WATER RESOURCES PROGRAM
SURFACE WATER QUALITY
MONITORING & EVALUATION
SIX HIGH VISITOR USE AREAS 1995

Project Report: NPS/YOSE/RM-1/96

US National Park Service
Resources Management Division
Yosemite National Park

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1995

During the summer of 1995, surface water was analyzed as a follow-up to 1993-94 water quality research and the 1992 pilot water quality monitoring and evaluation program in Yosemite National Park. This program evaluates the potential for human exposure, if any, to surface water bacterial contamination from natural waters within Yosemite. The primary indicator biological parameters of fecal coliform (FC)and fecal streptococcus (FS) were chosen to evaluate the general surface water quality of lakes and streams in high visitor use areas of the Tuolumne Meadows region. Phosphates and nitrates were tested for in a nutrient test as secondary indicators in the 1995 program.

Five lakes which receive high visitor use were established in 1992 for the monitoring program. The five lakes consisted of Dog Lake, Elizabeth Lake, Lower Cathedral Lake, Lower Young Lake, and Tenaya Lake. Upper Granite Lake, which has relatively little visitor use, was chosen as the control lake. A stream test site at the Tuolumne River/Cold Creek confluence, adjacent to the Glen Aulin High Sierra Camp, was added to the program for the 1995 testing. Because of the unusually heavy winter snowpack, none of Yosemite's High Sierra Camps opened in 1995. These conditions allowed for baseline data to be gathered for comparison with future years when Glen Aulin, and the other High Sierra Camps are in operation. Analyses for fecal coliform and fecal streptococcus were conducted by the NPS Water Quality Laboratory, Waste Water Treatment Plant, in El Portal. The additional tests for nitrates and phosphates for all sample sites were performed in the field. Standard sample collection, transport and laboratory QA/QC methods were used.

The spring run-off of 1995 was higher than average, and higher than the previous years of this study. This was reflected in this year's results. The bacterial levels of contamination at the test locations were much lower, although a high bacterial count of 240 was found at the midpoint test site of Dog Lake during the August 7, 1995 sampling. The National Environmental Health Association standard for fecal streptococcus for recreational waters is 100 colonies per 100 ml sample. In 1994 three lakes, Dog, Lower Cathedral, and Lower Young Lakes, did not meet these standards. Therefore, the results of this ongoing water quality monitoring project requires that wilderness users be notified to continue to treat all water before drinking. No elevated levels of fecal coliform were observed during the summer of 1995, nor were there any significant signs of nitrates or phosphates.

Recommended management actions for protecting water quality and safeguarding human health and safety include: continuing educational efforts; enforcing water quality protection statutes; planning facilities to accommodate future use levels; and possibly controlling visitor use limits.

WATER RESOURCES PROGRAM
SURFACE WATER QUALITY - MONITORING & EVALUATION
1995

I. MANAGEMENT OBJECTIVES:

A. PURPOSE:

The primary objectives of this water quality monitoring and evaluation program are: 1) to protect the health and safety of the Yosemite National Park's visitors and staff by assessing the potential for human exposure to water borne pathogens (see APPENDIX E); 2) to utilize the gained knowledge to manage, preserve and protect the integrity of Yosemite's natural resources; and 3) to provide the park's management with a clearer understanding of how current and future visitor distribution and use throughout Yosemite may affect water resources in the future. The monitoring and evaluation program will be important in assessing potential bacterial exposure during recreational and domestic use of water.

The park's management is aware that with the continuing increase in visitation comes the potential increase for water quality impacts. During the past few years a greater emphasis has been placed on water quality protection. Throughout the Tuolumne Meadows region, specifically, water quality protection efforts have been substantial over the past few years. The established water quality protection program is the result of two primary factors. First, the region includes significant portions of the upper Tuolumne River watershed, an important domestic water supply source for the City of San Francisco. Secondly, the Tuolumne Meadows area basin continues to be an increasingly popular recreational destination.

The monitoring and evaluation results will allow park managers to assess the effectiveness of their previous actions and possibly provide insights on the effects of visitor use on water resources. Therefore, the monitoring and evaluation program will allow for visitor and resource management decisions which will best preserve and protect water quality throughout Yosemite.

B. BACKGROUND:

Water quality monitoring and evaluation programs have been conducted by a variety of organizations and individuals in Yosemite. Regardless of the diverse approaches taken in previous water studies, all historical monitoring and evaluation programs provide essential baseline reference information.

In a related project, the City of San Francisco and CH2M Hill conducted field studies for a Draft Hetch Hetchy Sanitary Survey

in the summer and fall of 1993. Water samples were collected from the Dana and Lyell Forks of the Tuolumne River, the Tuolumne River at Tuolumne Meadows, the Hetch Hetchy Reservoir headwaters, Rancheria Creek and Wapama Falls at Hetch Hetchy Reservoir, and the diversion tunnel below O'Shaughnessy Dam. The City conducted analyses for the following parameters: Giardia, Cryptosporidium, total coliform, fecal coliform, pH, alkalinity, hardness, chloride, turbidity, conductivity, and temperature.[2] The results of these analyses will be in the Final Hetch Hetchy Sanitary Survey, expected in 1996.

Other studies of water quality in Yosemite have been somewhat limited in the past. However, the U.S. Geological Survey[10] (USGS) and Joe Holmes[3] have both completed water quality investigations for similar parameters. Correlations were made with the USGS and Holmes studies while developing the scope of the NPS monitoring and evaluation program. When possible, the monitoring network, sampling design, and water quality parameters selected were common to the USGS and Holmes studies.

In order to examine and correlate past information and data, the National Park Service (NPS), Water Resources Division is developing a water quality data management system. This data management system will allow for easy correlations of current conditions with earlier monitoring and evaluation results and will help clarify the changes occurring in Yosemite's natural aquatic systems. The water quality data management system will assist in standardizing the methodologies and approaches used to evaluate water quality conditions and impacts; thereby the usefulness of the information gained will be increased and future monitoring and evaluation costs will be reduced.

II. PROGRAM DESCRIPTION:

During the summer of 1995, surface water was collected and analyzed as a follow-up to 1993-94 water quality monitoring and evaluation and to the 1992 pilot water quality monitoring and evaluation program in the upper Tuolumne and Merced River watersheds in the Tuolumne Meadows region. Water quality was evaluated in several lakes and along a major river where high visitor use occurs, in an attempt to determine what effects, if any, current and past levels of visitation has had on water resources. The sample sites were evaluated for fecal coliform, fecal streptococcus, pH, temperature, and added for the 1995 program were tests for nitrates and phosphates. The 1992-95 monitoring and evaluation program was completed as a cooperative effort by the Mather District and Wilderness Management Units of the Visitor Protection Division, the Physical Science Unit of the Resources Management Division, and the Utilities Branch of the Maintenance Division.

The 1995 Monitoring Network includes seven sampling sites. Each site within the monitoring network is described in APPENDIX A and shown in APPENDIX C. To most effectively determine if human activities have impacted water quality, the Sampling Design included the primary parameters fecal coliform (FC) and fecal streptococci (FS). The nutrient test included the secondary parameters nitrates and phosphates. Details of these sampling designs are outlined in APPENDIX B.

The cost of the monitoring and evaluation program has been an important factor in determining the scope and extent of this program. To reduce program costs and to provide representative water resource information while maintaining the necessary quality control/quality assurance, a small number of sample sites and parameters were selected. The sites represent a wide spectrum of visitor use patterns and impacts. The sample parameters focus on evaluating the human health and safety risks and exposure potentials to pathogenic bacteria. Finally, standard methods were followed to compute all analytical procedures. Procedures are described in APPENDIX D.

III. DISCUSSION:

Again in 1995, the water quality monitoring and evaluation program provided valuable information and insight regarding the quality of Yosemite's water resources as well as the evaluation process. Aside from observations indicating that Dog Lake may have elevated fecal bacteria levels, most water quality was found to be good, indicating that Yosemite's past water quality protection programs are generally successful and should continue.

Two additions to the 1995 Water Quality Monitoring and Evaluation program included the Oakton pHTestr2 field meters as a more accurate method to measure pH, replacing the Hydrion pH paper used prior to the September 19,1994 sampling. In addition, as secondary parameter indicators for water quality, phosphates and nitrates were tested for and added to the data collection.

Dog Lake displayed a relatively high count of 240 for fecal streptococcus on August 7, 1995. The results from the program in 1994 showed much higher levels. Except for the midpoint sample sites at Tenaya and Lower Young Lakes, the maximum counts in the 1995 samples were equal or lower than the maximum counts in the 1994 samples. The increased spring snowpack that reduced access to these lakes in 1995 may have been responsible for the lower FS counts. The National Environmental Health Association standard for fecal streptococcus for recreational waters is 100 colonies per 100 ml sample. No elevated levels of fecal coliform were observed during the summer of 1995. Only at the Tenaya Lake midpoint sample site during the July 20, 1992 test was there an elevated level of fecal coliform detected in this four year

program. The results of all analyses conducted during 1995 are shown in APPENDIX G, sheet 1.

For Dog Lake during the August 1995 sampling, the elevated bacterial densities were above the established Environmental Protection Agency and National Environmental Health Association standards for recreational waters. Therefore, the Resources Management Division will be continuing to complete further data interpretation management and assessment. The Division will continue to provide recommendations to other park Divisions which are necessary for protection and preservation of human health, human safety, and environmental quality within Yosemite.

The 1995 monitoring and evaluation program provides guidance to address the outlined management objectives and actions. Additionally, the information gained supports the continuing National Park policy that visitors should purify any untreated water before drinking. Finally, correlative interpretations with previous data have been initiated to further evaluate temporal changes of bacterial densities. These statistics can be found in APPENDIX G, sheets 2-5.

