



PRELIMINARY ASSESSMENT OF GRAZING ON WATER RESOURCES
AT
GLEN CANYON NATIONAL RECREATION AREA

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Abstract

This preliminary study, carried out to assess the potential effects of grazing on ponds in Glen Canyon National Recreation Area showed that the local grazing index defined for this work was highly correlated with some of the water parameters. A Spearman coefficient was high for the relation between this index and turbidity (0.64), fecal coliform concentration (0.7638), total phosphorus concentration (0.8729), total suspended solids concentration (0.9276). These results reveal three points : first, grazing has an effect on water resources like ponds in the desert, secondly the local grazing index defined for this work is an indicator of grazing density around a pond and finally some these water parameters that were waste water quality parameters assessed the water status of a pond.

Resume

Cette etude preliminaire, conduite pour evaluer l'impact potentiel du paturage sur des mares au sien de l'Aire Recreative deGlen Canyon a montre que l'index local de paturage defini pour ce projet etait fortement correle avec certains parametres de l'eau etudies. Le coefficient de Spearman etait eleve pour la relation entre cet indexe et la turbidite (0.64), la concentration en bacteries fecales coliformes (0.7638), la concentration en phosphore total (0.8729), la concentration en matieres en suspension (0.9276). Ces resultats revelent trois points: Tout d'abord, le paturage a un impact sur les ressources en eau comme les mares dans le desert, l'index local de paturage defini pour ce projet est un indicateur de l'intensite de paturage autour d'une mare et les parametres utilises etaient des parametres d'analyse de la qualite des eaux usees ont permis de rendre compte de la qualite de l'eau d'une mare.

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**PART 1 – PRELIMINARY ASSESSMENT OF
GRAZING ON WATER RESOURCES AT GLEN
CANYON NATIONAL RECREATION AREA**

I. BACKGROUND

1. Federal Land Management

The United States of America is a federal system: an interlocking government that includes state, local, and federal governments. The federal government administers about one third of the land in the United States. The rate of federal owned lands varies from 2.3% in the northeast to 4.1% in the northern and central states, 5.2% in the south and can reach 60.4% in the west (Alaska, Colorado, Oregon). These federally owned lands consist mainly of spaces where human settlement is rare such as deserts, forests, quarries and mines. It has several functions since it is utilized for grazing, log exploitation and rough materials extraction while playing an important role in tourism and leisure.

The federal patrimony is managed by the Department of Agriculture and the Department of the Interior. The former includes the U.S. Forest Service. It manages national forests and grasslands, conducts forestry research and works with forest managers on state and private lands. It oversees 200 million acres of national forests and other lands. The latter includes the Bureau of Land Management (BLM), the National Park Service (NPS) and the Fish and Wildlife Service (FWS). The BLM, created in 1946, manages 264 million acres of public lands and an additional 300 million acres of below-ground mineral estates located throughout the country. The BLM's major programs are grazing administration, selling timber annually from the forest lands it manages, carrying out of environmental management programs, providing many and varied outdoor recreation areas to an increasing tide of visitors, and issuing oil, gas, and other mineral leases. In addition, it carries out cadastral surveys, land records, land classification and land disposal. In all of its programs, the BLM, like every other public resource-management agency, is both guided and limited by the demands of the public for its lands and their resources (Clawson, 1971). The NPS was established by the Organic Act voted by Congress in 1916. This administration was mandated to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations". It manages 51 national parks and oversees more than 300 national monuments, historic sites, memorials, seashores and battlefields. It corresponds to an area of approximately 43 million acres (Shelton and Fox, 1994). The U.S. Fish and Wildlife Service created in 1940, helps conserve the nation's wild animals and their habitats. The Service manages a system of almost 500 national wildlife refuges and other areas, which total more than 91 million acres of land and water. Regarding the environment, federalism is an important characteristic for two major reasons. First, the federal agencies mentioned previously relied upon the state to enforce the environmental regulation and in addition, it plays an important role in so far as many environmental problems cross political boundaries.

2. Glen Canyon National Recreation Area

a) Establishment of the Recreation Area

Glen Canyon National Recreation Area (GLCA), one of the 17 Recreation Areas in North America, was established in 1972 by Congress "in order to provide for public outdoor recreation use and enjoyment of Lake Powell and lands adjacent there to in the States of Arizona and Utah and to preserve scenic, scientific, and historic features contributing to public enjoyment of the area." This Recreation Area is subject to the same organic legislation as other units of the NPS such as National Parks, Monuments and Historic sites.

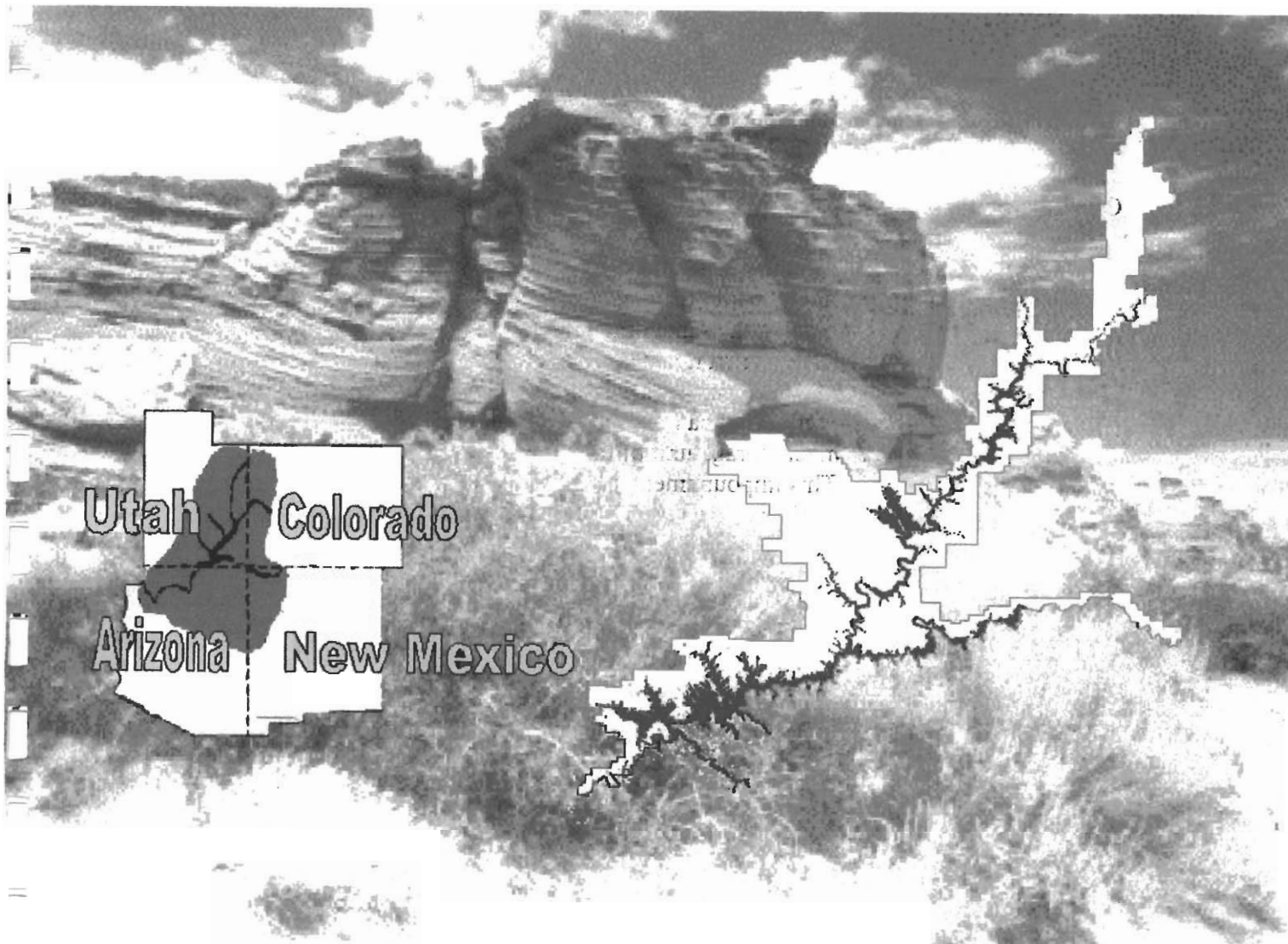
GLCA, located in the Colorado Region Plateau, encompasses 1,236,880 acres and is located in Southern Utah and Northern Arizona (Map 1). It includes Lake Powell that was created by Glen Canyon Dam, a major storage unit of the Upper Colorado River Storage Project authorized by Congress in 1956. This impoundment stretches along 186 miles of the Colorado River and 75 miles of the San Juan River. The reservoir is capable of holding 27 million acre feet of water and has a shoreline of 1,960 miles.

b) Climate

Although the Colorado River drains some areas receiving more than 50 inches annual precipitation, the Glen Canyon region is classified as semi-arid to arid. Glen Canyon NRA receives an average of only six to seven inches of precipitation per year, although high plateaus typically receive several inches more and canyon bottoms several inches less. Annual precipitation extremes of four inches (low) and ten inches (high) have been recorded in the recreation area. But the precipitation is extremely variable from year to year and even within years between different portions of the Recreation Area. Snowfall occurs in the area, but it normally remains on the ground only a few days below about 7,000 feet. Brief, intense thunderstorms produce virtually all of the moisture received during the summer. March, August, and September are generally the wettest months, and June is the driest (Figure 1). Summer minimums average between 60 and 70 degrees during July and August. Winter maximums average in the upper 40s and 50s. The average of frost-free days is about 200 days at Page (Figure 2).

c) Vegetation

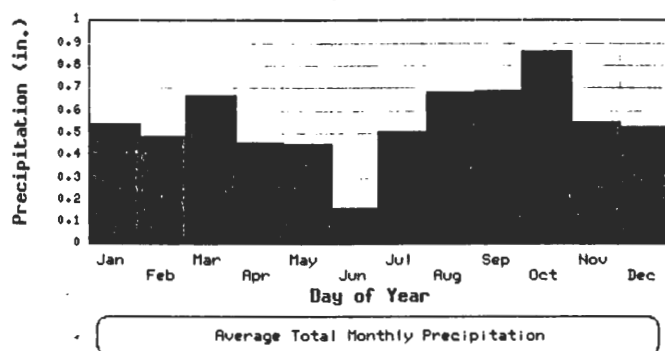
The vegetation of the region includes arid shrublands, grasslands, and semi-arid pinyon-juniper woodlands. Much of the Recreation Area consists of talus, cliffs, badlands formed by clay and slickrock that lacks vegetation and supports only scattered saltbushes and annuals (Picture 1).



Map 1 - Glen Canyon National Recreation Area.

PAGE, ARIZONA (026180)

Period of Record : 10/29/1957 to 12/31/1998



Western
Regional
Climate
Center

Figure 1 – Monthly average precipitation in Page from 10/29/1957 to 12/31/1998.

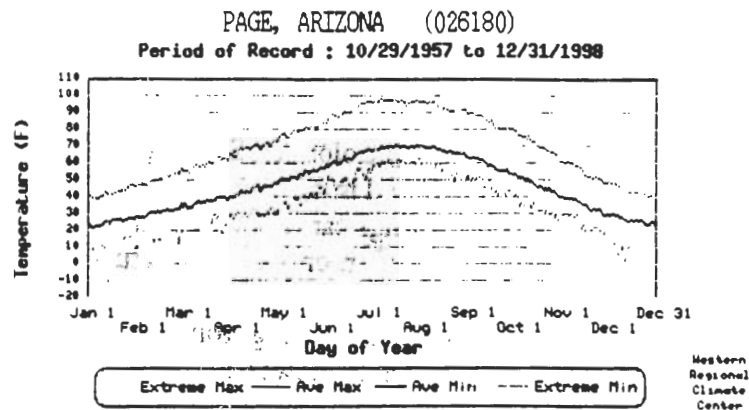


Figure 2 – Monthly average temperature in Page from 10/29/1957 to 12/31/1998.



Picture 1 – Landscape of the Colorado Plateau.

d) Water Resources

The water resources in the Recreation Area comprise ground-water resources and surface-water resources. The ground-water resources correspond to aquifers. Ground water typically occurs in the older rocks at or below the canyon floors, although perched bodies of water also occur on and beneath most mesas. The aquifers are composed of beds of sandstone that lie between nearly impermeable layers of siltstone and mudstone. The surface-water resources include rivers, springs, seeps and waterpockets. The principal sources of surface water in Glen Canyon NRA are five major rivers—the Colorado, San Juan, Dirty Devil, Escalante, and Paria—and Lake Powell. Springs are often found in canyons where the surface intersects water-bearing strata or structural features. These springs can emerge from alluvial aquifers, from a zone of contact with an impermeable bedrock layer, or where a fracture zone drains local bedrock aquifers. Springs emerging from the alluvial aquifer fluctuate seasonally and in response to rainfall. Changes in hydrostatic head resulting from the filling of Lake Powell have created several new, large springs that flow from the lower canyon walls between Glen Canyon Dam and Lees Ferry. Seeps occur where a canyon cuts through an aquifer or a joint connecting to an aquifer. Seeps commonly are found in canyon walls that cut through Navajo sandstone. On the mesas and benches of the NRA, the most common sources of surface water are waterpockets found in natural bedrock depressions. They occur where rain fills depressions weathered into exposed sandstone surfaces. Although some of these waterpockets are quite large, all are considered ephemeral.

