Total Maximum Daily Load For:
Oak Creek- Slide Rock State Park

Parameters: *Escherichia coliform*

June 1999

Open File Report 09-08

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Pathogen TMDL

Slide Rock State Park
Oak Creek Canyon, AZ

ADEQ
Hydrologic Support & Assessment

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I. EXECUTIVE SUMMARY

Slide Rock Swimming Area (now Slide Rock State Park) has experienced seasonal exceedances of State Water Quality Standards for fecal coliform since the late 1960s. In 1996, *Escherichia coli (E. coli)* replaced fecal coliform for protection of the Full Body Contact designated use. Also in 1996, the Arizona State Parks Service began daily testing of *E. coli* at Slide Rock State Park. However, although testing and risk management has improved since 1996, both the single sample maximum standard for (*E. coli*)(580 cfu/100 ml) and the corresponding geometric mean (130 cfu/100 ml) standards have been exceeded, in addition to continued violations of the remaining fecal coliform geometric mean standard (1000 cfu/100 ml) for other designated uses.

Oak Creek has been extensively monitored over the past three decades. Management agencies, particularly the United States Forest Service - Coconino National Forest, the Sedona Ranger District, the Arizona State Parks Service, the Arizona Department of Health Services, Coconino County Environmental Health Service, and the Arizona Department of Environmental Quality, have participated in monitoring and study to determine the causes of and solutions to this problem. Over the years, stakeholder involvement has increased to include local citizens and homeowners. A core watershed group known as the Oak Creek Task Force meets regularly.

Previous studies assumed that fecal coliform bacteria loading was 'mitigated' through assimilation and die-off, however, the 319(h)-funded National Monitoring Program (NMP, 1994-1998) established the presence of a significant sediment reservoir from which bacteria become resuspended as the result of recreation pressure and storm events. The areas of greatest concern include the low-gradient swimming areas such as Slide Rock and Grasshopper Point. These factors, along with overwintering and regrowth of bacteria, are the focus of ongoing study and human health concerns. Source identification has been approached through sampling and DNA typing. There are no point sources for fecal coliform or *E. coli*. Possible contributing nonpoint sources include recreation, improper waste disposal, septic seepage, and storm water runoff.

This TMDL builds upon previous studies and incorporates ongoing work in an approach focused on attaining all pathogen standards through a percent reduction in sediment fecal coliform. Three methods were used to evaluate necessary load reductions: 1) empirical correlation with single sample maximum *E. coli* standard , 2) empirical correlation with geometric mean *E. coli* standard, and 3) linear regression based on the apparent relationship of fecal coliform in water to fecal coliform in sediment (Section VI). Based on the existing data resolution, the predictive value from regression is poor; the correlation coefficient is 0.3.

Method 1 is the method used in this TMDL to establish load allocations because it focuses on the attainment of the acute exposure standard (single sample maximum of 580 cfu/100 ml), short-term seasonal exposure at Slide Rock State Park. Data variability empirically suggests that attainment of the single sample maximum standard will also achieve attainment of the geometric mean standard (130 cfu/100 ml, 5 sample minimum over a 30-day period). Method 1 uses empirical relationships developed from two years of summer data and targets a reduction in the existing summer arithmetic mean single *E. coli* value (from 823 to 580 cfu/100 ml). This is a 30% reduction in the probability that any one single water-column *E. coli* value will be at or above the standard. The empirically-derived ratio of sediment fecal coliform to water fecal coliform ranged from 100:1 to 10,000:1, with an average of 2000:1. Multiplying 580 (water value) by 2000 (sediment value) results in a target value of

1,160,000 cfu/100 ml in sediment. Therefore, this TMDL has two numeric targets: 1) reduction in summer sediment fecal coliform values to 1,160,000 cfu/100 ml, and 2) 100% attainment of the single sample maximum *E. coli* standard of 580 cfu/100 ml during recreational exposure. Daily summer *E. coli* samples should be collected in the afternoon and analyzed within six hours in order to plan for the following day; during periods of very high recreational use, both early morning and early afternoon samples are highly recommended.

Given the uncertainties inherent in the overwinter/regrowth phenomena and the relationship of sediment to water fecal coliform, this TMDL acknowledges that a phased approach to load reductions is warranted if the prescribed load reductions are deemed insufficient to meet the specified pathogen standard. Based on source identification through DNA typing, an Implementation Plan will be created to achieve the 30% reduction by 2002. This Plan may be geared toward any or all of the following: source loading external to the stream, overwinter populations, and regrowth. If the *E. coli* single sample maximum target is achieved by 2002 pursuant to this Plan, no further action will be required under this TMDL. However, if the *E. coli* standard is not achieved by 2002, the Plan will be automatically amended to further reduce sediment load an additional 15-30% by 2005. At the end of the summer of 2005, if sediment fecal coliform have been reduced by at least 30%, and water column standards for *E. coli* are consistently attained, this TMDL will be considered complete. If water column standards for *E. coli* are not consistently attained, necessary additional measures will be evaluated and a new TMDL considered.

Source reduction, coupled with suggested changes in management practices, are intended to ensure protection of public health at Slide Rock State Park. The goal is to totally avoid full body contact exposure when *E. coli* is at or above the single sample maximum level of 580 cfu/100 ml. To accomplish this goal, State Parks will rely on the support of all watershed stakeholders. This TMDL assigns a group Load Allocation (0 additional; 30% reduction) to all those identified in Section XIII. The Wasteload Allocation is “0" and there is no separate Margin of Safety. Progress will be reviewed annually and additional measures pursued accordingly. An Implementation Plan will be drafted within 6 months of TMDL approval, directing stakeholder responsibilities toward source reduction, required mitigation activities, and refined management practices. In order to achieve a significant reduction in sediment fecal coliform, it will take committed participation by all stakeholders to support continued research and to improve and broaden application of BMPs at and above Slide Rock State Park.

II. INTRODUCTION/PROBLEM STATEMENT

TMDL PROCESS

The Clean Water Act (CWA) establishes a national goal of “fishable, swimmable” waters. In cases where waters do not meet this goal, Section 303(d) of CWA requires States to develop Total Maximum Daily Loads (TMDLs), with oversight from the Environmental Protection Agency (EPA). A TMDL allocates pollution control responsibilities among pollution sources in a watershed, and is the basis for taking the actions needed to restore a water body.

WATER QUALITY STANDARDS/303(d)

Oak Creek currently carries designated use standards for Aquatic &Wildlife-cold (A&Wc), Fish Consumption (FC), Full Body Contact (FBC), Domestic Water Source (DWS), Agriculture-Irrigation (AgI), and Agriculture-Livestock Watering (AgL) (ADEQ, 1996). Lower Oak Creek (below the 5000 ft. elevation level) is proposed for a standards change in the yr-2000 Triennial Review; based on macroinvertebrate community type, this section of Oak Creek will be redesignated Aquatic &Wildlife-warm (A&Ww). Standards at Slide Rock State Park will not be affected. A previous TMDL established nutrient wasteload allocations for three point source discharges to Oak Creek, which along with other tributaries to the Verde River, carries nutrient standards for total nitrogen and total phosphorous (EPA, 1987). Oak Creek was designated as a Unique Water in 1986 (ADEQ, 1986).

One mile of the 24-mile reach of Oak Creek from the confluence with West Fork to the confluence with Dry Creek is listed as "impaired" for fecal coliform bacteria and *Escherichia coli (E. coli)*(ADEQ, 1998). Prior to 1996, the most restrictive fecal coliform standards pertained to FBC: geometric mean = 200 cfu/100 mls, 10% of samples over 30 days = 400 cfu/100 mls, and single sample max = 800 cfu/100 mls). In 1996, the FBC standard was changed from fecal coliform to *E. coli*, with a 30-day geometric mean (5 sample minimum) of 130 cfu/100 mls and a single sample maximum of 580 cfu/100 mls. The *E. coli* standard for full body contact is a better indicator of the potential for human gastroenteritis. The 1996 standards kept fecal coliform standards (1000 cfu/100 ml geometric mean; 2000 cfu/100 ml 10% of samples over 30 days; and 4000 cfu/100 ml single sample maximum) for other designated uses.

POLLUTANTS OF CONCERN

Dating from the early 1970's, a seasonal pattern of elevated fecal coliform bacteria has been found at Slide Rock State Park. Slide Rock is known principally for a series of natural sandstone 'slides' and pools and has become an extremely popular recreational resource within Oak Creek Canyon. Periodic exceedances of the bacteria standard have led to temporary closures or swimming advisories imposed by Coconino County Environmental Health Services (CCEHS). The Arizona Department of Health Services (ADHS) conducted an intensive water quality survey of Oak Creek from March to November, 1983 (ADHS, 1985). In 1985 the Arizona State Parks Service began limiting the number of visitors to Slide Rock State Park (ADEQ, 1989). Although water quality conditions have reportedly improved since 1985, bacteria counts still periodically exceed standards during summer months. Prior to 1996, exceedances applied to the fecal coliform standards; since 1996, exceedances apply to both *E. coli* and fecal coliform.

Bacterial Investigations/Data Analysis

Reportedly, NAU has a database with over 19,000 entries containing historical data collected since 1958 for Oak Creek (Foust, 1999). The following table (Table 1) is not exhaustive, but rather reflects a cross-section of studies from the 1960's, 1970's, 1980's, and 1990's that dealt at least in part, with bacterial investigations.

Table 1. Cross-section of Bacterial Investigations: 1968-1998

Year	Agency	Location(s)	Parameter	Media	Result Highlights	Comments
1968, 1969, 1970	ADHS	Banjo Bill, Slide Rock, Indian Gardens, Chavez Crossing, Page Springs	Fecal coliform	surface water	1968: levels too numerous to count (TNTC) at Banjo Bill, Indian Gardens & Page Springs; Slide Rock elevated but not above standards 1969: Chavez Crossing & Page Springs only above 500 cfu/100 ml 1970: maximum at Slide Rock of 358 cfu/100 ml; maximum at Page Springs of 1100 cfu/100 ml	NOTE: variability
1973	ADHS	Several sites in Oak Creek Canyon and below Sedona	Fecal coliform	surface water	Canyon: Rainbow Trailer Park at Indian Gardens above 200 cfu/100 m (also high P); Below Sedona: Red Rock Crossing, Lolamai Trailer Park, above and below Page Springs all above 200 cfu/100 ml (last 3 also high P)	Below Pumphouse Wash: 40 cfu/100 ml Mouth of West Fork: 220 cfu/100 ml Rainbow Bridge: 303 cfu/100 ml Red Rock Crossing: 448 cfu/100 ml Lomalai Trailer Park: 452 cfu/100 ml Above Page Springs: 430 cfu/100 ml Below Page Springs: 1050 cfu/100 ml
1975, 1976,1977, 1978, 1979	Forest Service	Several sites along Oak Creek	Fecal coliform Fecal strep	surface water	Range of values from 0 to TNTC Ratio of fecal coliform to fecal streptococcus was <1.0 in most cases, except Slide Rock	FC:FS <1.0 animals FC:FS >1.0 < 4.0 ? [4.0 = human indicator]
1976	Forest Service	Slide Rock	Fecal coliform Fecal strep	stream sediment	FC:FS exceeded 4.0 twice; FC:FS <1.0 50/63 samples; FC:FS >1.0 but <4.0 11/63 samples Large increase observed between July 6 and August 9: 790 to >2,400,000 cfu/100 ml Single sample from upper reaches showed no FC on July 6	Fecal streptococcus species: *avium 29.31%* (chicken, dogs, pigs, man) *bovis 1.73%* (cows, sheep, dogs, poultry) *equinus 1.03%* (horses, cows, deer, dogs moose, rodents, migratory waterfoul) *durans 11.72%* (man, mammals) *faecium 16.55%* - (cows, sheep, rodents) *faecalis 23%* - (man alone)

Table 1 continued. Cross-section of Bacterial Investigations: 1968-1998

Year	Agency	Location(s)	Parameter	Media	Result Highlights	Comments
1977	NACOG & ADHS	31 sites along Oak Creek	Fecal coliform Fecal strep	surface water	Four sites above 200 cfu/100 ml Concluded that creek has ability to recover from bacterial loading Wastewater sources present, but system capable of self-mitigation	Forest Houses Spring 1: 240 cfu/100 ml FC:FS 0.80 Chavez Crossing: 260 cfu/100 ml FC:FS 1.04 Oak Creek Mobilodge: 730 cfu/100 ml FC:FS 2.52 End Oak Creek School Rd: 250 cfu/100 ml FC:FS 1.64
1982	Forest Service	Slide Rock	Fecal coliform	surface water	Two samples above 800 cfu/100 ml; Five samples above 150 cfu/100 ml General trend of increasing coliforms with increasing visitors	Recommended limiting number of visitors (250-300 at the time)
1985	ADHS	31 sites along Oak Creek	Fecal coliform, Fecal strep, N&P etc.	surface water	Transects showed near-bank elevations in conductivity; 7/22 and 10/22 samples at Slide Rock above 200 cfu/100 ml	Below Slide Rock, at Indian Gardens, and at Sunset Trailer Park Highest values: 1100 July 4th (FS 4500) 1200 Sept 5 (FS 2000)
1988	ADEQ	38 sites (and seeps) along Oak Creek	Fecal coliform, Fecal strep, N&P etc.	surface water	Higher values at storm water sites & locations below Sedona Other high values at Hwy.. 179 bridge & Red Rock Crossing 3/15 sites above 200 cfu/100 ml located above Slide Rock Slide Rock sites blw 120 cfu/100 ml	Westview Motel: 6,000 cfu/100 ml & Dry Creek blw Hwy. 89A: 30,000 cfu/100 ml Hwy. 179: 12,000 cfu/100 ml Red Rock Crossing: 11,000 cfu/100 ml Chipmunk Lodge: 500 cfu/100 ml Cave Springs: 260 cfu/100 ml abv West Fork: 208 cfu/100 ml No FC:FS over 3.5 Cryptosporidium & Giardia w/FC&FS
1987, 1988	ADEQ	7 alluvial wells 15 deep regional wells	Fecal coliform	ground water	Detected in two shallow wells in Canyon ; one resort well in Sedona	10 cfu/100 ml; nitrate-nitrogen 0.4 mg/L & 2.0 mg/L

Table 1 continued. Cross-section of Bacterial Investigations: 1968-1998

Year	Agency	Location(s)	Parameter	Media	Result Highlights	Comments
1993	ADEQ	3 alluvial wells along Oak Creek	fecal coliform	groundwater	One well showed 300 total coliform (~60 fecal coliform)	Ground water at 10 feet below land surface; aquifer connected to stream
1994-1998	NAU (National Monitoring Network Project)	4 locations, upstream & downstream: Pine Flats, Slide Rock, Manzanita & Grasshopper Point	fecal coliform, N&P etc.	surface water; stream sediment	Slide Rock highest values; showed 14 exceedances; Grasshopper Point showed two exceedances; Campgrounds relatively low; Pine Flats Subdivision (1994 MS Thesis)	Pattern corroborated earlier results Sediment reservoir builds at Slide Rock over summer months No significant difference after 1996 BMPs
Academic Studies						
1980	NAU Masters Thesis	3 sites at Slide Rock	fecal coliform, N&P etc.	surface water	No significant relationship between site sample points, weekends and holidays, holidays vs. weekdays, or when raining Highly significant relationship between nutrients and date	Found negative correlation between number of swimmers and nitrate below last slide - attributed to algal uptake Concentrations declined steadily over the summer (nitrate, phosphate, & Kjeldahl)
1983	UofA	Pine Flats, Slide Rock, Indian Gardens, Grasshopper Point, and Red Rock Xing	fecal coliform, coliphage, enterovirus	surface water	Fecal coliform and coliphage detected in 50% of samples, but not correlated with # swimmers 13/30 samples positive for virus	Slight correlation between turbidity and viruses
1985	Uof A Masters Thesis	Pine Flats, Slide Rock, Indian Gardens, Grasshopper Point, and Red Rock Xing	bacteria & viruses	surface water & ground water	High bacteria counts are Slide Rock, Indian Gardens Intermediate levels at Grasshopper Point Enteroviruses were isolated	Poliovirus 1 (poliomyelitis) Echovirus 1 (meningitis, fever) Coxsackie B1 & B6 (meningitis, respiratory infection, myocarditis) Rotavirus (diarrhea, gastroenteritis)
1994	NAU Masters Thesis	2 subdivisions 2 campgrounds 2 swimming areas	complete suite	surface water	Transects showed either east or west bank higher in nutrients & conductivity at some locations	Pine Flat Subdivision ‘plume’ but transitory

Historically, it was thought that recreational pressure was the primary cause of bacterial contamination in Oak Creek, with the additional possibility of septic seepage. Initial work was conducted by Obr et al. (1970) from 1968 to 1969 (as cited in NACOG, 1978). From that time forward, ADHS and CCEHS participated in cooperative investigations with the Northern Arizona Council of Governments (NACOG), U.S. Forest Service (USFS), U.S. Geological Survey (USGS), Yavapai County Health Department (YCHD), the Arizona Game and Fish Department (AGFD), and others, to assess the water quality along Oak Creek. In addition, various universities have also conducted studies along the creek.

The 1983 ADHS study examined water quality at several stations along Oak Creek and its tributaries. With the exception of fecal coliform, chemical and physical data suggest excellent water quality for fisheries, recreation, and agricultural use, as well as a drinking water source. The stream is moderately hard (130 mg CaCO3/L), alkaline (pH 8 SU), and maintains dissolved oxygen levels at or above saturation (8-10 mg/L). Water temperature in the upper canyon remains less than 20 degrees centigrade. At lower elevations, water temperature can reach 29-30 degrees in hot summer months. Historical data indicate that total nitrogen values fall between 0.3 mg/l and the annual standard of 1.0 mg/L. Total phosphorous levels show a range between 0.04 mg/L and 0.10 mg/L. Background levels of phosphorous in ground water may be as high as 0.09 mg/L in some areas due to the influence of particular geologic formations.

Although the Slide Rock area has seen the most consistent fecal coliform bacteria violations, there have been other locations along Oak Creek where high levels have been recorded, particularly during the mid to late 1970's. Many of these reported violations could not be later corroborated, but the other key areas of concern have been below Sterling Springs Hatchery, Indian Gardens/Rainbow Trailer Park, Poco Diablo Resort (Chavez Crossing), and just above Page Springs at Lolamai Trailer Park and Sunset Trailer Park (Figure 3).

BACKGROUND

Watershed Description

Oak Creek arises from the southern rim of the Colorado Plateau about 10 km southwest of Flagstaff, Arizona (Figure 1). The stream flows 21 miles in a southwestern direction to join the Verde River near Cornville, Arizona. Oak Creek drops 2500 ft through a steep-walled canyon in the upper reaches to more gently rolling hills and plateaus in the lower reaches. The creek originates from springs located just above Sterling Springs Fish Hatchery and is augmented by discharge from West Fork of Oak Creek, Munds Creek, springs near Indian Gardens, and additional springs located near Page Springs Fish Hatchery and Spring Creek. Oak Creek drains a 610 square-mile watershed, most of which is within the Coconino National Forest (NACOG, 1978)

Geology

The first comprehensive investigation of geology in the Oak Creek area was made by Twenter and Metzger, 1963 (USGS Survey Bulletin #1177). Levings provided a review of ground water hydrology (Arizona Water Commission Bulletin #11, 1980). Oak Creek Canyon resulted from uplift of the 600 million year old Colorado Plateau near Flagstaff. This edge is distinguished by the Mogollon Rim, an erosional rampart 900-4500 ft high. The contemporary canyon follows an earlier Oligocene canyon and

fault. Near its head, Oak Creek Canyon is 1500 feet deep and relatively narrow; descending about 12 miles to Sedona, the Canyon drops to 2500 feet and opens to almost a mile across. As the creek flows south it is flanked by tall 600-ft colorful cliffs of Permian-age Kaibab Limestone, Toroweap Formation, and Coconino Sandstone.

Near Slide Rock, a series of deep, fluviatile pools were formed in the red sandstone of the Supai Formation. Farther downstream, near Wilson Canyon, the creek has carved a gorge in the exposed Redwall Limestone. Approaching the town of Sedona, the canyon opens to a spectacular series of high red sandstone buttes (part of the Supai Formation). South of Sedona, the creek has developed incised meanders, flowing across an ancient lakebed (Verde Formation). Parts of this area are capped by gray lava buttes and mesas with chalky gray-white lake deposits (ADHS, 1985).