IV. MANAGEMENT ACTIONS:

Objectives of the Water Resource Management Plan for Yosemite directs park managers to locate and document the magnitude and direction of changes in aquatic environments which are caused by management activities or visitor use patterns; and to develop and implement management programs to mitigate or eliminate those activities. Also stated, managers are to recognize aquatic conditions that are potentially hazardous to human health and safety; to implement programs to advise visitors of health or safety hazards; and to take corrective action where the cause is not natural.[7]

Management objectives established by Marnell[4] in 1971 for Yosemite's aquatic resources specify that waters shall be preserved in their natural condition, and that public visitation for scenic or aesthetic appreciation shall be allowed providing such activities do not threaten to impair the natural conditions. Our goals today remain consistent. This monitoring and evaluation program indicates that at some locations, such as Lower Cathedral, Lower Young, Dog, and Tenaya Lakes, the levels of visitation may now be beginning to have a negative effect upon aquatic resources. However, at this stage of the study it is unclear how much of the effects are derived from day use as opposed to overnight use in each area. In recognizing the potential impacts to aquatic resources (specifically, water quality impacts), it is recommended that management actions begin to take steps to control potential contamination in specific areas where visitor use patterns require.

A. WATER RESOURCE PROTECTION PROGRAM ACTIONS:

Based upon the results of the 1992-95 monitoring and evaluation program the following management actions are recommended:

SAMPLE LOCATION	STATUS	RECOMMENDATIONS
Dog Lake	Did not meet FS standards for June, July 1994, and August 1995 samplings	Increase education efforts; consider day use limits; continue day use surveys
Elizabeth Lake	Has met standards for each sampling	Increase education efforts
L.Cathedral Lake	Did not meet FS standards for August, September 1992, September 1993,June, July 1994 samplings	Increase education efforts; direct camping away from riparian areas; consider further limits on overnight and day use; continue day use surveys; installation of toilet facilities at the trailhead
L.Young Lake	Did not meet FS standards for September 1993 and June 1994 samplings	Increase education efforts; direct camping away from riparian areas; consider further limits on overnight and day use; continue day use surveys; installation of toilet facilities at the trailhead
Tenaya Lake	Did not meet FC standards for July 1992 sampling	Increase education efforts
Granite Lake	Has met standards for all samplings	Continue education efforts
Glen Aulin	Has met standards for all samplings	Continue education efforts

B. MONITORING AND EVALUATION ACTIONS

1. Continue to develop a programmatic approach to water quality monitoring and evaluation.

2. Continue to utilize previous water quality data, visitor use statistics, and aquatic habitat condition information as indicators for potential water quality impacts.

3. Continue to modify the monitoring and evaluation network, sample design and sampling points in order to more clearly evaluate and understand potential impacts.

4. Coordinate data analysis with the City of San Francisco and other park divisions to clarify water quality impacts.

APPENDICES

APPENDIX A. WATER QUALITY MONITORING NETWORK

APPENDIX A. WATER QUALITY MONITORING NETWORK:

The monitoring network was developed jointly by the Mather District Unit, Wilderness Management Unit and the Resources Management Division. Sites were selected to be a part of the network based upon: 1) existence of any previous monitoring results, 2) geographic similarity, and 3) visitor use and impact distribution.

The current monitoring network includes: Granite Lake, Lower Young Lake, Dog Lake, Elizabeth Lake, Lower Cathedral Lake, Tenaya Lake, and the Tuolumne River at Glen Aulin High Sierra Camp. Sample points have been designated for each location included in the monitoring network. Except for Tenaya Lake (roadside example) and Upper Granite Lake (control example), all monitoring locations are common to previous studies performed in Yosemite. All lakes are in the same general region and are geographically similar or have similar hydrologic features. Finally, each of the sample sites except Tenaya and Upper Granite Lakes have similar day and or overnight use patterns.

Dog and Elizabeth Lakes are both popular day-use destinations, but are closed to camping. Lower Cathedral and Lower Young Lakes are popular day-use and overnight camping destinations. Tenaya Lake receives very heavy visitor day-use (estimated to be over a thousand people per day during the summer) due to its proximity to the Tioga Road. However, camping has not been allowed at Tenaya Lake since 1991. Upper Granite Lake was chosen as a control lake because it receives little visitor use and is closed to camping. The Glen Aulin High Sierra Camp sample site was selected to represent a popular stream campsite that has potential impacts from the kitchen/compost toilet/leach field/corral setting of a high sierra camp.

The Mather District Unit collected samples at Dog and Elizabeth Lakes and the Glen Aulin High Sierra Camp location. The Wilderness Management Unit collected samples at Lower Cathedral and Lower Young Lakes. The Resource Management Division collected samples at Tenaya and Upper Granite Lakes. All the sample sites, with the exception of Tenaya and Lower Cathedral Lakes, are within the upper Tuolumne River watershed. Tenaya and Lower Cathedral Lakes are a part of the Merced River drainage. Coordination of sample pick-up and delivery to the laboratory was performed by Resources Management.

APPENDIX B. SAMPLE COLLECTION

APPENDIX B. SAMPLE COLLECTION:

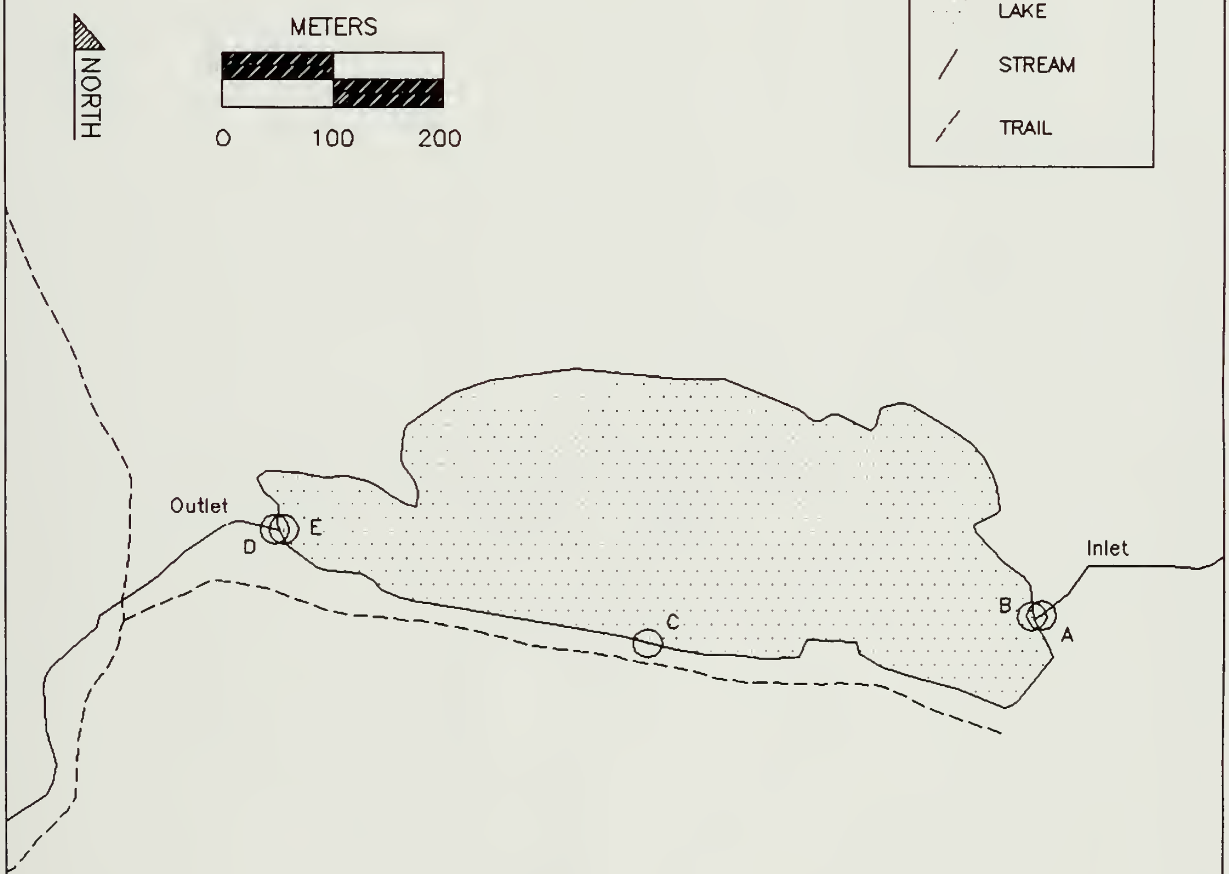
An attempt was made to maintain consistency with previous water quality monitoring programs conducted within Yosemite. Sampling was conducted on a monthly basis for three consecutive months during the 1995 summer season. The sample collection dates were August 7, September 11, and October 2, 1995.

The collection of water samples was intended to be analogous to the removal of drinking water by users. The bottle was submerged by holding the bottom of the bottle and aiming the mouth toward the current below the surface in a stream or by moving the bottle in a sweeping arc below the surface in a lake. Samples were withdrawn carefully to avoid any contamination of the sample by material floating on lake or stream surface, by hand of the worker, or outside of the bottle. Care was taken not to disturb bottom sediments where the sample was taken. Some of the sample was poured off so that the bottle was only about 90 percent full and could be easily mixed by shaking later in the laboratory. While sampling, the sampling location, date, time, temperature and pH of the water was noted. Hydrion pH paper was used for 1992, 1993, and most of 1994 evaluations. The samplers used Oakton pHTestr2 meters to determine the pH of the water for the September 19, 1994 sampling date, and all of the 1995 sampling dates. The pHTestr2 gave accurate pH results and invalidated the use of litmus paper for this study.