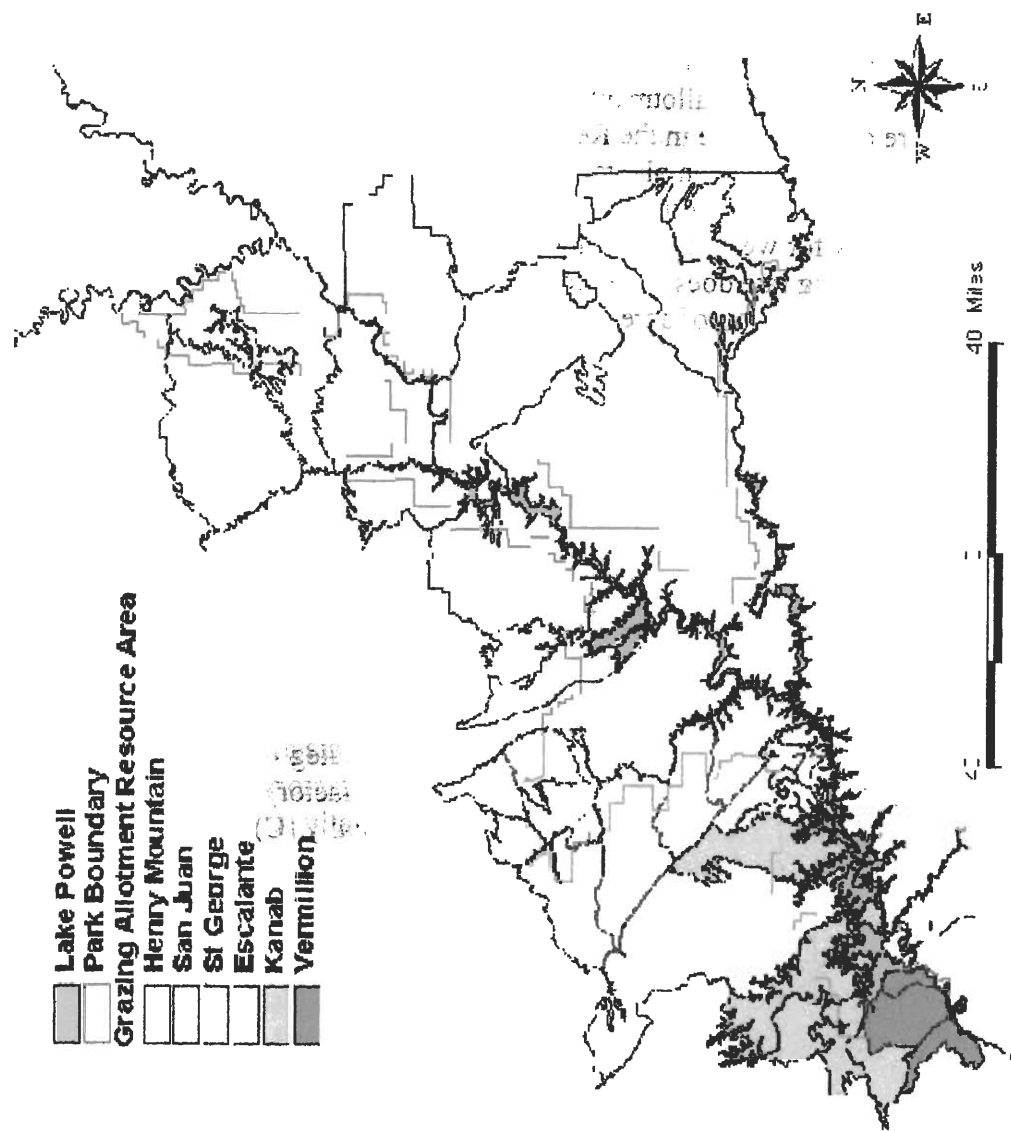
3. Statement of the problem

The lands in GLCA were used for livestock grazing 100 years prior to the establishment of the Recreation Area. Normally, the Code of Federal Regulations states that grazing is prohibited except "as specifically authorized by Federal Statutory Law." So grazing has continued up to the present time and is a use recognized by Congress in the act establishing the Recreation Area. Indeed, Congress directed the Secretary of the Interior to administer the area, through the NPS, in accordance with the purposes quoted in the first paragraph of the presentation of GLCA, as well as for "the fundamental purpose of conserving the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." Congress also directed that "The administration of ... grazing leases within the Recreation Area shall be administered by the BLM. The same policies followed by the BLM in issuing and administering ... grazing leases in other lands under its jurisdiction shall be followed in regard to lands within the boundaries of the Recreation Area, subject to provisions of section 3(a) and 4 of this Act" (Appendix A).

Grazing allotments of the Colorado plateau were defined in the 1950's. Today, 34 grazing allotments occur partially or entirely within GLCA. Those allotments are administered by six BLM Resource Areas (Map 2) : Henry Mountain, San Juan, St George, Escalante, Kanab and Vermillion. 882,678 acres of the Recreation Area are situated within these allotments. Approximately 85% (762,361 acres) are currently subject to grazing use while no livestock grazing is authorized in five of these allotments (approximately 120,317 acres). In addition, three areas (Antelope Island, Horseshoe South and the Escalante River) covering approximately 69,800 acres are no longer grazed by livestock due to retirement of the grazing privileges through a willing selling buyer arrangement.

The breed of cattle raised in these allotments is the Hereford domesticated cow (Picture 2). Perennial grasslands are relatively rare in the Recreation Area but provide much of the available forage for livestock. They feed on plants such as ricegrass, sand dropseed, galleta grass, mormon teas, winterfat, four wing saltbush and needle-and-thread (Appendix B). Stocking rates are generally low for western rangelands reflecting the sparse vegetation cover of the region. In GLCA, the stocking rate does not exceed 197 acre/AUM. However, the reported acres per AUM do not reflect the amount of acreage actually grazed because portions of most allotments consist of cliffs, talus, slickrock and other areas grazing is generally not feasible. Hence, the grazable acres per AUM are generally lower than the cited values.

The BLM practices selective management. It corresponds to concentrating available funding and personnel on areas where management action is most needed to improve resource condition, resolve serious resource-use conflicts, or where investments in range improvement will yield the greatest positive return. It is a land categorization process designed to help BLM managers assign management priorities among allotments or groups of allotments in a planning area. Three categories have been developed in which allotments are grouped according to their potential response to management. This potential was determined by analyzing the allotments' ecological status, resource potential, presence of resource-use conflicts or controversy and opportunity for positive economic return. The categories are: (1) Maintenance (M), (2) Improvement (I), and (3) Custodial (C). The objectives for the three categories are to (1) maintain current satisfactory condition (M), (2) maintain current satisfactory condition or improve current unsatisfactory conditions (I), and (3) manage custodially (C) while protecting existing resource values.



Map 2 - Grazing Allotment Resource Area



Picture 2 – Henceford domesticated cow.

The BLM's primary instrument for authorizing use is a grazing permit. This grazing permit is issued to qualified applicants to authorize use of public lands and other lands under the administration of the BLM designated as available for livestock grazing through a land use plan. In the Recreation Area, the land use plan is the GLCA General Management Plan issued in July 1979. This plan identifies land uses and describes "management zones" that specify long term allocation of the land and water resources within GLCA. These management zones established land and water use activities that are allowed or prohibited within the respective zones. The four management zones described in the plan are the Natural Zone (NZ), the Recreation and Resource Utilization (RRU), the Cultural Zone (CZ), and the Development Zone (DZ) (Appendix C). This General Management Plan also identified the need for a grazing plan. The core of this grazing plan is the BLM implementation of its grazing program insuring the integration of the NPS resource stewardship responsibilities. To foster coordination between BLM and NPS, an umbrella MOU (Memorandum Of Understanding) for grazing administration within units of the NPS where grazing is authorized was signed by the Director of the BLM and NPS on September 4, 1984. To implement this MOU, an interagency agreement was executed in 1993 between GLCA and both Utah and Arizona BLM state offices. The intention of this agreement is "to conduct a program to coordinate grazing management activities of GLCA...". These agreements state that "the BLM has expertise in developing,

implementing and analyzing grazing programs... and NPS has expertise in determining whether an activity is consistent with the values and purposes of GLCA”.

So in addition to selective management, the BLM took additional measures in part to help prioritize its grazing improvement efforts. As provided by the regulation developed by the Secretary of the Interior on February 22, 1995, the BLM adopted “Fundamentals of Rangeland Health” and their companion rules “Standards for Rangeland Health” and “Guidelines for Grazing Management” for all BLM lands including those in Utah and Arizona. The purpose for developing and implementing standards and guidelines is to help assure that the BLM is giving management priority to maintaining functioning ecosystems. This means that the needs of this land and its living and non living components (soil, air, water, flora, and fauna) are to be considered first. Only when ecosystems are functioning properly can the consumptive, economic, political and spiritual needs of man be maintained in a sustainable way.

4. The Grazing Management Plan

This plan was defined in July 1998. It provides an overview of grazing in GLCA and a description of BLM grazing management on other lands under its jurisdiction and on allotments in the Recreation Area (RA). It deals with the resources identified in the RA enabling legislation as values (scenic, scientific, and historical features) and purposes. The resources identified at the RA are vegetation, soils, water quality, wildlife, cultural resources, paleontological and quaternary resources, scenic resources and recreational resources. For each resource, a value statement is made. Then the goals and objectives for managing these resources are described (Appendix D). These goals and objectives are also used to determine if resource management or grazing administration actions are needed to protect resource values.

5. Focus of this study

It is foreseen that the NPS will identify unacceptable resource conditions and if degradation is the result of grazing activities, the NPS will request that the BLM initiate grazing administration actions to mitigate unacceptable effects to the water resources of the recreation area. It is to be noted that “backcountry hikers rely upon local springs and seeps to supply drinking water, and enjoy the aesthetic value of natural free flowing water” (Altson et al, 1998). This preliminary study was completed on three allotments for the following purposes:

- 1) Inventory the water resources (springs and ponds),
- 2) Identify the potential effects of grazing on these water resources,
- 3) Determine the relationship between grazing and water quality,
- 4) Discuss guidelines for grazing in the studied areas.

II. IDENTIFICATION OF THE AREAS OF STUDY

1. Allotments Selected

This study was carried out on three allotments (Map 3):

- Sewing Machine is part of the Hanksville Resource Area. It was selected because it is subject to continuous and intense grazing and does not have an allotment management plan.
- Soda is part of the Escalante Resource Area. Soda was selected because it was subject to overgrazing and non compliance to the allotment management plan.
- Lake Canyon is part of the San Juan Resource Area. It was selected for practical reasons after exploration of another selected allotment where all the ponds were dry.

One sampling site was part of Flint Trail, close to Sewing Machine.

More precise information on grazing and water resources of each allotment are given in the following table:

CRITERION	SODA	LAKE CANYON	SEWING MACHINE
Allotment Management Plan	Yes	Yes	-
Year	1987	1970	-
Implemented	Yes	No	-
Management Class (1)	I	I	C
Management System (2)	DR	DR	CG
Season Of Use (3)	10/1-5/31	10/6-6/5	11/1-4/30
Total Preference (4)	4,287	6,936	1,599
Active Preference (4)	2,755	4,895	1,599
Livestock Class	Cattle	Cattle/horse	Cattle
Wildlife AUMs	1,350	0	188
Total Acres in Allotments	75,983	651,060	131,609
Acres in NRA (5,6)	57,645 (76%)	186,769 (29%)	67,682 (51%)
Acres suitable for Grazing in NRA (6,7)	46,223 (80%)	115,797 (62%)	67,682 (100%)
Active Acres in NRA (6)	All	All	All
Unalloted Acres in NRA (6)	None	None	None
Developed Springs* (8)	3	0	1
Undeveloped Springs** (8)	1	6	2
Reservoirs*** (8,9)	2	0	5
Catchment **** (8,10)	0	0	0
Tanks (8,11)	2	0	0
Cattle Guards	2	0	2
Well	1	0	0

(1) C= Custodial, M= Maintenance, I= Improvement

(2) CG= Continuous Grazing, DR= Deferred Rotation, RR= Rest Rotation, WS= Winter/Summer

(3) Season of Use in Glen Canyon National Recreation Area

(4) Animal Unit Month

(5) Percentage of "Total Acres in Allotment"

(6) Glen Canyon National Recreation Area

(7) Percentage of "Acres in NRA"

(8) In or Adjacent (within two miles) to Glen Canyon National Recreation Area

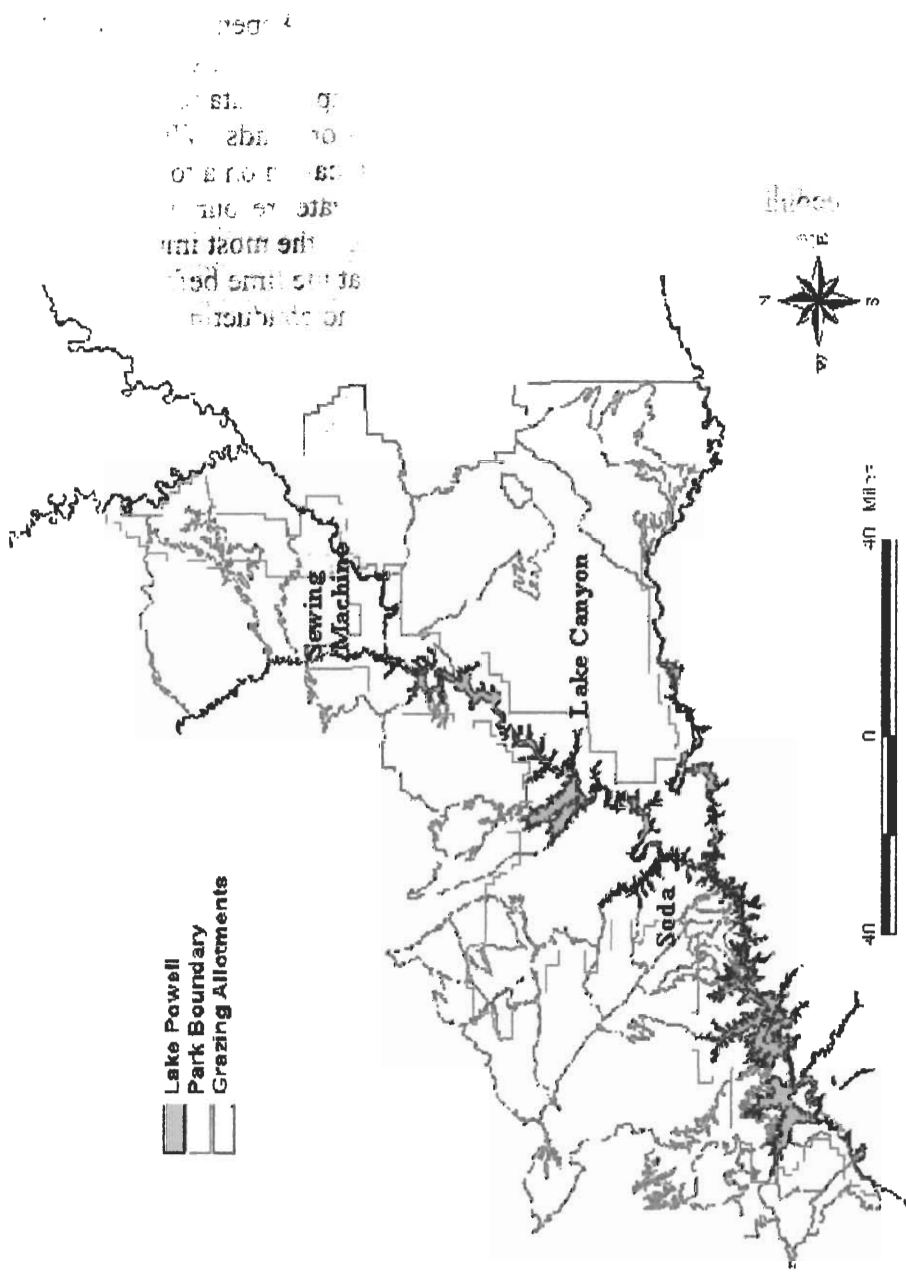
(9) Stock ponds, Impoundments, Earth "tanks"