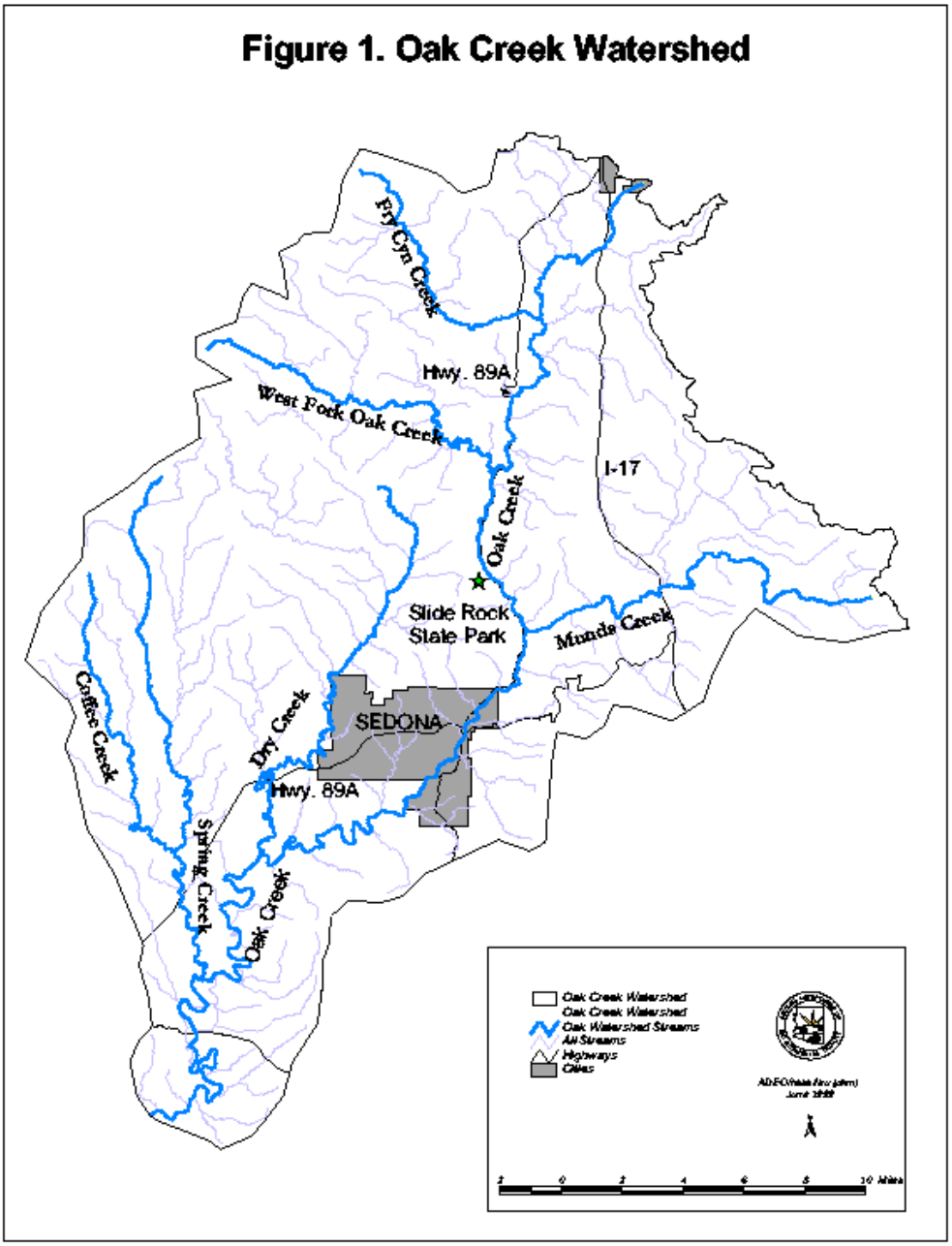
Soils

Soils in the watershed vary considerably with elevation and terrain (Arizona Dept. of Water Resources, 1986). The soils southeast of Flagstaff, where the elevations range from 4700 to 6500 ft are dominated by the Winona-Boysag association. These soils are shallow and have textures ranging from gravelly loam to clay and lie over limestone or calcareous sandstone bedrock. South and west of Flagstaff, where the elevations range from 6500 to 7500 ft, the dominant soils are of the Brolliar-Sponseller association. These soils are moderately deep to deep and are moderately fine to fine in texture. In the higher elevations below the Rim, the soils are of the Mirabal-Dandrea-Brolliar association which are moderately deep to deep, gently sloping to steep, and lying on basaltic bedrock. Further south the soils are part of the Rough Broken land association that make up the canyon walls and cliffs of the Sedona area. Because the main components of these units are excessively steep and/or rocky slopes, they are rated as severely limited for all uses. Coconino County ordinance prohibits development on lands with slopes in excess of 25 percent. Alluvium, where present within the Canyon, is relatively shallow in areas where bedrock in close to the surface.

For hydrologic purposes the Natural Resources Conservation Service (formerly the Soil Conservation Service) classifies soils by their general proclivity to produce runoff. Four hydrologic soils groups are recognized: types A, B, C, and D. Types C and D, with higher potential for runoff, are present above the Rim and below Sedona.

Hydrology

The Oak Creek watershed boundary is shown in Figure 1. Oak Creek originates from a series of springs at the head of Oak Creek Canyon. Water recharging from the Mogollon Rim percolates through the Coconino Sandstone and fractures along the Oak Creek fault, feeding the upper reaches of Oak Creek. Baseflow near the headwaters of Oak Creek is approximately 3-5 cfs; with tributary and ground water contributions, baseflow increases to approximately 18 cfs at Slide Rock and 24 cfs at the Sedona gage. From Sedona to Cornville, Oak Creek is a losing reach; baseflow near the Verde River drops to 21 cfs. The average discharge of Oak Creek at the Cornville USGS gage is 83.4 cfs with a maximum of 12,000 cfs, showing the extreme variability in seasonal flow.



The regional aquifer is composed of the Verde Formation, Coconino Sandstone, Supai Formation, Redwall Limestone, Martin Formation, and Tapeats Sandstone. Regional ground water flow is to the southwest, with the exception of a small region of north and northeasterly flow above the Rim. Ground water depths range from 200 to over 500 feet below land surface. Seeps and springs feed the alluvium along the Creek, supplementing baseflow from the regional aquifer. Water is present in the alluvium and is in hydraulic connection with the flow in the creek (Levings, 1980). In general, the portion of the watershed below the Rim experiences little or no recharge in summer months. During the winter there may be some recharge when precipitation exceeds evaporation.

There are five major tributaries to Oak Creek: Pumphouse Wash, West Fork, Munds Canyon, Dry Creek and Spring Creek. Oak Creek and West Fork are the only perennial streams. Severe monsoons in summer and high runoff periods in spring generate frequent flooding, especially in the middle to lower portions of the watershed where the geology consists of easily eroded formations and shallow soils. Surface water is chemically similar to ground water, with the exception of summer increases in total dissolved solids (TDS) from irrigation return flow and evaporation. There is a general increase in ionic composition as water flows from Sterling Springs to the Verde River (ADHS, 1985).

Climate

Due to the 2500-ft elevational difference, climatic conditions are difficult to summarize. The climate is characterized by extreme temporal and spatial variations in precipitation and temperature. Storms generally move into the area from the south and southwest. Winter storms commonly distribute low-intensity precipitation over a large area and may last for several days. Major flooding can occur when rain falls on snow or when rainfall is abnormally intense. During July, August, and September, convectional storms of high intensity are common; however, such storms are usually localized and of short duration.

In general, the upper portions of Oak Creek Canyon receive approximately the same precipitation as the Mogollon Rim (35 inches/yr), falling predominantly as snowfall. By the time the canyon opens at Sedona, precipitation is reduced on average to 17.5 inches/yr, with about 60% falling as snow. The lowest section of Oak Creek receives approximately 12-15 inches/yr, almost all of which is rainfall.

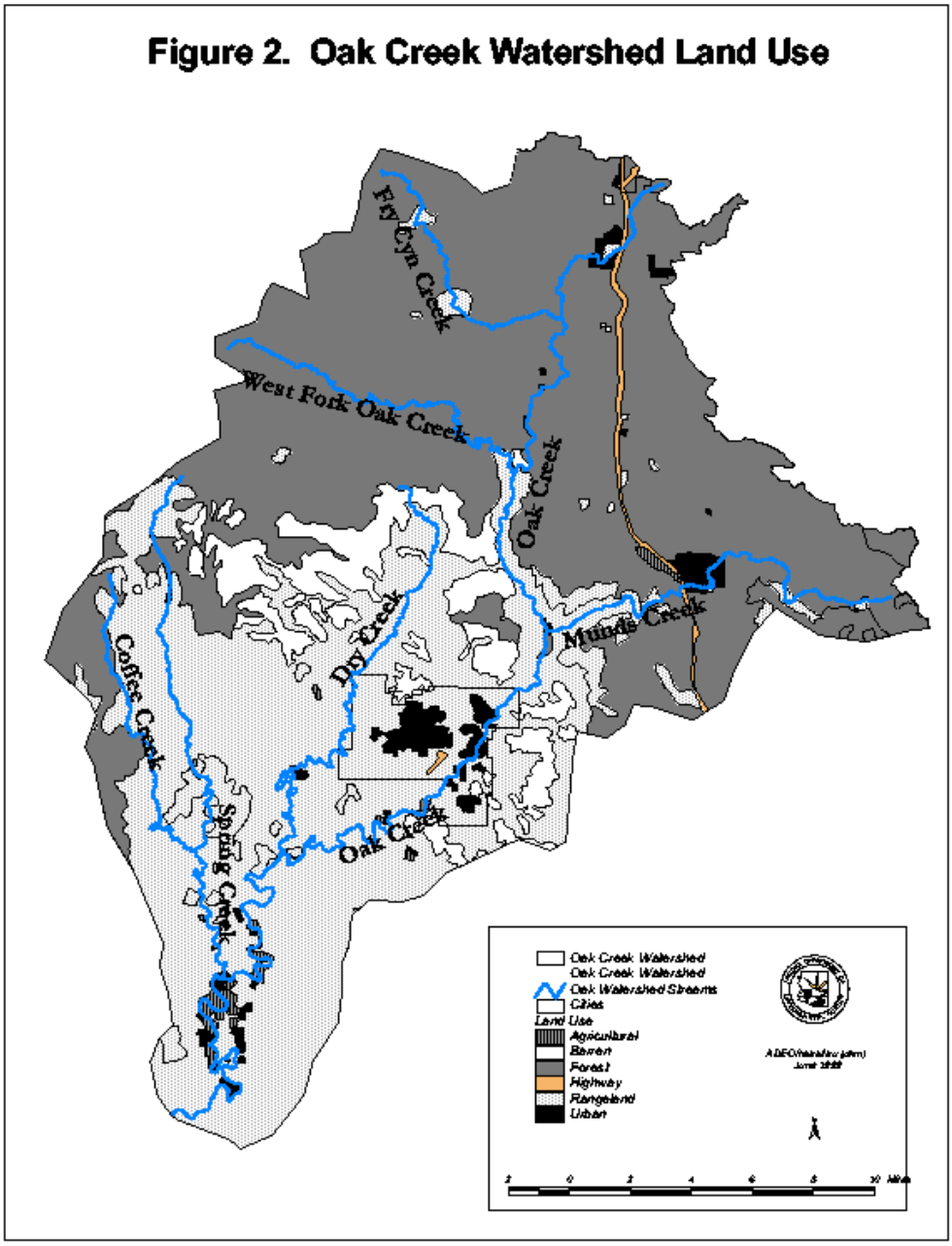
Ecology

Vegetation within Oak Creek Canyon was divided into five major communities by Aitchison and Theroux in 1972 (as cited in ADHS, 1985). Beginning at the head of the canyon and moving downstream, the communities are: Ponderosa Pine-Douglas Fir Forest, Chaparral, Pinon-Juniper Woodland, Oak Woodland, and Cypress-Juniper Woodland. Oak Creek takes its name from dense stands of Gambel's Oak and Arizona Oak.

Riparian communities along the creek are divided into upper and lower, with the West Fork serving as a demarcation. The upper riparian community is dominated by alder, box elder, and ash. The lower community is dominated by sycamore, cottonwood, and walnut. Below Sedona, the creek passes through semi-desert grassland before reaching the Verde River corridor, which is again dominated by sycamore and cottonwood, in addition to willow.

Land Use

Land use in the watershed is predominantly forest, owned and managed by the United States Forest Service (Figure 2). Above the Mogollon Rim forest lands are managed for wildlife and timber production. A few grazing allotments are located in the upper watershed, the largest of which is the "Windmill Allotment"(USFS, personal communication). There is relatively little private land within the upper watershed. The communities of Kachina Estates, Mountainaire, and Pinewood (Munds Park), drain to Oak Creek via either Pumphouse Wash, above Slide Rock, or Munds Creek, below Slide Rock.



Upper Oak Creek Canyon from the Mogollon Rim down to Pine Flats Campground is also almost entirely publicly owned under the management of the US Forest Service. The only development above Pine Flats is a fish hatchery at Sterling Springs, owned and operated by the Arizona Game and Fish Department since the early 1900s.

There are a total of 435 acres of private lands within the Canyon; 402 acres are separately assessed. Five hundred and forty five structures exist, including single family dwellings, mobile homes, travel trailers, resort facilities, and commercial buildings. There are approximately 90 acres (102 separately owned parcels) of flood prone private property subject to high velocity flood waters. In particular there

are at least 20 single family residences and 150 trailers that may be threatened by these events (NACOG, 1978; CCEHS, 1984).

Highway 89-A is a major north-south artery. Numbers are approximate, but daily vehicular traffic has increased from less than 5000 vehicles/day in 1981 to 6500/day in 1993. Put in perspective, the entire Oak Creek Canyon has parking spaces for 1,630 vehicles and a capacity for 4,890 daily visitors. The Forest Service estimates that 7 million people visit Sedona/Oak Creek throughout the year. Of those 7 million visitors, about 5 million travel through on 89-A, one million visit publicly owned recreation sites in Oak Creek Canyon, and 300,000 visit Slide Rock State Park (Stafford, 1993) Recreation in the form of camping, picnicking, fishing, and swimming is a major land use within the canyon. From 1969 to 1981, visitor days increased over ten-fold at popular locations such as Slide Rock and Grasshopper Point, which are both day-use areas only. One visitor day represents 12 hours of use. Oak Creek Canyon is surpasses only by the Grand Canyon in popularity and visitation, and represents an extremely valuable natural resource to Arizona and local communities.

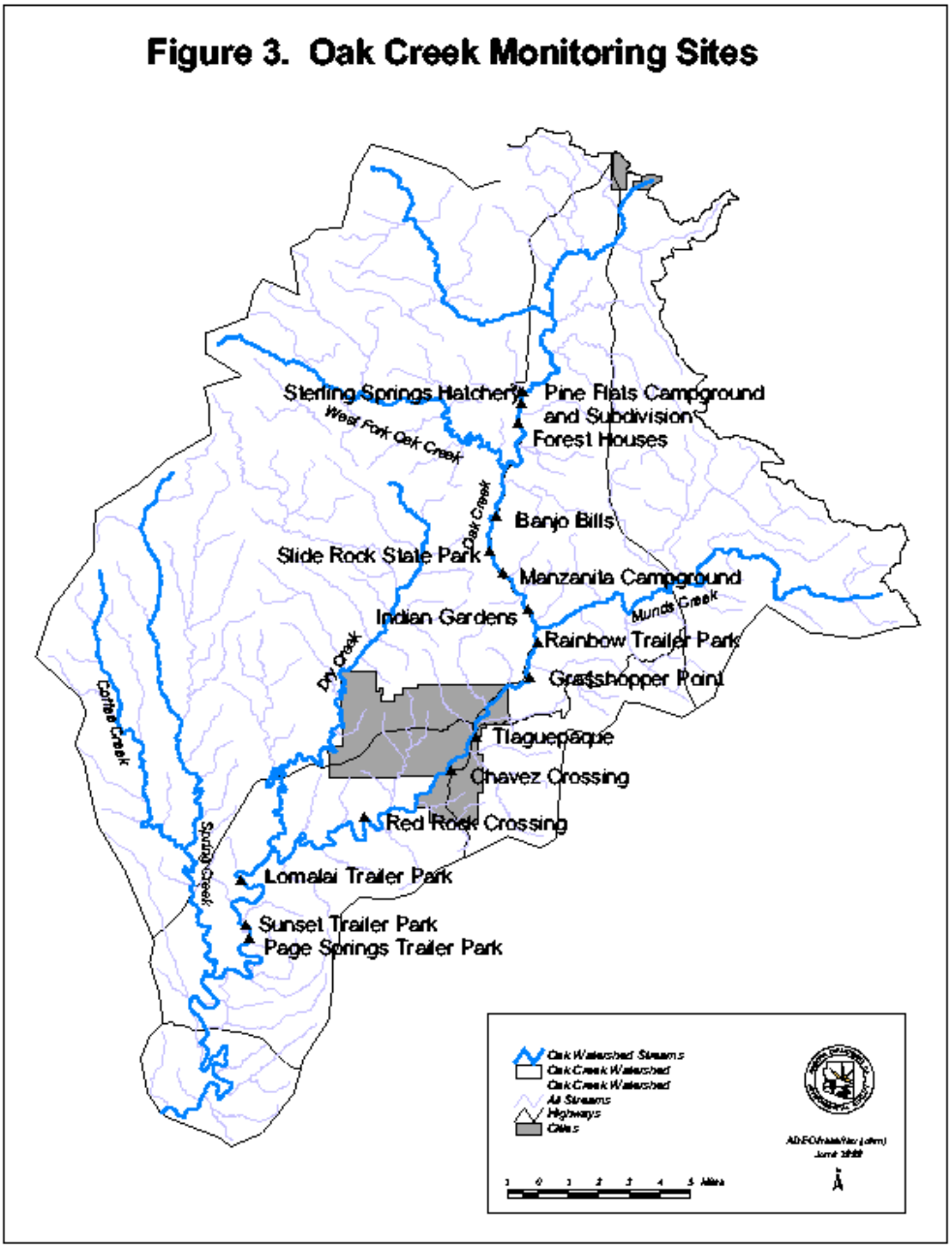
Residential Development

Pockets of private land are interspersed with Forest Service land and State parks. As of 1982, Coconino County ordinance specified that all development of private lands within the canyon would be restricted to single family uses at a density not to exceed one unit per "net developable acre" (the gross or total land area proposed for development minus that portion of the property within the floodway of Oak Creek and that portion where existing slopes exceed 25 percent) (CCEHS, 1984). Figure 3 depicts the developed areas within Oak Creek Canyon and their relationship to Slide Rock. Appendix B contains more detail on each developed area.

IN-STREAM & NONPOINT SOURCE ISSUES

Septic systems are the dominant means of waste disposal within Oak Creek Canyon. It is likely that with almost 400 residences and several commercial facilities above Sedona, few of these facilities are connected to the city sewer. Though the exact number of septic systems has not been confirmed, estimates range from 125 to 150 septic systems above Slide Rock, and an additional 150 to 175 below the Park (Morgan Stein, personal communication). In 1982, Coconino County reported a population of 84 residing in the floodplain.

In general, soil depth varies and conditions are less than optimum for percolation. Bedrock surfaces in numerous locations along the creek. Many of the septic systems within the canyon are more than 25 years old and their status is unknown. With these conditions in mind, it is possible that aging septic systems are contributing to fecal contamination. The Coconino County Environmental Health Department is currently conducting a survey of the number and status of systems in the Canyon, and within the year, is scheduled to begin a demonstration project to test and replace selected systems.
Historically, it was thought that recreational pressure was the primary cause of bacterial contamination in Oak Creek, with the additional possibility of septic seepage. Initial work was conducted by Obr et al.



(1970) from 1968 to 1969 (as cited in NACOG, 1978). From that time forward, ADHS participated in cooperative investigations with the Northern Arizona Council of Governments (NACOG), U.S. Forest Service (USFS), U.S. Geological Survey (USGS), Yavapai County Health Department (YCHD), Coconino County Environmental Health Services (CCEHS), the Arizona Game and Fish Department (AGFD), and others, to assess the water quality along Oak Creek. In addition, various universities have also conducted studies along the creek.

The 1983 ADHS study examined water quality at several stations along Oak Creek and its tributaries. Generally, chemical and physical data suggest excellent water quality for fisheries, recreation, and agricultural use, as well as a drinking water source. The stream is moderately hard (130 mg CaCO3/L), alkaline (pH 8 SU), and maintains dissolved oxygen levels at or above saturation (8-10 mg/L). Water temperature in the upper canyon remains less than 20 degrees centigrade. At lower elevations, water temperature can reach 29-30 degrees in hot summer months. Historical data indicate that total nitrogen values fall between 0.3 mg/l and the annual standard of 1.0 mg/L. Total phosphorous levels show a range between 0.04 mg/L and 0.10 mg/L. Background levels of phosphorous in ground water may be as high as 0.09 mg/L in some areas due to the influence of particular geologic formations.

Although the Slide Rock area has seen the most consistent fecal coliform bacteria violations, there have been other locations along Oak Creek where high levels have been recorded. Some of these reported violations could not be later corroborated, but the other key areas of concern included sites just below Sterling Springs Hatchery, Indian Gardens/Rainbow Trailer Park, Poco Diablo Resort (Chavez Crossing), and just above Page Springs at Lolamai Trailer Park and Sunset Trailer Park (Figure 3).

EXISTING MANAGEMENT PLANS FOR NONPOINT SOURCE ACTIVITIES

Several management plans address activities within Oak Creek Canyon. The primary management agencies include ASPs, USFS, ADEQ, and CCEHS. In addition, the Oak Creek Property Owners Association and the Pine Flats Property Owners Association has community bi-laws applicable to private lands. Management plans are outlined in Section VIII. TMDL implementation will be integrated into existing management plans where possible.

III. NUMERIC TARGETS

EXISTING CONDITIONS

As outlined above, the Slide Rock swimming area has been found to periodically exceed surface water quality standards for fecal coliform bacteria and/or *E. coli*. Despite BMP implementation and facility upgrades dating from 1996, data collected between 1996 and 1998 by the National Monitoring Program (NAU, 1998) do not show a statistically significant decrease in bacterial levels. As *E. coli* data were not collected routinely prior to 1996, comparison of pre-BMP conditions to post-BMP conditions must be approached in multiple ways: 1) analysis of available water column data for fecal coliform, 2) analysis of available water column data for *E. coli*, 3) analysis of the apparent relationship between water column data for fecal coliform and *E. coli*, 4) analysis of sediment data for fecal coliform and *E. coli*, and DNA typing of *E. coli* for source identification.