APPENDIX C. SAMPLE POINT LOCATION MAPS AND DESCRIPTIONS:

For each lake, water samples were collected at three locations, which included the inlet, midpoint, and outlet. At the Glen Aulin sample location, four samples sites were selected: upstream from the Glen Aulin High Sierra Camp, on Cold Creek, at the Tuolumne River/Cold Creek confluence, and downstream of the Camp on the Tuolumne River. All samples were collected from the shore at the following locations:

DOG LAKE
WATER SAMPLING LOCATION MAP



SAMPLE POINT DESCRIPTION:

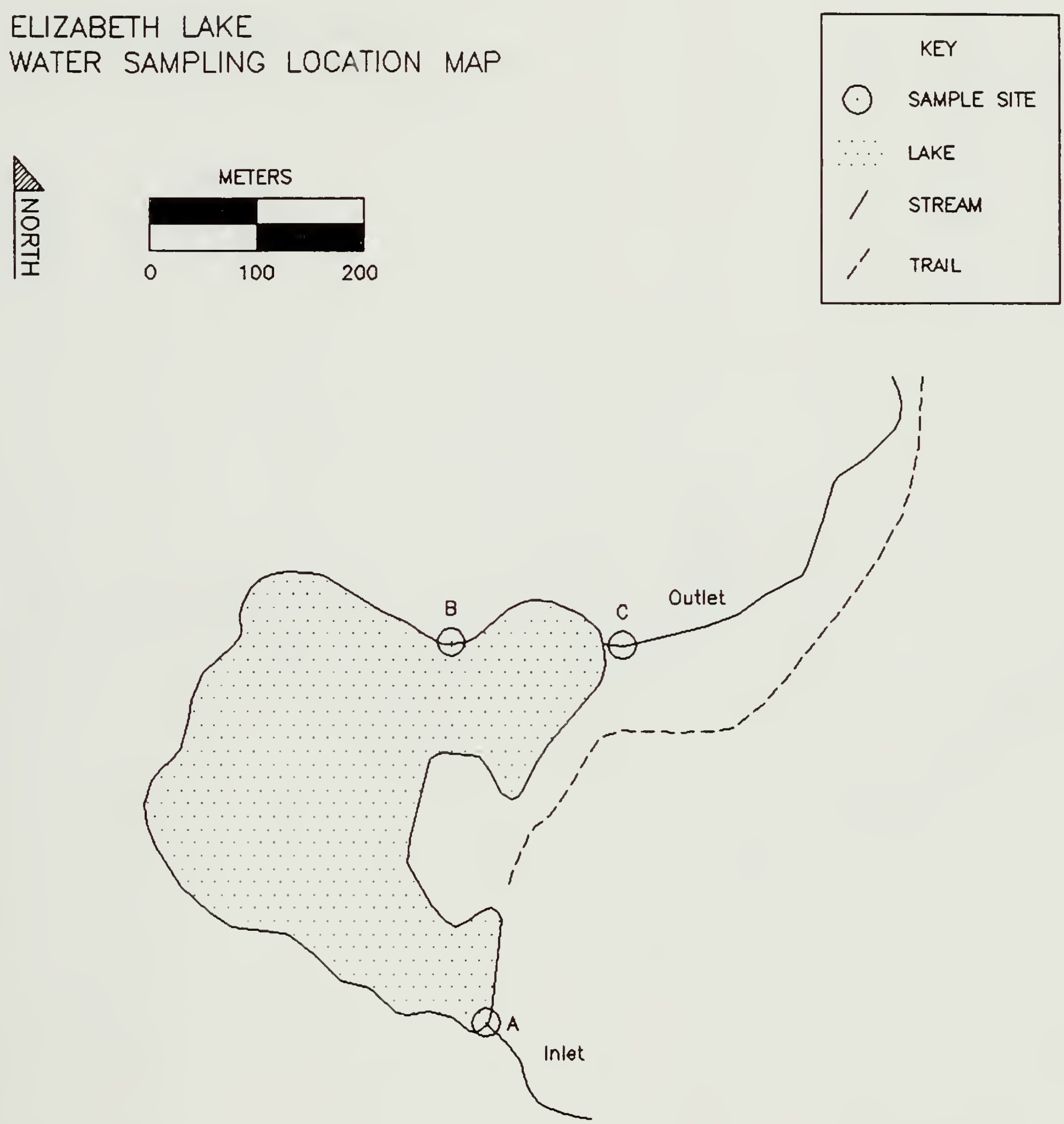
A: Inlet to Dog Lake, at east end of lake, 9 m upstream from lake shore. If inlet to Dog Lake has dried up, sample should be collected from alternate location B

B: In Dog Lake, at east end, immediately north of inlet in A

C: In Dog Lake, on south shore, midway from inlet to outlet. Approximately 15 m west of a large rock in the water, where a small peninsula extends into the lake

D: Outlet to Dog Lake, at west end of lake, 1.5 m downstream from lake shore. If outlet from Dog Lake has dried up, sample should be collected from alternate location E

E: In Dog Lake at the outlet area, from logs protruding into lake at outlet — deepest water without getting feet wet



SAMPLE POINT DESCRIPTION:

A: Inlet to Elizabeth Lake, at southeast corner of lake, from a 1.5 m angular rock at inlet

B: In Elizabeth Lake, at midpoint on north shore, where land protrudes south into lake and directly opposite (north of) peninsula on south side

C: Outlet to Elizabeth Lake, 10 m north of outlet on east-northeast shore near two large boulders approximately 20–30 m offshore

LOWER CATHEDRAL LAKE
WATER SAMPLING LOCATION MAP

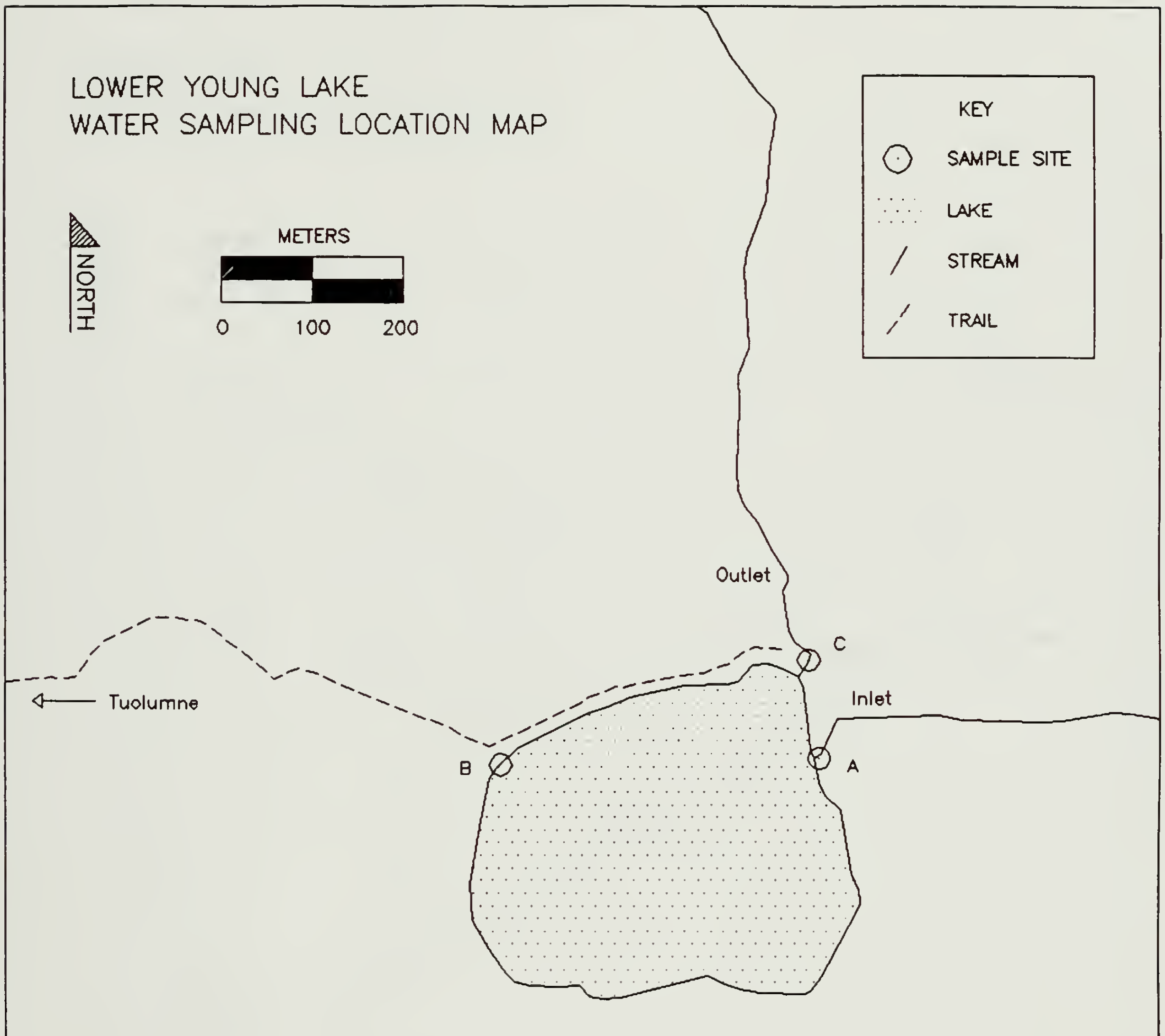
SAMPLE POINT DESCRIPTION:

A: Inlet to Lower Cathedral Lake, at northeast end of lake, below a 9 m pool where the trail crosses the inlet

B: In Lower Cathedral Lake, at a small sandy beach at the approximate midpoint on the north shore, 80 m from rocks near inlet and 100 m from the narrows towards outlet, and 30 m east of a fallen tree pointing into a lake

C: Outlet to Lower Cathedral Lake, at west end of lake, 9 m downstream of lake surface, 2 m upstream of a small waterfall

LOWER YOUNG LAKE
WATER SAMPLING LOCATION MAP



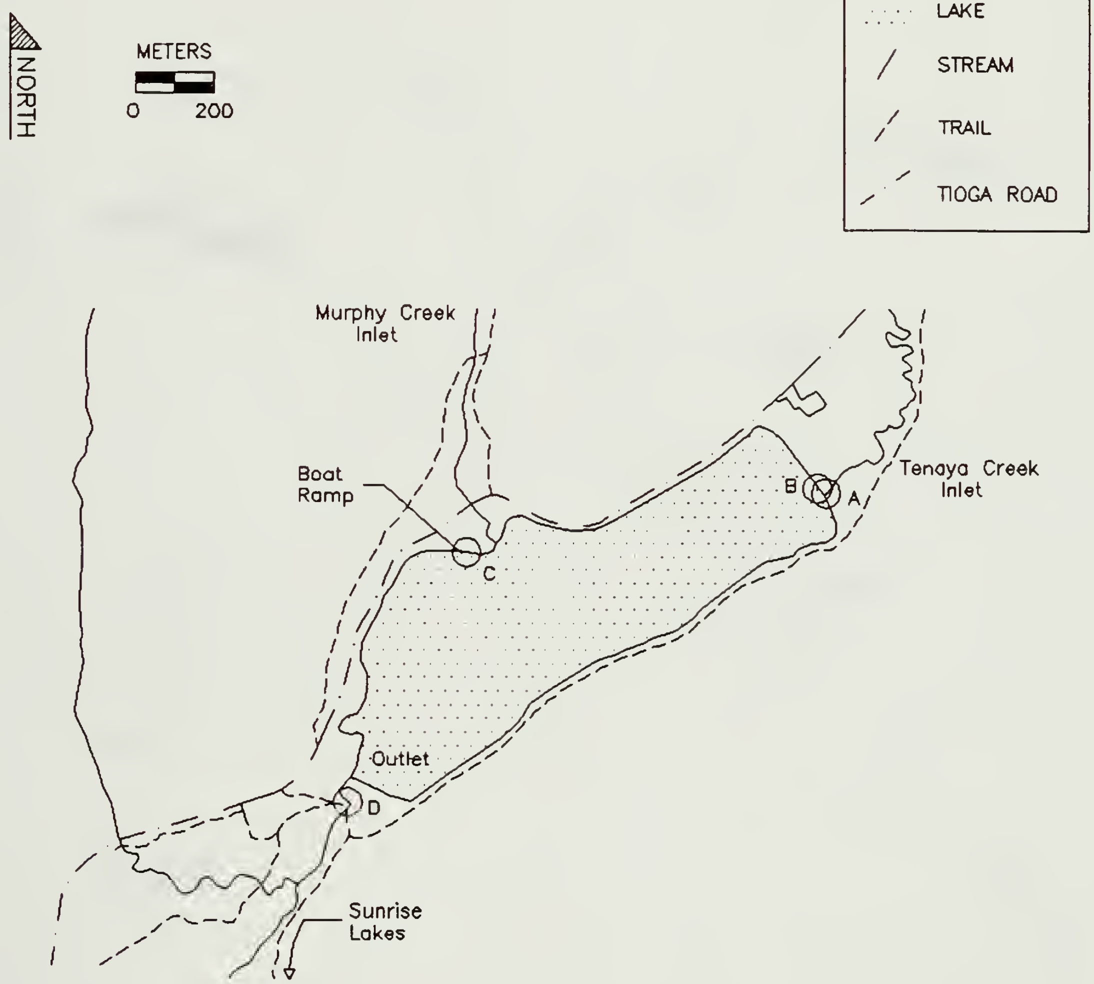
SAMPLE POINT DESCRIPTION:

A: Inlet to Lower Young Lake, at the east end of lake, 5 m from lake shore, on the south fork, near the large boulders on the southwest side of the stream channel

B: In Lower Young Lake, near the west end of the north shore, just east of meadow area where trail from Tuolumne arrives at the lake, by 2.5 x 3.5 x 1 m boulder in trees

C: Outlet to Lower Young Lake, at the north end of lake, approximately 30 m north of lake, and 5 m below log-free lake water, on east side of outlet

TENAYA LAKE
WATER SAMPLING LOCATION MAP



SAMPLE POINT DESCRIPTION:

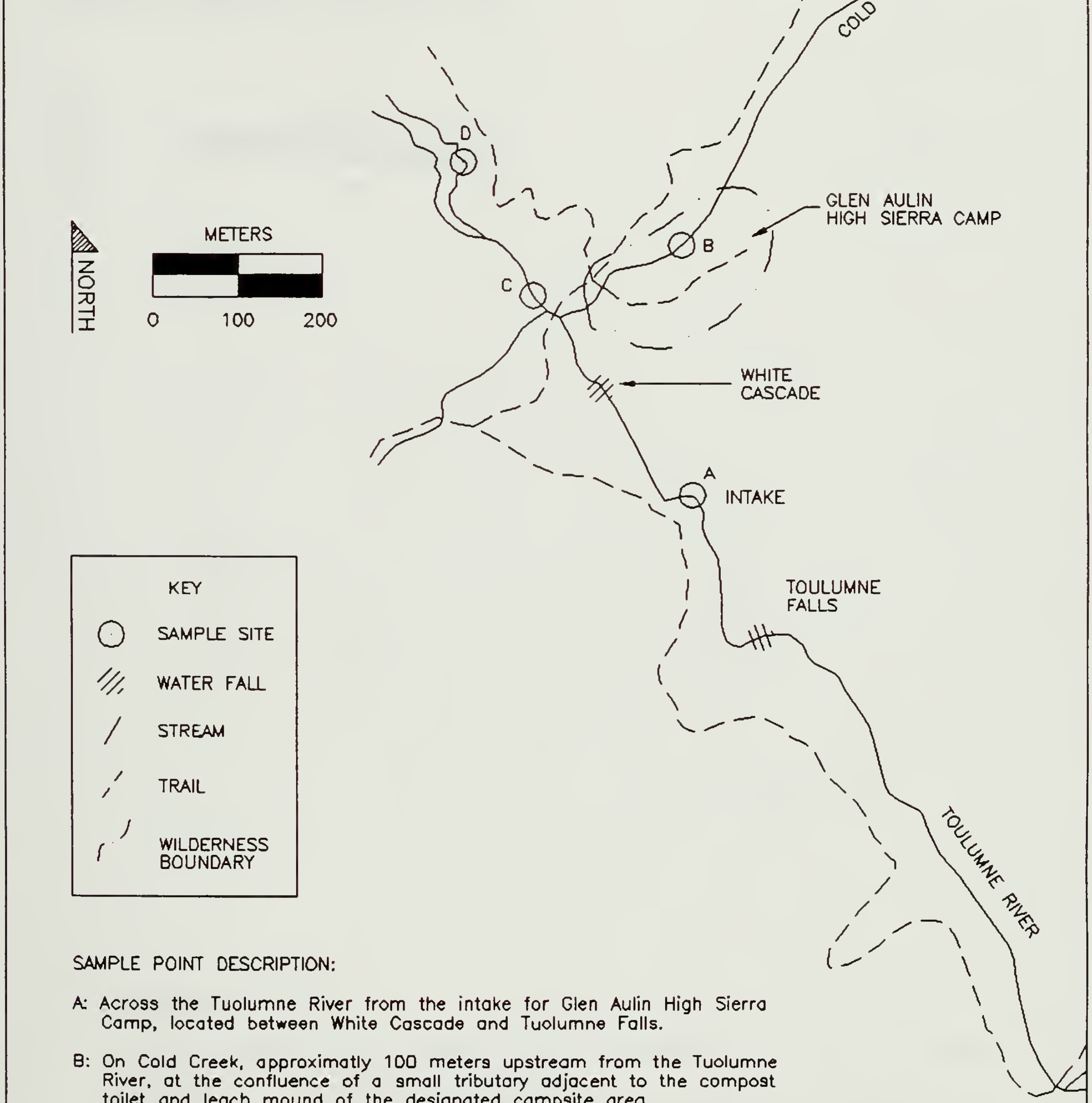
A: Inlet to Tenaya Lake, at east end of lake (Tenaya Creek), approximately 5 m from lake shore. If inlet (Tenaya Creek) to Tenaya Lake has dried up, sample should be collected from alternate location B

B: At east end of Tenaya Lake, immediately north of Tenaya Creek

C: On north shore near Murphy Creek in Tenaya Lake, approximately 5 m east of the Tenaya Lake boat ramp

D: Outlet to Tenaya Lake, at southwest end of lake, approximately 10 m upstream from where trail to Sunrise Lakes crosses Tenaya Creek

TUOLUMNE RIVER/COLD CREEK WATER SAMPLING LOCATION MAP



SAMPLE POINT DESCRIPTION:

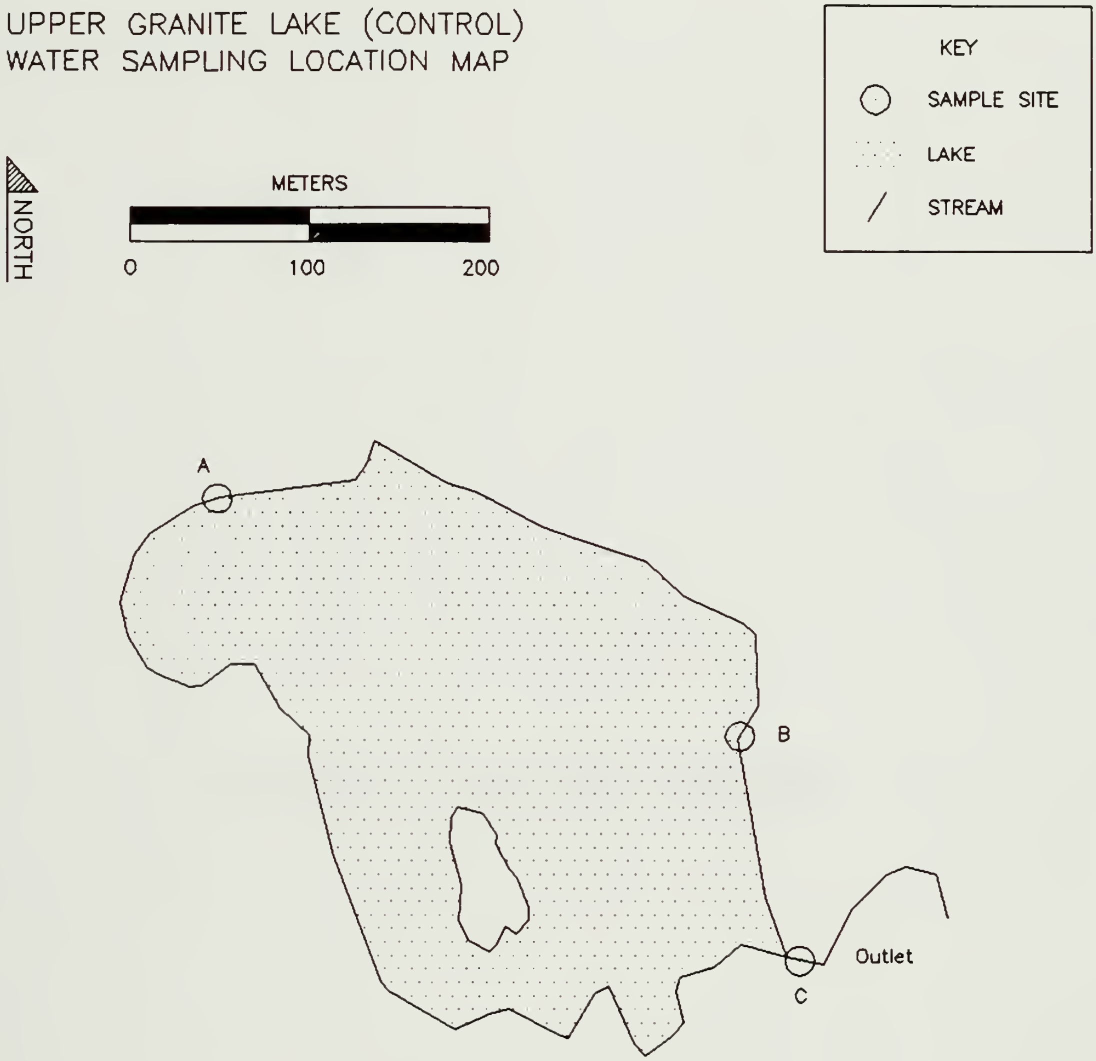
A: Across the Tuolumne River from the intake for Glen Aulin High Sierra Camp, located between White Cascade and Tuolumne Falls.

B: On Cold Creek, approximatly 100 meters upstream from the Tuolumne River, at the confluence of a small tributary adjacent to the compost toilet and leach mound of the designated campsite area.

C: Just downstream of the Cold Creek/Tuolumne River confluence, on the north side of the Tuolumne River, five meters downstream from the bridge, before the cascade.

D: On the Tuolumne River, approximately 200 meters downstream of sample site C.

UPPER GRANITE LAKE (CONTROL)
WATER SAMPLING LOCATION MAP



SAMPLE POINT DESCRIPTION:

A: There are no obvious inlets to Upper Granite Lake. Sampling point is from a small grassy area on the north-northwestern portion of lake

B: On eastern shore, from a large flat rock that extends into water approximately midway between north shore and outlet, approximately 50 m south of trees on northeast shore

C: Outlet of Upper Granite Lake, at south end, approximately 2 m west of rock and log dam

APPENDIX D. ANALYTICAL PROCEDURES

APPENDIX D. ANALYTICAL PROCEDURES:

Analyses for water temperature and pH were conducted in the field at the time of sample collection. Temperature was taken using a partial immersion thermometer. The pH was determined by using an Oakton pHTestr2; whereas in previous years Hydrion paper was used. Tests for the presence of fecal coliform (FC) and fecal streptococcus (FS) were conducted after samples were transported to the NPS - El Portal, Waste Water Treatment Plant water quality laboratory. The nutrient tests for nitrates and phosphates were performed in Tuolumne Meadows with a field test kit.

Standard laboratory methods were used for analyses of FC and FS. Briefly, the fecal coliform test (using EC medium) differentiates between coliform of fecal origin (intestines of warm-blooded animals) and coliform from other sources. This test is applicable to investigations of drinking water, stream pollution, raw water sources, waste water treatment systems, bathing waters, and general water quality monitoring.[1] Testing for FS was conducted in order to develop a FC to FS ratio and provide further information about the source of bacterial contamination. However, it should be noted again that this ratio is considered questionable by some sources and has not yet been verified as absolute.

The water samples were delivered to the laboratory and analyzed within the allowable 6 hour time limit. The Most Probable Number (MPN) procedure was used to evaluate the extent of FC and FS bacteria in the sample water. The MPN procedure is outlined in Standard Methods For the Examination of Water and Waste Water, 18th ed. and is summarized below.

1. FECAL COLIFORM TEST

The Most Probable Number (MPN) method for the FC test consists of a presumptive phase and a confirmed phase.

A. PRESUMPTIVE PHASE

For the presumptive phase of the FC test, the culture media lauryl tryptose broth was used. The lauryl tryptose broth was dispensed into fermentation tubes which each contained a small inverted vial. The tubes were then covered with metal caps and sterilized in an autoclave.

After the fermentation tubes with lauryl tryptose broth were sterilized, the tubes were inoculated with the sample water. For each water sample collected, three different dilutions of sample water were used in nine fermentation tubes. Three tubes received 10 ml of sample water, three tubes received 1 ml of sample water, and three tubes received 0.1 ml of sample water. A sterile pipette was used to inoculate the fermentation tubes with the

three different dilutions of sample water.

Once the transfers were made, the fermentation tubes were incubated at 35° C. for 48 hours. The tubes were checked after 24 hours and again at 48 hours for any positive growth of bacteria. Positive growth is any amount of gas trapped inside the inverted vial inside the fermentation tube. Any fermentation tubes showing positive growth after the 24 or 48 hour incubation were transferred to the confirmed phase of the FC test.

B. CONFIRMED PHASE

The confirmed phase of the FC test is used to confirm or deny the presence of coliform in the positive presumptive test. For the confirmed phase of the FC test, the culture media EC medium was used. The positive fermentation tubes from the presumptive test were gently shook or swirled. With a sterile metal loop, a transfer was made from each positive presumptive fermentation tube to a confirmed fermentation tube with EC medium.

After the EC medium tubes were inoculated, they were incubated in a water bath at 44.5° C. for 24 hours. The EC medium tubes were placed in the water bath within 30 minutes after inoculation. A sufficient water depth in the water bath was maintained to keep the tubes immersed to at least the upper level of the medium in the tubes.

Gas production with growth in an EC medium culture within 24 hours or less is considered a positive fecal coliform reaction. Failure to produce gas (with little or no growth) constitutes a negative reaction indicating a source other than the intestinal tract of warm-blooded animals.

The Most Probable Number (MPN) of fecal coliform colonies were then calculated from the number of positive EC medium (confirmed) tubes. The calculation was made from the coliform table "Most Probable Numbers per 100 ml of Sample," which is used at the NPS El Portal Waste Water Treatment Plant for potable water. The table is from <u>Standard Methods For the Examination of Water and Waste Water</u>, 10th edition, and is endorsed as the appropriate table from the State of California, Department of Public Health.

2. FECAL STREPTOCOCCUS TEST

The Most Probable Number (MPN) method was also used for the FS test, and consists of a presumptive phase and a confirmed phase.

A. PRESUMPTIVE PHASE

For the presumptive phase of the FS test, an azide dextrose broth was used as the culture media. The azide dextrose broth was dispensed into fermentation tubes, but did not contain a small

inverted vial like the tubes for the fecal coliform test. Double-strength broth was used for tubes which received 10 ml of sample water. The tubes were then covered with metal caps and sterilized in an autoclave.

After the fermentation tubes were sterilized, they were inoculated with sample water. As in the fecal coliform presumptive test, three different dilutions of sample water were used in nine fermentation tubes. The three tubes with double-strength azide dextrose broth received 10 ml of sample water. The three tubes receiving 1 ml of sample water and the three tubes receiving 0.1 ml of sample water each had regular strength broth. A sterile pipette was used to inoculate the fermentation tubes with the three different dilutions of sample water.