(10) Catchment = apron + storage tank + pipe + trough

* Due to human action

** Natural Spring

*** Accumulation of water due to a small dam



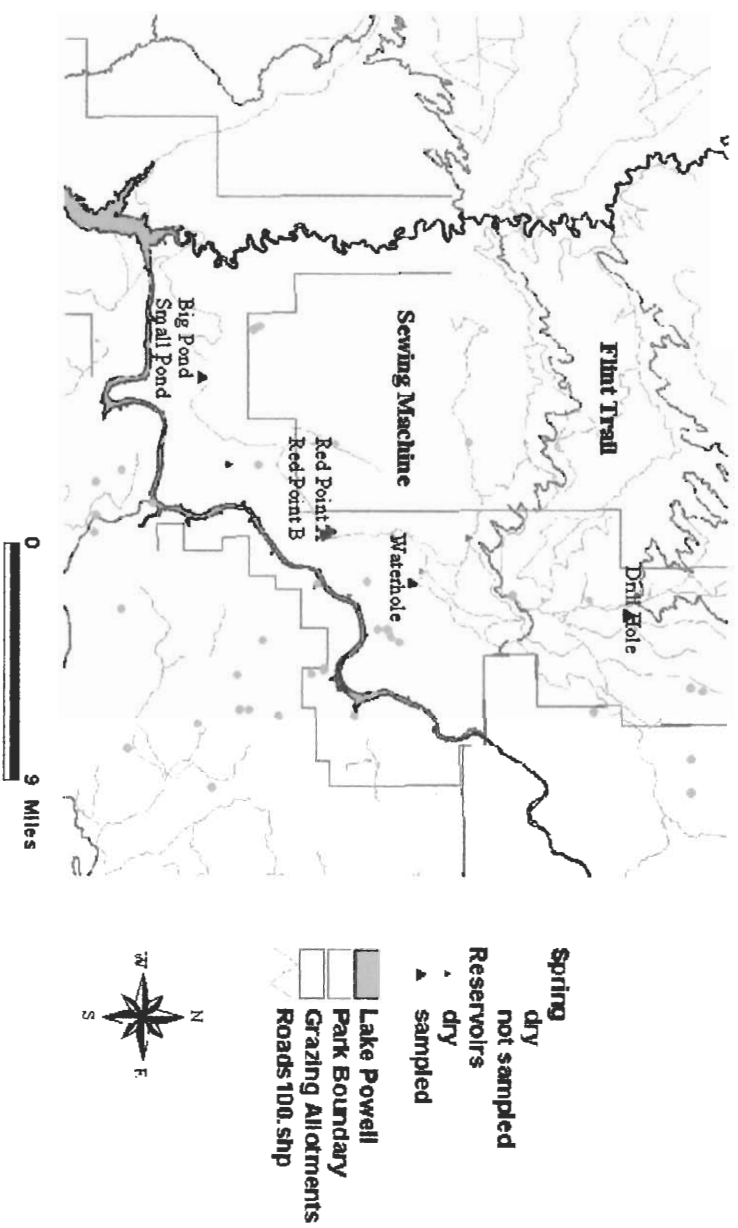
Map 3 - Grazing allotments selected.

2. Selected Sites in Each Allotment

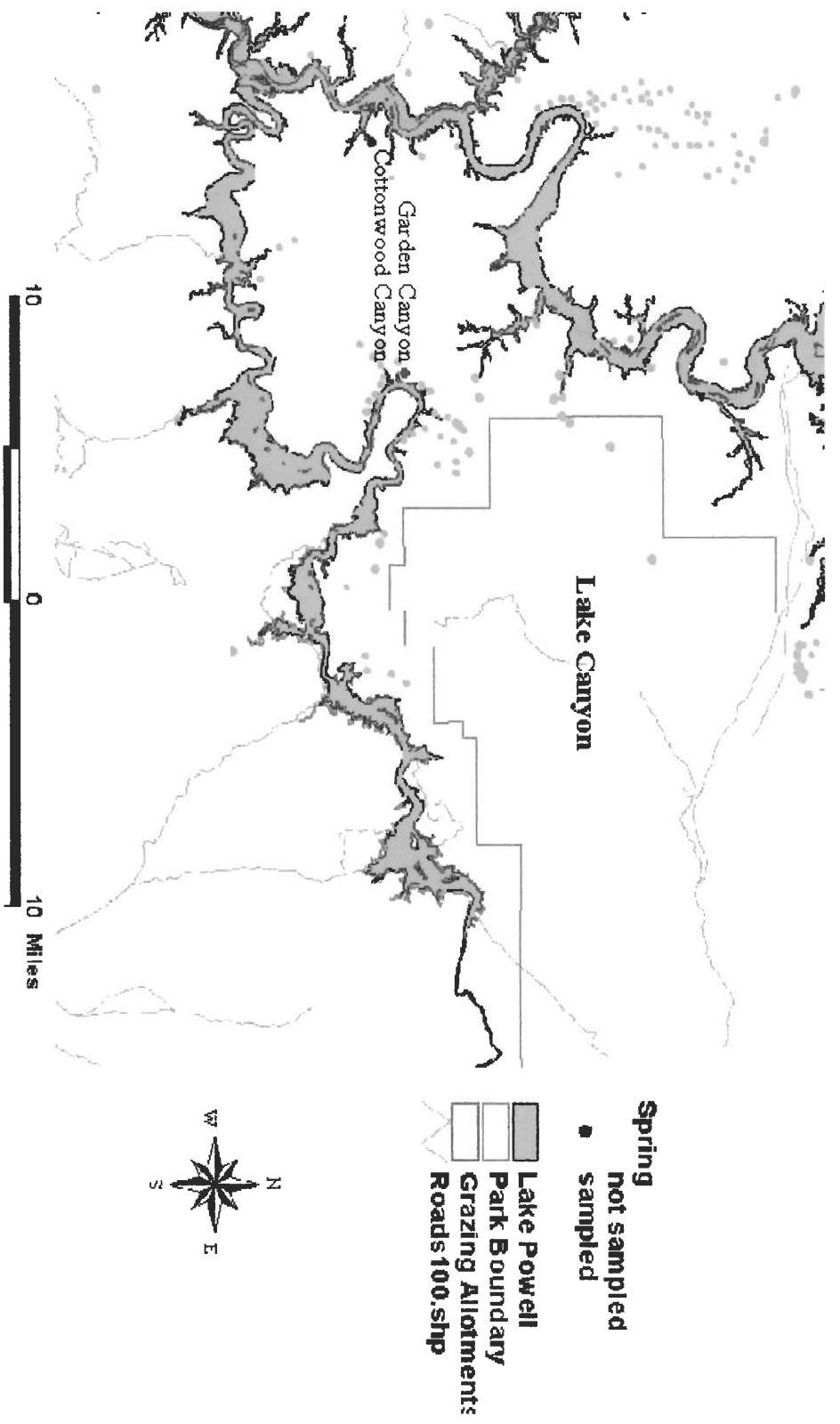
Themes for soil, vegetation, hypsometry and springs (Appendix E) were available from data files in Arcview from the National Park Service. The first step consisted in contacting the BLM staff of each allotment in order to complete data regarding water resources especially for water development like reservoirs or ponds. With this information, a new theme for reservoirs was created by digitizing their location on a topographical background. The second step consisted in defining what water resources were in areas homogeneous for vegetation, elevation and soil. In practice, the most important and limiting factor was to identify what water resources were not dry at the time before field work. This required contacting field staff like backcountry Rangers and conducting overflights of certain allotments.

Two types of water resources were sampled. Ponds formed by human improvement that are most commonly called "earth and dam" development or reservoirs and ponds that are naturally occur as waterpockets due to spring evaporation in canyons. Both can be temporarily dry or permanently wet.

A map of each allotment shows the ponds sampled (Map 4,5,6). A picture was taken of each pond sampled (Picture 3,4,5,6,7,8,9) except for Redpoint A, Redpoint B and Waterhole.



Map 4 - Sewing Machine water resources



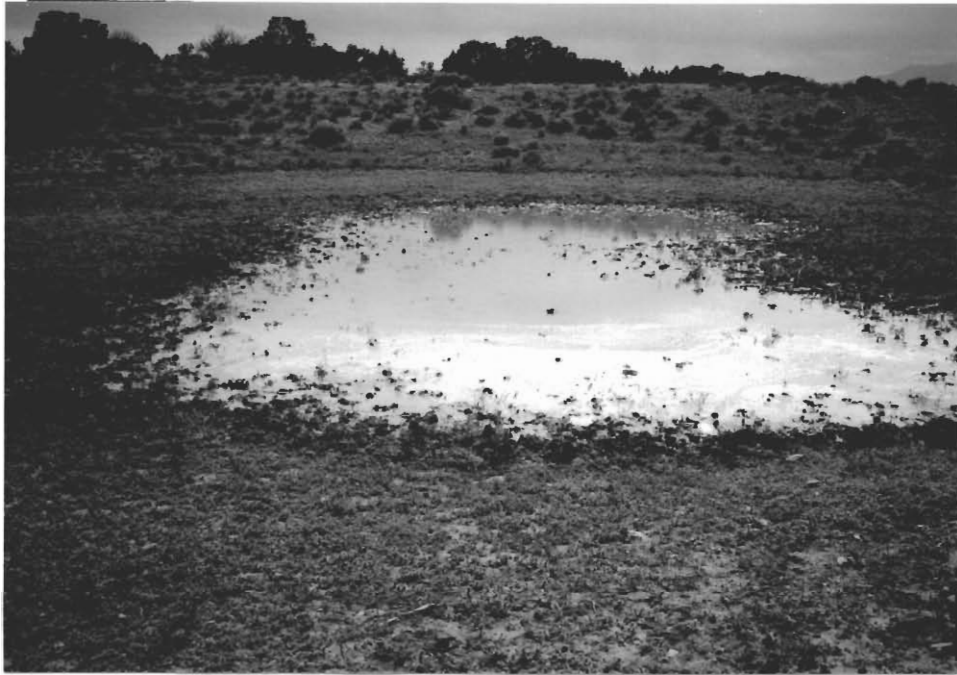
Map 6 - Lake Canyon Water Resources.



Picture 3 – Garden Canyon Pond, Lake Canyon



Picture 4 – Cottonwood Canyon Pond, Lake C



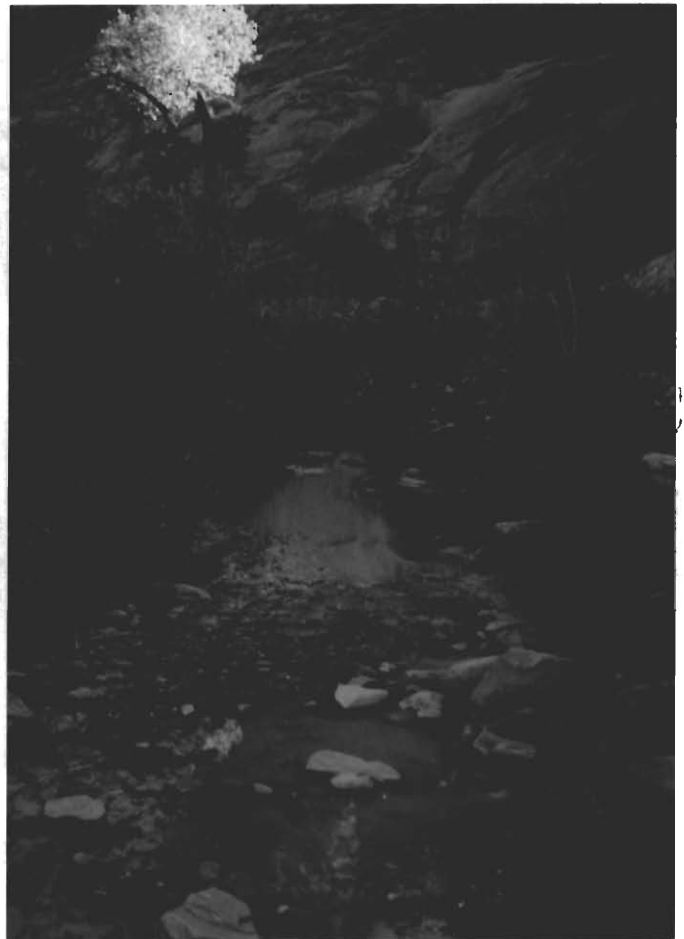
Picture 5 – Drill Hole Pond, Flint Trail.



Picture 6 – Big Pond, Sewing Machine.



Picture 7 – Small pond, Sewing Machine.



Picture 8 - Fiftymile Pond, Soda.



Picture 9 - Davis Gulch Pond, Soda.

3. Complementary information on each Allotment

Soda and Lake Canyon allotment have both an Allotment Management Plan whereas Sewing Machine does not. Soda is on a deferred rotation grazing system. The grazing season is for eight months from October 1st to May 31st. The allotment is divided into three pastures (Map 7) and the grazing schedule is as follows:

Year	Carcass Wash	Soda	Hole-in-the-rock
1	10/01-12/31	01/01-03/31	04/01-05/31
2	03/01- 05/31	10/01- 12/31	01/01-02/28
3	12/01-02/28	03/01- 05/31	10/01- 11/30
Surface (acres)	9,494	10,411	30,978
AUM's	1,026	981	791

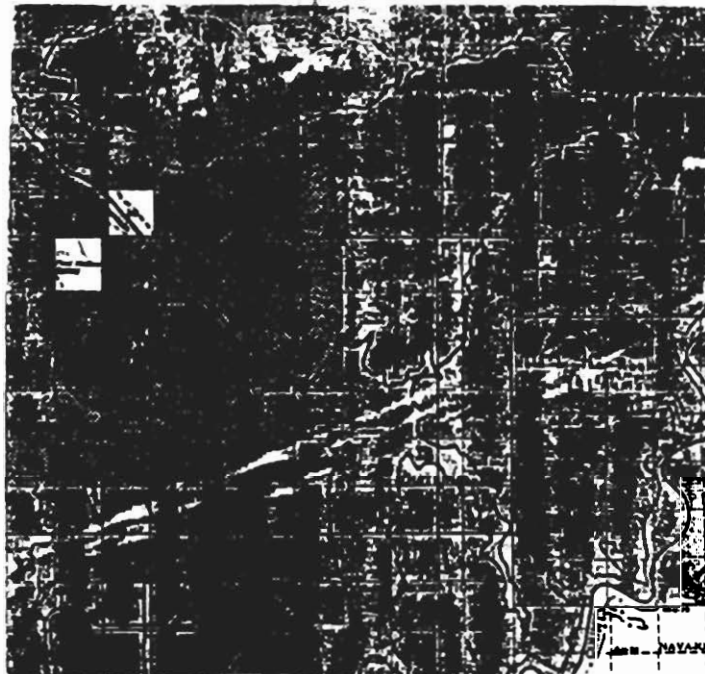
For 1999, the cattle were spread on Soda and Carcass Wash pastures and then were moved to Hole-in-the-Rock from January to May. So actually the grazing management plan was not respected. In addition, I was aware that Fiftymile Creek which is part of Soda is grazed whereas Davis Gulch did not have had any cattle for at least 12 years. Indeed, the cliffs around are very steep and unless the ranchers pushed them in the canyon there is rare chance that they go there.