In conjunction with Oak Creek's designation as a "Unique Water" (A.A.C. R18-11-112), more stringent surface water quality standards were established to protect recreational and ecological status. Arizona's Antidegradation Rule (AZ Administrative Code Rule 18, Chapter 11, Section 107) specifies "Unique Waters" as Tier 3 waters for protection purposes; under this designation, Oak Creek water quality may not be degraded. Oak Creek also carries specific water quality standards for pH, nitrogen, phosphorous, dissolved chromium, and turbidity. Areas where camping and water recreation occur are particularly sensitive. However, despite heavy recreational pressure, water and habitat quality are generally good; Oak Creek has met or exceeded most of its water quality standards over the years, with

the exception of fecal coliform levels.

The NMP study (1994-1998) demonstrated that fecal coliform builds to very high levels in Oak Creek sediments, particularly in low gradient areas like Pine Flats, Slide Rock, and Grasshopper Point. Based on the added risk from swimmers stirring the sediments, the first numeric target for this TMDL is sediment fecal coliform. It is assumed that if sediment levels can be sufficiently reduced, much less will be available for resuspension in the water column. As there is no sediment fecal coliform standard, and the ratio of sediment fecal coliform to water fecal coliform varies, setting numeric targets will be difficult. However, this TMDL proposes a stepped/iterative approach that, along with conscientious management of recreational areas, is designed to protect public health.

MONITORING STRATEGY

DNA typing for source identification of *E. coli* will be ongoing until the summer of 2000. Isolates have been obtained from elk, deer, cattle, horses, dogs, racoons, beaver, mountain lion, bear, and humans (method pursuant to Keim, et al., 1997). Thus far, results from this portion of the project show that elk and other hoofed mammals are a significant source of bacteria to the creek, contributing approximately 40% overall to the bacterial pool (NAU, 1998). Humans (approximately 50%) and an "unidentified mammal pool" make up the remainder. Initial findings do not indicate cattle or dogs to be major

contributors, but further work is needed to characterize the "unidentified pool" of bacteria found in the upper canyon below Pumphouse Wash.

In addition to DNA typing, this project is looking at the distribution of apparent sources using a diversity index of *E. coli* isolates. The diversity of *E. coli* is first calculated for individual host animals (e.g., cow 1, cow 2, dog 1, dog 2, etc.), and then for the overall animal type (e.g., cows, dogs, humans, etc.). Work is ongoing to examine the diversity of the overwintering population and compare it to the early spring population; results will be used to analyze the mixed-source population that accumulates during the summer. Overwintering and/or regrowth may be more significant than previously thought. The establishment of a significant sediment reservoir from which bacteria become resuspended by swimmers and storm events is a major contribution. The assumption from previous studies that fecal coliform bacteria loading was 'mitigated' through assimilation and die-off does not appear to hold. In addition, under favorable environmental conditions, fecal coliform may be actually growing in sediments. Further investigation is recommended into the effects of temperature, nutrient supply, available oxygen, and organic matter. Regrowth of *Klebsiella* was found to occur in warm, shallow enriched sediments at Lake Havasu (ADEQ, 1998).

NUMERIC TARGETS

The test for Fecal coliform bacteria has been used as an indicator of human pathogenic risk for over thirty years. This group of bacteria, a subset of Total coliform bacteria, include several that can live and reproduce at 44.5 degrees centigrade, a temperature that only coliforms from the intestine of warm-blooded animals can tolerate (Microbiology, 1990).

The more specific standard for *E coli* was adopted in 1996 for protection of Full Body Contact (recreation & swimming). *E coli*, one of the fecal coliform group (a subset of total coliform), has

become the most cost-effective, reliable, and preferred indicator for risk evaluation in regard to potential human gastro-enteritis and related illnesses. Other heat-tolerant bacteria may be present in the environment and can yield false positive results in a test for fecal coliform.

Numeric targets identified in this TMDL include levels of fecal colifrom in sediments, and existing water quality standards for both Fecal coliform and *E. coli* Both indicators are included because 1) Oak Creek was originally listed for Fecal coliform, 2), fecal coliform levels in sediment appear to be driving spikes in water values, and 3) violations of the less restrictive fecal coliform standard have continued to occur since adoption of the *E coli* standard in 1996.

INDICATORS/ENDPOINTS

To ensure ultimate compliance with *E. coli* and fecal coliform standards, ADEQ proposes an approach that will build on previous and ongoing studies, BMP implementation, and stakeholder involvement. Because source identification is not complete, and because fecal contamination in Oak Creek Canyon is complex, the problem will be approached through attainment of a series of benchmarks. ADEQ proposes to meet State pathogen standards through implementation of a percent-reduction approach over the course of a five-year period. Implementation will include continued source identification, source reduction, evaluation of regrowth, improvement/increased application of BMPs, and cooperative/comprehensive long-term monitoring (see Section VIII).

NUMERIC TARGET with regard to EXISTING CONDITIONS

Periodic high levels of fecal coliform bacteria have been recorded at Slide Rock State Park since the early 1970s. Because these spikes corresponded to periods of high recreational pressure, for years the primary source was assumed to be the sheer numbers of bathers coupled with inadequate disposal facilities. Intensive visitation and recreational pressures are still considered a significant contributor, though it seems likely that septic seepage is also a contributor to the human bacterial component. Animal sources have also been implicated as a significant source of both fecal coliform and *E. coli*. Thus, numeric targets will address all potential source contributions.

There is only one mile of Oak Creek listed as “impaired” on the State “Water Quality Limited List” for bacteria. This mile includes the Slide Rock State Park and swimming areas (Figure 1). The National Monitoring Program has established the existence of a sediment plume around Pine Flats, and from West Fork to Grasshopper Point. Numeric targets will be focused on reduction of fecal coliform loading to sediments and water, with corresponding reduction of *E. coli* for the entire watershed above Slide Rock.

V. SOURCE ANALYSIS

Watershed Condition

The Northern Arizona Council of Governments (NACOG) produced two documents in 1978, the Assessment of Nonpoint Sources of Water Pollution, and the Water Quality Assessment. According to NACOG, the Oak Creek watershed covers 390,510 acres, or 610 square miles. More recent delineation of the watershed using GIS places the size closer to 500 square miles (Nix, 1999). Most of the watershed is managed by Coconino National Forest. Small areas are managed by the State Land

Department and private individuals. Coconino County has excavation and grading ordinances which require erosion control measures; the portion of Oak Creek particularly sensitive to erosion includes the watershed below Sedona.

Historically, grazing was a significant land use in the upper watershed. However, as a result of overgrazing, loss of soils to support sufficient vegetation has reduced the carrying capacity of the land severely (NACOG, 1978). Ongoing grazing occurs primarily on the Coconino National Forest with some grazing on State Trust Lands. Water quality data from the 1970s showed increased levels of turbidity where tributaries enter Oak Creek, particularly below Sedona. Both construction and range management may be contributing to sediment loads. There are no mines or major hydrologic modifications in the Oak Creek watershed. The hydrologic modifications that do exist are stock tanks and irrigation diversions, but impacts from these modifications have not been investigated.

Timber harvests occur on a small portion of the watershed (Forest Service land) above the Mogollon Rim. Pollution associated with silviculture has been reported historically, though reduced logging in recent decades makes the current contribution relatively small. Since the late 1960s, changes in management strategy have resulted in an increase in elk and deer populations. Though hunting is allowed, the number of elk above the Rim number approximately 600-800 (AGFD, personal communication). Recreation above the Rim includes fishing, hunting and four-wheeling.

Besides the Sterling Springs Fish Hatchery, the only other historical point source discharge above Slide Rock was from the Kachina Village Wastewater Treatment Plant located several miles up Pumphouse Wash. This facility now has a treatment wetlands and does not discharge. At this time, there are no permitted point source discharges within Oak Creek Canyon; Sterling Springs Fish Hatchery discharges seasonally, but does not meet the flow requirement for obtaining a NPDES permit. Based on its Unique Water status and prescriptions in the Sedona Wastewater Management (208) Plan, new or expanded point source discharges are not currently allowed to be permitted (NACOG, 1988). In addition, if discharges are sought to ephemeral tributaries of the Canyon, it must be demonstrated that there will be no impact on Oak Creek (A.A.C. R18-11-107: Antidegradation Rule).

Potential nonpoint sources in the watershed above Oak Creek Canyon include recreation, forestry activities, wildlife management, grazing, urban runoff, and road construction/maintenance activities. Potential nonpoint sources within the canyon include recreation (camping, swimming, hiking, fishing), residential and commercial, septic systems, wild and domestic animals, and roads. Campground and swimming area facilities are the responsibility of the USFS - Sedona District and the Arizona State Parks Service (ASPs). The Forest Service maintains four campgrounds, a picnic area, and two day-use swimming areas (Banjo Bill and Grasshopper Point). The Forest Service contracts with private concessionaires for operation and maintenance of campgrounds. There has been a concerted effort in the last few years to update toilet facilities, increase trash containers, increase signage, and limit parking. ASPs and USFS are committed to continued improvements.

The 1978 NACOG Assessment found a correlation between increased recreation at Slide Rock and Grasshopper point and increased coliform levels. Illegal RV disposal due to a lack of disposal sites. was also mentioned in this assessment.

Spatial & Temporal Water Quality

Water quality investigations in Oak Creek have been numerous but localized in time or space. In general, the three categories of pollutant investigations include turbidity (suspended sediment), nutrients (nitrogen and phosphorous), and fecal coliform. The 1994-1998 National Monitoring Network Project has been the most comprehensive study of surface water quality within the Canyon to date. Increases in sediment input from the upper watershed occur when there are rain-on-snow events in the spring, and for short duration following a monsoon event. The banks along Oak Creek are well armored with cobbles and boulders and bedrock can be seen in some locations. Elevated nutrients have been observed along some banks in developed areas; this phenomenon needs further investigation in order to link nutrient input with bacterial input (Wan, 1994; Foust, personal communication).

The 1987 nutrient TMDL is currently being reviewed through application of a watershed simulation model (BASINS). Evidence of excessive productivity or sediment-related degradation does not appear to be forthcoming. Overall, water quality within Oak Creek is very good with isolated pockets of higher phosphorous or turbidity (suspended sediment) attributed to local geology and the natural reduction of native soils.

Critical Conditions

Critical conditions identified in this bacteria TMDL include 1) high visitation and concentrated recreational pressure, 2) inadequate waste disposal facilities, 3) aging septic systems in close proximity to the creek, 4) highly permeable soils/rapid drainage, 5) small lot size, 6) high density, 7) well locations, 8) the influence of springs, 9) surface runoff, and 10) animal impacts. Historically, access to the creek has not been limited, apart from private lands. The Forest Service has suggested a plan to limit and/or better control general access. This plan may include a system to shuttle visitors in and out of the Canyon to recreational 'nodes' focused on a particular activity such as swimming, hiking, or fishing. However, the switch to increased day use may mean additional camping above the Mogollon Rim; care must be taken not to simply displace the problems. Some fencing or other means of animal control is also under consideration. Potential problems associated with failing septic systems include: 1) age of the system, 2) shallow soil depths, 3) inadequate percolation, 4) proximity to the creek itself, and 5) subsurface flows. The risk of pathogens from septage is high; to date, however, assimilative capacity for nutrients in Oak Creek appears adequate.

Data from National Monitoring Program

Several points need to be made regarding National Monitoring Program results. First, data were collected weekly; this means there is less resolution to draw conclusions than if the data had been collected daily. As Figure 4 shows, there was a weak correlation between discharge (flow) and fecal coliform in water over the 4-yr period. Load calculations based on these results would not be advised.

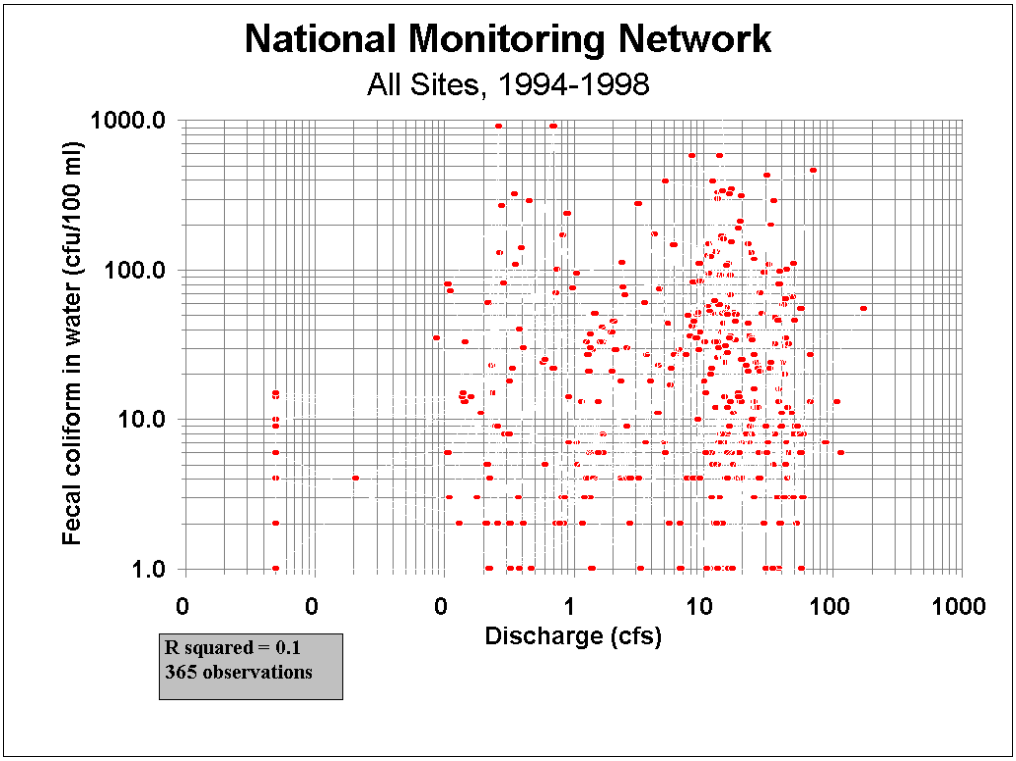


Figure 4.

Second, as Figure 5 demonstrates, there appears to be a relationship between *E. coli* levels in water and the number of visitors present at Slide Rock (1998). Looking at Figure 5, spikes appear to occur more frequently following high use days.

However, linear regression on summer data produces a correlation coefficient of 0.2, which is only slightly better than previously obtained for water values vs. flow (Figure 6).
The relationship between fecal coliform levels in water and summer precipitation/runoff is even more unclear. Though summer storms may mobilize coliform in sediments and contribute to water column spikes, this was not demonstrated through regression analysis (Figure 7).

Increasing the resolution to daily monitoring (data collected by ASPs), a regression of *E. coli* on temperature produces a correlation coefficient of 0.4 (Figure 8). Interestingly, a backwards stepwise regression also indicated that temperature is most highly correlated to coliform values (Tables 3 and 4).

Figures 9 and 10 demonstrate the general pattern of fecal coliform exceedances in the summer, and the development of a sediment reservoir. Regression of sediment fecal coliform vs. water fecal coliform produces a correlation coefficient of 0.3 Figure 11). Using this relationship as one possible method to predict the necessary level of reduction in sediment fecal coliform in order to achieve water column standards (assuming all fecal coliform is *E. coli*), a 90% reduction would be required.