Once the transfers were made, the fermentation tubes were incubated at 35° C. for 48 hours, just as in the FC presumptive test. The tubes were checked after 24 hours and again at 48 hours for any positive growth of bacteria. For the FS presumptive test, positive growth was any amount of turbidity formed in the clear azide-dextrose broth. Any fermentation tubes showing positive growth after the 24 or 48 hour incubation were transferred to the confirmed phase of the FS test.

B. CONFIRMED PHASE

Like the FC test, the confirmed phase of the FS test is also used to confirm or deny the presence of streptococci in the positive presumptive test. For the confirmed phase of the FS test, the culture media bile esculin azide agar was used. The agar could not be made more than 4 hours before it was used. After the agar was mixed from powder form and thoroughly heated and stirred, it was put into an autoclave for sterilization. Once the agar had cooled down considerably from the autoclave, it was poured into petri dishes and let harden to a gel consistency. Positive tubes from the presumptive test were gently shaken or swirled. A transfer was made from each positive presumptive fermentation tube to a streak on a petri dish with PSE agar using a sterile metal loop or pointer.

After the FS petri dishes were streaked with positive growth from the presumptive tubes, they were inverted and incubated at 35° C. for 24 hours. The petri dishes were placed in the incubator within 30 minutes of being streaked with the positive growth from the presumptive test. Brownish-black colonies with brown halos after the 24 hour incubation confirmed the presence of fecal streptococci.

The Most Probable Number (MPN) of fecal streptococcus colonies was calculated the same way as the MPN for fecal coliform was calculated. The tables at the end of this report summarize the 1992-1995 results of the water quality monitoring.

3. NUTRIENT TEST

The nutrient tests for nitrates and phosphates were performed with a HACH Nitrate Test Kit 0-50mg/L, and a HACH Orthophosphate Test Kit 0-5 mg/L. Separate sample bottles were filled at each sample site and brought back to Tuolumne Meadows for testing.

To test for phosphates, phosphate reagent powder was added to a test tube containing 5-ml of the sample water and shaken. A color comparison was made with a test tube of clear sample water. If a blue-violet color developed, the amount of phosphates could be determined with the color comparator disk. The testing for nitrates was similar, using nitrate reagent powder and measuring for the amount of amber color present.

APPENDIX E. HEALTH and SAFETY WATER QUALITY CONCERNS

APPENDIX E. HEALTH AND SAFETY WATER QUALITY CONCERNS:

The prevention of human exposure to waterborne disease causing pathogenic bacteria is a primary concern for park managers. Since many different bacteria are found naturally in aquatic environments, it is very important to be cautious when determining the potential risks facing recreational users of the park's waters. For recreational bathing waters, the U.S. Environmental Protection Agency has set standards for fecal coliform densities at an average of 200 colonies of FC per 100 ml of sample water. For FS, densities of greater than 100 colonies per 100 ml of sample water is said to be high.[5] Previous observations made of FC/FS ratios have suggested that it can be shown whether fecal contamination has derived from human or other animal sources.[11] A relatively low ratio points to contamination from animal sources. A ratio greater than 4.1 is said to have derived from human sources. It should be noted, however, that this ratio is questionable by some sources, and has not yet been verified as absolute.[1]

In order to conduct a representative risk assessment for human exposure to bacterially contaminated surface waters, a methodology was selected that duplicates specific human water use actions. This methodology was also selected by Holmes and consisted of actions similar to those used when filling a water bottle from a lake or stream.

Fecal coliform and fecal streptococcus bacteria were selected as an indicator for other waterborne pathogenic bacteria as well as for the FC/FS ratio to identify contaminant sources. The majority of the water samples did not show high levels of fecal coliform or streptococcus bacteria. The observed fluctuations in the amount of bacteria discovered can be generally interpreted as natural. For example, bacterial increases may accompany organic matter from surface runoff after seasonal rains.

However, one specific location within the study area showed elevated levels of fecal bacteria. Dog Lake showed an elevated count of fecal streptococcus bacteria for the August 7, 1995 sample of 240 at the midpoint. Even higher FS bacteria counts were noted in the 1994 program at Dog, Lower Young and Lower Cathedral Lakes. Lower bacterial counts in 1995 can be attributed to the above normal spring runoff and the limited access to the backcountry during the summer from heavier than normal snowpack, high stream runoff, and the late opening of the Tioga Road.

The results indicate that at the specific sample point at the time of sample collection bacteria was present at elevated levels. It can be concluded that due to the existence of fecal contamination at the observed elevated levels, there is indeed a potential for recreational exposure to pathogenic bacteria, and

thus there are potential risks to human health and safety as well. Conversely, exposure potential via formal domestic supply can be considered to be very minor at these sites since neither are directly a part of a supply system.

Tenaya and Lower Cathedral Lakes drain into Tenaya Creek and eventually flow down Tenaya Canyon into the Merced River. Lower Young Lake flows into Conness Creek and then into the Tuolumne River. Granite, Dog, and Elizabeth Lakes also flow into the Tuolumne River. The nearest domestic supply system which draws water out of the Merced River is many miles downstream well beyond the boundary of the park. On the Tuolumne River, the Hetch Hetchy Reservoir is the nearest domestic water supply system. Therefore, the most immediate health and safety risks are considered to exist at the lakes and streams themselves via the indigenous recreational water uses.

Some recommended management actions for health and safety and water quality protection can be initiated without conducting further water quality monitoring and evaluation. However, in order to more clearly understand to what degree potential exposure exists and to develop a successful strategy for natural resources management protection, further evaluations are strongly recommended.

APPENDIX F. RESOURCE PROTECTION/PRESERVATION IN HIGH VISITOR USE AREAS OF TUOLUMNE MEADOWS

APPENDIX F. RESOURCE PROTECTION/PRESERVATION IN HIGH VISITOR USE AREAS OF TUOLUMNE MEADOWS:

Evaluating the natural resource damages, beyond the primary assessment of water quality conditions, has not been the main focus of this monitoring and evaluation program. However, at the locations where elevated levels of fecal contamination were observed, other substantial visitor use related impacts have been recognized.

Lower Cathedral Lake, along the renowned John Muir Trail, is a very popular day use destination that has the additional stress of overnight use as well. No toilet facilities exist at Cathedral trail-head locations nor at the lake itself. Also at Cathedral, it is a continual effort to prevent campsites from encroaching and impacting the riparian vegetation along the lake shore. The riparian vegetation plays an important role in preserving water quality as an interceptor of surface runoff containing nutrients, bacterium and other organic materials.

The Glen Aulin High Sierra Camp has been in operation at it's present location during the summer season since 1927[9] until this year due to heavy snowpack and above normal spring run-off. This area now has designated campsites for backpackers, a self contained compost toilet, a leach mound for the gray water and black water from the High Sierra Camp's kitchen and bathroom, a camp that normally houses 32 people nightly[9], and a corral for housing stock. Due to this area's popularity with day use and overnight hikers, this area is patrolled regularly by NPS Watershed and Wilderness Rangers. The human impacts to the water quality have been mitigated with the construction of the compost toilet, leach mound, and designated campsites created in 1993. Results from the 1995 sampling, taken during a rare season that the Camp was closed, will be beneficial as baseline data to compare to future years' data collection while the Camp is in operation. The NPS Backcountry Utilities branch takes weekly water samples at all five high sierra camps while in operation to test the camps' drinking water quality. The information can be used to compare with this study.

Results of a 1993 Day Use Survey conducted by NPS Wilderness and Watershed Rangers indicate that Cathedral, Young, and Dog Lakes receive significant visitation from day and overnight use. The Tuolumne Watershed Site Report statistics for 1993 (gathered by field rangers on patrol) showed that Cathedral Lakes received an average of 19.9 day users and 26.1 overnight users per day. Young Lakes received an average of 12.2 day users and 25.8 overnight users. Dog Lake received an average of 37.8 day users and 7.6 overnight users.[6] The 1994 statistics from the Tuolumne Watershed Site Report showed that Cathedral Lakes received an average of 20 day users and 20.3 overnight users. Young Lakes received an average of 16.1 day users and 23.7 overnight users.

Dog Lake received an average of 26.4 day users and 3.6 overnight users per day, and Elizabeth Lake received 25.1 day users and 4.5 overnight users. In 1995 the Watershed statistics showed Cathedral Lakes received an average of 11.5 day users and 13.0 overnight users per day. Young Lakes received an average of 8.7 day users and 11.3 overnight users per day. Dog Lake received an average of 17.9 day users and 2.7 overnight users per day. Glen Aulin received an average of 13.8 day users and 19.7 overnight users per day (see APPENDIX H).[8]

Wildlife species also rely upon natural waters. Further monitoring and evaluation will be necessary to fully determine and assess potential wildlife impacts.