Lake Canyon allotment is also on a deferred rotation grazing system. The grazing season is from early June to early October. The allotment is divided into four pastures (Map 8) and the grazing schedule is the following one:

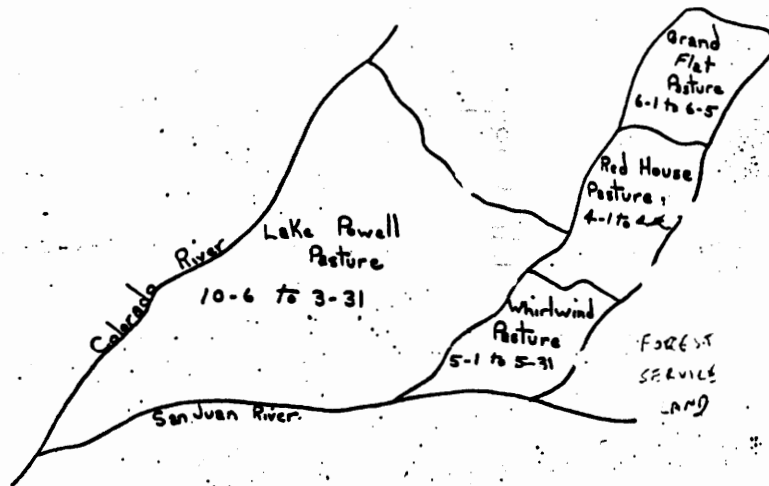
Pasture Name	Lake Powell	Red House	Whirlwind
AUM's cattle	5,123	829	911
AUM's horses	52	9	10
Occupation	10/6- 3/31	4/1- 4/30	5/1-5-31

Grand Flat is used as a stock driveway for going out or into the allotment. By early June, the cattle is transferred on Forest Service land until late March. Then, they go on Red House during April and Whirlwind during May. From early June to October they stay on Lake Powell pasture. When they are on this last pasture, the canyons are much more used than the mesa from December to March. The two ponds sampled in this allotment are located on Lake Powell pasture. Garden Canyon is surrounded by steep cliffs, so there is little chance that cattle access this pond whereas Cottonwood Canyon is pretty easy to access.

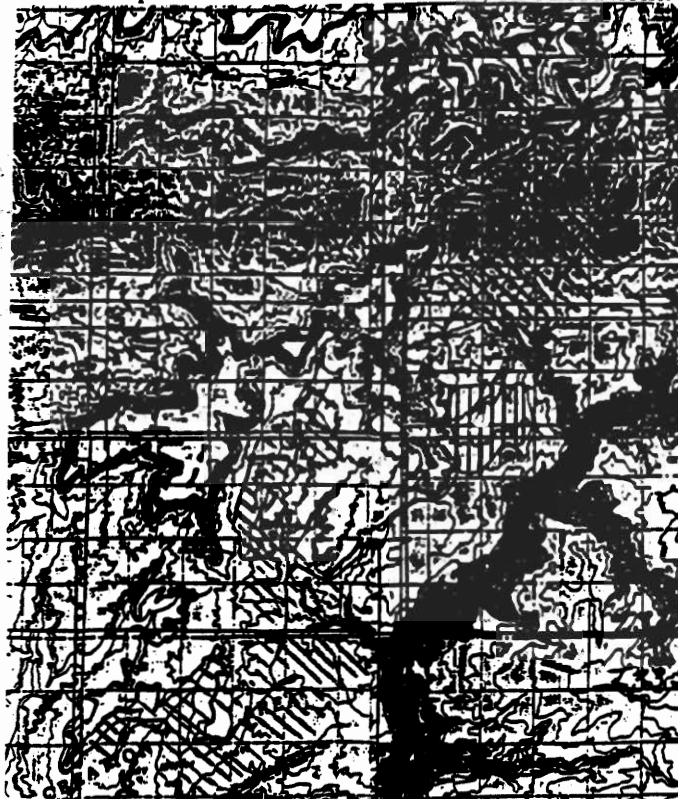
Sewing Machine is on a continuous grazing system from November 1st to the end of April. It is managed differently from the two other allotments since no grazing system existed. A grazing index existed, based on key species. It is determined as follows: after livestock has left the allotment, vegetation on the trend plot (where livestock has been grazing) is studied. In several range cage, an average height of browsed plants is estimated for each key species. Then, an average for the trend plot is determined and for an average superior to 65%, it is considered that grazing is too heavy and that cattle has to be removed to another place. From 0 to 5%, it is said slight, from 5% to 20%, light, from 20 to 45%, medium and from 45 to 50% moderate. Water Hole, Redpoint A, Redpoint B, Big Pond and Small Pond are located in a light grazing area (Map 9). Drill Hole is part of Flint Trail which theoretically does not have any grazing activities but it was said to be grazed year round.



Map 7 – Pastures of Soda Allotment.



Map 8 - Pastures of Lake Canyon Allotment.



Map 9 - Grazing intensity at Sewing Machine for 1999.

|||| Light
 \\\ Slight

III. POTENTIAL GRAZING EFFECTS ON A POND

Livestock use of rangelands for grazing can have significant effects on the environment. Grazing reduces water quality and quantity, destroys and alters wildlife habitat, erodes and compacts the soil. The potential impacts on a pond are recorded in a diagram (Figure 3).

These impacts can be assessed by chemical (pH, conductivity, dissolved oxygen), physical (turbidity), biological (aquatic insects population, zooplankton population) and microbiological (fecal coliform concentration) parameters.

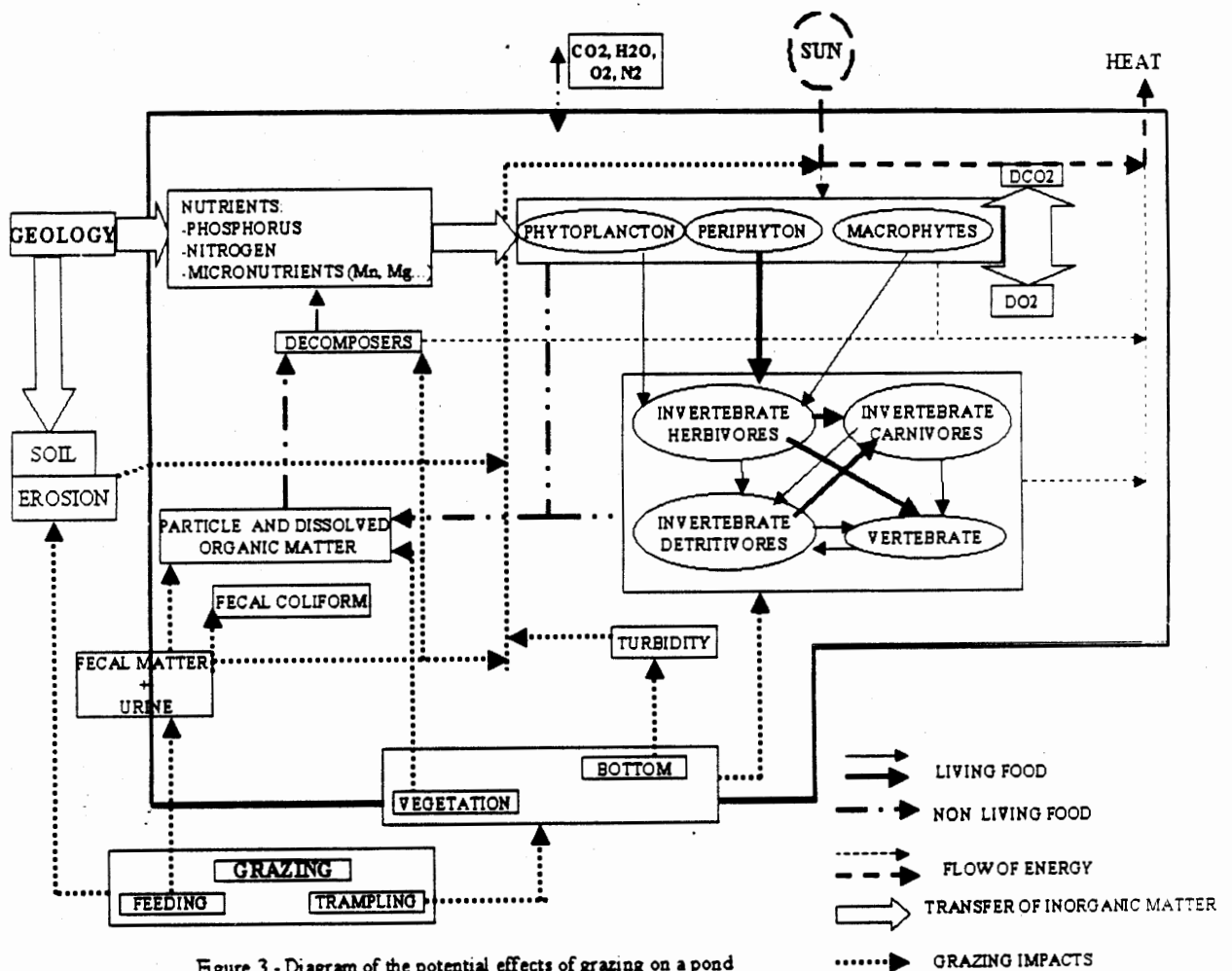


Figure 3 - Diagram of the potential effects of grazing on a pond

IV. HYPOTHESIS TESTED

Hypothesis 1:

Is the local grazing index linked to the water quality parameters: pH, conductivity, turbidity, dissolved oxygen, fecal coliform, ammonia, nitrate total phosphorus, total suspended solid, total dissolved solids?

Hypothesis 2:

Is there a link between the water quality of the ponds and their community of insects and zooplankton?

Hypothesis 3:

Is the vegetation around the pond affected by cattle grazing?

V. METHODOLOGY

1. Estimation of a Pond Volume

The volume of each water resource was determined by measuring the central length and the central width of the water resource with a steel tape and 3 depths, one was the deepest and the two others were chosen randomly. Then, the volume V of the water resource was calculated by multiplying the surface S by the mean depth D .

$$V \text{ (cm}^3\text{)} = S \text{ (cm}^2\text{)} \times D \text{ (cm)}$$

2. Water Quality Analysis

a) Chemical parameters

- pH

The pH was measured on three randomly chosen sites at each pond with a Checkmate 90 and the appropriate probe (Picture 10). The calibration was done each time before going in the field as follows : after removing the wetting cap, the tip of the pH electrode was placed in about 2.5 cm of the 7.00 buffer; the probe was agitated continuously. After pressing CAL, the display showed a CAL 1 and the A started flashing. The A stopped flashing when the display was 7.00. The electrode was rinsed with deionized water and the tip was blot and placed in about 2.5 cm of a second buffer. The A stops again flashing when the reading was stable and the display was correct to 4.00 or 10.01 depending on the row of pH that were willing to be measured and the pH of the second buffer. Then, the electrode was rinsed with deionized water, blot dry and the tip was placed back in its cap. In the field, the wetting cap was removed and the tip of the probe was placed into the pond at one of the sampling site. The button READ was pressed and the probe was kept moving until a stable value was reached.

- Dissolved Oxygen (DO)

The Dissolved Oxygen was measured on three randomly chosen sites for each pond with a Checkmate 90 and the appropriate probe (Picture 10). The calibration was done each time before going in the field as follows: after removing the wetting cap, the meter was turned on and the tip of the DO probe was placed in about 4 cm of zero oxygen standard. The button CAL was pressed. The showed CAL 1 and the A started flashing. The A stopped flashing when the reading was stable and the display would correct to 0.00%. The tip of the probe was rinsed with deionized water. The tip was held about 1 cm above a beaker of water. The button CAL was pressed. The A stopped flashing when the reading was stable and the display would correct to 100%. The probe was rinsed with distilled water. The button Mode was pressed to change the readings to mg/l. In the field, the tip of the probe was placed into the pond at one of the sampling site. After pressing READ, the probe was kept moving until a stable value was reached.

- Conductivity

The conductivity was measured on three randomly chosen sites for each pond with the DiST WP probe (Picture 10). The calibration was operated each time before going in the field as follows: after removing the protective cap, the tester was immersed into deionized water that is to say a 0 US/cm. The reading was allowed to stabilize and by using a small screwdriver the calibration trimmer was turned to match with the solution value. The same operation was done with a 1000 US/cm conductivity solution. In the field, the instrument was switched on. It was immersed into the water at each sampling site. It was stirred gently until the display stabilized. DiST WP compensates for the temperature automatically and variations on the display can be due to the temperature sensor adjusting to the new environment.



Picture 10 – pH probe, dissolved oxygen probe, conductivity probe (from right to left):

- Total nutrients: Total Phosphorus, Nitrate, Ammonia.

250 ml volume samples were collected and fixed by acid in the field (the sample bottle contains 2 ml of acid at the bottom). The samples were kept in ice until the analysis.

The analysis of the samples were done at the Department of Environmental Quality Division of Water Quality of Utah with the EPA methods cited in Appendix F.

- Dissolved nutrients: Calcium, Magnesium, Potassium, Sodium

250 ml volume samples we collected, filtered with a 45Um filter size and fixed by acid in the field (the sample bottle contains 2 ml of acid at the bottom). The samples were kept in ice until the analysis.

The analysis of the samples were done at the Department of Environmental Quality Division of Water Quality of Utah with the EPA methods cited in Appendix F.

- Total metals: Aluminum, Barium, Chromium, Iron, Manganese, Selenium, Zinc, Arsenic, Cadmium, Copper, Lead, Mercury, Silver

150 ml volume samples we collected and fixed by acid in the field (the sample bottle contains 2 ml of acid at the bottom). The samples were kept in ice until the analysis.

The analysis of the samples were done at the Department of Environmental Quality Division of Water Quality of Utah with the EPA methods cited in Appendix F.

- Chemical analysis: pH, Bicarbonate, Carbonate, Hydroxide, Total Hardness, Conductivity, Total suspended Solids, Carbon Dioxide, Chloride, Sulfate, Total alkalinity, Turbidity, Total Dissolved Solids, CO3 Solids

Half gallon volume samples were collected. The samples were kept in ice until the analysis.