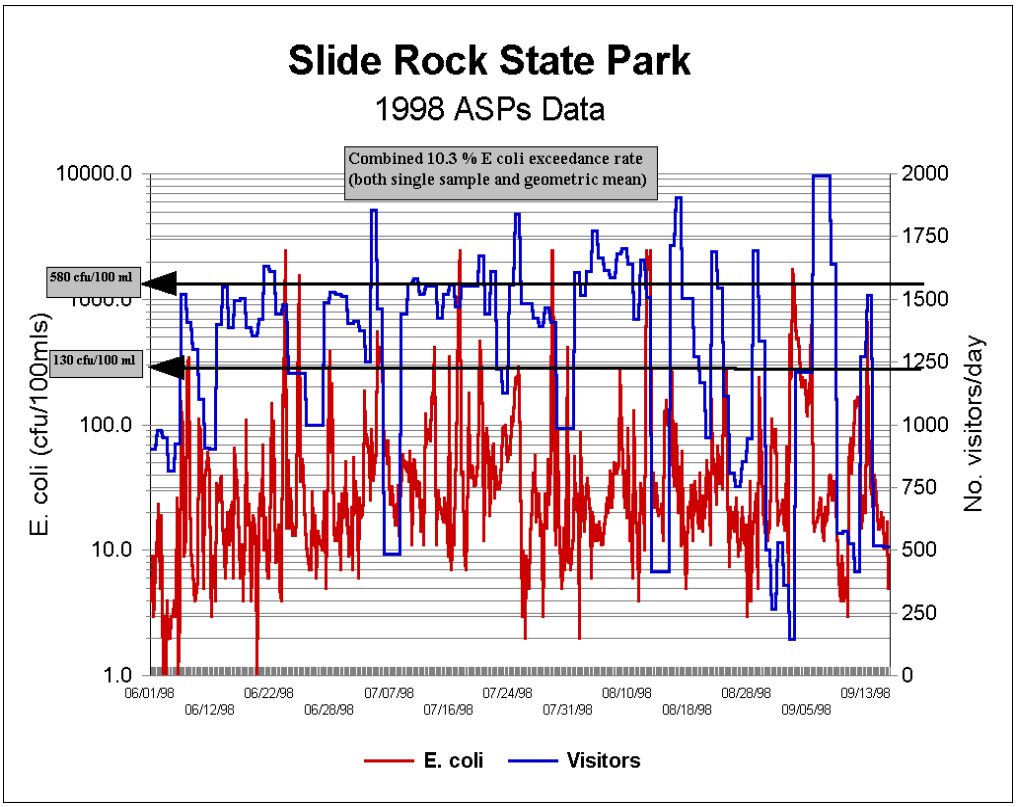


Figure 5

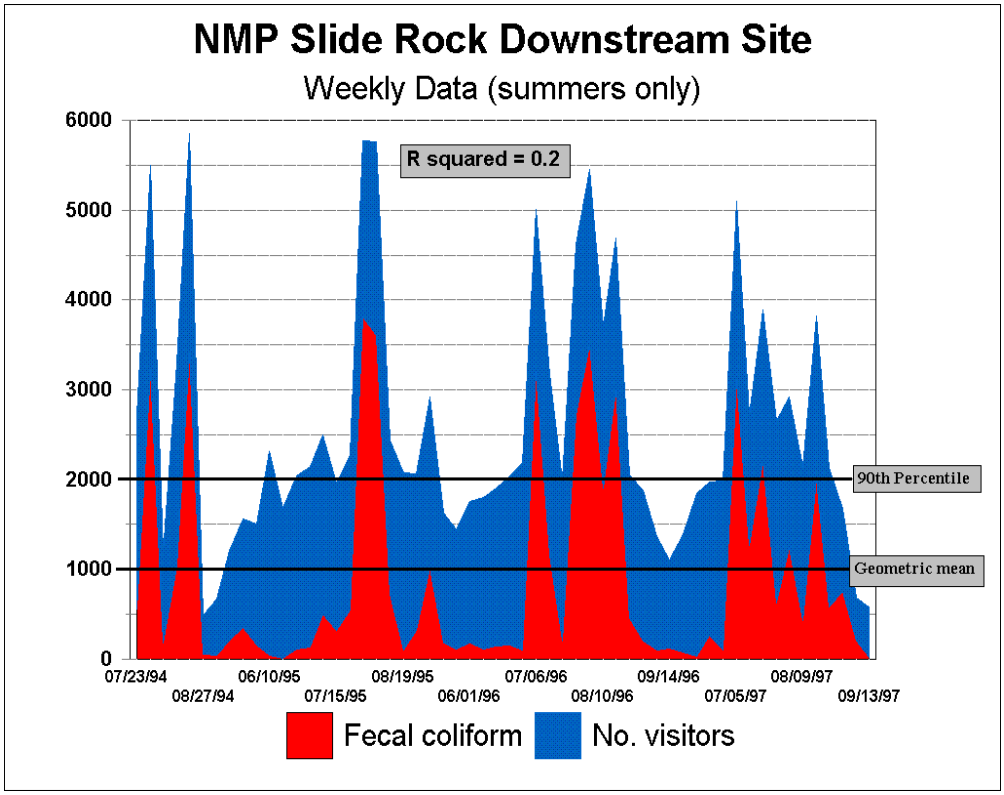


Figure 6

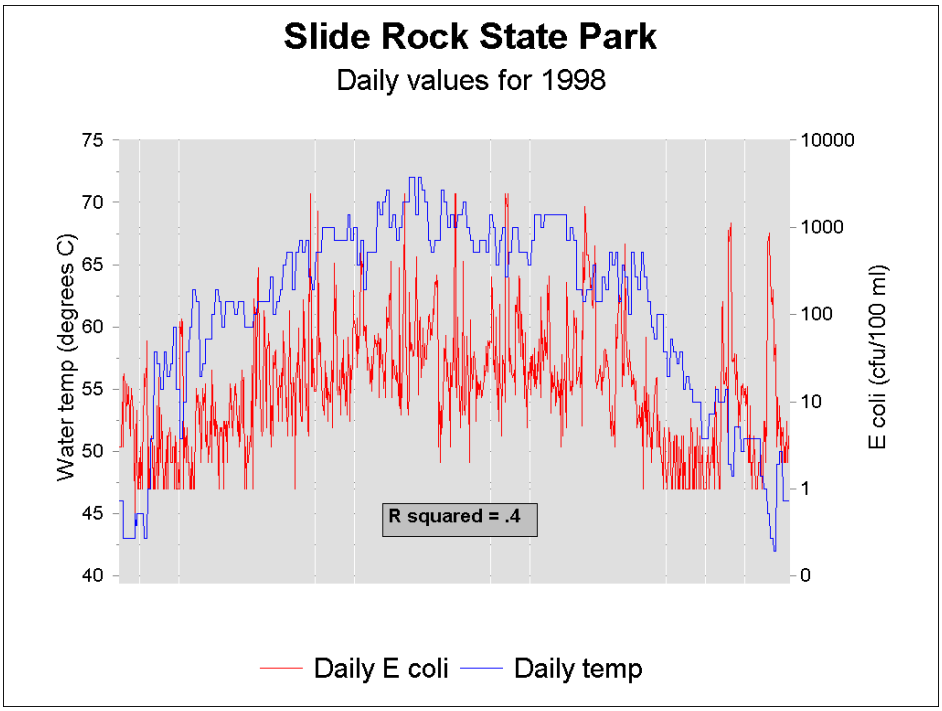


Figure 7

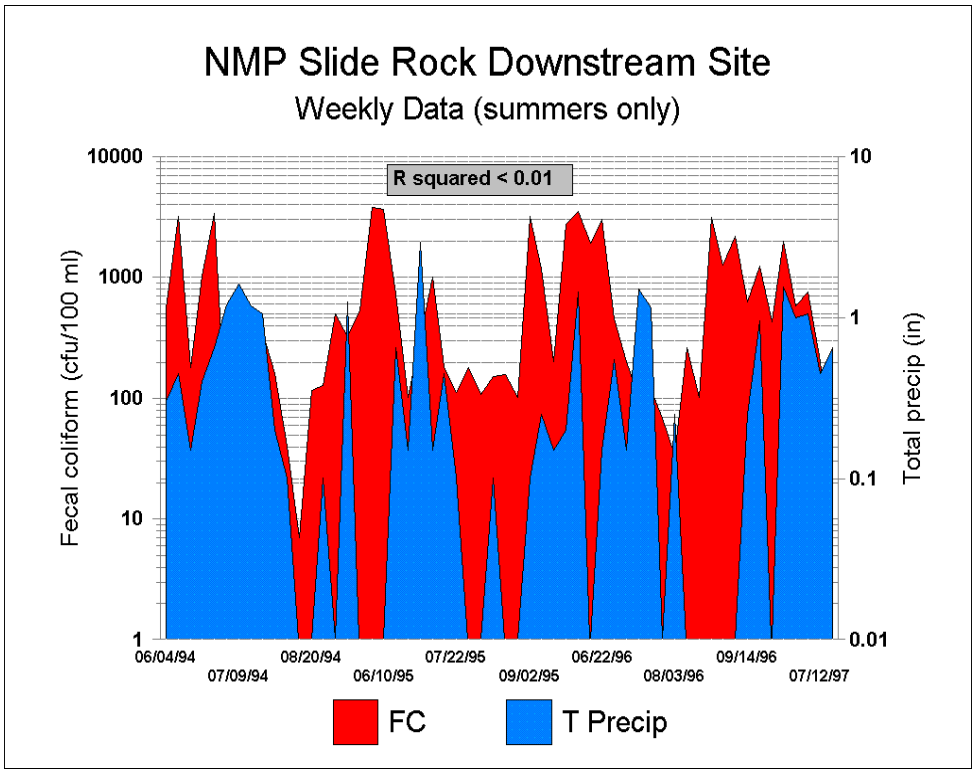


Figure 8

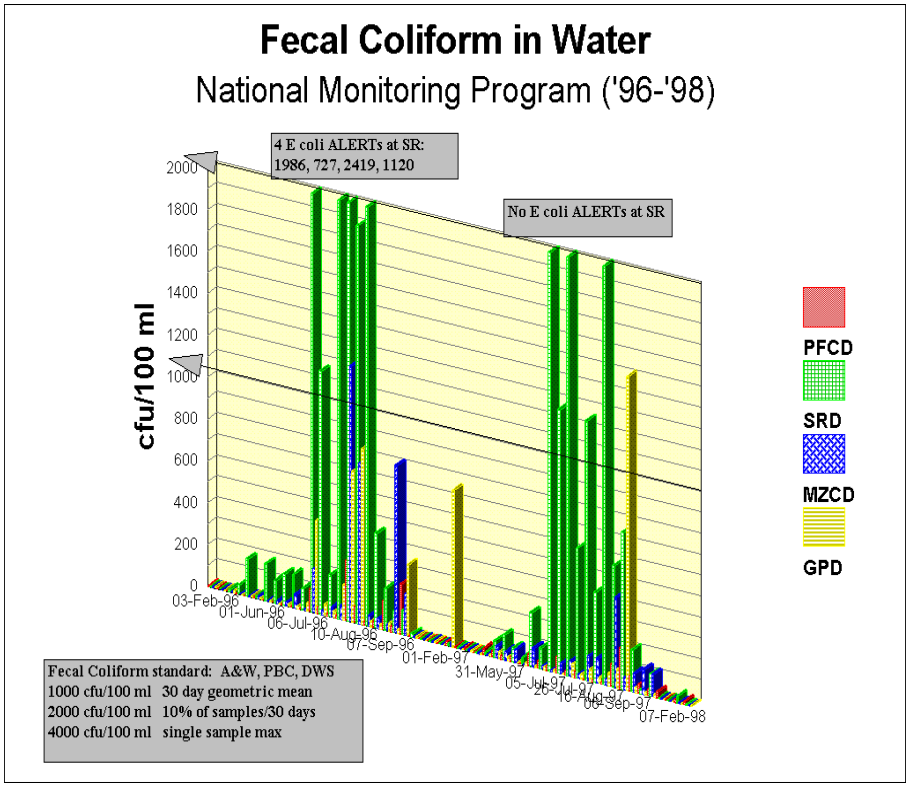


Figure 9

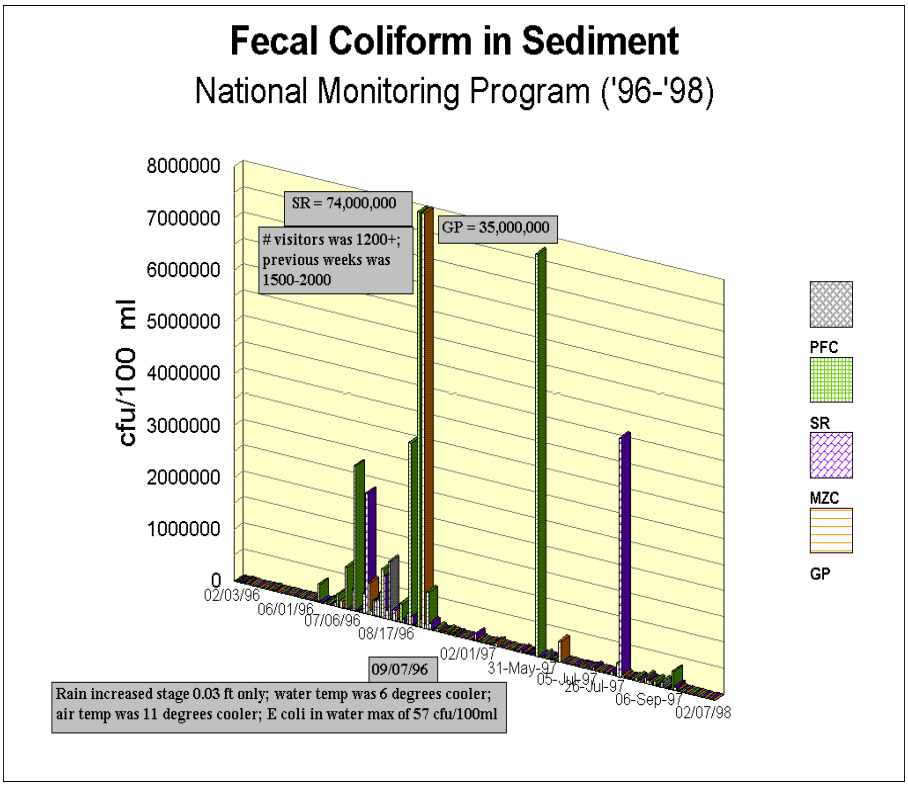


Figure 10

Point Sources

As stated previously, there are no permitted point source discharges within Oak Creek Canyon. Sterling Springs Fish Hatchery is the only known point source, but does not meet the flow threshold requiring a discharge permit. Data from Sterling Springs have recently been reviewed within the context of the nutrient TMDL (Nix, 1999).

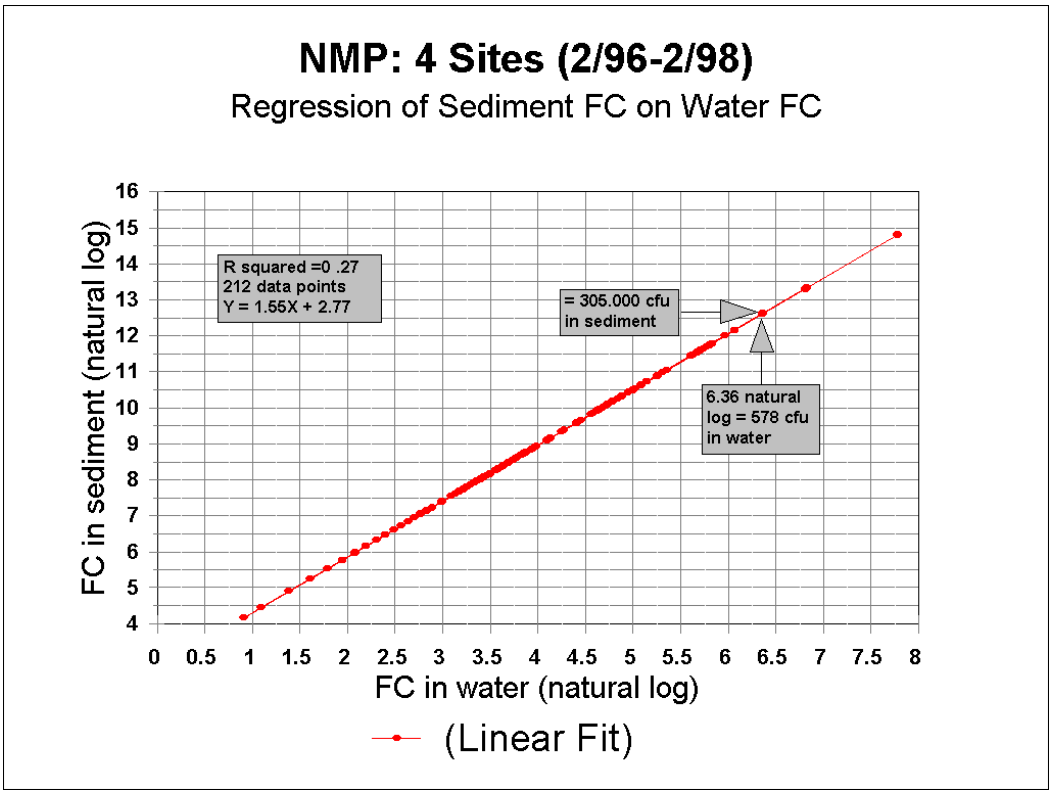


Figure 11

Nonpoint Sources

Nonpoint contributions of bacteria to Oak Creek certainly exist but the percentage of specific sources and their contributions are not yet well defined. It appears that bacteria loading may originate from three primary sources: septic tank seepage, wildlife populations, and recreational impacts within Oak Creek Canyon. Once the sediments are inoculated with fecal coliform bacteria, regrowth may also be occurring.

V. LINKAGE ANALYSIS

Existing Conditions & Numeric Targets

The cross-section of studies cited above makes it clear that "existing conditions" are variable in time and space. Oak Creek has been one of the most 'studied' water bodies in Arizona, yet discrete

"smoking gun" sources of fecal contamination have proven elusive to date. Several studies have pointed out particular locations suspected of contributions. The next step would be to do whatever is technologically and economically feasible to reduce and minimize potential inputs (runoff, bank leachate, animals, and recreators). The ongoing DNA-typing work is expected to determine the relative overall contribution from human and animal waste to enteric pathogen risk. Full isolation of the relative contributions from septic seepage, recreation-related practices, and animal populations may not be

possible, however, load reductions will be pursued on several fronts simultaneously while DNA typing and regrowth continue to be investigated.

ID Cause(s) & Effect(s)

As stated previously, the causes (sources) of bacterial contamination in Oak Creek, with particular emphasis to Slide Rock State Park, are complex and not yet fully understood. Several studies have focused on this problem since the late 1960s and early 1970s, with the most comprehensive study recently concluding in the Spring of 1998. The National Monitoring Network Project revealed a significant sediment reservoir of fecal coliform, primarily at Slide Rock, with lesser build-up occurring in other locations where the gradient is relatively low. The sources of this sediment reservoir are thought to be a combination of runoff from roads, wildlife, and domestic animals in the watershed, failing septic systems, and human activities near or in the stream itself. This reservoir appears to build on an annual basis and become potentially problematic during the peak summer recreation period when swimmers "roil" the sediments.

In 1996, ADEQ adopted standards for *E. coli* in addition to existing standards for fecal coliform. In Oak Creek, the *E. coli* standards (580 cfu/100 ml single sample maximum; 130 cfu/100 ml geometric mean) are currently the most stringent pathogen standard. Also in 1996, specific BMPs were implemented to address waste disposal at Slide Rock State Park, along with daily monitoring for *E. coli*, water level, discharge, and precipitation. Analysis of data collected since 1996 of both fecal coliform and *E. coli* counts fails to show a statistically significant improvement. It is not known whether two years is sufficient to demonstrate reductions in pathogen levels. However, when DNA analysis of *E. coli* showed significant human contribution (greater than 50%), the National Monitoring Network Report concluded that septic seepage must also be a major contributor. In order to accomplish the needed investigation and remediation, a combination of 'phased approach' and percent reduction is being proposed by ADEQ. Other recently completed pathogen TMDLs have used one or both of these mechanisms, especially where data for modeling are lacking (EPA Region X, Draft 1997; Anderson Run & South Fork Potomac, EPA Region III, 2/20/1998)

Upslope/In-stream Linkage

The connection between upland loading and in stream loading of fecal coliform bacteria has been partially clarified through DNA analysis of *E. coli* extracted from various sites and typed against known mammal signatures (NAU, 1998 et. seq.) The results indicate that elk and other ungulates are contributing about 45% on the total load of *E. coli* to the Oak Creek sediment reservoir. Although at least part of this level of animal input could be considered "natural background", until there is further clarification, this TMDL does not acknowledge a "natural background" level. Some form of

management of mammal populations within the watershed may need to be addressed.

System Dynamics in regard to Pollutants

The dynamics at work within the Oak Creek watershed are not completely understood. Climatologically, the watershed can be characterized as dynamic, with episodic and fluctuating cycles in weather. Elevational gradients exist within the Canyon that will to some degree determine the range of conditions. Both spatially and temporally, the Oak Creek watershed experiences variable precipitation, this applies to winter storms/runoff, short-term intense monsoonal activity in the summer, and weather patterns in general. Climatological factors are exacerbated by historic land use impacts, extreme changes in topography, and problematic geology and soil conditions.

Given that mammal populations (both in the upper watershed and more locally) may be contributing a significant bacterial load to Oak Creek, data regarding the numbers and ranges of animals and a predictive model of their impact may be needed. This work should be undertaken in joint cooperation between the Arizona Game and Fish Department, the U.S. Fish and Wildlife Service, and the U.S. Forest Service. Loading simulations based on different scenarios for wildlife and domestic animal control should be reviewed and considered.

In addition to testing of individual septic system integrity, septic inputs are likely to be influenced to some degree by climate and hydrology. Further investigation into the hydraulic conductivity of both unsaturated and saturated alluvium/soils is needed. There may be two sensitive periods to consider: 1) high flow conditions which tend to hydraulically 'pull' septic contaminants out of the banks, and 2) low flow warmer periods when the stream is most susceptible to stagnation and eutrophication and sediment may build up. Future sampling should focus both spatially and temporally on critical periods and indicator parameters to further clarify the sources of bacterial loading.

Recreational contribution is complicated by time lag considerations, localized conditions, bathing pressure, rainfall events, and conditions of bacterial dormancy, survival, and/or regrowth. It may be possible to date *E. coli* in sediments and/or conduct in-situ experiments on regrowth potential. Further work is recommended to establish the relative risk from other pathogens associated with fecal coliform bacteria such as protozoans and viruses.

VI. LOADING CAPACITY

Water Quality Limited Segments

One mile of Oak Creek, including Slide Rock State Park, is listed for bacterial contamination on the CWA Section 303(d) "Water Quality Limited List". A review of historical data and investigations dating from the 1960s indicates that Slide Rock State Park has not been the only problem area within the Oak Creek Watershed, but has presented the most consistent and greatest health risk due to the shear numbers of visitors.

Many historical "hot spots" showing elevated fecal coliform have been addressed through compliance actions. However, the National Monitoring Program data collected between 1996 and 1998 has

demonstrated a pattern of sediment fecal coliform build-up in two main areas above Slide Rock. The upper area extends from Pumphouse Wash to Pine Flats Subdivision, and the lower area from West Fork to Grasshopper Point. Slide Rock State Park and Grasshopper Point swim areas have the lowest gradient, where sediment tends to accumulate. It is thought that these sediment reservoirs reflect a combination of inputs: storm runoff from the upper watershed, animals, possible septic seepage, recreators, and regrowth.

Load Contributions

There is no discernable relationship of bacteria levels to discharge; therefore loads cannot be calculated using regression. The sediment 'reservoir' is most critical from Memorial Day through Labor Day, but has not appeared in significant degree before the July 4th holiday. Review of 1996 and 1997 sediment and water data indicates a 2-prong emphasis on source reduction and management may be needed: reduce upstream inputs and reduce localized inputs and health risk. The relationship of fecal coliform in sediment to fecal coliform in water has been demonstrated to be anywhere from 100:1 to 10,000:1, with an average of 2000:1. The relationship between fecal coliform in water and *E. coli* in water has not been developed as a ratio. For purposes of this TMDL, the conservative assumption will be made that all fecal coliform is *E. coli* (1:1).

Sediment fecal coliform values in the 250,000 to 750,000 cfu/100 ml range have been seen early in the season, whereas much higher values have been recorded later in the summer (2 million to 75 million). However, only two years of sediment monitoring data have been analyzed (1998 data has not yet been analyzed). Given the limitation in data (53 data points at the downstream Slide Rock State Park site), bacterial loading at the Slide Rock State Park will be estimated three ways to bracket options for stakeholders . The first two methods consider only the 32 summer values for fecal coliform in water and sediment at Slide Rock State Park. The third estimation method considers all 214 data points for water and sediment (53 data points from the four downstream NMP sites).

Method 1: *Target is single sample maximum E coli standard (580 cfu/100 ml)*
Assume all fecal coliform are E coli
Analysis relies on arithmetic mean
Assumes linear relationship between reductions in water coliform and reductions in sediment coliform (and vice-versa)
30% reduction in sediment fecal coliform

The arithmetic mean of 32 water samples for fecal coliform is 823 cfu/100 ml. A 30% reduction would be required to reach the single sample maximum standard of 580 cfu/100 ml. The mean sediment fecal coliform value over the same two-year period is 3,000,000 cfu/100 ml. To meet the single maximum standard of 580 cfu/100 ml using the 'law of averages' and extrapolating to sediment, the necessary reduction target in sediment fecal coliform would be 1,800,000 cfu/100 ml.

However, because the empirically-derived ratio of sediment fecal coliform to water coliform ranges anywhere from 100:1 to 10,000:1; a significant level of uncertainty may be involved with using this method for predicting the necessary reduction in sediment fecal coliform to meet the target water

quality standard.

Method 2: *Target is geometric mean E coli standard (130 cfu/100 ml)*
Assume that all fecal coliform are E coli
Analysis relies on geometric mean and assumption that reduction in water fecal coliform equate to reduction in sediment coliform (and vice-versa)
66% reduction in sediment fecal coliform

The geometric mean of 32 water samples for fecal coliform is 396 cfu/100 ml. A 66% reduction would be required to reach the geometric mean standard of 130 cfu/100 ml. The geometric mean sediment fecal coliform value over the same two-year period is 16,147 cfu/100 ml. To meet the geometric mean water standard of 130 cfu/100 ml, the projected target reduction in sediment fecal coliform would be a geometric mean value of 5,298 cfu/100 ml.

Again, this method does not consider the variability inherent within the empirically-derived sediment-to-water ratios in fecal coliform values. This variability may prove to be extremely important, particularly if growth or regrowth of fecal coliform bacteria are occurring at Slide Rock State Park and other high-risk locations along Oak Creek.