APPENDIX G. TABLES OF WATER SAMPLING DATA

SURFACE WATER QUALITY MONITORING AND EVALUATION
SIX HIGH VISITOR USE AREAS 1995

Sample Location	August 7					September 11					October 2				
	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C
Dog Lake															
#1 Inlet	3.0	<3	<1.00	7.1	10.0	7.2	<3	<0.42	7.3	10.5	<3	<3	1.00	6.8	11.0
#2 Mid	240.0	<3	<0.01	7.0	19.0	<3	<3	1.00	7.3	15.5	<3	<3	1.00	7.4	11.0
#3 Outlet	23.0	<3	<0.13	7.3	19.0	<3	<3	1.00	7.5	14.0	<3	<3	1.00	6.8	10.0
Elizabeth Lake															
#1 Inlet	<3	<3	1.00	5.6	13.0	<3	<3	1.00	8.1	14.0	<3	<3	1.00	8.1	6.0
#2 Mid	<3	<3	1.00	8.1	14.0	<3	<3	1.00	8.3	14.0	<3	<3	1.00	7.4	12.0
#3 Outlet	<3	<3	1.00	7.9	14.0	<3	<3	1.00	8.1	13.0	<3	<3	1.00	7.9	10.5
L. Cathedral Lk.															
#1 Inlet	9.1	<3	<0.33	8.0	9.0	11.0	<3	<0.27	8.0	12.3	<3	<3	1.00	7.1	11.0
#2 Mid	3.6	<3	<0.83	8.9	11.0	<3	<3	1.00	8.6	14.5	<3	<3	1.00	6.7	12.0
#3 Outlet	<3	<3	1.00	5.3	14.0	7.3	<3	<0.41	8.8	16.2	<3	<3	1.00	6.5	12.0
L.Young Lake															
#1 Inlet	<3	<3	1.00	7.2	14.0	53.0	<3	<0.06	7.8	11.0	44.0	<3	<0.07	8.0	6.0
#2 Mid	<3	<3	1.00	6.8	9.0	23.0	<3	<0.13	8.1	13.0	<3	<3	1.00	8.3	10.0
#3 Outlet	<3	<3	1.00	6.8	10.0	43.0	<3	<0.07	7.9	14.0	3.6	3.6	1.00	7.8	8.0
Tenaya Lake															
#1 Inlet	3.6	<3	<0.83	7.2	12.0	3.6	<3	<0.83	7.0	9.5	3.6	<3	<0.83	7.1	9.0
#2 Mid	93.0	<3	<0.03	6.8	16.0	<3	<3	1.00	7.0	16.0	<3	<3	1.00	7.4	11.0
#3 Outlet	<3	<3	1.00	6.8	16.0	9.1	<3	<0.33	6.9	15.0	3.6	<3	<0.83	7.1	13.0
Granite Lake															
#1 Inlet	<3	<3	1.00	7.1	4.0	<3	<3	1.00	7.4	10.0	<3	<3	1.00	7.5	8.0
#2 Mid	<3	<3	1.00	7.2	4.0	<3	<3	1.00	7.3	9.0	<3	<3	1.00	6.5	8.0
#3 Outlet	<3	<3	1.00	7.1	4.0	<3	<3	1.00	7.1	9.0	<3	<3	1.00	6.7	3.0
Glen Aulin															
#1 Intake	3.0	<3	<1.00	6.3	6.0	3.0	3.6	1.20	6.8	N.A.	<3	3.6	<1.20	6.9	5.0
#2 Confluence	9.1	<3	<0.33	7.1	5.0	20.0	3.6	<0.18	6.9	N.A.	<3	<3	1.00	6.7	5.0
#3 Cold Creek	93.0	<3	<0.03	7.0	5.0	9.4	<3	<0.32	7.1	N.A.	3.0	<3	<1.00	6.8	4.0
#4 Downstream	N.A.	N.A.	N.A.	N.A.	N.A.	7.3	<3	<0.41	6.9	N.A.	<3	<3	1.00	7.1	5.0

N.A. = Not Available   pH = Taken with a pHTestr2 in the field to replace Hydrion pH paper
FC = Fecal Coliform   FS = Fecal Streptococcus
Samples taken by Resources Management, Yosemite National Park. Tests performed by Kimberly Cole-Priddell, Environmental health Technician, at the El Portal Laboratory. Cert. #E-752

SURFACE WATER QUALITY MONITORING AND EVALUATION
FIVE HIGH VISITOR USE AREAS 1994

Sample Location	June 27				July 25				August 29				September 19				
	FS	FC	FC/FS	°C	FS	FC	FC/FS	°C	FS	FC	FC/FS	°C	FS	FC	FC/FS	pH	°C
Dog Lake																	
#1 Inlet	460.0	<3	.007	9.2	15.0	<3	<.200	18.0	3.0	3.6	1.20	16.5	<3	<3	1.00	7.3	11.5
#2 Mid	240.0	<3	<.013	17.6	9.1	<3	<.330	19.0	<3	<3	1.00	17.0	<3	<3	1.00	6.8	12.0
#3 Outlet	1100	<3	<.003	15.2	460.0	<3	<.007	19.0	9.1	<3	<.330	16.0	<3	<3	1.00	6.9	11.5
Elizabeth Lake																	
#1 Inlet	<3	<3	1.00	15.0	<3	3.6	<1.20	17.0	<3	<3	1.00	13.5	<3	23.0	<7.6	7.6	N.A.
#2 Mid	<3	<3	1.00	15.0	9.1	<3	<.330	17.0	<3	<3	1.00	17.0	<3	<3	1.00	7.8	N.A.
#3 Outlet	<3	<3	1.00	14.5	<3	<3	1.00	17.0	<3	<3	1.00	16.0	<3	3.6	<1.20	6.9	N.A.
L. Cathedral Lk.																	
#1 Inlet	460.0	<3	.007	16.0	>1100	<3	<.003	11.0	75.0	<3	<.040	11.8	<3	15.0	<5.00	6.5	10.5
#2 Mid	23.0	<3	<.130	18.0	290.0	<3	<.010	18.0	3.6	<3	<.833	11.5	<3	7.3	<2.43	6.5	11.0
#3 Outlet	23.0	<3	<.130	17.0	1100	<3	<.003	13.0	29.0	<3	<.103	14.5	<3	11.0	<3.6	6.0	9.5
L.Young Lake																	
#1 Inlet	1100	<3	<.003	13.0	3.0	3.6	1.20	7.0	<3	<3	1.00	8.5	<3	<3	1.00	7.3	7.0
#2 Mid	<3	<3	1.00	13.0	3.6	<3	<.833	9.0	<3	<3	1.00	9.5	<3	<3	1.00	6.8	11.0
#3 Outlet	240.0	<3	<.013	13.0	43.0	<3	<.070	11.5	23.0	<3	<.130	8.0	<3	<3	1.00	6.8	11.0
Tenaya Lake																	
#1 Inlet	3.6	<3	<.833	14.0	<3	3.6	>1.20	12.5	<3	<3	1.00	20.0	<3	<3	1.00	7.1	10.0
#2 Mid	23.0	<3	<.130	22.0	<3	3.6	>1.20	20.5	<3	<3	1.00	20.0	<3	<3	1.00	7.1	10.0
#3 Outlet	<3	<3	1.00	21.0	93.0	11.0	0.118	20.0	3.6	<3	<.833	20.0	3.6	11.0	3.05	7.3	9.0
Granite Lake																	
#1 Inlet	3.6	<3	<.833	9.8	<3	<3	1.00	14.0	<3	<3	1.00	14.0	<3	<3	1.00	7.5	4.5
#2 Mid	23.0	<3	<.130	10.1	<3	<3	1.00	14.0	3.6	<3	<.833	14.0	3.6	<3	<.833	7.3	4.0
#3 Outlet	<3	<3	1.00	10.6	<3	<3	1.00	15.0	<3	<3	1.00	15.0	<3	7.3	<2.43	7.1	2.0

N.A. = Not Available   pH = Taken with a pHTestr2 in the field to replace Hydrion pH paper
FC = Fecal Coliform   FS = Fecal Streptococcus
Samples taken by Resources Management, Yosemite National Park. Tests performed byKimberly Cole-Priddell, Environmental health Technician, at the El Portal Laboratory.
Cert. #E-752

SURFACE WATER QUALITY MONITORING AND EVALUATION
FIVE HIGH VISITOR USE AREAS 1993

Sample Location	July 19					August 16					September 20				
	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C
Dog Lake															
#1 Inlet	N.A.	N.A.	N.A.	N.A.	N.A.	23.0	<3	<0.13	4.2	16.7	75.0	<3	<0.04	4.4	14.0
#2 Mid	N.A.	N.A.	N.A.	N.A.	N.A.	12.0	<3	<0.25	4.3	16.5	3.6	<3	<0.83	4.3	12.9
#3 Outlet	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.4	15.1	<3	<3	1.00	4.4	12.9
Elizabeth Lake															
#1 Inlet	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.4	19.0	<3	<3	1.00	4.6	18.0
#2 Mid	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.4	19.0	<3	<3	1.00	4.6	18.0
#3 Outlet	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.4	17.0	<3	<3	1.00	4.4	14.0
L. Cathedral Lk.															
#1 Inlet	N.A.	N.A.	N.A.	N.A.	N.A.	43.0	<3	<0.07	4.3	9.5	460.0	<3	<0.01	4.4	6.0
#2 Mid	N.A.	N.A.	N.A.	N.A.	N.A.	3.0	3.6	1.20	4.4	14.0	<3	<3	1.00	4.4	14.0
#3 Outlet	N.A.	N.A.	N.A.	N.A.	N.A.	14.0	<3	<0.21	4.4	13.5	240.0	<3	<0.01	4.4	5.0
L.Young Lake															
#1 Inlet	N.A.	N.A.	N.A.	N.A.	N.A.	93.0	<3	<0.03	4.8	9.0	460.0	<3	<0.01	4.2	6.0
#2 Mid	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.6	12.0	<3	<3	1.00	4.4	13.5
#3 Outlet	N.A.	N.A.	N.A.	N.A.	N.A.	<3	<3	1.00	4.4	13.0	240.0	<3	<0.01	4.4	10.5
Tenaya Lake															
#1 Inlet	<3	<3	1.00	4.4	N.A.	<3	<3	1.00	4.4	14.0	<3	<3	1.00	4.1	12.2
#2 Mid	15.0	<3	<0.2	4.4	N.A.	<3	<3	1.00	4.4	21.0	<3	<3	1.00	4.1	10.6
#3 Outlet	3.6	<3	<0.83	4.4	N.A.	23.0	<3	<0.13	4.4	20.5	93.0	<3	<0.03	4.4	6.0
Granite Lake															
#1 Inlet	<3	<3	1.00	4.4	N.A.	<3	<3	1.00	4.4	11.0	43.0	43.0	1.00	4.4	N.A.
#2 Mid	<3	<3	1.00	4.4	N.A.	3.6	9.1	2.53	4.4	11.0	<3	<3	1.00	4.4	N.A.
#3 Outlet	<3	<3	1.00	4.1	N.A.	<3	<3	1.00	4.4	11.0	<3	<3	1.00	4.4	N.A.