The analysis of the samples were done at the Department of Environmental Quality Division of Water Quality of Utah with the EPA methods cited in Appendix F.

b) Physical parameter

- Turbidity

20 ml volume samples were collected in a plastic bottle, being careful not to take any bottom sediments, and kept in ice until measurement at the water laboratory in Wahweap.

The measurement was performed with the HACH MODEL 16800 turbidimeter (figure 4). It consists of a nephelometer (figure 5). This instrument is highly sensitive for measuring small amounts of turbidity and has a linear and direct response to increases in turbidity. In this instrument, the light beam enters the sample through the bottom of the sample cell and passes up through and into a light shield whose black interior acts as a light trap to help minimize straight line. As the light passed through the sample, some light was scattered by turbidity in the sample. A portion of that light was scattered at 90 degrees was sensed by a photocell and the resulting photocell output was conditioned to drive the instrument meter. The meter scale was calibrated in nephelometric turbidity units to provide direct turbidity readouts. The light source was a lens-end tungsten lamp

with a usable life of approximately 3000 hours. The detector was a silicon photocell.

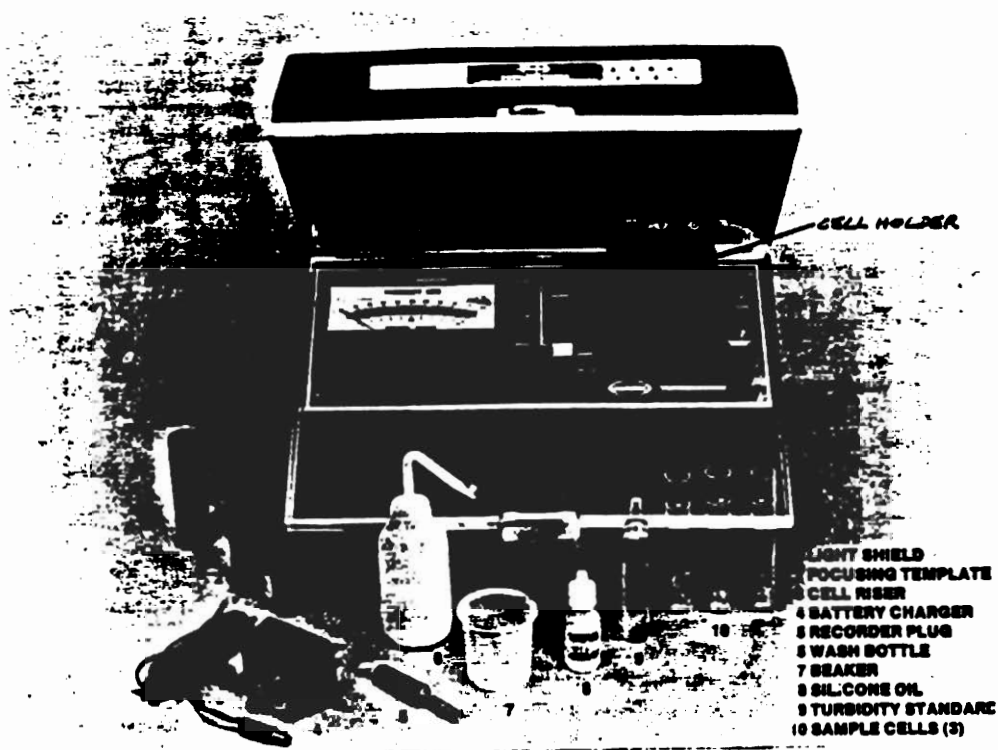


Figure 4 - Portalab turbidimeter 16800.

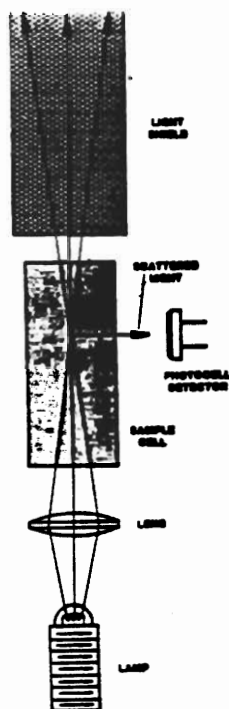


Figure 5 - Light path diagram nephelometer.

Before each series of measures, the apparatus was calibrated as follows: As the instrument was turned off, the mechanical zero setting was checked. If necessary, the screwdriver adjustment control on the meter face was adjusted to obtain a zero-NTU reading. After pressing the switch to ON, a battery check was performed by pressing the BATT CHECK switch and verifying that the meter indicated in the BATTERY CHECK area. If not, the battery pack has to be recharged. Then, the focusing template was placed into the cell holder. The focusing template would block the all light from reaching the detector and allow the instrument to be zeroed electronically. The 1.0 range switch was pressed and the ZERO control for a reading of zero NTU was adjusted. The 10 range switch was pressed and it was verified that the meter still indicates zero NTU. The readjustment of the ZERO control was done if necessary. The focusing template was removed and the turbidity standard of 10 NTU was placed into the cell holder. By using the black dot on the standard ampoule to orient the vessel in the same direction each time, it eliminated variations due to rotation. The light shield was placed over the turbidity standard and the meter was allowed to stabilize. The SPAN control was adjusted for a reading of 10 NTU. The same steps were taken with another standard of either 0.9 NTU or 100 NTU depending on the range of turbidity of the samples. With the instrument turned off, the mechanical zero setting was checked. The SPAN control was also checked not to have changed since standardization. After pressing the power switch and BATT CHECK switch, the meter was verified for indicating in the BATTERY AREA area. If it did not, the battery pack has to be recharged. The appropriate range switch was pressed and the range that would exceed the expected turbidity of the sampler under test was pressed too. The focusing template was placed into the cell holder and the ZERO control for a reading of zero NTU was adjusted. The focusing template was removed.

Each measure was done as follows: after shaking well the sample to be measured, the sample cell was filled with a volume of 18 ml with a pipit. The exterior of the cell was gently cleaned with silicone oil and towel in order to remove any fingerprints, dust and droplets. Then, the sample cell was placed in the cell holder covered with the light shield. The white dot on the sample cell was used to orient the cell in the same direction each time. The sample cell was covered with the light shield and reading of the turbidity was done on the appropriate scale.

c) Microbiological parameter

- **Fecal coliform concentration**

100 ml volume samples were collected in sterile plastic bottles and stored in ice until their processing. The membrane filtration apparatus was used to determine the fecal coliform concentration. It consisted of a plastic funnel housing placed on a funnel base with an underdrain screen (figure 6). All these materials had to be passed under UV for 3 minutes in order to be sterilized. The funnel base was linked to a vacuum source. A sterile forceps (sterilized by plunging it in alcohol and a flame) was used to place a sterile 0.45µm pore filter (diameter: 47 mm) on the underpain screen. Then, a measured volume of water sample was poured in the

funnel housing to the right graduation and the vacuum pump was switched on in order to filter the sample. After the sample had all passed, the inside of the funnel was rinsed three times carefully with deionized water. After all the water had passed through the filter, the filter was removed with a forceps (previously sterilized as before) into a 47 mm diameter petri dish containing 2 ml of mFC broth appropriate for fecal coliform growth and containing a pad in order to absorb it. The mFC media used for the fecal coliform test contains lactose, protein digest, vitamins, bile salts, selective chemicals and aniline blue dye. Then, the petri dishes were placed in two zip storage bag in order that no water came in. Indeed, the bags were placed in a water bath at $44.5 \pm 0.2^\circ\text{C}$ for 24 hours ± 2 hours. These conditions allowed coliforms of fecal origin to grow into blue colonies while inhibiting growth of other bacteria. Indeed, as the fecal coliforms grew, they fermented lactose producing acid which reacted with the aniline dye to produce a blue color. All the colonies exhibiting a blue color were counted and reported as fecal coliforms. The grid on the filter was used to count the colonies (figure 7,8).

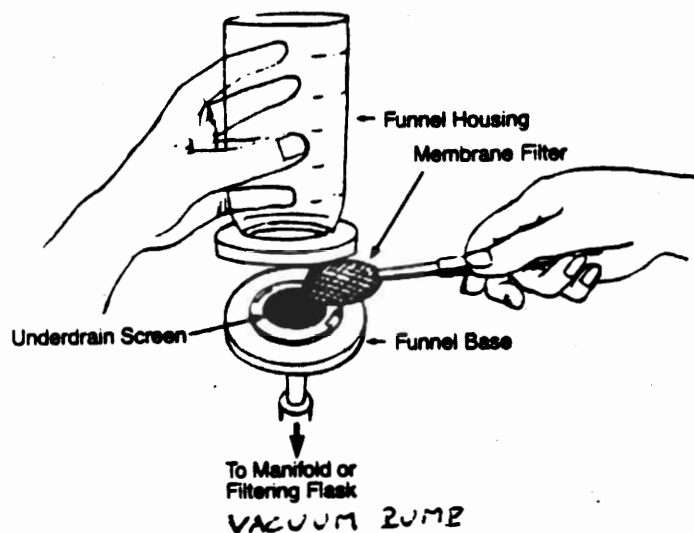


Figure 6 – Filter funnel for membrane filtration process.

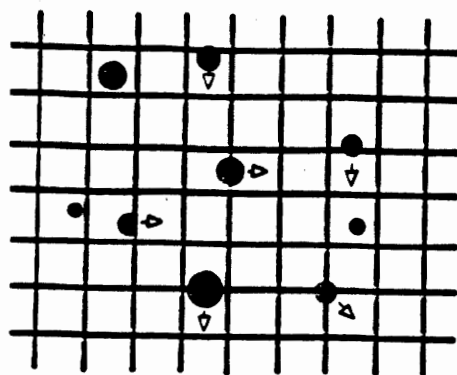


Figure 7 – Colony counting pathway (the inner circle indicates the effective filtering area. dashed line indicates the pathway).

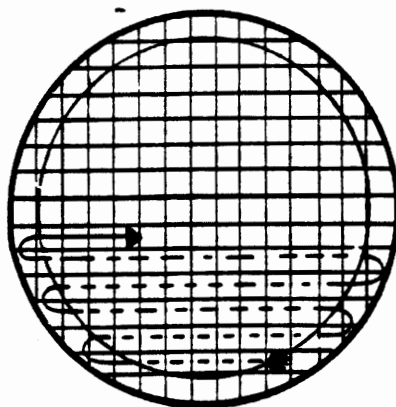


Figure 8 – Enlarged portion of grid marked square of filter (colonies are counted in squares indicated by the arrow).

Then, the fecal coliform concentration was reported in # fecal coliform unit or colony (FCU) per 100 ml:

$$\#FCU/100ml = \frac{\text{number of colonies counted} \times 100}{\text{volume of sample filtered (ml)}}$$

It is to precise that the filtration of the samples has to be done in the following order:

Solution to filtrate	Volume	Frequency	purpose
Blank: 100ml of sterile buffer solution	100ml	Always start with a blank and do it every ten samples	To insure sterility of equipment, buffer solution and lack of cross contamination among samples as well as proper operation of the UV sterilizer.
Up to 10 samples	variable	-	To determine #CFU/100ml
Blank	100ml	Every ten samples	Same as previously
EC2 (Appendix F) +3minutes under UV	100ml	Always after second series of up to 10 samples and blank	To check that UV sterilizes
Media control: sterile membrane in a media	-	Always after EC2 (Appendix F)	To insure that the mFC medium, membrane filter, and petri dish are uncontaminated.
Negative control: EA2 (Appendix F)	100ml	Always after media control	To insure that the medium is selective for coliform and the water bath temperature is correct. <i>Enterobacter aerogenes</i> growth is suppressed at 44.5C
Solution to filtrate	Volume	Frequency	purpose
Positive control: EC3 (Appendix F)	100ml	Always after EA2	To insure the Medium and the water bath temperature are conducive to coliform growth.
Positive control: EC4 (Appendix F)	100ml	Always after EC3	To insure the Medium and water bath temperature are conducive to Coliform growth.

Solution to filtrate	Volume	Frequency	purpose
Final-rinse: sterile buffer running through the filter for the positive control, EC3 after sterilization	100ml	Always after EC3	To determine of the UV Sterilizer is working.
Pre-rinse: sterile buffer running through the unsterilized filter apparatus used to filter one of the positive control, EC4	100ml	Always after EC4	To determine efficiency of the triple rinse step.

d) Biological parameters

- Aquatic insects

The sampling was performed with a square frame net 15 cm x 18 cm and 0.5mm aperture was used to collect aquatic insects. By approaching the sample site very slowly and plunging the net into the water column and going forth and back on approximately 1 meter length. The aquatic insects caught in the net were transferred into a 100 ml bottle containing one third of 95% ethyl alcohol.

The analysis of the samples was done as follows: each sample was filtered through a mesh net and transferred into a white pan of water. Insects were hand sorted with forceps and each of them was transferred into separate vials. The identification was processed under an Olympus dissecting microscope. It was checked if they were insects and after the order and the family were identified by using analytical keys.

- Zooplankton

The sampling was performed with a bucket of a 125 μ m aperture plankton net was used. A total volume of water taken in the water column of approximately 4 liters was filtered through the bucket. This was done with a 250 ml jar and each volume filtered was noted.

The analysis of the samples was done as follows: each sample was filtered through a mesh net. The contents were put in a 6.5 cm diameter watchglass and observed under an Olympus dissecting microscope. The order and the family were determined and the invertebrates were counted.

3. Grazing Index Complementary Analysis

a) Grazing index

No common and clearly defined grazing index existed for the allotments studied. The information was collected from the BLM on the management of the three allotments. A global grazing index was attempted to be defined in AUM/time/acre. A local grazing index was defined based on a random counting of cow pies around each pond. Five squares of 2mx2m were settled randomly and the cow pies were counted in each square. Each square was designated by walking fifteen feet randomly and settling the frame on the left side around each pond.

b) Complementary analysis of the soil and vegetation

The soil cover was analyzed with the point method in the four cardinal directions. A steel tape was settled in the direction of a cardinal direction and every 50 cm was recorded what was at the vertical of the tape: cow pie, bare ground, litter, annual grass, annual forb, perennial grass, perennial forb, seedling, shrub, pebble, rock, cryptobiotic crust, sand. This was done on 12 meters in each direction.

The vegetation around the pond was analyzed by roughly noting the abundance of each species.

The color of the water of the pond was also noted as follows: very clear, middle clear, grey, orange clear, orange and orange dark.

4. Data Analysis

The low number of ponds sampled is a criterium to choose non parametric tests for analyzing the data. The analysis of the normality of the water parameters was also performed to confirm that choice. This was accomplished by running a Wilk Shapiro/Rankit Plot with Statistix.

A non parametric test was done to evaluate quantitatively the relations between water quality parameters (chemical and physical) and local grazing index. Spearman's rho correlation coefficient was computed to assess a linear relation between this index and the water quality variables like turbidity, conductivity, dissolved oxygen, pH, fecal coliform, total phosphorus, nitrate, ammonia, total suspended solids and total dissolved solids. This test was performed with Statistix.