Method 3: *Target is either single sample of geometric mean E coli standard*
Assume that all fecal coliform are E coli
Analysis relies on linear regression and natural log transformation (due to great data variability)
90% reduction of fecal coliform in sediments

Raw values were first log-transformed; the data spread necessitated this transformation in sediment fecal coliform data, but water values were also log-transformed. Using SYSTAT, linear regression was performed on the log-transformed data, with water fecal coliform as the independent variable. The resulting correlation coefficient (R^2) was 0.3. The best fit regression line predicted a value of 305,000 cfu/100 ml fecal coliform in sediment from the single sample maximum value of 580 cfu/100 ml fecal coliform in water. This value of fecal coliform in sediment represents approximately a 90% reduction from the current summer mean value. Whereas the two previous methods did not account for the variability in sediment values and how they may relate to water column values, this method compensates for that variability. The consequence, however, is that the overall reduction target is higher.

Complicating variables

The potential health risk at Slide Rock State Park results from the fact that sediment fecal coliform values reach extremely high levels during the peak recreational season (summer months). In order to protect the public from the risk of high water column fecal coliform and associated E coli, further work must be undertaken to tease out contributing variables. This TMDL has discussed the fact that bathers in the pools are Slide Rock State Park are likely contributing to their own risk through stirring up fecal-laden sediments. The TMDL has also discussed the need to reduce fecal coliform loading upstream of Slide Rock State Park. However, there are also key environmental variables that may be increasing the

risk by stimulating the growth (or regrowth) of fecal coliform bacteria, once the sediments are inoculated. These variables include higher temperatures, a sustained level of adequate oxygen, and the presence of an adequate nutrient source.

To examine the possible contributions of these additional variables, a (backward) stepwise regression was performed, using 2 years of weekly data from four NMP sites. Results of this analysis are shown in Tables 2 and 3. In stepwise multiple regression, variables are entered into, or removed from, the model one at a time to determine relative significance in predictive value. A backward stepwise model was used in analysis of selected environmental variables from the National Monitoring Program database. Independent variables were dropped whose removal did not appreciably lower the determination of predicting the dependent variable. The "*p*-to-remove" value was set at 0.15, which does not equate to a conventional confidence level; these values may underestimate the correct probabilities.

Table 2. Results of Backward Stepwise Regression: FC in Water as Dependent Variable

Site ID	R squared	Available N (N03/NH4)	Dissolved oxygen	Water temperature	FC in sediment
PFCU	.427	* (.05)	* (.01)	term removed	* (.01)
PFCD	.446	* (.05)	term removed	* (.01)	* (.01)
SRU	.498	term removed[a]	term removed[b]	* (.01)	* (.05)
SRD	.646	term removed[b]	term removed[a]	* (.01)	* (.11)
MZCU	.490	term removed[b]	term removed[a]	* (.01)	* (.01)
MZCD	.593	term removed[b]	term removed[a]	* (.01)	* (.01)
GPU	.456	* (.01)	* (.05)	term removed	* (.01)
GPD	.396	term removed[a]	term removed[b]	* (.01)	* (.01)

* significantly accounts for variation (alpha level) in water FC values, based on test assumptions; remove set at .15;
a,b,c order in which terms were removed

It can be seen that no one variable is consistently implicated in accounting for water column fecal coliform values. Aside from the close relationship between observed sediment and water fecal coliform values, temperature appears to be the single-most correlated variable in predicting water column fecal coliform. However, at the sites upstream of Pine Flats Campgound and Grasshopper Point, available nitrogen and oxygen appear to be more important in explaining fecal coliform values in water. Temperature and oxygen may not be variables that can realistically be controlled. However, available nitrogen is more easily controlled, and may represent the single-most important side in the triangle of variables.

Running the reverse regression (predicting sediment fecal coliform) again shows the close relationship of water values to sediment values. However, for prediction of sediment fecal coliform, water

temperature does not appear to play a significant role, with the exception of the site upstream of Slide

Rock State Park.

Dissolved oxygen was a significant contributor above and below Slide Rock and above Grasshopper Point. As with prediction of fecal coliform in water, available nitrogen was a significant contributor above Pine Flat Campground and above Grasshopper Point.

Table 3. Results of Backward Stepwise Regression: FC in Sediment as Dependent Variable

Site ID	R squared	Available N	Dissolved oxygen	Water temperature	FC in water
PFCU	.326	* (.10)	term removed[a]	term removed[b]	* (.01)
PFCD	.275	term removed[c]	term removed[b]	term removed[a]	* (.01)
SRU	.307	term removed	* (.01)	* (.15)	* (.01)
SRD	.214	term removed[a]	* (.05)	term removed[b]	* (.01)
MZCU	.410	term removed[c]	term removed[b]	term removed[a]	* (.01)
MZCD	.416	term removed[c]	term removed[a]	term removed[b]	* (.01)
GPU	.284	* (.10)	* (.15)	term removed	* (.01)
GPD	.250	term removed[a]	term removed[c]	term removed[b]	* (.01)

* significantly accounts for variation (alpha level) in sediment FC values, based on assumptions; remove set at .15
a,b,c order in which terms were removed

These results point generally to contributions from environmental variables on the presence of fecal coliform. However, additional sampling and analysis would need to target a particular variable's influence. Running a straight linear regression on daily values for water temperature and *E. coli* at five Slide Rock State Park sites (1998) shows a 0.4 correlation coefficient (R^2). Though correlation does not equal causation, further work is recommended to assess the influence of these environmental variables.

Monitoring & Modeling Requirements

WLA+LA+MOS

This equation represents the scheme whereby TMDL loads have traditionally been calculated. "WLA" stands for "point source waste load allocation(s)", "LA" stands for "nonpoint source load allocation(s)", and "MOS" stands for a reasonable margin of safety, given assumptions and uncertainty.

There are no waste load allocations applicable to this TMDL, as there are no point sources containing fecal pathogens. Nonpoint source load allocations have been estimated empirically, based on two years of data and the current state of knowledge from DNA typing: percent contribution by source type 50% human and 50% other mammals. This TMDL has not utilized a computer model to estimate loads or to simulate percent-reduction scenarios. The choice not to use a model was based 1) on the number of factors with high uncertainty, and 2) the fact that an integrated and active stakeholder group is already highly invested in addressing the problem. Using the empirical relationship of fecal coliform in water

to fecal coliform in sediment, an initial load reduction of 30% fecal coliform in sediments at Slide Rock is proposed. This target is to be attained by year three of this TMDL, with additional reductions benchmarked according to results of ongoing work; 15-30% has been proposed. The load allocation is a grouped allocation, combined to reflect the involvement of all public and private land owners/managers within the basin at and above Slide Rock State Park.

VII. MARGIN OF SAFETY (MOS)

The Margin of Safety will be set at 0, as assumptions and uncertainty have been accounted for in the load allocation.

Uncertainty

There are many uncertainties involved in projecting the necessary reduction in pathogen loading at Slide Rock. To reiterate, 1) a significant sediment reservoir of fecal coliform builds every summer but the relative sources have not yet been quantified, 2) both fecal coliform and *E. coli* standards (in water) are exceeded periodically during summer months but may be linked to multiple and possibly interrelated factors, 3) low gradient, high temperature, rainfall/runoff events, stage increase, and number of swimmers "roiling" the sediments appear to be related to increased water column values of fecal coliform and *E. coli*, 4) human contribution includes both recreation and waste disposal - to some as yet unquantified degree, 5) animal contribution includes both wildlife and domestic animals - to some as yet unquantified degree, and 6) regrowth of coliform. Uncertainties listed above are expected to be addressed and answered over the course of implementing this TMDL.

Based on the foregoing reasons, this TMDL has taken a percent-reduction approach calculated 1) to be achievable over a 5-6 yr period, 2) to build on previous and ongoing work, and 3) to involve all necessary stakeholders in a concerted and focused effort to achieve the goal.

Assumptions

1) all fecal coliform are *E. coli;* a ratio of 2000:1 sediment to water fecal coliform is accurate for loading projections

2) lower trigger levels at Slide Rock State Park for further testing and closure, based on sample results, stage, and precipitation, will result in reduced exceedances

3) limiting the number of swimmers and access to the creek in general, along with proposed additional BMPs, will result in reduced exceedances

Critical Conditions; Seasonal & Long-term Variations

Critical conditions at Slide Rock State Park have been discussed at great length already, but in short, the priority is to protect the public health and minimize the risk to those in contact with Oak Creek. The focus of this TMDL is to achieve source reduction and to utilize all best management practices

available. This approach will integrate the resources, concerns, and commitments of all stakeholders. A series of activities and expectations has been laid out for accomplishment over the next five years; ADEQ will participate as a stakeholder in implementation of this TMDL, but ultimately, success will result from the cooperation of all stakeholders in restoration of this resource.

VIII. IMPLEMENTATION (see Appendix A for existing Management Plans)

STRATEGY

The following Implementation Strategy addresses: Stakeholders, Management Plans/BMPs, Technology-Based Controls, Water Quality-Based Controls, Monitoring Requirements, and Procedures for Review, Assessment, and Revision of this TMDL.

GOAL: Achieve *E. coli* and fecal coliform water quality standards by 2005 (i.e., 580 cfu/100 ml and 1000 cfu/100 ml respectively)

OBJECTIVES:

- reduce sediment FC reservoir in stream sediments
- identify relative contributions from sources: septic, recreation, runoff, animals within the watershed
- accelerate implementation of BMPs for recreation/'traffic' management
- increase safety margin for protection of swimmers
- accelerate septic upgrades/repair schedule
- TMDL Implementation Plan to include identification and implementation of stakeholder responsibilities
- develop and implement long-term contingency plan to meet standards

Policy: Phase benchmarks to reduce sediment FC (as measured at peak summer season)

- 30% after three years (2003)
- 15+% additional after two more years (2005)
- TOTAL of 45+% reduction in sediment fecal coliform

Policy: Set additional health "triggers" at Slide Rock State Park to reduce likelihood of violation & increase swimming safety:

- 450 cfu/100 ml (single sample max); 100 cfu/100 ml (geometric mean)
- stage increase 0.3 ft or precipitation of 0.3 in/24 hrs
- issue swimming passes: number & time restrictions

Phase I (1999-2000) Source Identification Benchmarks

- Arizona Department of Environmental Quality (ADEQ), United States Forest Service (USFS), Arizona State Parks Service (ASPs), Arizona Game and Fish Department (AGFD), Coconino County Environmental Health Service (CCEHS), and homeowners will create a document formalizing 1) this Implementation Plan, and 2) Procedures for Review, Assessment, and Revision of this TMDL

- Northern Arizona University will finish DNA work and tie to absolute numbers
- Arizona Game and Fish, United States Forest Service, and homeowners will cooperate to collect FC & *E. coli* data in water & sediment (once/month September 15 to March 15), (once/week (March 16 to September 14)
  - lower Pumphouse Wash
  - (ab. & bl.) Sterling Springs
  - (ab., within, bl.) Pine Flats CG & SubD
  - (at) Troutdale Ranch
  - lower West Fork
  - (ab. & bl.) Hoel's/Forest Houses
  - (at) Banjo Bill
  - Slide Rock sites per ASP Plan
- ADEQ, CCEHS & Property Owners will work together
  - to formalize specific criteria to define "failure" of septic systems,
  - complete phase I "Oak Creek Septic Initiative": identification of failures & prioritize upgrades
- Establish additional funding support for upgrades
- If DNA tests conclude >50% FC from mammal sources (other than human) <u>and</u> of that pool, there is >50% *E. coli* contribution, the USFS, USFW, AGFD, and ADEQ will cooperate to evaluate mammal populations and recommend a plan for further mitigation

- Phase II (2001-2003) Source Reduction Benchmarks
  - Complete prioritized septic upgrades & BMPs
  - Continue upstream monitoring (scaled back to focus on known hot spots if septic survey 100% complete)
  - Begin animal management plan and monitor effectiveness
  - Evaluate success of meeting *E. coli* standards at SRSP

- Phase III (2003-2005) Source Reduction Benchmarks
  - Complete remainder of septic upgrades & BMPs
  - If *E. coli* standards still not being met at SR, impose further limitations on swimming & creek access
  - Continue animal management plan; step up if DNA testing in 2002 does not indicate adequate progress toward meeting 2003 reduction target
  - Continue focused monitoring to demonstrate source reductions

- Phase IV (2005) Evaluation of TMDL Success
  - Is there full compliance with both *E. coli* standards?
  - Has FC in sediment at Slide Rock State Park been reduced by 45% or more?
    - % attributable to human waste
    - % attributable to waste from other mammals

- Phase V (2005-2010) Revised TMDL (if needed)

- Additional % reduction
- Additional BMPs & monitoring
- Evaluate need for Use Attainability

Actions relevant to ASPs:

- continue daily monitoring of *E. coli* - in the afternoon (using Colilert[R] or other approved method), flow, water level, and rainfall at Slide Rock State Park; commence analysis of fecal coliform in water and sediments once per week; provide data on web page
- Collect 'split' samples with ADEQ, USFS, and CCEHS on regular basis
- set "trigger" for alarm system at 450 cfu/100 ml (single sample) *E. coli*; pursuant to Management Plan, close park to water activity immediately upon attaining this "trigger" level and for one full day following...review for effectiveness; pursuant to Management Plan, collect confirmation sample(s)
- set "trigger" for alarm system at 0.3-ft - 0.5 ft rise in stage or 0.3 in precipitation within 24 hours; close park to water activity for one full day following rainfall event...review for effectiveness
- issue park visitors a "swimming pass" (enumerate; limit to "X" at time)...review for effectiveness
- patrol and imposition of fines for violations
- participate in annual review of TMDL status with other stakeholders

Actions relevant to USFS:

- Continued oversight and maintenance of campground and day-use facilities to ensure compliance with proper animal and human waste disposal
- Continued education and posting of signage
- Patrol of campgrounds and imposition of fines for violations
- Cooperation with ASPs, AGFD, ADEQ, and CCEHS for quarterly water quality and sediment monitoring for fecal coliform and *E. coli* above and below campgrounds and day-use areas (weekly from Memorial Day to Labor Day); cooperate with ASPs, ADEQ, and CCEHS to collect 'split' samples on regular basis; provide data on web page
- Development of BMPs for restriction of animal access to Oak Creek and drainages in the upper watershed
- conduct census of numbers and ranges of ungulates and other major contributors
- participate in annual review of TMDL status with other stakeholders

Actions relevant to ADEQ and CCEHS & homeowners:

- Development of a time line and enforcement provisions for upgrade of existing septic systems within Oak Creek Canyon identified as "priority" for source reduction
- Continued source identification, both through analysis of animal and human DNA and through pilot studies to establish selection of the best waste disposal systems for Canyon conditions
- Develop and implement monitoring to isolate septic seepage hot spots with cooperation from

homeowners - FC and *E. coli* (role this study in with ASP to determine relationship of FC to *E. coli*

- Provide training and guidance in use of Colilert[R] sampling; provide hot-line to report bacteria-related problems participate in annual review of TMDL with other stakeholders
- participate in annual review of TMDL status with other stakeholders

<u>Actions relevant to AGFD</u>:

- Monitor and report *E. coli* monthly at input sites to Oak Creek: Pumphouse Wash, Sterling Springs, Fry Canyon
- Continue BMPs for control/minimization of wastewater products from Sterling Springs Fish Hatchery that could exacerbate bacterial growth (nutrients in particular)
- Cooperate with USFS, USFW, and ADEQ to develop "Animal Management Plan"
- participate in annual review of TMDL status with other stakeholders

<u>Actions relevant to residents, homeowners associations, and commercial businesses within Oak Creek Canyon:</u>

- in cooperation with ADEQ and other stakeholders, participate in development and implementation of monitoring strategy for refined source identification
- cooperate in seeking and obtaining timely upgrades of septic systems or alternative systems of waste disposal
- be responsible for support and enforcement of BMPs along Oak Creek; note and report any violations to ADEQ, USFS and CCEHS
- participate in annual review of TMDL status with other stakeholders

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Appendix A: *Existing Management Plan for Arizona State Parks* (ASPs)

In 1997, ASPs established a Surface Water Quality Management Plan (ASPs, 1997). The following items were included in this Plan:

- An on-site laboratory at Slide Rock State Park, sampling & analysis of *E. coli* using Colilert[R]
- A minimum of 5 samples to be collected each week during the months of May-September
- Results of sampling to be evaluated against 1) single sample maximum value, and 2) geometric mean value (minimum of 10 samples taken within a 30 day period)
- If the single sample maximum value (580 cfu/100 ml) is exceeded, a minimum of 3 additional samples from the vicinity of the violation shall be collected in both the morning and afternoon; if additional violations occur, process is repeated until all values fall below the standard
- If the 10-sample geometric mean should reach a level at or above 125 cfu/100 ml (standard is 130 cfu/100 ml), frequency of testing will increase to 10 random samples within a one-week period; testing will resume at 5 samples per week when spikes diminish, and/or when 10-sample mean levels fall below 125 cfu/100 ml
- There will be three management categories: STAGE 1 = LOW RISK, STAGE 2 = WATER QUALITY ALERT, and STAGE 3 = HIGH RISK to be determined by the running 10-day geometric mean and/or violations of the single sample maximum value

STAGE 1: Low Risk

1. range of geometric mean between 0-109 cfu/100 ml
2. kiosk with interpretive material and guidance
3. fliers and brochures available at contact station and bulletin boards
4. no law enforcement action

STAGE 2: Water Quality Alert

1. range in geometric mean between 110-129 cfu/100 ml or 580 or greater single sample maximum value
2. posters and signs using a “warning” tone: swimming not prohibited but risks outlined
3. referrals to other swimming areas provided
4. issue of public information announcement to media

STAGE 3: High Risk

1. geometric mean *E. coli* at or above 130 cfu/100 ml
2. emergency closure of entire swim area, or partial swim area, depending on the spatial extent of the violations; if only one site (of three) is closed, closure will extend 1/4 mile downstream from that location; if entire swim area is affected, closure extends from the Hwy. 89a bridge upstream for ½ mile to include the most upstream swim area access point
3. in event of closure or partial closure, patrols from ASP, volunteers, or USFS will give verbal notification of closure and enforce compliance
4. release of public information announcement to media
5. only non-swimming activities will be allowed

6. return to STAGE 2 when geometric mean falls below 130 cfu/100 ml or when single sample violation readings have diminished

Existing Management Plan for USFS - Coconino National Forest & the Sedona Ranger District

The USFS (all districts) operates on a 10-year cycle with regard to their Comprehensive Management Plan. The 1987 version is still in use today, with the addition of 12 amendments. The USFS-Sedona Ranger District formulated a working document entitled the Oak Creek Water Quality Management Plan in January 1996 and the Oak Creek Canyon Scenic Corridor Plan in 1997. The latter document has recently been revised; a draft was released for public review in April 1999. Elements of these plans are highlighted below:

I. 1987 EIS and Coconino National Forest Plan (still in effect w/12 amendments)
   - A. Plan applies to all Districts: includes BMPs
   - B. Amendment #12: Sedona Ecosystem Management Area Analysis

II. Sedona Ranger District 1996 Plan to protect public health and safety
   - A. Water quality monitoring (Grasshopper Point and Manzanita Campground)
     Note: sampling has been conducted by volunteers (Friends of the Forest) since 1997
   - B. Risk Management
     1. Slide Rock Swim Area sampling for fecal coliform (later revised to *E. Coli* following promulgation of 1996 Water Quality Standards)
     2. Proposal of several risk categories triggered by coliform counts

III. 1997 Plan
   - A. Preparation of an Intrinsic Quality Report
   - B. Development of Action Plan
   - C. Conduct "visioning" sessions with other stakeholders

IV. April 1999 Draft Oak Creek Corridor Action Plan
   - A. Vision: Protect Oak Creek Canyon's rustic and natural character while providing a remarkable experience for residents and visitors
   - B. Goals
     1. Preservation: of natural and historic value and quality
     2. Stewardship: to sustain a healthy environment
     3. Human Experience: provide access, build ownership and respect
     4. Transportation and Safety: serve pedestrians, bicyclists, and motorists
   - C. Review of resources and conditions: setting/scenery, water (general), wildlife (general), plants, recreation (swimming, hiking, camping), cultural, transportation, fire safety, interpretation/information
   - D. Key issues associated with water
     1. How can people, domestic animals, and solid waste be managed?
     2. Where should public restrooms be located, and by whom?
     3. How can water quality be protected from vehicle emissions/oils?
     4. What practices need to be implemented to meet State regulations?
     5. What added public information would protect water quality?

6. How can riparian areas be protected?
7. Can recreation activities be modified to better protect wildlife?
8. Are there noxious plants that should be discouraged or removed?

