creek (Kale October 1999). Before any work would be initiated in this section, protective measures required in any appropriate U.S. Army Corps of Engineers permit would be followed.

I. Historic, Prehistoric, Architectural, Archaeological, and Cultural Sites - Under Alternative A, no grounds would be disturbed and it is unlikely that any historic, prehistoric, architectural, archaeological, or cultural sites would be impacted. Since it is possible that sites of interest may be in the project area, a monitoring program would be established during all ground disturbing activities under Alternatives B and C. Thus, any potential impacts should be below a level of significance.

J. Aesthetic Resources - Given that there are no current impacts to aesthetics, Alternative A would not result in impacts now or in the future. Alternative B would result in new facilities on the current site. Aesthetic impacts would be minimal given that they would not be visible from main roads. Alternative C would also include the creation of constructed wetlands. This can be considered a positive impact. In both Alternatives B and C, rehabilitation of the collection system will be below ground level and will not adversely affect aesthetics in the Project Area.

K. Socioeconomic - It is unlikely that any of the alternatives would have socioeconomic impacts. While Alternatives B and C provide improvements to wastewater infrastructure that accommodate the Town's growth projections, the expected increase of only 65 people over the next 20 years should have minimal effects.

L. Utilities - Since the Town appears to have an adequate electrical supply to meet current needs Shahbander 1999), Alternative A, the no project alternative, would result in no impacts. While power consumption would increase with Alternatives B and C, it does not appear to limit the feasibility of either of these alternatives and is therefore not considered a significant impact. However, a backup generator would be included in Alternatives B and C to ensure that power is available during outages (Shahbander 1999).

M. Noise - Existing background noise levels in Patagonia are probably affected by the following sources: wind, traffic on Arizona Highway 82, pedestrians, households, commercial establishments, and other common town noises. The existing public wastewater treatment system, and therefore the no project alternative, is not associated with any noise pollution in the Project Area. Some noise will be associated with construction activity under Alternatives B and C. Property owners within 1000 feet of the treatment processes must consent to the new construction.

N. Environmental Justice - Given that construction of the treatment facilities would be on the existing

site and the collection system rehabilitation would be throughout the town limits, impoverished and minority populations would not be disproportionately impacted by any of the alternatives.

VII. Cumulative Impacts

In the future, the Town of Patagonia may consider improvements to the public water system. The following measures are potential improvements to Patagonia's public water supply system:

- Rehabilitation of existing wellheads. The wellheads are currently situated at ground level in Sonoita Creek's 100-year flood plain. Raising the wellheads by approximately two feet will prevent possible inundation and submersion by flood waters.

- Replacement of the existing telemetry system. The existing telemetry system only reads "high" or "low" making it difficult to gauge the amount of water in the storage reservoirs without visual inspection.

- Replacement of transmission mains, undersized or deteriorated distribution lines. The Town has several 1,000 feet of 4-inch distribution line where 6-inch line should have been installed. These undersized sections need to be upgraded to a minimum of 6-inch line because fire demands cannot be met with 4-inch line.

- Replacement of fire hydrants, isolation valves, and meters. The Town is in the process of replacing fire hydrants and meters. Several isolation valves no longer work and need to be replaced in order to operate the system efficiently in the event of a water line break.

- Installation of additional looping within the existing distribution system. The Town only has one line connecting the Patagonia with the storage reservoirs and groundwater wells. Without looping in this section, a break in this line would cut off the Town's water supply.

- Implementation of wellhead protection measures.

These improvements are intended to improve system reliability, enhance fire-fighting capabilities, and protect the wells from possible flood damage. It is unlikely that impacts from the above measures, when combined with impacts from the wastewater project described in this assessment would cumulatively cause significant impacts.

VIII. Summary of Impacts and Mitigation for the Proposed Alternative

As described earlier the project would result in the following impacts:

- Groundwater quality would be improved by reducing nitrate loadings and raw sewage losses in the collection system, and

- The reduction in ammonia in the effluent will potentially improve the habitat of aquatic species in Sonoita Creek.

The following mitigation steps are necessary to minimize potential impacts:

- If dust is generated during the construction process dust control measures would be implemented (such as watering down the site),

- Property owners within 1000 feet of the treatment processes must consent to the new construction,

- Since it is possible that Historic, Prehistoric, Architectural, Archaeological, and Cultural sites of interest may be in the project area, a monitoring program would be established during all ground disturbing activities, and

- To protect Sonoita Creek, silt fences would be placed at the down stream end of the construction site to minimize siltation impacts.

IX. References

Note: substantial portions of this document are extracted and/or adapted from the SAIC March 1999 document described below.

Arizona Administrative Code 1996. Title 18. Environmental Quality, Chapter 11. Department of Environmental Quality Water Quality Standards.

Arizona Department of Commerce (ADC) 1998a. Profile: Santa Cruz County, Arizona.

ADC 1998b. Community Profile: Patagonia.