VI. RESULTS

1. Normality of the water variables studied

The Wilk Shapiro test showed that for fecal coliform, turbidity, volume, total suspended solids, nitrate and ammonia the trend between ordered data and rankits was not linear. This systematic departure off the ranking plot from a linear plot indicates non-normality. In addition, the approximate Wilk Shapiro statistic calculated which is the square of the linear correlation between rankits and ordered statistics is inferior to 0.9. For the local grazing index, dissolved oxygen, pH, total dissolved solids and total phosphorus, the trend was rather linear one or two outliers (Appendix G). From this preliminary analysis of the data, it was assumed that non parametric test should be done.

2. Information from the local grazing index and the chemical and physical data

Data were sorted by local grazing index as the first variable and successively by pH, dissolved oxygen, conductivity, turbidity, fecal coliform, volume, total phosphorus, ammonia, nitrate, total suspended solids and total dissolved solids as a second variable. No pattern was assessed between the cow pie index and pH, dissolved oxygen, conductivity, volume, ammonia, nitrate.

On the contrary, two groups of ponds could be assessed with turbidity, fecal coliform and total phosphorus total suspended solids and total dissolved solids (Table 1). Concerning the relationship between the cow pie index and turbidity, the two following groups were assessed:

Group 1: low turbidity (<100)	Group 2: high turbidity (=100)
Davis Gulch, Garden Canyon, Small Pond, Fiftymile.	Drill Hole, Waterhole*, Red Point A, Red Point B, Big Pond.

*Waterhole was an outlier because of its low turbidity (Table 1).

Concerning the relationship between the cow pie index and fecal coliform, the two following groups appear:

Group 1: low fecal coliform (<30)	Group 2: high fecal coliform (>30)
Davis Gulch, Garden Canyon, Small Pond, Fiftymile*.	Drill Hole, Waterhole*, Red Point A, Red Point B, Big Pond.

*Fiftymile and Waterhole were two outliers because the first one has a high fecal coliform concentration whereas the second has a low one (Table 1).

Concerning the relationship between the local grazing index and total phosphorus, the two following groups were assessed:

Group 1: total phosphorus <0.1 mg/l	Group 2: total phosphorus >0.1 mg/l
Davis Gulch, Small Pond, Fiftymile, Waterhole.	Red Point A, Red Point B, Big Pond.

Concerning the relationship between the local grazing index and total suspended solids, the two following groups were assessed:

Group 1: total suspended solids<80 mg/l	Group 2: total suspended solids>80 mg/l
Davis Gulch, Small Pond, Waterhole.	Red Point A, Red Point B, Big Pond, Fiftymile,.

Fiftymile was an outlier because it presents a high total suspended solids concentration (Table 1).

Concerning the relationship between the local grazing index and total dissolved solids, the two following groups were assessed:

Group 1: total dissolved solids<300 mg/l	Group 2: total dissolved solids>300 mg/l
Davis Gulch, Small Pond, Waterhole.	Red Point A, Red Point B, Big Pond, Fiftymile,.

Fiftymile was an outlier because it presents a high total dissolved solids concentration (Table 1).

The two groups identified for fecal coliform and turbidity are the same. The groups identified for total phosphorus, total suspended solids and total dissolved solids are the same as the ones identified for the fecal coliform and turbidity except for Waterhole, Cottonwood and Garden Canyon for which there was no data for that parameter.

The Spearman coefficient computed for each couple of variables previously analyzed confirm these relationships (Table 2). A high coefficient was found for the relations local grazing index-turbidity (0.64) and local grazing index-total phosphorus (0.8729). A low coefficient was found for the relations local grazing index-fecal coliform (0.2979), local grazing index-total suspended solids (-0.1802) and local grazing index-total dissolved solids (0.3424). The correlations local grazing-total suspended solids and local grazing index-fecal coliform concentration were assessed when the outliers were put apart. Indeed, the Spearman coefficient for local grazing index-fecal coliform was 0.7638 and for local grazing index- total suspended solids it was 0.9276.

A high Spearman coefficient was found for turbidity-fecal coliform (0.78). No dependence was assumed for the relations turbidity- total phosphorus, turbidity total suspended solids and turbidity-total dissolved solids.

Table 1 -Water quality parameters sorted by local grazing index

Pond	Type of pond	Management	E* (feet)	Vol* (cm3)	color	LGI* (H3O+)	(mol/l)	DO2* (mg/l)	C* (US/cm T* (NTU)
Garden Canyon	natural	no grazing	3600	63	very clear	0	0.0007	4.3	10
Cottonwood	natural	deferred rotation	4960	7	orange clear		0.0004	1.77	8.3
Davis Gulch	natural	no grazing	3920	3	middle clear	0	0.0004	6.07	6
Fiftymile	natural	year round not summer	5560	6	grey	0	0.0007	1.33	85
Small Pond	natural	light	4960	5	orange clear	0.4	0.0001	3.5	71.5
Drill Hole	earth and dam	year round	5680	11	orange dark	1	0.0002	0	100
Waterhole	earth and dam	deferred rotation	6440	156	middle clear	1.2	0.00052	1.73	3
Red Point B	earth and dam	light	4000	54	orange	1.6	0.00014	4.47	100
Red Point A	earth and dam	light	3880	47	orange	1.6	0.0005	1.87	100
Big Pond	earth and dam	light	5320	133	orange dark	2	0.0004	5.17	100

Pond	FC* (#/100ml)	TP* (mg/l)	(NH4+)	(NO3-)	(mg/l)	TDS* (mg/l)	TSS* (mg/l)
Garden Canyon	13.5						
Cottonwood	0						
Davis Gulch	27	0.027	0	0	283.33	4.8	
Fiftymile	538	0.065	0.294	0	602	7646.7	
Small Pond	7	0.039	0	0	133	5	
Drill Hole	350						
Waterhole	0	0.075	0	0.03	162.7	11.2	
Red Point B	39.3	0.226	0.15	0.116	504	87.33	
Red Point A	115	0.178	0.245	0.146	327.3	122	
Big Pond	1000	0.188	0.037	0	328	427.3	

* E: Elevation, Vol: Volume, LGI: Local Grazing Index, DO2: Dissolved Oxygen, C: Conductivity, T: Turbidity, FC: Fecal Coliform, TP: Total Phosphorus, TSS: Total Suspended Solids, TDS: Total Dissolved Solids

Table 2 - Summary of the correlation between the local grazing index and water quality parameters and between turbidity and some water quality parameters

Relation Tested	Spearman coefficient w	0.975* correlation
local grazing index-(H3O+)	-0.32	0.6364 none
local grazing index-total suspended solids	-0.1802	0.745 none
local grazing index-total suspended solids without Fiftymile	0.9276	0.8286 high
local grazing index-conductivity	0.06	0.7143 none
local grazing-dissolved oxygen	0.1107	0.6364 none
local grazing index-ammonia	0.151	0.745 none
local grazing-total dissolved solids	0.3424	0.745 none
local grazing-total dissolved solids without Fiftymile	0.7247	0.8286 none
local grazing index-nitrate	0.4815	0.745 none
local grazing index- volume	0.5703	0.6364 none
local grazing index-turbidity	0.64	0.6364 high
local grazing index-turbidity without Waterhole	0.8632	0.6833 high
local grazing index-fecal coliform	0.2979	0.6364 none
local grazing index-fecal coliform without Waterhole, Fiftymile	0.7638	0.7143 high
local grazing index-total phosphorus	0.8729	0.745 high
turbidity-fecal coliform	0.78	0.6364 high
turbidity-total phosphorus	0.7412	0.745 none
turbidity-total phosphorus without Fiftymile	0.759	0.8286 none
turbidity-total suspended solids	0.5768	0.745 none
turbidity-total dissolved solids	0.6301	0.745 none

*w0.975: value of the Spearman coefficient in 95% of the cases with n samples.

For n=6, w0.975=0.8286; for n=7, w0.975=0.745; for n=8, w0.975=0.7143; for n=10, w0.975=0.6364 (Appendix G)

3. Soil cover and vegetation analysis

The data for annual grass, annual forb, perennial grass, perennial forb, seedling, shrub, cryptobiotic crust, cow pie did not regroup the ponds in a common pattern. Bareground, litter and mud regrouped the ponds into three groups. Bareground classifies the ponds into three groups:

Group 1: low bareground (0-10%)	Group 2: middle bareground (22%)	Group 3: high bareground (40-60%)
Cottonwood, Fiftymile, Davis Gulch	Small Pond, Waterhole	Garden Canyon, Drill Hole, Big Pond, Red Point A, Red Point B

Litter classified the ponds into two groups:

Group 1: low litter (<10%)	Group 2: high litter (>10%)
Small Pond, Red Point A, Red Point B, Drill Hole, Big Pond	Garden Canyon, Cottonwood, Fiftymile, Davis Gulch, Water Hole

Mud classified the ponds into three groups:

Group 1: no mud	Group 2: low mud (<10%)	Group 3: high mud (>10%)
Garden Canyon, Cottonwood, Fiftymile, Davis Gulch	Red Point A, Red Point B, Water Hole	Small Pond, Drill Hole, Big Pond.

The plant species were classified as indigenous or weed (Table 4).

For the indigenous species, *Stipa Hymenoides* was found around Cottonwood, Fiftymile and Red Point A and *Gutierrezia species* were found around Red Point A, Garden Canyon, Drill Hole, Small Pond, Red Point B.

For the weed species (Table 5), a total was done for each pond. This first operation shows that the ponds can be separated into two groups:

Group 1: low number of weed species (0 to 3)	Group 2: high number of weed species (4 to 9)
Fiftymile, Davis Gulch, Cottonwood, Big Pond, Small Pond	Drill Hole, Red Point A, Red Point B, Waterhole

The most common weed species found were *Bromus tectorum*, *Salsola iberica*, *Rumex crispus*, *Xanthium strumarium*.

A Shannon index was computed for each pond:

Pond	Local grazing index	Shannon index
Garden Canyon	0	1.62
Cottonwood	0	2.12
Davis Gulch	0	1.2
Small Pond	0.4	1.4
Drill Hole	1	1.68
Waterhole	1.2	2.07
Red Point B	1.6	1.75
Red Point A	1.6	1.85
Big Pond	2	1

No trend appeared between the local grazing index and the Shannon index.

Table 3 - Percentage of ground cover around the ponds*

Soil Cover	CP	B	L	P	R	AG	AF	PG	PF	S	SH	Sa	M	C
Pond														
Garden Canyon	0	52	19	0	0	7	6	14	2	0	0	0	0	0
Cottonwood Canyon	0	11	19	1	5	17	1	1	1	1	0	36	0	7
Drill Hole	0	54	0	3	0	1	30	0	0	0	0	0	12	0
Big Pond	1	54	0	0	0	3	5	0	0	0	25	0	12	0
Small Pond	1	22	2	0	11	6	0	0	0	0	9	0	49	0
Fiftymile spring	0	0	19	3	30	11	4	0	0	1	0	32	0	0
Davis Gulch Canyon	0	0	32	0	4	1	1	0	0	0	0	62	0	0
Red Point A	0	42	2	34	5	6	3	0	1	1	2	0	4	0
Red Point B	3	60	10	14	1	5	0	0	0	0	1	0	6	0
Waterhole	1	22	39	0	0	5	18	0	0	2	4	0	9	0

*CP: Cow Pie, B: Bareground, L: Litter, P: Pebble (diameter>1"), R: Rock (diameter<1"), AG: Annual Grass, AF: Annual Forb, PG: Perennial Grass, PF: Perennial Forb, S: Sealing, SH: Shrub, Sa: Sand, M: Mud,

Table 4 - Indigenous species abundance around the ponds

Pond*	GC	CW	DH	BP	SP	FM	DG	RPB	RPA	WH
Plant species										
<i>Abronia fragans</i>	0	1	0	0	0	0	0	0	0	0
<i>Ambrosia acanthicarpa</i>	0	0	0	0	2	0	0	0	0	0
<i>Apocynum canadense</i>	1	0	0	0	0	0	0	0	0	0
<i>Artemisia dracunculoides</i>	0	0	0	0	0	0	0	1	0	1
<i>Artemisia ludoviciana</i>	0	1	0	0	0	0	0	0	0	0
<i>Artemisia</i> sp.	0	0	0	0	0	0	0	0	1	0
<i>Atriplex canescens</i>	0	2	0	0	0	0	0	2	0	0
<i>Atriplex confertifolia</i>	0	0	0	0	1	0	0	0	0	0
<i>Baccharis emoryi</i>	0	0	0	0	0	2	3	0	0	0
<i>Bridellia microphylla</i>	0	0	0	0	0	1	0	0	0	0
<i>Castilleja linariifolia</i>	0	0	0	0	0	0	1	0	0	0
<i>Centaurea catycosum</i>	0	2	0	0	0	0	0	0	0	0
<i>Cercocarpus intricatus</i>	0	0	0	0	0	0	0	0	2	0
<i>Chrysothamnus nauseosus</i>	0	1	0	0	0	0	0	1	0	0
<i>Cleome serrulata</i>	0	0	2	0	0	0	0	0	0	0
<i>Dalea florescens</i>	0	1	0	0	2	0	0	0	0	0
<i>Dalea</i> sp.	0	1	0	0	0	0	0	0	0	0
<i>Descurainia pinnata</i>	0	0	0	0	0	0	0	0	1	1
<i>Elocharis palustris</i>	0	0	0	0	0	0	0	0	0	2
<i>Elymus canadensis</i>	0	0	0	0	0	0	3	0	0	0
<i>Equisetum hyemale</i>	1	0	0	0	0	2	0	0	0	0
<i>Erigeron dirverzens</i>	0	0	0	0	0	0	0	0	0	1
<i>Eriogonum corymbosum</i>	0	0	0	0	0	0	0	0	2	0
<i>Gilia aggregata</i>	0	1	0	0	0	0	0	0	0	0
<i>Gilia gunnisonii</i>	1	0	0	0	0	0	0	0	0	0
<i>Gilia</i> sp.	0	1	0	0	0	0	0	0	0	0
<i>Grayia spinosa</i>	0	1	0	0	0	0	0	0	0	0
<i>Gutierrezia microcephala</i>	1	0	0	0	0	0	0	1	2	0
<i>Gutierrezia sarothrae</i>	0	0	2	0	2	0	0	0	0	0
<i>Hymenopappus filifolius</i>	0	0	1	0	0	0	0	0	0	0
<i>Juncus balticus</i>	3	0	0	0	0	0	0	0	0	0
<i>Lepidium montanum</i>	1	0	0	0	0	0	0	0	0	0
<i>Machaeranthera canescens</i>	0	1	0	0	0	0	0	0	0	0
<i>Melilotus</i> sp.	0	0	0	0	0	0	1	1	0	0
<i>Mentzelia albicaulis</i>	0	0	0	0	0	0	0	0	1	0
<i>Muhlenbergia aspenfolia</i>	1	0	0	0	0	0	0	0	0	0
<i>Oenothera longissima</i>	1	1	0	0	0	0	0	0	0	0
<i>Oxytenia acerosa</i>	0	0	0	0	0	2	0	0	0	0
<i>Panicum virgatum</i>	0	1	0	0	0	0	0	0	0	0
<i>Plantago patagonica</i>	1	0	2	0	0	0	0	0	0	0
<i>Psoralea lanceolata</i>	0	1	0	0	0	0	0	0	0	0
<i>Salix exigua</i>	0	0	0	0	0	0	0	0	0	2
<i>Senecio multilobatus</i>	0	0	2	0	0	0	0	0	0	0
<i>Shepherdia rotundifolia</i>	0	0	1	0	0	1	0	0	0	0
<i>Silene arenaria</i>	0	0	0	0	1	0	0	0	0	0
<i>Sphaeralcea</i> sp.	0	1	0	0	0	0	0	0	0	0
<i>Sporobolus cryptandrus</i>	1	0	0	0	0	0	0	0	2	0
<i>Sporobolus</i> sp.	0	2	3	0	0	0	0	0	0	0

Table 4 – Indigenous species around the ponds (cont.)