E. Recommendations pertaining to water

1. Limit development of remaining highly visible, publicly owned stream side parcels
2. Encourage development of shuttle system to decrease highway traffic
3. * Emphasize recreation at 'nodes' rather than entire corridor: full service 'nodes' include restrooms, partial service 'nodes' may not
4. Minimize creek crossings (trails)
5. Leave woody debris in stream
6. "Minimum impact" signs at trail heads (no trails along creek)
7. Restrict access to critical riparian areas
8. * Improve waste management by replacing older septic systems, place trash bins and toilets at all trail heads, hold advertised cleanups, minimize grazing in the Canyon, test effluent sources to assign responsibility, establish the carrying capacity of the Canyon, use limitations at certain sites/facilities for watershed protection
9. Evaluate parking restrictions and application of a "parking pass"; set vehicle restrictions based on biological considerations
10. Continue to monitor water quality; expand scope of testing
11. Make environmental research a priority
12. Expand the existing Wilderness area to encompass more of the riparian habitat at the upper end of the Canyon; establish wildlife viewing areas in 'marsh' habitat
13. Provide information packets in day packs handed out at visitor centers; promote more day use in general
14. Provide day use parking and additional toilets at these locations and shuttle stops
15. Fines for non-disposal of animal waste
16. Do not expand campgrounds or build new campgrounds
17. Private lands acquired by FS should be restored and maintained in natural or historic state
18. Acquire following: Call of the Canyon Lodge, portion of Slide Rock Lodge, east side of Forest Houses, west side of hwy. by Trout Farm, small holding by Indian Gardens, 25 acres at Don Hoel's with ½ of Hoel's property
19. Consider development of a common underground utility corridor that houses both sewage and power lines (logistically and economically very difficult)

* Note: USFS is committed to a policy of sustainable resource management and supports ongoing efforts by other agencies to ensure long-term improvements within the Canyon.

Existing Management Plan for Coconino County Environmental Health Services

In 1984, CCEHS established the Oak Creek Area Plan which laid out policies for development of private lands. This Plan set a tone restricting development to single family uses at a density not to

exceed one unit per net developable acre. A design review was adopted with the Plan that addressed standards for architectural style, building materials, and color. Site planning and signs not consistent and compatible with the historic and natural environment were to be restricted or prohibited. Currently these standards do not apply to single family residences.

With regard to wastewater management, CCEHS is delegated authority (pursuant to A.R.S. §49-107) under Engineering Bulletin 12 (ADEQ, 1989) to approve the systems cited in Chapters 4 (septic) & 5 (alternative on-site systems). A cooperative study is underway to revise Engineering Bulletin 12 to include additional alternative systems and upgrades (319h Grant).

Existing Management Plan for Arizona Department of Environmental Quality

ADEQ initiated the Oak Creek Policy on August 15, 1990. This policy presented ADEQ's position regarding septic systems along Oak Creek. The Policy has been periodically revised through the efforts of CCEHS, the Oak Creek Canyon Property Owners Association, and ADEQ. An addendum to the Oak Creek Guidance document has been developed entitled: "Repair and Replacement of Existing Septic Systems in Oak Creek Canyon" (ADEQ, 1998), which has been designed to supplement the 1990 Policy. The Guidance has been issued as a formal agency policy following resolution of site investigation methodology, consistent definition of what constitutes a "failed" system, and the addition of approved treatment systems. Some of the recommended systems in this Guidance - as well as others that may be added in the future, are antecedent to Bulletin 12, thus requiring a mechanism to link the various documents and authorities (Swanson, personal communication).

The Water Permits Section of ADEQ reviews permit applications for wastewater Aquifer Protection Permits in this area to identify any proposal that may be in direct hydrologic contact with Oak Creek. If a facility is in direct hydrologic contact with Oak Creek, the application is denied pursuant to A.A.C. Rule 18 Chapter 11 Section 405(B). The Water Permits Section also reviews applications for NPDES permits in an analogous fashion.

The Oak Creek National Monitoring (319h) Project was initiated by NAU in 1994 and completed in early 1998 (NAU, 1998). With oversight by ADEQ and USEPA Region IX, this project was designed in part to assess recreational and other nonpoint sources of bacteria in Oak Creek. Following a two-year baseline monitoring study, additional data collection and analyses were completed to document the effects of BMP implementation and facility improvements initiated in 1996. Since 1996, NAU has been working to isolate and type the DNA extracted from fecal coliform in sediments.

Appendix B: Development in Oak Creek Canyon

Within Oak Creek Canyon, Pine Flats is the uppermost developed area. Approximately 9.2 acres at Pine Flats is zoned residential, subdivided into 82 individual lots containing permanent single-family residences. In addition, there is a small chapel and a 2.6-acre commercial zone on which the Chipmunk Lodge and associated facilities are located. About one half mile south of Pine Flats is the privately owned Troutdale Ranch property. This 5-acre parcel of land historically contained three single-family dwellings; the old buildings were replaced with more modern structures in the 1980s. Half of this property is located within the floodplain of Oak Creek. Just three quarters of a mile south of Troutdale Ranch there is a 1.2-acre parcel with one single family residence.

Proceeding south, about one half mile north of the Confluence of West Fork (Oak Creek) with Oak Creek, is another privately owned area known as the Rosa Thomas Tracts. This area is topographically flat and contains an 11-acre subdivision with 18 separate parcels (one single family residence per parcel). In the general vicinity of the confluence, an additional 28 parcels on 32.6 acres contain single family residences (one each); portions of each parcel are encumbered by the floodplain of Oak Creek.

In the vicinity of Don Hoel's Cabins and the Forest Houses Resort there are 20 single family residences, 24 small cabins, a general store, and a Forest Service Fire Station located on approximately 59 acres.

The next section of private land going south along 89-A contains the Junipine Resort (10.7 acres) and Garlands Resort (8.9 acres). Junipine Resort historically included 18 small cabins, a general store and dining facilities. In the late 1980's most of the buildings were replaced with a 50-unit time-share resort. There is still a restaurant, bar, and general store, as well as one single family residence. On the west side of Oak Creek, across from Junipine, is a 20 acre area that has been developed into 18 private single family residential lots. Garlands Resort consists of a lodge and dining facility, 17 small cabins, the owner's residence, two employee residences, out-buildings, and two orchards on this property.

Traveling south towards Sedona, the next private land encountered is a 46.7-acre parcel located immediately south of the Slide Rock bridge which has become part of Slide Rock State Park. Six-tenths of a mile beyond are 5.9 acres subdivided into 17 individual parcels (single family residences); adjacent is Slide Rock Lodge, which sits on 2.9 acres and has 20 motel units, a small coffee shop, and a residence for the operator.

One mile south of Slide Rock Lodge is the Rancho Shangri-La Subdivision. Approximately 9 acres, there are 38 individual lots zoned for single family residences, though only about half of the lots contain dwellings.

Twin Oaks Restaurant and three small homes are located about one mile below Shangri-La. On the creek side of the road, the Hidden Oaks Mobil Park consists of 19 travel trailers, three mobile homes and eight houses; all of these dwellings are permanent residences. The number of dwellings situated closely together make for a very high density of residential land use on a relatively small area. Oak Creek Terrace Motel, with 9 motel units is located on the east side of Highway 89-A just south of Hidden Oaks. Creek Side Mobil Village occupies the southernmost portion of land adjacent to Oak Creek Terrace. There are 16 mobile homes in which residents live year-round.

At the confluence of Munds Wash and Oak Creek, there are 53.8 acres of private lands, primarily on the east side of Highway 89-A. Within this area there are approximately 45 trailers or mobile homes (permanent) and 20-25 single family residences. The two most heavily population subdivisions are Indian Gardens Terrace Trailer Park and Twin Springs Terrace Mobile Home Subdivision. There are additional lots that may be developed in the Twin Springs Terrace area; some lots are located within the Oak Creek Floodplain. Indian Gardens and adjacent private property contain an additional 12 single family residences, 8 mobile homes, and 31 trailers. The entire trailer complex is located within the Oak Creek Floodplain.

Two miles north of Midgely Bridge are 50 acres of developed land. Four single family residences lie partially in the Oak Creek Floodplain. The Rainbow Trailer Park encompasses about 8.3 acres that support approximately 75 travel trailers and 18 mobile homes. The Rainbow Trout Farm, which sits on 1.7 acres, operates this property. Development includes a quarter-acre pond, one hatchery building, a cleaning house, a barn, seven trailers for employees, and fish tanks capable of supporting 2.5 million trout per year.

About one half mile below Rainbow Trout Farm is another 40-acre area made up of five sub-units. Developed areas include the Terracotta Inn which has four small cottages, two duplexes, one single family residence with a guest addition, and a couple of other buildings. The Briarpatch Mobile Home Park contains 18 mobile homes and one residence. Six additional residences are located close by, along with 22 acres which may now be developed.

Appendix C: Response to Comments: Slide Rock TMDL (in no particular order)

Commentor 1. David Walker, Arizona Game & Fish Department, July 9, 1999

Comment 1.1 The Department does not believe that the intent of the Clean Water Act involves reducing naturally occurring wildlife populations in order to meet water quality standards. This is supported by ADEQ - Water Quality Standards: R18-11-119 - Natural Background: which states, "where the concentration of a pollutant exceeds a water quality standard and the exceedance is not caused by human activity but is due solely to naturally occurring conditions, the exceedance shall not be considered a violation of the water quality standard." Free ranging wildlife is not a source of water pollution (i.e., a human induced effect on water quality or watershed condition), but instead is a component of the natural watershed in the same way as the air, water and plants are a natural part of the watershed.

Response 1.1 ADEQ agrees it is important to consider and define appropriate levels of "natural background" for wildlife *E. coli*. However, A.A.C. (R18-11-119) does not pre-empt the intention of the Clean Water Act to provide for clean and safe water. Section 101(a)(2) of the Clean Water Act identifies the national goal/purpose as: wherever attainable, water quality should provide for protection and propagation of fish, shellfish, and wildlife - *and* provide for recreation in and on the water (the classic "fishable/swimmable" goal). Section 303(c) of the Act states that, "...standards shall be such as to protect the public health and welfare, enhance the quality of water and serve the purposes of this Act." 40 CFR §130.3 reiterates the wording from §101(a)(2) and adds that to "serve the purposes of the Act", consideration must be taken of the use and value of the water body for public water supplies, propagation of fish, shellfish, wildlife, recreation in and on the water, and agricultural, industrial and other purposes including navigation.

Propagation of wildlife is part of the Clean Water Act goal, but "natural background" for wildlife contaminants is arguably subject to interpretation in a system that is no longer truly "natural". Humans manage wildlife populations in the absence of natural predators; 40 CFR §130.2(c) defines pollution as the man-made or man-induced alteration of the chemical, physical, biological, or radiological integrity of water. The issue isn't whether or not wildlife may be contributing to fecal pollution in Oak Creek, but ensuring that "best management practices" are implemented to minimize that contribution.

Comment 1.2 The Department requests clarification regarding the DNA diversity study and a copy of the study design and the report on DNA typing.

Response 1.2 The DNA typing project was initiated within the context of the 4-year National Monitoring Network Program (1994-1998). The final report for this project was completed in June of 1998 and discusses data analysis completed at that time. A copy of this report may be obtained from Dan Salzler (207-4507). The typing project is continuing under a subsequent grant with NAU; development of mammal *E.coli* diversity indices is part of this project's scope. The idea is to create further confidence in the genetic 'signature', first for individual animals, and second for the species. In this way it should be possible to determine the relative contribution and timing of *E coli* contamination to the sediment pool by comparing the diversity within the sediment to the developed diversity indices. A report will not be released until June 2000, however, the Scope of Work for this ISA can be obtained through Dan Salzler (207-4507).

Comment 1.3 The Department questions ADEQ authority to suggest specific changes in wildlife species management: "We agree that the protection of public health and the minimization of the risk to those in contact with Oak Creek should be a priority. However, we also believe that the conservation of wildlife should also be a priority, and should not be manipulated solely to meet water quality standards".

Response 1.3 ADEQ is granted full authority under A.R.S. §49-202 for all purposes of the Clean Water Act. However, ADEQ is not suggesting specific changes in wildlife management, nor is it questioning the importance of wildlife conservation. The draft TMDL suggests the necessity for a team approach in the cooperation between agencies to further identify sources and management options for meeting water quality standards. One of these needs is for animal surveys; another need relevant to AGFD is the development and implementation of all reasonable and practicable best management practices to minimize nonpoint sources of bacterial contamination within its purview.

The water quality standards for *E coli* are specific to the Full Body Contact designated use (swimming etc.). All other designated uses (aquatic & wildlife, domestic water source, agriculture-livestock, agriculture-irrigation) except fish consumption are covered under existing fecal coliform standards: 1000 cfu/100 ml 30-day geometric mean, 2000 cfu/100 ml for 10% samples over 30-days, and 4000 cfu/100 ml single sample maximum. Both the FBC (*E coli)* and A&W (5 sample/30-day geometric mean) standards have been exceeded at Slide Rock. The Clean Water Act does not create a hierarchy within categories of designated use protection; if there is a conflict between standards, designated uses, or water body resources values, full stakeholder participation is required to decide a course of action. There are very stringent criteria that must be met in order to de-designate a designated use (40 CFR 131.10).

Comment 1.4 The Department is concerned about BMPs that involve restriction of animal access to Oak Creek's upper watershed; wildlife movement & migration, access to water, and access to forage are cited as examples.

Response 1.4 The intent of the proposed draft TMDL is not to imperil wildlife populations but to examine the realm of options available to minimize bacterial input to Oak Creek.

Comment 1.5 The Department is concerned with the proposed monthly monitoring of *E. coli* at various locations within Oak Creek, asserting that they do not have lab capabilities or expertise to collect samples.

Response 1.5 The Arizona State Parks Service laboratory at Slide Rock is open for public use, as stated in comments received by that agency within the context of this TMDL review (July ..., 1999). Collection of samples and analysis of *E coli* using Colilert^{R} is relatively straightforward; ADEQ is confident that a training workshop public agencies as well as private citizens could be accomplished within the context of implementing a monitoring strategy.

Comment 1.6 The Department would be willing to provide ADEQ with statistics regarding hunting of

deer and elk; AGFD does believe it would be valuable to better understand the dynamics of the elk and deer populations.

Response 1.6 ADEQ appreciates the Department's willingness to provide hunting statistics. However, ADEQ suggests that information on hunting (alone) is not sufficient to better understand deer and elk population dynamics. Further study needs to be made of seasonal factors such as spatial distribution of animals, migratory patterns, forage availability, runoff patterns, etc.

Comment 1.7 The Department requests a meeting with ADEQ to discuss their comments and concerns. Contact David Walker @ (602) 789-3604.

Response 1.7 ADEQ would be happy to set up a meeting with AGFD at whatever level is necessary to explore/clarify TMDL implementation.

Commentor 2. Loyd Barnett, retired from USFS - Coconino NF

Comment 2.1 A 16% reduction in *E coli* loading from mammal sources seems unrealistic, possibly impractical, and possible undesirable. Mr. Barnett requests that any management action to reduce numbers or ranges be carefully thought out and based on whole ecosystem view. He would like to see any management of wildlife be approached as a last resort, only after much more data has been collected and analyzed and there has been further public involvement.

Response 2.1 The proposed reduction in mammal *E coli* of 16% was founded on existing data resolution; DNA typing estimates the relative contribution from mammals (other than humans) to be approximately 40-45%. 16% reduction from mammals is still 2.5 times less than the reduction proposed from humans (41%). There is nothing magical about the proposed percentages; they represent a place to start, an initial benchmark target. As DNA research continues, seasonal influences are better understood, septic problems are identified/systems are replaced or upgraded, and best management practices are improved across the board, reduction targets may be modified - either downward or upward toward the goal of meeting water quality standards.

Comment 2.2 Mr. Barnett spent 22 years on the Coconino NF with responsibilities in watershed and soils and later in land management planning. He states he has never heard of any soils on the Coconino NF derived from either granite or schist.

Response 2.2 ADEQ has checked references cited (NAU Department of Geography Resource Atlas of Coconino County, and NACOG 1978 reports). ADEQ acknowledges that no mention is made of granite or schist; the final TMDL will reflect this change.

Comment 2.3 With regard to historical grazing impacts on the upper watershed, Mr. Barnett refers to the citation from NACOG, 1978. First, Mr. Barnett points out that problems with soil destabilization occurred below Sedona, not in the upper watershed. Secondly, he participated in the NACOG 208

planning in 1977 and 1978; the technical review committee included active representation from the livestock grazing community. He questions the figure of 8 cattle per acre carrying capacity due to historic overgrazing and soil loss: "we would not have knowingly allowed such a grossly incorrect statement to be included". Mr. Barnett says the figure of 8 cattle per acre is off by at least an order of magnitude: could be 8 cattle per section (640 acres) - meaning 640 acres would support 8 cattle on a year-long basis, which equates to 6.67 acres per cow per month...or it could have been eight acres per cow per month.

Response 2.3 ADEQ will change the language in the Final TMDL, deleting specific enumeration of cattle per area.

Comment 2.4 In reference to the carrying capacity of the land above the Mogollon Rim, Mr. Barnett asserts that dense ponderosa pine forests have developed as the result of fire suppression; the resulting reduction in livestock carrying capacity is due to conversion of grassland to forest. Mr. Barnett states he knows of no evidence of major soil loss above the Mogollon Rim. In addition, Mr. Barnett agrees that elk populations have increased dramatically since the 1960's, but he does not believes the deer population may have actually decreased and suggests checking with AGFD.

Response 2.4 It is very difficult to quantify impacts to either the land or wildlife populations over the last 150 years. Some degree of soil destabilization and loss, changes in vegetation, and shifts in wildlife populations have certainly occurred. ADEQ suggests that pressure from elk may be more dramatic than from cattle in sensitive areas close to the Rim, and that part of wildlife management must involve assessment of wildlife 'carrying capacity' as it pertains to fecal coliform loading.

Commentor 3: Kelly Moffitt, Northern Regional Office Manager AZ State Parks Service

Comment 3.1 Mr. Moffitt asserts that TMDL actions proposed for his agency place the agency in a different role from the role they have been occupying, more like regulatory compliance officers than park rangers, ..."this effectively changes our role as a resource management agency protecting the public health and safety of park visitors, to something more resembling a research agency compiling data for a regulatory agency (ADEQ, EPA)".

Response 3.1 ADEQ sees the proposed actions for ASPs as increasing the effectiveness of existing roles. Setting a lower trigger for additional monitoring assures the public, the agency, and regulators that there will be less likelihood of bacterial exceedances. ADEQ would like to work with ASPs to determine threshold levels for meaningful and achievable trigger levels for rainfall or stage also. In any case, the goal is to further minimize exposure to pathogens.

Comment 3.2 ASPs is concerned that they are being singled out. There has been significant watershed effort and involvement to date; ADEQ should change the title of the TMDL to "Pathogen TMDL, Oak Creek Basin".

Response 3.2 The TMDL is focused on Slide Rock because 1) based on recreational pressure, health risk is greater than elsewhere on the creek, 2) there is a longstanding monitoring history at Slide Rock showing regular summer coliform exceedances. However, ADEQ agrees that watershed efforts should include consideration of the entire creek, both in seeking causes and finding solutions.

Comment 3.3 ASPs wants language indicating that this, or "an equivalent or superior method" be added so that they will not be locked in to that specific test.

Response 3.3 Language will be changed to reflect this request.

Comment 3.4 Mr. Moffitt asserts that ASPs does not have the staff/resources/time to do this additional sampling for fecal coliform and to determine the relationship between fecal coliform and *E coli*.

Response 3.4 Data collection (fecal coliform in water and sediment) and a monitoring strategy in general, should be a priority topic of discussion among the stakeholders. ADEQ will consult with contractors at NAU and other professionals in the field to determine the best monitoring strategy, however, it is likely that all stakeholders will be called upon to participate so that no one entity need carry the entire burden.

Comment 3.5 Mr. Moffitt is concerned with the proposition to lower the "trigger" level for the alarm system from 580 cfu/100 ml to 450 cfu/100 ml. This alarm indicates "Stage 2 alert status", in which additional sampling is initiated. ASPs asks where the 450 number came from, how it was derived, and how it compares with the full body contact requirements?

Response 3.5 The ASPs Management Plan cites Stage 2 Water Quality Alert as: a warning to swimmers (geometric mean between 110-129; or one single sample max violation). Although swimming/wading is not prohibited, it is recommended that caution be exercised, especially for persons with weak immune systems. In other words, swim at your own risk. Stage 3: High Risk is reached when either 1) a geometric mean of 130 or greater is reached, or 2) if/when a previous single sample maximum violation at 580 or above is <u>confirmed.</u>

The time elapsed between first apparent exceedance and results from confirmation samples is a minimum of 60 hours. In the meantime, the public is potentially exposed to harmful pathogen levels. The idea in proposing a trigger of 450 cfu/100 ml is to reduce the probability that levels of *E coli* at or above the standard will be reached at all, thus minimizing exposure and risk.

Comment 3.6 With regard to establishing a water level (stage) trigger, Mr. Moffitt cites findings made by Bob Sejkora (Water Rights Specialist for ASP): a stage change of 0.03 ft or greater occurs daily during the time when phreatophytes are leafed out/temperatures are high enough to increase evapotranspiration. Also, there can be a stage fluctuation, or "blip" between 0.03 and 0.07 ft without precipitation. If ADEQ is going to require a stage trigger, the request is to make it 0.50 ft, "but this should not be implemented without a clearly articulated, planned, and feasible response". In addition, ASPs would need to evaluate the precipitation data further before suggesting an appropriate trigger for

the rain-gauge.

Response 3.6 ADEQ acknowledges the need to establish a meaningful trigger in relation to precipitation. Variation around the baseline should definitely be accounted for in this determination. ADEQ will work with ASP and others to determine the appropriate trigger level(s).

Comment 3.7 Mr. Moffitt asserts that limiting the number of swimmers is "unacceptable; ...swimming is a legal activity, it is not within our (ASP) visitor service philosophy to treat legal activities as crimes. To date, our data suggest no correlation between swimming and the existing water quality standard". ASP wants to know why ADEQ is treating swimming as a regulated activity?