N.A. = Not Available   pH = Taken with Hydrion pH paper
FC = Fecal Coliform   FS = Fecal Streptococcus
Samples taken by Resources Management, Yosemite National Park. Tests performed at the El Portal Laboratory.

SURFACE WATER QUALITY MONITORING AND EVALUATION
FIVE HIGH VISITOR USE AREAS 1992

Sample Location	July 20					August 17					September 14				
	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C	FS	FC	FC/FS	pH	°C
Dog Lake															
#1 Inlet	23.0	3.6	0.15	5.1	N.A.	<3	<3	1.00	5.1	N.A.	<3	<3	1.00	5.1	14.5
#2 Mid	<3	7.3	<2.4	4.8	N.A.	<3	<3	1.00	5.1	N.A.	<3	<3	1.00	5.1	14.2
#3 Outlet	<3	<3	1.00	4.7	N.A.	23.0	3.6	0.16	5.2	N.A.	<3	<3	1.00	5.1	14.5
Elizabeth Lake															
#1 Inlet	6.2	<3	<0.48	4.8	N.A.	<3	<3	1.00	4.8	N.A.	3.6	<3	<0.83	4.4	10.0
#2 Mid	14.0	<3	<0.21	4.6	N.A.	<3	<3	1.00	4.8	N.A.	<3	<3	1.00	4.4	14.0
#3 Outlet	<3	<3	1.00	4.4	N.A.	3.6	<3	<0.83	4.8	N.A.	<3	<3	1.00	4.4	12.0
L. Cathedral Lk.															
#1 Inlet	15.0	3.6	0.24	4.4	N.A.	150.0	3.6	0.02	4.4	N.A.	9.1	<3	<0.33	4.4	7.5
#2 Mid	<3	<3	1.00	4.4	N.A.	3.6	3.6	1.00	4.4	N.A.	<3	<3	1.00	4.4	14.0
#3 Outlet	<3	<3	1.00	4.4	N.A.	1100	150.0	0.14	4.4	N.A.	1100	23.0	<.02	4.4	5.5
L.Young Lake															
#1 Inlet	3.6	<3	<0.8	4.4	N.A.	21.0	39.0	1.90	4.3	N.A.	<3	<3	1.00	4.9	4.0
#2 Mid	<3	<3	1.00	4.3	N.A.	<3	<3	1.00	4.3	N.A.	<3	<3	1.00	4.4	15.0
#3 Outlet	<3	<3	1.00	4.2	N.A.	3.6	<3	<0.83	4.2	N.A.	15.0	<3	<0.2	4.4	7.0
Tenaya Lake															
#1 Inlet	43.0	11.0	0.25	4.4	N.A.	9.1	<3	<0.33	4.4	N.A.	<3	<3	1.00	4.4	19.0
#2 Mid	75.0	1100	14.7	4.4	N.A.	3.6	9.1	2.53	4.4	N.A.	93.0	3.6	0.04	4.4	20.0
#3 Outlet	3.6	23.0	6.4	4.4	N.A.	3.6	3.6	1.00	4.4	N.A.	<3	<3	1.00	4.4	13.0
Granite Lake															
#1 Inlet	<3	<3	1.00	4.2	N.A.	<3	3.6	1.20	4.4	N.A.	<3	<3	1.00	4.4	9.0
#2 Mid	<3	<3	1.00	4.2	N.A.	<3	<3	1.00	4.4	N.A.	<3	<3	1.00	4.4	10.5
#3 Outlet	<3	<3	1.00	4.2	N.A.	<3	<3	1.00	4.4	N.A.	<3	<3	1.00	4.4	6.5

N.A. = Not Available pH = Taken with a pHTestr2 in the field to replace Hydrion pH paper
FC = Fecal Coliform FS = Fecal Streptococcus
Samples taken by Resources Management, Yosemite National Park. Tests performed at the El Portal Laboratory.

SURFACE WATER QUALITY MONITORING AND EVALUATION
SIX HIGH VISITOR USE AREAS 1992-95

Sample Location	1992 Analysis			1993 Analysis			1994 Analysis			1995 Analysis			1992-95 Summary		
	FSmax	FSmin	FCmax	FSmax	FSmin	FCmax	FSmax	FSmin	FCmax	FSmax	FSmin	FCmax	FSmax	FSmin	FCmax
Dog Lake															
#1 Inlet	23.0	<3	3.6	75.0	23.0	<3	460.0	<3	3.6	7.2	<3	<3	460.0	<3	3.6
#2 Mid	<3	<3	7.3	12.0	3.6	<3	240.0	<3	<3	240.0	<3	<3	240.0	<3	7.3
#3 Outlet	23.0	<3	3.6	<3	<3	<3	1100.0	<3	<3	23.0	<3	<3	1100.0	<3	<3
Elizabeth Lake															
#1 Inlet	6.2	<3	<3	<3	<3	<3	<3	<3	23.0	<3	<3	<3	6.2	<3	23.0
#2 Mid	14.0	<3	<3	<3	<3	<3	9.1	<3	<3	<3	<3	<3	14.0	<3	<3
#3 Outlet	3.6	<3	<3	<3	<3	<3	<3	<3	3.6	<3	<3	<3	3.6	<3	3.6
L. Cathedral Lk.															
#1 Inlet	150.0	9.1	3.6	460.0	43.0	<3	>1100.0	<3	15.0	11.0	<3	<3	1100.0	<3	15.0
#2 Mid	3.6	<3	<3	3.0	<3	3.6	290.0	<3	7.3	3.6	<3	<3	290.0	<3	7.3
#3 Outlet	1100.0	150.0	<3	240.0	14.0	<3	1100.0	<3	11.0	7.3	<3	<3	1100.0	<3	3.6
L.Young Lake															
#1 Inlet	21.0	<3	39.0	460.0	93.0	<3	1100.0	<3	3.6	53.0	<3	<3	1100.0	<3	3.6
#2 Mid	<3	<3	<3	<3	<3	<3	3.6	<3	<3	23.0	<3	<3	23.0	<3	<3
#3 Outlet	15.0	<3	<3	240.0	<3	<3	240.0	<3	<3	43.0	<3	3.6	240.0	<3	3.6
Tenaya Lake															
#1 Inlet	43.0	<3	11.0	<3	<3	<3	3.6	<3	3.6	3.6	3.6	<3	43.0	<3	3.6
#2 Mid	93.0	3.6	1100.0	15.0	<3	<3	23.0	<3	3.6	93.0	<3	<3	93.0	<3	1100
#3 Outlet	3.6	<3	23.0	93.0	3.6	<3	93.0	<3	11.0	9.1	<3	<3	93.0	<3	11.0
Granite Lake															
#1 Inlet	<3	<3	3.6	43.0	<3	43.0	3.6	<3	<3	<3	<3	<3	43.0	<3	43.0
#2 Mid	<3	<3	<3	3.6	<3	9.1	23.0	<3	<3	<3	<3	<3	23.0	<3	9.1
#3 Outlet	<3	<3	<3	<3	<3	1.00	<3	<3	7.3	<3	<3	<3	3.0	<3	7.3
Glen Aulin															
#1 Intake	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	3.0	<3	3.6	3.0	<3	3.6
#2 Confluence	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	20.0	<3	3.6	20.0	<3	3.6
#3 Cold Creek	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	93.0	3.0	<3	93.0	3.0	<3
#4 Downstream	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	7.3	<3	<3	7.3	<3	<3

APPENDIX H. MONITORING NETWORK DAY/OVERNIGHT VISITOR USE STATISTICS

APPENDIX H. MONITORING NETWORK DAY/OVERNIGHT VISITOR USE STATISTICS[6,8] 1993-1995

Cathedral Lakes	**1993**	**1994**	**1995**
Average # Day Users/Day	19.9	20.0	11.5
Average # Overnight Users/Day	26.1	20.3	13.0
% Day Use	43.3%	49.6%	46.8%
Young Lakes			
Average # Day Users/Day	12.2	16.1	8.7
Average # Overnight Users/Day	25.8	23.7	11.3
% Day Use	32.0%	40.4%	43.5%
Dog Lake			
Average # Day Users/Day	37.8	26.4	17.9
Average # Overnight Users/Day	7.6	3.6	2.7
% Day Use	83.3%	87.8%	86.7%
Elizabeth Lake			
Average # Day Users/Day	27.5	25.1	11.6
Average # Overnight Users/Day	5.7	4.5	2.6
% Day Use	82.4%	84.9%	91.8%
Granite Lakes			
Average # Day Users/Day	18.7	8.3	8.5
Average # Overnight Users/Day	3.5	2.2	0.4
% Day Use	84.4%	79.1%	95.2%
Glen Aulin			
Average # Day Users/Day	N/A	N/A	13.8
Average # Overnight Users/Day	N/A	N/A	19.7
% Day Use	N/A	N/A	41.2%

APPENDIX I. REFERENCES CITED

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