Pond*	GC	CW	DH	BP	SP	FM	DG	RPB	RPA	WH
Plant species										
<i>Stanelya pinnata</i>	0	0	0	0	0	0	0	0	2	0
<i>Strepanthella longirostris</i>	0	0	0	3	0	0	0	0	0	0
<i>Stephanomeria tenuifolia</i>	0	0	0	0	1	0	0	0	0	0
<i>Stipa hymenoides</i>	0	1	0	0	0	0	0	0	2	0
<i>Typha latifolia</i>	0	0	0	0	0	0	0	2	0	0

* FM: Fifty mile, DG: Davis Gulch, CW: Cottonwood, GC: Garden Canyon, BP: Big Pond, SP: Small Pond, DH: Drill Hole, RPA: Red Point A, RPB: Red Point B, WH: Waterhole.
0: absent, 1: very few, 2: a few, 3: a lot

Table 5 - Exotic species abundance present around the ponds

Pond*	FM	DG	CW	GC	BP	SP	DH	RPA	RPB	WH
Plant species										
<i>Agropyron cristatum</i>	0	0	0	0	0	0	0	2	1	1
<i>Agrostis stolonifera</i>	0	2	0	0	0	0	0	0	0	0
<i>Amaranthus blitoides</i>	0	0	0	0	0	0	0	0	0	1
<i>Amaranthus sp.</i>	0	0	0	0	0	0	3	0	0	0
<i>Bromus tectorum</i>	0	0	2	2	0	3	3	3	2	3
<i>Conyza canadensis</i>	0	1	0	0	0	0	0	0	0	0
<i>Grindelia sp.</i>	0	0	0	0	0	0	0	0	0	1
<i>Marrubium vulgare</i>	0	0	0	0	0	0	0	0	0	1
<i>Lypogon monspellier</i>	0	0	1	0	0	0	0	0	0	0
<i>Potulaca oleracea</i>	0	0	0	0	0	0	3	0	0	0
<i>Rumex crispus</i>	0	0	0	0	0	0	0	0	0	2
<i>Salsola iberica</i>	0	0	0	0	3	3	0	2	1	3
<i>Solanum rostratum</i>	0	0	0	0	0	0	3	0	0	0
<i>Solanum sp.</i>	0	0	0	0	0	0	0	0	0	2
<i>Sonchus asper</i>	0	0	0	1	0	0	0	0	0	0
<i>Tamarisk sp.</i>	0	0	0	0	2	0	0	2	2	0
<i>Xanthium strumarium</i>	0	0	0	0	0	0	0	0	2	2
total number of weec	0	1	2	2	2	2	4	4	5	9

* FM: Fifty mile, DG: Davis Gulch, CW: Cottonwood, GC: Garden Canyon, BP: Big Pond, SP: Small Pond, DH: Drill Hole, RPA: Red Point A, RPB: Red Point B, WH: Waterhole.
0: absent, 1: very few, 2: a few, 3: a lot

4. Information from insects and zooplankton analysis

Insects collected were classified according to their fractionned feeding groups into four classes::Predators, Collectors, Shredders and Scrapers (Appendix G). No trend was noted for each group when the local grazing index increased (Table 6).

Regarding the zooplankton, only a trend appeared for the Cladocera. Their concentration tended to increase when the local grazing index increased (Figure 9).

Figure 9 – Cladocera concentration against local grazing index

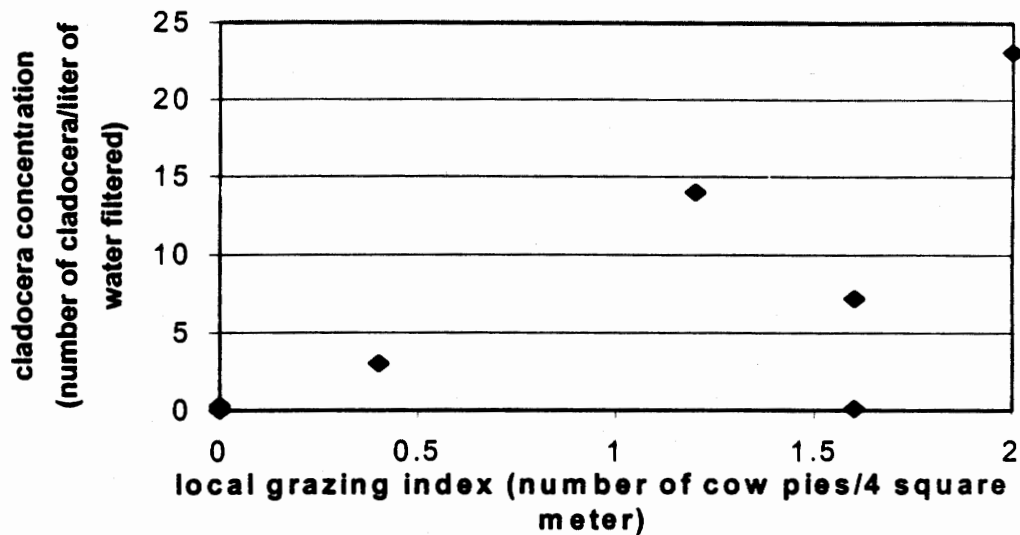


Table 6 - Quantity of insects of each feeding group per sweep (13cmx18cmx100cm)

Pond	Local grazing index	Collectors	Predators	Scrapers	Shredders
Garden Canyon	0	0	0	0	0
Davis Gulch	0	0	0	2.66	0
Fiftymile	0	0	1	0	0
Small Pond	0.4	114.5	0	0	0
Drill hole	1	0	0	0	0
Waterhole	1.2	31.33	8.66	1.33	4.67
Red Point B	1.6	0	0.67	0	0
Red Point A	1.6	10.33	0	0	0
Big Pond	2	31.67	0	0	0

VII. DISCUSSION

No global grazing index in AUM/time/area could be defined in so far as the information obtained from the BLM on the management of the allotments were incomplete and different from one allotment to another. In addition, such an index would have been inappropriate for the situation in so far as cattle do not browse on the whole allotment but tend to concentrate close to water resources. Also, there are water resources in these allotments that are not visited because they are inaccessible unless the rancher pushes the cows in the canyon. For Soda allotment, the Allotment Management Plan was not respected this year. Concerning Sewing Machine, it does not have an Allotment Management Plan. It is continuously grazed and a grazing index based on key species already existed. So, the information from BLM should be used cautiously. The local grazing index based on cow pie counting around each pond tends to be more appropriate because it reflects the presence/absence of cattle and also their quantity. It can be criticized on one point; the age of the cow pies counted is unknown so they could have been here for one or two years since degradation is very slow. Nonetheless, it is numerical and standardized index, so it can be used for statistical analysis.

On one hand, no correlation was assessed between the local grazing index and the other parameters like conductivity, pH, dissolved oxygen, nitrate, ammonia and total dissolved solids. These parameters don't reveal any pattern because the sampling method was not sensitive enough. The number of samples at each pond was not enough to represent a potential effect of grazing because these parameters may be influenced by other phenomena like bacterial activity and geology. Therefore, the effect of grazing would be minor compared to these phenomena.

On the other hand, the local grazing index was strongly correlated with the fecal coliform, turbidity, total phosphorus and total suspended solids dividing the ponds into two similar groups: Group 1 for low fecal coliform, low turbidity and low total phosphorus contains Garden Canyon, Cottonwood, Davis Gulch, Fiftymile except Cottonwood and Garden Canyon for which total phosphorus data were not available ; Group 2 for high fecal coliform, high turbidity and high total phosphorus contains Red Point A, Red Point B, Waterhole, Drill Hole, Big Pond except Drill Hole for which total phosphorus data was not available. Also, Waterhole was an outlier when classified by fecal coliform and turbidity and it appears in Group 1 when classified by total phosphorus. Fiftymile was an outlier when classified for fecal coliform and total suspended solids.

These correlations were checked by computing Spearman's coefficient and they were all the more obvious when taking off the outliers since the coefficient for the relations local grazing index-turbidity was 0.64, local grazing index-fecal coliform was 0.7638, local grazing index-total phosphorus was 0.8729 and local grazing index-total suspended solids was 0.9276.

For the relation local grazing index-turbidity, Waterhole was an outlier. This pond is an "earth and dam" like Big Pond, Red Point A, Red Point B and Drill Hole which means it was dug into the earth and presents a slope. So, the run off of ground during a rainfall can be potentially important. But, Waterhole presents only 22% of bareground compared to 40-60% of bareground for the other "earth and dam" ponds. In addition, the litter represents 39% of the soil cover compared to 0% for Big Pond and Drill Hole and 2 and 10% for Red Point A and Red Point B. These elements indicate that Waterhole has a more important vegetation cover, thicker than the other "earth and dam" ponds, which was observed in the field. The vegetation,

essentially *Salsola iberica* formed very thick aggregates. This would therefore retain better the ground around the pond when cows trample around or when there is a rainfall.

For the relation local grazing index-fecal coliform, Waterhole and Fiftymile were outliers. It was assessed that bacteria in the water column often absorb particles and settle out into the sediments. The concentration of fecal coliform bacteria in the sediments are often higher than in the overlying water column (Whitman et al, Van Donsel and Geldreich 1971, Irvine and Pettibone 1993), in the water fecal coliform were higher in sediments than in the water column (Davis et al, 1995) because of an abundant supply (Whitman et al, Paerl, 1975) and perhaps protection from adverse radiation. Waterhole presented a low turbidity which means less suspended sediments and therefore less fecal coliform in the water column. Fiftymile was subject to a rainfall the day before sampling. Sediments were resuspended and bacteria were flushed into the water column increasing the concentration of fecal coliform.

The high correlation between the local grazing index and fecal coliform, turbidity, total phosphorus and total suspended solids indicates that the local grazing index defined for this study is good since related to four water quality parameters. This point is important because turbidity, pathogens and nutrients are the major water quality parameters associated with range management (USEPA, BLM, 1976). Indeed, when the cow pies increase around the pond and therefore in the pond, the concentration of total phosphorus and fecal coliform increase because both are contained in the cow pies. The increase in turbidity is not clear immediately. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. The relation between turbidity and other water parameters was tested. A high Spearman coefficient was found for turbidity-fecal coliform (0.78) only. The increase in cow pies in the water increased organic matter and sediments and therefore the input in phosphorus. As phosphorus is the limiting factor in plant growth in freshwater ecosystems, this input of phosphorus from cow pies leads to an increase in the aquatic vegetation, phytoplankton, algae. It was noted that the Cladocera that feed essentially on phytoplankton tend also to increase with the local grazing index. Therefore, an input of phosphorus leads to an increase in primary producers which results in an increase of turbidity. Also a recent trampling by cows or a recent rain could have led to resuspend sediments in the water column which would tend to increase turbidity. Fecal coliform are more important in sediments than in the water column as mentioned previously. So, an increase in turbidity leads to an increase in fecal coliform in the water column. So, turbidity could be explained partly by suspended solids and partly by total phosphorus. Turbidity, total phosphorus, fecal coliform, total suspended solids are therefore good water parameters to assess the grazing impact on a pond.

Regarding vegetation, two groups of ponds could be separated out for the number of exotic species: Group 1 which contains Fiftymile, Cottonwood, Small Pond, Davis Gulch, Garden Canyon and Big pond presented a low number of exotic species and Group 2 which contains Drill Hole, Red Point A, Red Point B and Waterhole presented a high number of exotic species. Some exotic plants are favored by grazing such as Red Brome, Indian Cheatgrass (*Bromus tectorum*), Russian Thistle (*Salsola iberica*), Russian Knapweed and Cocklebur (*Xanthium strumarium*) (NPS, 1999). Indian Cheatgrass, Russian Thistle and Cocklebur were found around some ponds but not in a clear pattern. For instance, Indian Cheatgrass was found around Garden Canyon although it is not grazed. In addition, the Shannon index did not show any decrease regarding the local grazing index. Spence and Henderson (1993) noted that grazed waterpockets were significantly different from ungrazed sites, exhibiting less vegetation and

species richness (NPS, 1999). This shows that the link between vegetation and grazing impact is not well established. Indeed, the vegetation analysis consisted in noting the abundance by visual observation probably biased the results. In addition, vegetation is affected by other factors like elevation, the soil seeds bank, soil type, exposure and wind dispersion. Therefore, vegetation in the way it was analyzed constitutes an incomplete information of grazing impact.

Aquatic insects classified in feeding groups did not reveal any relationship with the water status of the ponds. The method probably biased the data in so far as only three samples were done as for the other variables and it was noted that the aquatic insects are very sensible to the shade produced by the sampler. Therefore, more samples should have been done in order to be more representative.

VIII. CONCLUSION

This preliminary study has brought up several interesting points regarding grazing that occur in the Recreation Area. First of all, the local grazing index defined for this study is an indicator of the grazing situation. Nonetheless, in a further study it needs to be defined with more samples and improvements and compared with the water quality parameters qualified as good indicators of water status in this work. Secondly, turbidity, total phosphorus, fecal coliform, total suspended solids appear to be the best water quality parameter to assess grazing impact on a pond. Regarding the explanation of the high relation between turbidity and local grazing index, a study of phytoplankton concentration in a similar study would be of great interest to define to what extent the phytoplankton and total suspended solids contribute to increase turbidity.