Response 3.7 The proposal to limit swimming at Slide Rock is based solely upon the fact that more people in the water stir up more sediment. The greater the 'roiling' of sediment, the greater the risk of exposure to potentially harmful pathogens. The data collected under the National Monitoring Program points clearly to this phenomenon; ASPs data may not show the same trend because 1) ASPs is not collecting sediment and water fecal coliform data, and 2) the time lag between *E coli* sample results, and 3) is not enumerating swimmers and looking for trends.

ADEQ sees the proposal for a pass system as a responsible step - within what ASP states is their objective: to provide a safe and clean environment at the Slide Rock swim area. ADEQ acknowledges the concern that such a system must be effective and manageable.

Comment 3.8 Mr. Moffitt expresses concern regarding patrol of the area and possible imposition of fines: ASP currently has 3 full-time law enforcement officers at Slide Rock; "the policy is to inform and educate, not be heavy-handed as this TMDL suggests". ASP does not impose fines and claims, "we have no such authority, nor do we desire to treat visitors in this manner. We enforce established park rules and regulations that are currently in place, and our staff responds to violators on an individual basis. We will continue to do so".

Response 3.8 It is not ADEQ's intention to turn Slide Rock into a police zone. Park patrol and imposition of fines should be undertaken with the support of other stakeholders and the full knowledge of all visitors. Visitors not only have the right to swim, but should also have the right to a clean and safe swimming experience. Unfortunately, this may mean compromise and limited access.

Comment 3.9 Mr. Moffitt cites a Resolution signed by Jack A. Brown on July 11, 1984 (Water Quality Control Council Chairman): "Resolution to Designate Oak Creek and the West Fork of Oak Creek as Unique Waters of the State". The Resolution designates the entire length of Oak Creek plus West Fork, "*except for Oak Creek from below Banjo Bill Campground to the Manzanita Campground and from above Page Springs to below Page Springs which should receive conditional designations subject to compliance with Remedial Criteria on pg 23 of the Final Report - by July 11, 1989".*

Response 3.9 The Final Report referenced was prepared by Ed Swanson of the Ambient Water Quality Unit, Bureau of Water Quality Control, ADHS, July 11, 1984. Page 23 cites three conditions that must

be met in order for designation of the two areas as Unique Waters: 1) ID of bacterial source, 2) abatement of contamination, and 3) continued monitoring. The report goes on to state, if these conditions are not met after 5 years, the designation of these segments shall be withdrawn by the Council.

The specified segments were never de-designated as Unique Waters. In addition, regardless of Unique Water status, the Final Report clearly states that water quality standards and management practices applicable to designated segments should be applied to all segments. (ADHS, 1984; pg 24)

Comment 3.10 ASPs does not trust National Monitoring Program data collected over the period of time that Tom Harrison (NAU) was project manager. ASPs would like clarification as to percentages of *E. coli* attributable to mammals and humans; there is a contradiction between page 9 and page 18. Claim that a disproportionate focus is placed on Slide Rock, when there are many other locations where humans recreate.

Response 3.10 ADEQ cannot respond to the statement made regarding Mr. Harrison; the National Monitoring Program was approved by EPA Region 9 Quality Assurance in 1997. Exact percentages of *E coli* attributable to mammals vs humans is still being worked out. There is a pool of (to date) unidentified *E coli* that makes up about 10% of the total. Overall, the contribution between mammal and human seems to be about equal.

Slide Rock swim area has by far the highest recreational pressure (swimming) along Oak Creek. The TMDL does not single Slide Rock out in any way other than the site of highest risk potential. Sources of pathogens are still being investigated using DNA typing and development of diversity indices that will allow better attribution.

Comment 3.11 Mr. Moffitt considers the proposed 30% reduction in sediment fecal coliform as unrealistic, ...”a 41% reduction [in the human component] within five years is impossible, even if all existing septic systems can be brought up to proper standards within the time frame”. Mr. Moffitt asserts that ADEQ needs to determine the exact count of septic systems within Oak Creek. He also cites the existence of ‘native’ wildlife contribution to fecal coliform in sediments and asks why the TMDL focuses on sediment fecal coliform when we have no sediment standards. The focus should be on the existing *E coli* standard in water; ASPs suggests a goal of less than 10% exceedance of *E. coli* within a five year period.

Response 3.11 The standard for *E coli* has only been in existence for three years. Although it replaces the full body contact fecal coliform standard, Slide Rock was listed as “water quality limited” under the previous fecal coliform standard. Further complicating matters, there is still a fecal coliform standard for all other designated uses on Oak Creek.

Gordon Southam has established a link between the buildup of a fecal coliform reservoir in sediment and increased levels of fecal coliform in water as the result of stirring up contaminated sediments. ADEQ recognizes that the ultimate goal is to reduce *E. coli* in the water column, but it appears that the

sediment reservoir has become a secondary source, in this case, directly relevant to swimming activity. On what else could an assurance of "less than 10% *E coli* exceedance" be based?

Comment 3.12 [under separate cover from Mr. Moffitt, 7/14/99] Upon analysis of all *E. coli* test results taken from the water quality laboratory at Slide Rock State Park since 1996, we find that the true exceedance rate is [provided in table] 2.24% overall, not 37% as presented at the June 29, 1999 public meeting.

Response 3.12 ADEQ received data from ASPs in several installments, beginning with hard copies provided to Ms. Julie Cox which covered 1996 and part of 1997. Last Fall, ADEQ requested an electronic copy of all data available. ADEQ received data from Bob Sejkora and Steve Pace. Only 1998 data was analyzed to evaluate exceedances.

ADEQ would like to formally apologize for offering misleading information to the general public. ADEQ considered both single sample and geometric mean standard violations. The 37% was erroneously derived from double counting parts of the data set. Thus an error was made in the interpretation of a frequency histogram, which should have been obvious at the time, but which was apparently missed, especially since other graphs did not support that exceedance level.

<u>In no way was this unfortunate event preconceived or intended</u>. Subsequent analysis of this same data set (1998) still yields a percentage higher than that reported by ASPs; considering only data from May 31st to September 15th, produces an overall exceedance rate of 10.3%, including both single sample and geometric mean values. Perhaps there is a fundamental difference in data analysis approach. Problems such as this must be avoided in the future through frequent contact. Please note however, that additional exceedances of the fecal coliform geometric mean standard (1000 cfu/100 ml) have also occurred during summer months at Slide Rock.

<u>Commentor 4 Bill Stafford, for Ken Anderson: USFS - Sedona Ranger District</u>

Comment 4.1 Mr. Stafford agrees with ASPs comments stated in letter of July 7, 1999.

Response 4.1 ADEQ acknowledges this fact. Please review ADEQ's responses to ASPs comments.

Comment 4.2 Mr. Stafford points out that 8 cattle per acre should be 8 cattle per section.

Response 4.2 ADEQ will correct this language in the TMDL text.

Comment 4.3 Mr. Stafford cites the concern that swimming is a "legal activity". The Forest Service's Good Host Philosophy is inconsistent with issuing permits for swimming. Mr. Stafford asserts that the ASPs 1999 Management Plan is adequate to protect public health.

Response 4.3 With regard to swimming as a "legal activity", ADEQ agrees. However, is not true that swimmers also have a legal right to clean and safe swimming conditions? Actions proposed in the

TMDL are aimed only at reducing the risk to swimmers. If risk cannot be sufficiently reduced through other means, consideration must be given to ways to reduce 'roiling' of the sediments; one obvious means is by reducing the numbers of people in the water at any one time, and/or limiting the time period for swimming. As stated under Response 3.7, 60 hours during which *E coli* levels may be at or above standards is not an acceptable health risk.

Comment 4.4 The USFS has a program in place (since 1997) to monitor sites both upstream an downstream of Slide Rock, using "Friends of the Forest" volunteers. Samples are collected weekly for *E. coli* at Grasshopper Point, the Ladders, pools upstream of Slide Rock, Red Rock Crossing, Mormon Crossing, and Spring Creek. Results are sent to Dan Salzler of ADEQ's Nonpoint Source group. This monitoring uses the same warning system in place at Slide Rock State Park. The USFS does not have a budget for collection and analysis of fecal coliform data (water and sediment).

Response 4.4 ADEQ acknowledges and commends the USFS for coordinating these additional monitoring effort. Data on record at ADEQ was provided by Dan Salzler during TMDL preparation. However, sampling once a week is not sufficient to characterize water quality for pathogen risk. ASPs has indicated their willingness to make their laboratory available for outside use. The TMDL suggests review of the existing monitoring efforts to ensure sufficient spatial and temporal coverage to adequately protect human health. Stakeholders should explore additional funding sources to cover a comprehensive monitoring program so that no one entity has to bear a disproportionate burden.

Thank you for providing a copy of the 9/'97 Region 3 Surface Water Sampling Plan for Selected Sites in Oak Creek Canyon. This document was regrettably overlooked in ADEQ's review of background information. However, ADEQ did review the draft Oak Creek Corridor Plan and found mention of regular monitoring at Grasshopper Point and Manzanita Campgrounds only. Several citizens have expressed an interest in participating in ongoing monitoring; perhaps one of the first stakeholder meetings should focus on how to expand and share monitoring responsibility, as well as the logistics of how it will be accomplished.

Comment 4.5 The USFS is actively fencing livestock out of wetlands and riparian areas in the upper watershed. BMPs too numerous to count are cited in the Coconino National Forest Land Management Plan; all Coconino National Forest projects are required to follow these BMPs. What does the sentence, "Development of BMPs for restriction of animal access to Oak Creek and drainages in the upper watershed" mean?

Response 4.5 ADEQ is very glad to hear the assertion that the USFS is actively managing the upper watershed according to BMPs listed in the Coconino National Forest Management Plan. The TMDL addresses use of BMPs generically as a vital requirement for nonpoint source activities. ADEQ recommends that USFS, AGFD, ASPs and all other stakeholder groups, meet to compile and officilize a synthetic management plan citing all BMPs currently in use, and any others that may be considered specifically focused on pathogen reduction.

Animal populations of potential concern include both domestic and wild mammals within the

watershed, therefore, BMPs for their control are relevant to all stakeholders identified in the TMDL.

Comment 4.6 In particular, the USFS underscores comments made by ASPs concerning *E.coli* as the only standard, maintaining the trigger level at 580 cfu/100 ml, the unacceptability of issuing swimming passes, and a precipitation trigger of at least 0.5 ft.

Response 4.6 ADEQ acknowledges these concerns and directs the USFS to responses made to ASPs. Because this TMDL is designed to be a working/planning document, please be assured its intent is to stimulate and encourage continued refinements to both source ID efforts, and management efforts. It is to these global ends all stakeholders must be committed. All points are well-taken and should be negotiated within the forum of a watershed workgroup.

Commentor 5 Dan Smith: Coconino County Environmental Health Services (CCEHS)

Comment 5.1 What is the impact of the pathogen TMDL on the 1990 Oak Creek Policy which requires all new developments with an onsite wastewater system to reduce nitrogen by 80%? What is the impact on the 1999 Guidance Document for the Repair and Upgrade of Existing Onsite Wastewater Systems in Oak Creek Canyon?

Response 5.1 The pathogen TMDL recommends a course of action pertaining to pathogen reduction only and is indirectly relevant to the 1990 Policy. The 1999 Guidance will pertain to pathogen compliance, as well as nutrient influences. This document will be finalized and made consistent with ADEQ Bulletin 12; this effort will require cooperation between CCEHS, ADEQ, and NAU, under contract to recommend onsite systems for Oak Creek. In the meantime, a ground survey should be conducted to establish location and functional status of all septic systems within Oak Creek Canyon.

Comment 5.2 On page 1, paragraph 2 of the TMDL: note that extensive monitoring has also been provided by CCEHS.

Response 5.2 ADEQ acknowledges monitoring by CCEHS and will add language to the Executive Summary.

Comment 5.3 On page 8, paragraph 2 of the TMDL: include Grasshopper Point as an area of concern.

Response 5.3 ADEQ acknowledges Grasshopper Point as an area of concern. Although the TMDL mentions Grasshopper Point as one of four locations sampled through the National Monitoring Program, additional language will be added to clarify sampling results and ongoing monitoring by the Friends of the Forest.

Comment 5.4 On page 24, paragraph 2 of the TMDL: delete the second sentence as this has no relevancy to the Oak Creek Pathogen TMDL.

Response 5.4 The specified sentence will be deleted as requested.

Comment 5.5 On page 24, paragraph 1, sentence 4 of the TMDL: delete the words "A revised" and replace with the words "An addendum to the" and delete "replace" and replace with the word "supplement"; paragraph 5 delete "will be released" and replace with "has been issued".

Response 5.5 The specified changes will be made in the final TMDL.

Commentor 6 Joelle Wirth: Coconino County Environmental Health Services (CCEHS)

Comment 6.1 The Executive Summary should include CCEHS as a land manager.

Response 6.1 The final TMDL will reflect this change.

Comment 6.2 There are no sediment standards and therefore no standard methods for sediments. Use of sediment fecal coliform is a bit arbitrary; the better directive would be to derive sediment standards.

Response 6.2 ADEQ acknowledges that no sediment standards exist for fecal coliform. Development of sediment standards is one option which may be pursued in the future; however, in the meantime, management practices designed to minimize inputs of fecal coliform sources and the buildup of fecal coliform in sediments is one practical approach to meeting standards for fecal coliform in water - and to *E. coli* in water. The questions of regrowth and over-wintering will continue to be pursued. If continued research demonstrates a better approach for attaining standards, benchmarks can be reworked.

Comment 6.3 Is the [*E. coli*] standard more restrictive or is it just that it is more specific? Also, note there have been additional locations with water quality violations above and beyond Slide Rock.
Response 6.3 The *E. coli* standard is a more specific indicator of human pathogenic risk than the fecal coliform standard. The actual numeric limits for *E. coli* (580 cfu/100 ml single sample; 130 5-sample/30-day geometric mean) are lower than previous fecal coliform numeric limits. Previously, a violation at 800 cfu/100 ml fecal coliform may or may not have reflected a count of 800 cfu/100 ml *E. coli*, but if that were the case, the subsequent standard could be considered more restrictive. A better way to look at it is to say that *E. coli* is a more accurate indicator.

Comment 6.4 The most common problem is not shallow soils but rather highly permeable soils designated by Soil Conservation Service as unstable, coupled with small lot size, location of drinking water wells, and spring or ground water influences. Page 12 should include: additional conditions include highly permeable soils, rapid drainage, small lot size, high density, aging systems, artesian springs, an/or other ground water influences, and well locations.

Response 6.4 ADEQ fully agrees with these statements. The contribution from these combined factors is what makes the canyon vulnerable to both septic failure and possible flushing of contaminants into Oak Creek.

Comment 6.5 Potential sources on nonpoint contamination need to include the shift in the usage of the canyon: switch to day use has created more camping above the switchbacks and close to water and/or drainage into the creek.

Response 6.5 ADEQ appreciates this comment and will add this consideration to the final TMDL.

Comment 6.6 Additional problem areas [to Slide Rock] include Pine Flats Campground, large swimming hole below Troutdale, Grasshopper Point, and Manzanita.

Response 6.6 Perhaps the TMDL did not adequately relate this information; language in the final TMDL will reflect this concern.

Comment 6.7 The information presented on page 9 [pertaining to *E. coli* diversity indices] needs to be deleted. Dr. Southam indicated that this part of the study is in its earliest phase and is not yet complete.

Response 6.7 This point is well taken, as Dr. Southam has also made clear. The final TMDL will discuss development of a diversity index as one of the grant tasks, but will not include the tables of data.

Comment 6.8 On page 17, should runoff be included as a contributor [under Nonpoint Sources]?

Response 6.8 Runoff is mentioned further down on page 17 under the subheading ID Causes & Effects.

Comment 6.9 I believe that there is not sufficient information [to link fecal coliform in sediments, fecal coliform in water, and *E. coli]* to establish a management TMDL. It seems unfair for the residents of Coconino County to be held to a more stringent standard simply because test information has been available. Unless you continue the scope of the project down throughout the watershed you are implying that pollution stops at the boundary.

Response 6.9 This TMDL focuses on Slide Rock because of 1) extraordinary high recreational use, 2) three decades of sampling that indicates a seasonal bacterial problem, and 3) only a one-mile reach of Oak Creek is listed as "water quality limited" for fecal coliform and *E. coli*. ADEQ agrees that imposing boundaries on the problem of bacterial contamination is artificial, however, because a TMDL must be done on this particular reach, stakeholders are advised to look at it as an opportunity to address bacterial contamination watershed-wide.

<u>Commentor 7 Will Newman: President of Recreation Resource Management (private company)</u>

Comments in general reflect those of ASPs. Please refer to responses 3.1 through 3.12.

Comment 7.1 Mr. Newman expresses disappointment at the release by ADEQ of the 37% exceedance rate during the public meeting on June 29, 1999. He states, "My research suggests that you deliberately

released false information in an open public meeting just before the 4th of July weekend. As noted in the public meeting this was just an attempt by yourself [Susan Fitch] and ADEQ to alarm the public and create more funding for this cause. This type of misinformation seems to be the norm for yourself and ADEQ when the facts do not support your radical anti-tourism agenda".

Response 7.1 As stated in response 3.12 to Kelly Moffitt of ASPs, ADEQ acknowledges and makes apology for the mistaken figure of 37% violation quoted for Slide Rock. This mistake was not intentioned and did not reflect the intent by either Susan Fitch or ADEQ to alarm the public prior to the July 4th holiday. The timing of the public meeting was an unfortunate coincidence to the misinformation. Note however, that records provided by ASPs and reviewed by ADEQ do indicate an exceedance rate of just over 10% for the summer of 1998; this rate includes both violations of the single sample maximum value and violations of the geometric mean value.

Comment 7.2 It should be noted that RRM implemented the *E. coli* standard at ADEQ's recommendation, supported by the ADEQ publication "Adoption of *Escherichia coli* as a Bacterial Indicator of Water Quality". In this paper, ADEQ concurred with the findings of EPA that *E. coli* was a better indicator of swimming associated gastrointestinal illness than fecal coliform. The paper cites EPA's acceptable swimming associated illness rate of 8 per 1000. Examination of the record at Slide Rock shows that the ratio has not approached that number, but is much lower. This was substantiated by Coconino County "DHS" at the 6/29/99 ADEQ TMDL public meeting. Documented reports of illness from visitors to Slide Rock are practically nonexistent....Logically, if the *E. coli* standard is satisfied, then the fecal coliform standard would likewise fall within compliance limits. It seems ADEQ and EPA should be working together to bring all standards into a state of consistency and apply the *E. coli* standard universally, including the TMDL process"...

Response 7.2 ADEQ must conduct TMDLs for all parameters for which a waterbody is listed. In the case of Slide Rock/Oak Creek, listed parameters include fecal coliform and *E. coli.* It is true that the latter is a superior standard as an indicator of risk to enteric pathogens. This TMDL makes the conservative assumption that all fecal coliform are *E. coli.* Coupled with the fact that there have been a sufficient number of exceedances of the *E. coli* standard since 1996 to keep Slide Rock State Park on the "water quality limited list" , load analysis of pathogens includes the greater universe of fecal coliform bacteria, both initial sources and the secondary sediment reservoir that becomes a potential risk to swimmers. Criteria used to establish a standard set an initial benchmark for enforcement of that standard, however, an acceptable risk of 8 illnesses per 1000 does not equate to an acceptable standards exceedance number. Does the analogy of establishing an acceptable excess cancer risk of 1 per million justify violation of toxics standards?

<u>Commentor 8 Gary Garland: President of Oak Creek Canyon Property Owners Association</u>

Comment 8.1 This TMDL appears to be an attempt to comply with EPA requirements, but without the necessary data or good science to justify its conclusions or plan of action. The following is a list of subjective conclusions: 1) after making a statement that the background work is not completed, the authors attempt to calculate detailed load contributions in Section VI, along with conclusions as to

source and remediation; 2) there is inconsistency between “greater than 50%” human contribution and “55% human contribution” cited in the load calculation; 3) it is difficult to understand how the figure of 3,000,000 cfu/100 ml was arrived at for the mean sediment value at Slide Rock State Park in the summers of 1996 and 1997...Figure 8 does not appear to support that number; 4) Figures 7 and 8 do not support a link between fecal coliform in water and in sediment; 5) as pertains to “septic failure”, while there is the need to upgrade many systems in the canyon, there are probably few “failing” system...when a septic system does fail, is does not short circuit to the creek, but will back up and surface, thereby alerting the property owner...; 5) the efficacy of the treatment in the soil and type of soils in the Canyon has been misrepresented...in many parts of the upper Canyon there is some of the best soil for treating effluent found in Coconino County; 6) the nearest septic system to Slide Rock is almost 2 miles upstream...why didn’t the National Monitoring Program indicate violations?