Arizona Department of Economic Security. 1997. July 1, 1997 to July 1, 2050 Arizona Subcounty Population Projections for Counties, Places, and Reservations.

Arizona Department of Environmental Quality. 1999. Water Quality Data for Sonoita Creek below Patagonia Wastewater Treatment Plant (October 1987 - September 1993).

Arizona Department of Water Resources. 1997. Cienega Creek Basin. Http://www.adwr.state.az.us/AZWaterInfo/O...theasternArizona/Basins/cienegacreek.html (3/16/99).

Arizona Geological Survey (AGS) 1988. Geologic Map of Arizona.

Arizona State Historical Preservation Office. 1999. Review of ASHPO's archaeological site files by Robert Naeser, SAIC, on February 12, 1999.

Bloom, A. 1991. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. Prentice Hall (Englewood Cliffs, NJ).

Boggs, J.M. 1980. Impact of Future Ground-Water Development in Cienega Creek Area, Pima, Santa Cruz and Cochise Counties, Arizona. Unpublished Masters Thesis, Department of Hydrology and Water Resources, The University of Arizona.

Brown, D.E., Ed. 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press (Salt Lake City, UT).

Cooper, J. 1999. Personal communication between Jeffrey Cooper of the Patagonia Preserve and Talal Shahbander, Pentacore Arizona, in October 1999.

Duncan, D. 1999. E-mail message from Doug Duncan, U.S. FWS to Ben Machol, EPA dated 9/29/99

EPA, Office of Federal Activities. 1997. Interim Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analysis.

Kale, D. 1999. Personal communication between Dan Kale, Patagonia Public Works Director,

and Robert Naeser, SAIC, on March 8, 1999.

Kale, D. October 1999. Personal communication between Dan Kale, Patagonia Public Works Director, and Talal Shahbander, Pentacore in October 1999.

Metcalf & Eddy, 1991, Wastewater Engineering, McGraw Hill

Newman, T. 1999. Personal communication between Tom Newman, USFS Nogales Ranger District Biologist, and Robert Naeser, SAIC, on March 8, 1999.

Patagonia, Town of. 1997-1998. National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Reports (DMRs) for AZ0021679.

Pentacore Arizona April 1999. Draft Report - Wastewater Collection System Evaluation and Infiltration/Inflow Analysis, Town of Patagonia, Arizona.

Pentacore Arizona May 1999. Final Report - Wastewater Treatment Facilities Alternatives, Town of Patagonia, Arizona.

Robinett, D. 1999. Personal communication between Dan Robinett, USDA-NRCS Range Conservationist, and Robert Naeser, SAIC, on March 1, 1999.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22 (1994), pp. 169-199.

Science Applications International Corporation (SAIC). March 1999. Site visit by Robert Naeser on March 8, 1999 of Patagonia, Arizona's public water system and wastewater treatment system.

SAIC, May 1999. Patagonia, Arizona Public Water System and Wastewater System Improvement Project - Final Environmental Pre-Assessment/Environmental Information Document - EPA Contract No. 68-W7-0050, Delivery Order No. 1005

Shahbander, T. 1999. Personal Communication between Talal Shahbander, Pentacore and Ben Machol, EPA on October 12, 1999.

The Nature Conservancy. 1999. Patagonia-Sonoita Creek Preserve. Http://www.fourcorners.com/tnc/patagoni.htm (3/9/99).

U.S. Census Bureau. 1990. 1990 U.S. Census Data.
http://venus.census.gov/cdrom/lookup/921088001,
http://venus.census.gov/cdrom/lookup/921089159,
http://venus.census.gov/cdrom/lookup/921089066,
http://venus.census.gov/cdrom/lookup/921087934 (3/10/99).

U.S. Department of Agriculture - Natural Resources Conservation Service. 1971. Soil Survey of Santa Cruz and Parts of Cochise and Pima Counties, Arizona.

U.S. Department of Agriculture - Natural Resources Conservation Service. 1988a. Range Site Description for Sandy Loam Upland. Tucson, Arizona Field Office.

U.S. Department of Agriculture - Natural Resources Conservation Service. 1988b. Range Site Description for Loamy Bottom. Tucson, Arizona Field Office.

U.S. Department of Housing and Urban Development. 1980. Flood Insurance Rate Map Santa Cruz County, Arizona (Unincorporated Areas) - Panel 170 of 350.

U.S. Forest Service. 1991. Coronado National Forest 1:126,720 Scale Map with Surface Management Status.

Urban, S. 1999. Conversation between Sharon Urban, ASM Public Archaeologist, and Robert Naeser, SAIC, on 3/5/99.

VanNest, I. 1999. Conversation between Isabel VanNest, Patagonia Deputy Town Clerk, and Robert Naeser, SAIC, 0n 5/5/99.

Water Development Corporation. 1997. Hydrogeology and Stream Characteristics of Sonoita Creek in Vicinity of Patagonia Wastewater Treatment Plant Santa Cruz County, Arizona.

Appendix

List of Species of Concern