Response 8.1 ADEQ must assume from the comments that Mr. Garland is questioning the validity of the National Monitoring Program and associated studies. This TMDL is intended to build upon the 4-year EPA-approved project and subsequent related work and to provide a planning template under which to proceed in reducing bacterial contamination. This TMDL is written to empower the stakeholders to combine forces in seeking solutions on a watershed basis. In response to comment 8.1.1: detailed load contributions have not been calculated or allocated, rather a group allocation (in the form of a percent reduction) has been assigned, toward which attainment all stakeholders must cooperate. It is precisely because of the gaps in information that this approach has been taken. In response to comment 8.1.2: The ultimate figure for human *E. coli* contribution, whether is turns out to be 50%, 55%, or only 45% is less important at this juncture than the recognition that human sources are indeed a major contributor. As stated in the TMDL, the percent reduction can be refined over the course of the five years to better reflect either science, or practicality, as long as the ultimate goals of reducing pathogen risk and meeting standards is achieved. In response to 8.1.3: the figure of 3,000,000 is exactly the mean value for sediment coliform over the summers of 1996 and 1997; given the tremendous variability shown in the data and the relatively short time over which data have been collected, targeting the mean value for percent reduction is a defensible starting point. Others have suggested that a 30% reduction is not aggressive enough. In response to comment 8.1.5: conditions within Oak Creek Canyon are reportedly less than optimum for operation of septic systems; if systems are either backing up effluent is being flushed into the creek by spring flow or high ground water elevations, the situation must be addressed. ADEQ is in total support of having the septic input hypothesis disproved, but to date sampling has neither proved nor disproved this hypothesis. In response to 8.1.6: National Monitoring Program data do suggest some near-shore inputs of nutrients to the creek; if nutrients are leaching, it is likely that pathogens may also be entering the creek from septic systems.

Comment 8.2 Property owners in Oak Creek are stakeholders, and are very interested in the health of Oak Creek. We would like to see ADEQ and CCEHS allow property owners to upgrade their older systems with cost effective, site appropriate septic systems, or where the soils require it simple secondary systems.

Response 8.2 ADEQ completely agrees with this comment and fully intends to participate with

CCEHS in clearing the way for upgrades and repairs. It may be possible to obtain Clean Water Act Section 319 monies to offset costs. This option should be explored.

Comment 8.3 We would like to see the Forest Service and State Parks evaluate the carrying capacity of the creek as to recreational use, and to implement effective management of numbers of users, and enforce littering regulations along the creek so animals are not attracted to the stream side to feed. All of these things can be accomplished without the need of the action plan in this TMDL.

Response 8.3 ADEQ agrees with the comment that recreational carrying capacity must be evaluated and existing regulations enforced. However, given the fact that pathogen problems persist along Oak Creek, ADEQ asserts that an integrated action is needed.

Comment 8.4 An attempt to write a TMDL for bacteria, etc., could be productive and successful if the stakeholders and responsible agencies were included in the process. Therefore I recommend that the EPA not accept this TMDL for bacteria in Oak Creek Canyon. Also, it should not be used by ADEQ for the purpose of rule making, policy making, or the writing of guidance documents.

Response 8.4 ADEQ would like to remind Mr. Garland that there has been a six-year history of stakeholder involvement in Oak Creek pathogen issues. The Oak Creek Task Force, and later the Oak Creek Advisory Committee, has included all the stakeholders cited in this TMDL. Regular meetings were held to discuss both the nutrient TMDL and the National Monitoring Program. It was not until October of 1998 that the decision was made to go forward with a TMDL based on results of the National Monitoring Program. Dan Salzler continued to chair Oak Creek Task Force meetings throughout the winter and spring of 1999. The TMDL's author, Susan Fitch was not able to attend a Task Force meeting until May. ADEQ hopes that you will consider this TMDL as a synthesis of past developments and a call for continued involvement; it is the stakeholders that will ensure success.

Commentor 9 Morgan Stine: Secretary of the Oak Creek Canyon Property Owners Association, Inc.

NOTE: some comments are duplicative of those offered by others; please note responses elsewhere.

Comment 9.1 During the previous twelve years there have been numerous meetings and discussions between stakeholders, regulators and academics evaluating the need, form and objectives for these [nutrient an d pathogen] TMDLs. It is my opinion that the two draft documents fall far short of the objectives set by the stakeholder TMDL Technical Review Team. I recommend that you do not

proceed with these two documents in current form, but that you create a new stakeholder Technical Review Team to review and advise you how to proceed.

Response 9.1 ADEQ acknowledges the comment that discussion has been ongoing for several years with regard to Oak Creek TMDLs. Concerning pathogens, the National Monitoring Program Final Report, dated June 1998, articulated four years of study specifically focused on addressing the bacterial phenomenon at Slide Rock. As you know, the study's design intended to tease out relative recreation inputs. In the process, a secondary source of bacterial contamination was discovered: a significant reservoir of fecal coliform in sediments - particularly at low-gradient locations along the creek. Data analysis showed an apparent trend between the build-up of this sediment reservoir and increased levels of fecal coliform in the water column. DNA analysis determined that *E. coli* bacteria are present in this reservoir. Humans and other mammals are apparently contributing to this reservoir; further work is ongoing to determine loading patterns.

As an involved stakeholder, you must have reviewed the 1998 Report. You will have noticed that the report did not make specific recommendations. However, because the reach that includes Slide Rock continues to be listed on the "water quality limited list", the EPA requires that the State complete a TMDL to ensure standards compliance. The TMDL as structured attempts to empower the stakeholders to continue pursuit of actions already underway in order to bring Oak Creek into standards compliance. Further study is built into this TMDL, as is continued technical review by stakeholders. In fact, the TMDL will not succeed without this involvement. The TMDL does not impose untenable actions, but rather builds on what is known. The requirement of a TMDL to allocate source reductions has been addressed through assignment of a group allocation (30% reduction in sediment fecal coliform) in the absence of specific information that would allow either geographic or stakeholder-specific allocations. If, over the course of the five year period, it becomes apparent that standards will be achieved and pathogen risk sufficiently reduced through other or modified means, the intent of the TMDL has been met. Your continued involvement is extremely valuable in the ongoing stakeholder review process.

Comment 9.2 There exists significant data and evidence that indicator organism regrowth is occurring in the swim areas and causing these [bacteria] standards violations. A combination of inoculated sediments, a flowing oxygenated water column, ammonia nitrogen as a nutrient source and recreational bathers to mechanically agitate the sediments into the flowing water column all occur the same time water temperatures become ideal for organism regrowth. If regrowth of the indicator organism is occurring, it may be disproportionate to pathogenic regrowth. Has adequate research been performed to eliminate the regrowth question?

Response 9.2 It is ADEQ's understanding that both regrowth of bacteria and overwintering may play a key part in the build-up of fecal coliform in sediments. Gordon Southam (NAU) is continuing to explore these hypotheses. There is no question that these phenomena need to be weighed into the TMDL action plan. The TMDL fully support further definition of bacteria sources, sinks, regrowth, the impact of environmental conditions, and the relative determination of what percentage of the sources are controllable, always keeping in mind the ultimate goal of meeting standards.

Comment 9.3 Have remote streams (watersheds with less human impact such as upper Clear Creek) in Arizona been evaluated to determine natural background sediment coliform loadings?

Response 9.3 ADEQ is not aware of any such study, but acknowledges the relevance of the question. However, any such watershed comparison would be relativistic only; it would still fall to the stakeholders of Oak Creek to determine how bacterial standards will be met.

Commentor 10 Jeff Chappell: Sedona Redrock News

Comment 10.1 I wasn't there for Susan's presentation, but assuming the bacterial TMDL analysis shows similar results [to the nutrient TMDL analysis], what action if any will need to be taken?

Response 10.1 The bacterial TMDL did not use the same modeling approach that Dr. Nix used - for several reasons. This TMDL is being completed as a result of continued summer exceedances of relevant bacterial standards for over 30 years. The approach taken by ADEQ is to continue with application of best management practices, continue source identification through DNA typing, and work out a plan for reducing sediment fecal coliform and *E. coli* over the life of this TMDL, which has been suggested to be a five-year period. The goal of the TMDL is to meet water quality standards by 2004. There will be benchmarks established for completion of BMPs, studies, system upgrades (where needed), and other demonstrated improvements. The percent reduction in loading replaces assignment of individual numeric loads and will apply collectively to the stakeholders.

Commentor 11 Tom O'Halleran: Chairman of the Verde Watershed Association

Comment 11.1 Your presentation at the June 29th meeting in Sedona was both professional and educational. [From my perspective as Chairman of VWA] we feel that there has not been enough time allowed for review of the draft document that was provided in mid-June. Although the VWA did meet after release of the draft our organization requires more turn around time in order to provide comments that reflect the feeling of our membership and stakeholders. We feel an extension of the comment period is necessary.

Response 11.1 Thank you for your positive words. Your request for extension will be passed on the EPA.

Comment 11.2 On a more personal note, I feel that the approach being taken of placing the reduction amount of 30% on the recreational community is short-sighted. This is especially true when it has not been identified as the major problem and when so much information is still unknown. There has been no evaluation of impacts to other areas of the creek [if swimming is not allowed at Slide Rock]; what is the economic impact to the park? What is the impact to the Sedona area due to increased bacterial alerts?

Response 11.2 ADEQ would like to clarify that the 30% reduction in fecal coliform in sediments at

Slide Rock is not placed solely on the recreational community. In fact, in order to achieve a 30% reduction, all upstream stakeholders must participate and share the burden. It is not the intention of this TMDL to close Slide Rock State Park to swimming; a limitation in the number of bathers was suggested and should be reviewed by the stakeholders within the big picture. Other refinements in management were also proposed for consideration. The actual number of bacterial alerts has not significantly changed; the TMDL is necessary because the situation is long-standing and requires focused solutions. Source identification is a primary objective of this TMDL.

Commentor 12 Gabriel of Sedona and Niann Emerson Chase: Ministers of Aquarian Concepts

Comment 12.1 As a church that owns property bordering Oak Creek...we are concerned that many sources of pollution were overlooked and the dangers were underestimated. In the summer we have looked at the water in Oak Creek and made the determination not to allow our children to swim in it that day...this visual technique // has been effective to see the water teeming with many organisms at certain times. It is not enough. More testing needs to be done downstream from Slide Rock State Park. We would like to test the water that runs through our property and would be happy to allow those test results to be used in future studies. If you could provide equipment and instruction, we would volunteer our services in water or sediment collection or testing. We suggest other property owners on Oak Creek be given the ability to test water quality from their property as well.

Response 12.1 ADEQ appreciates the concerns of property owners along Oak Creek. You and others like you would be welcome to participate in monitoring. As stakeholders both downstream and upstream of potential bacterial sources, it would be advisable to establish a volunteer monitoring coalition. The ADEQ Surface Water Monitoring and Standards Unit could provide initial oversight and training (602) 207-4219.

Comment 12.2 Page 8 shows monitoring sites along Oak Creek and yet the results of this monitoring are not widely shared with the public. What is being discovered at these sites and how extensive is the testing? These sites should carry on daily or weekly testing and inform area residents when bacteria levels are high.

Response 12.2 The monitoring sites cited in the TMDL report include those tested most frequently in past years. Among those currently monitoring Oak Creek, are Coconino County Environmental Health Services, the Forest Service, State Parks, Friends of the Forest, and members of the Oak Creek Property Association. There may be others. However, there is no central data repository; perhaps there should be?

Comment 12.3 Septic seepage should be monitored with waste disposal systems in Oak Creek Canyon regularly tested.

Response 12.3 Coconino County Environmental Health Services is in the process of conducting a survey of septic systems within the Canyon.

Comment 12.4 Other pathogens should be looked at, not just *E. coli*. For example, *Giardia lambia* and certain types of protozoa are a potential health threat which may be present.

Response 12.4 *E. coli* is a good indicator of the general presence of enteric pathogens. There have been other microbiological investigations on Oak Creek, as cited in the TMDL. Standards development issues should be directed to Steve Pawlowski, Manager of the Surface Water Monitoring and Standards Unit at ADEQ (602) 207-4219.

Commentor 14 Michael White: citizen

Comment 14.1 I certainly agree that whatever necessary be done to reduce bacteria levels in Oak Creek and if the source of these are the result of too many visitors to Slide Rock State Park then this needs to be addressed. In my view the priority should be in keeping the water quality high even if this means reducing the number of bathers at Slide Rock. I live down stream and the difference in water quality of Oak Creek after, for example, the July 4th weekend, is palpable. At a minimum bathers down stream should have some way of knowing whether or not it is safe to swim in Oak Creek and so some kind of increased monitoring and warning system at various locations, for example, Red Rock Crossing, should be implemented.

Response 14.1 Keeping the water clean and safe is certainly the goal of this TMDL. Consideration needs to seriously taken regarding recreational pressure in general along Oak Creek. Slide Rock State Park just happens to focus the efforts. The Forest Service is monitoring other sites along Oak Creek: pool north of Slide Rock, Grasshopper Point, the Ladders, Crescent Moon, Mormon Crossing, and Spring Creek.

Commentor 15 William Bennett: citizen

Comment 15.1 I want to pass along my appreciation for your presentation at the Sedona public hearing. Those of us who live near the creek and work and play along its banks feel it is a vital resource and we want to protect it and help it. My concern is that the creek is in trouble. I feel strongly that we should identify more specifically what is polluting this stream. I think the septic systems in the canyon must be reviewed along with other sources of pollutants that are allowed to run into the creek. When pathogen levels are reached and violated, I feel notice of the fact should be communicated down stream from Slide Rock Park...also additional sites or at least warning sites should be added down stream...such as Red Rock Crossing (Crescent Moon Park). I support your recommendation of a 30% reduction in the pathogens in the sediment and I request the preparation of a more detailed plan/strategy for achieving that goal in your 5 year time frame. I would like to know how I and others can help.

Response 15.1 The TMDL calls for source identification as a priority. Septic systems will be surveyed, repaired, or upgraded as necessary. The Forest Service is monitoring several other sites along Oak Creek (see Response 14.1), Crescent Moon Park is one of them. The best way to become involved is to organize others citizens like yourself and participate in regular stakeholder meetings. This forum will need to be created. An existing group, the Oak Creek Task Force, may provide a foundation. The

TMDL will be successful in proportion to stakeholder commitment.

Commentor 16 Jaqueline S. Munro: citizen

Comment 16.1 Has there been consideration of effects of water pollution of fish and other aquatic life?

Response 16.1 At least with regard to the kind of bacterial pollution that affects humans, fish and other aquatic life are not negatively impacted.

Comment 16.2 Limiting the study to *E. coli* is not an effective means of determining the real effects of water pollution of humans swimming in the water. A more comprehensive study should be undertaken, including such pathogens as *Giardia lambia* and *Enteroamoeba histolytica*.

Response 16.2 *E. coli* has been determined to be the best overall indicator of enteric pathogens. Other microbes have been investigated in Oak Creek, as referenced in the TMDL document. Concerns regarding standards development issues should be directed to Steve Pawlowski, Manager of the Surface Water Monitoring and Standards Unit, ADEQ (602) 207-4219.

Comment 16.3 I agree that further limits to the number of swimmers needs to occur. However, an even greater priority is tightening up requirements on septic systems and making sure that the septic seepage is reduced.

Response 16.3 This TMDL addresses both recreation and septic influences. Implementation will continue source investigation and determine management actions needed.

Comment 16.4 I disagree with number 3 of section E on page 23: "emphasize recreation at 'nodes' rather than entire corridor"...your recommendation to further concentrate swimming in certain areas will cause there to be an increase in the Slide Rock phenomenon...this will lead to further economic discrimination by state and federal park and forest agencies, allowing only those who can afford to pay the fees to recreate. Five dollars a carload, such as charged at Slide Rock, is prohibitive to many low income families...

Response 16.4 The concept of 'nodes' of recreation was suggested in the Forest Service's draft Oak Creek Corridor Plan, April 1999. ADEQ is not recommending this action, only citing that it exists as a draft proposal. Concerns regarding resource management should be raised in TMDL stakeholder meetings.

Commentor 17 Anthony Flesch: citizen

Comment 17.1 Thank you for your concise presentation at the meeting of June 29th...I would like to commend you a job well done... Based on both intuitive assessment, as well as some random water sampling of my own, it is my opinion that septic systems could be a major source of bacterial

contamination. I would urge your agency to focus and concentrate on assessing this source as a priority...

Response 17.1 Septic systems will be a priority in the investigation for bacterial sources.

Commentor 18 Jeff Haworth: citizen

Comment 18.1 I am a citizen of Yavapai County and I would like to express my concern for the water-safety levels of Oak Creek. I request: 1) that when pathogen levels reach an unsafe level that my family and I, along with the rest of the inhabitants downstream of Oak Creek, are made aware of the dangerous and unsafe condition, 2) that a 30% reduction in bacterial pollution become a priority over the next five years and research into what is causing the bacterial pollution become a priority, and 3) that additional testing sites or at least warning sites should be added downstream, especially in highly visited areas such as Red Rock Crossing (Crescent Moon Park).

Response 18.1 Your concerns have been cited in the TMDL document and will be addressed as part of its implementation. The Forest Service is conducting monitoring at Crescent Moon Park.

Commentor 19 Sonia Gasser: citizen

Comment 19.1 I fully support the reduction in the number of visitors allowed at Slide Rock recreational area. I feel that this is only part of the solution and there also needs to me more detailed studies on the source of the bacteria. The problem is not going away overnight. It is going to take a concerted effort on everyone's part to help our environment come into proper balance. I comment the ADEQ for its efforts and I urge you as a member to help implement strategies to improve and preserve the water quality of Oak Creek.

Response 19.1 As you have recognized, the bacterial problem is complicated and will take concerted effort to solve. Perhaps you can pass the word along to others, who, like yourself care about a balanced environment. As a stakeholder, ADEQ will participate in development and implementation of this TMDL.

Commentor 20 John Garwood: citizen

Comment 20.1 I first came to the Sedona area 31 years ago originally from Turkey to attend the Verde Valley School. I moved back to this area six years ago and noticed a huge decrease in the water quality...I find it difficult to believe that the problems are being caused by animals, as there were just as many or more animals then than now...I believe the overall attitude of your agency is shifting responsibility away from where it really deserves to be placed: the increasing development and often careless use of the land by tourists and residents. I would like to know where the animals are coming from [that are mentioned as a source]. More effort should be made to make sure that septic systems are

safe and up to code. Perhaps merely looking at *E. coli* is not enough, as I suspect this ubiquitous bacteria normally found in the human body is not as much of a concern or threat to our future as other sources, such as viruses, or pesticides and herbicide pollution. Let's step into the 21st century and take aggressive action to clean up our water and make this a priority over short term revenue gain for the state through Slide Rock State Park. I am sure that this is a significant source of income gained by charging $5.00 per carload of four people that the state would hate to lose or reduce, but I encourage you to remain steadfast and find the real facts without being swayed by political maneuvering.

Response 20.1 From ADEQ's perspective, the pathogen TMDL is a value-neutral document, other than the requirement to meet water quality standards. It will be largely up to the local stakeholders to follow through with implementation of this TMDL. Consensus on matters of value is difficult to reach. ADEQ will continue to participate as a stakeholder and encourages you and others interested to become actively involved in the TMDL process to ensure its success.

Commentor 21 Michael Fitzpatrick: citizen

Comment 21.1 I live in the Upper Red Rock Loop area and frequently swim in Oak Creek with my two children. I believe that testing of the water should occur at other sites, not just Slide Rock ..for example, Red Rock Crossing. More preventative measures should be taken. New construction of facilities, such as the proposed bridge at Red Rock Crossing, should first be reviewed by the ADEQ...residents of Sedona and those that live near the downstream portions of Oak Creek should be notified when the bacteria levels are high, even if they are not high enough to close Slide Rock. It is not enough to merely hear about it several days later in the newspaper, but rather they should be notified immediately through networking, neighborhood spokespersons, or radio/TV announcements. Signs could be posted at popular swimming areas regarding the degree of danger from bacteria for that day...at least a 30% reduction in bacteria levels should occur over the next five years, if not a greater reduction. More research into the causes of this pollution should occur. There is obviously great political pressure

to keep Slide Rock open as it draws in a lot of revenue. The health and safety of Sedona area residents should take priority over all such economic considerations.

Response 21.1 The Forest Service is conducting sampling at Crescent Moon Park and other locations along Oak Creek; you may contact Bill Stafford (520) 282-4119 at the Sedona Ranger District for information. Proposed work along a waterbody that may result in water quality impacts should be reported to the ADEQ Federal Permits group; if a formal application has been filed, the U.S. Army Corps of Engineers will notify ADEQ for a water quality "certification"; the ADEQ contact is Andy Travers at (602) 207-4538. Your comments referring to notification and networking should be taken to the TMDL stakeholder meetings; perhaps you can become involved in this effort as a service to the community. The TMDL puts a high priority on continued research and focused identification of bacterial sources.

Commentor 22 Gordon Southam: NAU Microbiology Department

ADEQ 319(h) Contractor; comments incorporated into revised TMDL.

Commentor 23 Diana Marsh: ADEQ Water Quality Assessment

Internal review; comments incorporated into revised TMDL.

Commentor 24 Dan Salzler: ADEQ Nonpoint Source/Planning

Internal review; comments incorporated into revised TMDL.

Commentor 25 Larry Stephenson: ADEQ Nonpoint Source/Watersheds

Internal review; comments incorporated into revised TMDL.

Commentor 26 Douglas G. Cullinane, P.E: Circle G Engineering

Response to May 24, 1999 questions/comments addressed in June 29, 1999 letter from Chuck Graf, Deputy Director of the Water Quality Division, ADEQ

Response to August 18, 1999 e-mailed comments/questions addressed in August 20, 1999 letter from Frank Metzler, Unit Manager of the TMDL & Assessment Unit, ADEQ

Response to September 17, 1999 comments/questions sent to EPA will be addressed by EPA