**PART II – BIBLIOGRAPHY ON GRAZING AND
WATERPROTECTION IN THE WESTERN
UNITED STATES OF AMERICA**

I. INTRODUCTION

Livestock grazing is a major land use in the Western United States. In Arizona and the rest of the Southwest, it tends to concentrate around water sources. This leads to overgrazing damage around rivers, streams, and lakes. Damage to watersheds includes erosion, sediment release, and nutrient release into streams that seriously affects water quality. This point is all the more important in so far as water resources are limited in this part of the country since the climate is arid to semi-arid. Therefore, flowing water in the arid desert is a vital natural resource not only for livestock but also for wildlife of all kinds. However, this type of non point source pollution associated with grazing has been especially problematic for establishing contamination effects and limits. Several studies and programs carried out by the Environmental Protection Agency and the Bureau of Land Management were carried out in order to define grazing management practices.

After presenting the legislation concerning water through the "Clean Water Act", a background of rangeland use and an overview of BLM grazing decisions will be given and three examples of studies regarding water quality and grazing. The first example is a review of research, prevention, and control techniques for reducing water pollution due to grazing; the second example, the Chino Wind project, deals with another problem which is the ownership of the land when considering water pollution due to grazing; the third one is a part of an Environmental Impact Statement on water resources alternatives for their protection in grazing allotments.

II. THE CLEAN WATER ACT

Originally titled the Federal Water Pollution Control Act of 1972 and significantly amended in 1977 and 1987, the Clean Water Act was enacted to ... "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" by attaining the goals of providing for the protection of fish, shellfish, wildlife, and recreation by 1983; eliminating the discharge of pollutants to the waters of the United States.

As with most environmental programs, Congress established with the Clean Water Act a federal system with the intent that the administration and enforcement of most of its requirements would be passed onto the states, albeit with an appropriate level of federal oversight. Through the standards promulgated by the individual states, the Clean Water Act provides a valuable tool to the National Park Service for protecting its water resources from the influences of external point and nonpoint sources of pollution. At the same time, the National Park Service is implementing its management activities, to "...comply with all Federal, State, interstate, and local requirements, administrative authority, and process and sanctions respect in the control and abatement of water pollution in the same manner and to the same extent as any non-government entity including the payment of reasonable service charges."

To attain the Clean Water Act's goal of eliminating the discharge of pollutants into the nation's water, two broad sources of water pollution, point and nonpoint have been targeted for control, management, and regulation. Point sources of pollution are those that generally result from a discharge from a specific, single location such as a pipe or other conduit. Nonpoint pollution is caused by diffuse sources that are not regulated as point sources and normally is associated with agricultural and silvicultural runoff. These definitions are general, and legal and regulatory decisions have sometimes resulted in certain sources being assigned to either point or non point source categories because of considerations other than their manner of discharge. For example, irrigation return flows are designated as nonpoint sources by section 402 of the Clean Water Act, even though the discharge is usually through a discreet conveyance (USEPA 1985).

The backbone of the Clean Water Act's effort to eliminate point sources of pollutants into the nation's waters is the National Pollutant Discharge Elimination System (NPDES) created by section 402 of the act. The NPDES program is in itself an interesting regulatory conundrum in that it authorizes by permit what otherwise would be illegal under the act—the discharge of pollutants into the waters of the United States. Thus, the program has become known in some quarters as the "permission to pollute" system (Laws 1990). The program has, however, been successful in significantly improving the quality of the nation's surface waters by requiring industrial and municipal dischargers to meet stringent standards for conventional and toxic pollutants. National Park Service facilities that include a discharging wastewater treatment plant must meet the requirements of the NPDES program. The 1977 amendments added best management practices for the control of toxic pollutants at point sources handling hazardous substances.

The management and control of nonpoint sources of pollution have posed a much more difficult problem to resolve through the Clean Water Act. Original scientific uncertainty on the relative significance of nonpoint pollution as a major source of water quality degradation, political and economic difficulties in developing a regulatory program, and, until the 1987 amendments, the lack of clear statutory policy for regulating non point source pollution have resulted in a poorly focused program to address this category of pollution, which is now recognized as the major source of sediment, nutrient, and bacterial water pollution.

The 1972 act sought to address this category of pollution primarily through Section 208, which provided for area wide waste treatment planning. However, this planning program resulted in the adoption of few actual controls on nonpoint source pollution, and funding for the program was terminated in 1980.

It was not until the 1987 amendments that a stringent nonpoint source control mandate emerged in the act, beginning with amendments to Section 101. These stated that "it is the national policy that programs for the control of nonpoint sources of pollutants, be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of point and nonpoint sources of pollution."

Three other amendments punctuated this policy, leaving little doubt that Congress wanted action on non point sources of pollution: (1) amendments to Section 319 required the states to develop regulatory controls over nonpoint sources of pollution; (2) special planning mechanisms for estuaries under Section 320 emphasized the development of nonpoint source controls for areas engaged in those planning activities; and (3) stormwater runoff from industrial, municipal, and construction activities was brought under the control of the NPDES program (Section 402) (Randall 1990). Depending on state regulations, many of the National Park Service's construction activities will be regulated by the Clean Water Act under the stormwater permitting requirements.

Assuming that these programs are successful in the long-term, many parks should experience improvement in water quality, especially in areas where sediments, nutrients, and bacteria are significant pollutants.

III. BACKGROUND OF LAND USE IN THE WESTERN OF THE UNITED STATES

The history of the use of rangeland is synonymous with the American West – colorful, wide-open, and largely uncontrolled. But the effect of uncontrolled use was dramatic. Arid-land-use decisions historically have been made on an experimental basis using models and data derived from non arid, dissimilar regions. When John Wesley Powell, as early as 1878, warned against such an approach in Report on the Lands of the Arid Regions, few people listened. Political pressures, poor understanding of arid-land use, and other considerations, including the idea of the national progress and economic development, led policy makers into adopting a land-use program for the West that was not unlike the one operating in the humid East. It did not always work, and years passed before Powell's ideas were recognized as valid. Also, by the close of the last century, competition among livestock owners left much of the land degraded. Bitter winters and severe drought, combined with the deteriorating condition of the rangeland crippled the range livestock industry. By the early 1930's, it was abundantly clear that swift, decisive action was necessary to save the public land.

Although the United States Department of Agriculture and Forest Service began managing grazing on the Forest Reserves in the early 1900's, the public land administered by the General Land Office, and later by the BLM, went unregulated until 1934. In that year, the Taylor Grazing Act was passed to regulate livestock grazing on public land, marking a trend toward increasing Federal involvement in rangeland management. Under the Act, specific parcels of the Federal range were allotted for grazing use. At the same time, efforts were started to bring livestock numbers into balance with the sustained productive capability of the range.

It was not until 1976 that Congress passed the Federal Land Policy and Management Act (FLPMA). It requires

- (1) "An inventory to be prepared and maintained on a continuing basis of all public lands and their resource and other values (including, but not limited to, outdoor recreation and scenic values), giving priority to areas of environmental concern. This inventory shall be kept current so as to reflect changes in conditions and to identify new and emerging resource and other values. The preparation and maintenance of such an inventory or the identification of such areas shall not, of itself, change or prevent change of the management or use of public lands."
- (2) "Land use Planning with public involvement and consistent with the terms and conditions of this Act, to develop, maintain, and, when appropriate, revise land use plans which provide by tracts or areas for the use of the public lands."
- (3) "In the development and revision of land use plans, agencies shall (a) use and observe the principles of multiple use and sustained yield set forth in this and other applicable laws; (b) use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences; (c) give priority to the designation and protection of areas of critical environmental concern; (d) rely, to the extent it is available, on the inventory of public lands, their resources, and other values; (e) consider present and potential uses of the public lands; (f) consider present and potential use consider the relative scarcity of the values involved and the availability of alternative means (including recycling) and sites for realization of those values ; (g) weigh long-term benefits to the public against short-term benefits; (h) provide for compliance with applicable pollution control laws, including State and Federal air, water, noise, and other pollution standards or implementation plans; and (i) to the extent consistent with the laws governing the administration of the public

- (4) lands, coordinate the land use inventory, planning, and management activities of or for such lands with the land use planning and management programs of other Federal departments and agencies of the States and local governments within which the lands are located."
- (5) "Any classification of public lands or any land use plan in effect on the date of enactment of this law is subject to review in the land use planning process conducted under this section, and all public lands, regardless of classification, are subject to inclusion in any land use plan developed."

FLPMA recognized the rangelands were a valuable national resource, capable of providing for a variety of uses, and should be retained in public ownership. FLPMA established the broad policy by which BLM land would be managed. In 1978, Congress went beyond FLPMA to focus attention on the Nation's rangeland by passing the Public Rangeland Improvement Act (PRIA). In passing PRIA, Congress acknowledged there still were problems after nearly half a century of Federal involvement in managing rangeland. Through PRIA, Congress concluded:

- Rangeland was still producing below its potential.
- Rangeland would remain in unsatisfactory condition – or decline even further – under present levels of funding and management.
- The unsatisfactory condition of the public rangeland presented a high risk for soil loss, siltation, desertification, water loss, loss of wildlife and fish habitat, loss of forage for livestock and other grazing animals, degradation of water quality, flood danger, and threats to local economies.

Much has changed in the 60 years since passage of the Taylor Grazing Act: urbanization, economic diversification, the growth of leisure activities, and a growing recognition both globally and nationally that the capabilities of the natural resources are not limitless.

However, some things remain the same. Many people continue to express concern about the condition of the public rangeland, as Congress did when it passed PRIA. The General Accounting Office (GAO) and Office of Inspector General (OIG) have both produced several reports critical of BLM's rangeland program. Although the BLM has begun to address many of these concerns, much remains to be done. User groups representing all sides of the issues have produced reports, testified before Congress, and have been very active and vocal in expressing their concern for the condition of the rangeland and the direction of BLM's rangeland management program.

Discussion also focused on the economic importance of public resources to rural communities. The livestock industry has historically played a major role in the economy of the West. The BLM is challenged with providing a stable resource base and a reasonable return for the livestock industry, while recognizing the growing social and economic importance of other diverse resource values to rural communities.

There are other approaches to using arid land, particularly deserts. Naturalists and some environmentalists, as Stahrl W. Edmund notes, want little development and prefer to keep deserts in a "pristine form, without any apparent human change." Others, Edmund writes, might want a minimum development where a few houses might be placed but otherwise retain the desert in its pristine form. Another group wants the desert open only for recreational use in hiking, biking, camping or similar "off road activities". Such nontraditional approaches to the occupation of arid lands are not only valid, but also perhaps desirable. Indeed, more people hike, fish, and hunt on public land than ever before. Recreation and tourism are among the fastest growing sectors of Western States economies. Congress has recognized in law the value of wilderness areas and wild and scenic rivers, the need to protect threatened and endangered species from extinction, and the rights of the public to expect clean air and water. Proper management of riparian areas, the "ribbons of green" in the West, is recognized as a critical issue that demands immediate attention. These issues reflect an increasing demand that the BLM ensure sustainability for the diverse uses and purposes of the public land. The public is also demanding accountability of public officials and agencies and policies that reflect a wise investment in our resources.

IV. OVERVIEW OF BLM GRAZING DECISIONS

BLM makes decisions about grazing on the public lands at three levels: the national level, the Resource Area level and the allotment level.

1. National level

National level grazing decisions include such actions as amendments to the grazing regulations and adoption of management policies, such as riparian area policies. These decisions are made through formal notice and comment procedures;

2. Resource Area level

BLM makes decision about livestock grazing at the Resource Area level by developing land use plans. BLM land use plans must show the following:

- areas where livestock grazing will be excluded;
- quantified management objectives and a schedule for their completion;
- initial stocking levels for livestock, including the kind of livestock, the period or season of use, and estimated final stocking rate expected when the plan is fully implemented;
- restrictions on grazing needed to protect wildlife, water, and recreation values, and
- monitoring intervals and standards.

3. Allotment level

The administration of livestock grazing is handled through grazing allotments and a livestock permit. Most livestock operators who graze BLM lands have a ten-year permit, the maximum allowed by FLPMA and the Taylor Grazing Act. Some have only an annual permit. According to FLPMA, each ten-year permit should either incorporate an AMP or contain all necessary management terms and conditions. FLPMA requires that all ten-year permits must specify the number of animal to be grazed, the times or seasons when grazing is allowed, and that the condition of the allotment may be examined at any time and, based on the condition of the range, livestock use can be adjusted. All permits must specify the kind of livestock, the allotment(s) to be used, and the amount of grazing use expressed in animal unit months (AUMs) in addition to the information required by statute.

For allotments being grazed under ten-year permits, BLM makes critical management decisions annually or before the start of grazing season. It decides, for example, which parts of an allotment will be grazed in a particular season, how many will be grazed in a particular season, how many animals will be placed on each part of the allotment, and the dates each part will be grazed. These decisions are often found in annual or seasonal grazing licenses which contain details that are not specified in the ten-year permit.

Permits are subject to cancellation, suspension or modification if any term or any provision of the grazing regulations has been violated. Ranchers are, in most permits, responsible for maintaining structures such as fences and stock ponds. If it is noticed that a fence is down or isn't keeping cattle out of a sensitive riparian area, the BLM has to be notified so that he can notify the rancher. Not meeting this maintenance responsibility is a violation of the permit.

An Allotment Management Plan (AMP) is a detailed plan for managing grazing on a particular allotment. An AMP should specify the objectives to be achieved by grazing on the allotment, including protection and restoration of riparian areas and wildlife habitat. It also specifies the on-the-ground projects, known as "range improvements," that will be constructed or maintained, the number of pastures that the allotment has been (or will be) divided into and the sequence of "grazing system" to be followed. An AMP must also specify limits of flexibility for the livestock operator and must provide for monitoring to evaluate the effectiveness of prescribed management actions.

Since 1982, the major emphasis of BLM's range program has been on monitoring. Since that time, BLM has directed field employees to collect a variety of data, including "actual use",

"utilization" and climate data. This information is used to evaluate the effects of management practices and determine whether those practices are achieving the objectives established in land use plans. These determinations are to be made no later than the end of the fifth year of monitoring, at which time BLM is also supposed to identify the management changes needed to achieve established objectives. Document known as "Allotment Evaluations" (AEs) or "Allotment Interpretation Evaluations" (AIEs) are prepared by the agency to serve as a basis for these determinations. The procedures to be followed in issuing these decisions are found in BLM's grazing regulations. Funding and staff time to carry out the monitoring schedule are frequently unavailable. Assert that the AMP should state that one condition of grazing is that monitoring be implemented on schedule.

V. EXAMPLES OF PROGRAMS, SURVEYS CARRIED OUT FOR WATER QUALITY PROTECTION

1. The livestock grazing and water quality protection program

In November 1979, the BLM and the EPA prepared and issued this document. This literature review was built with information gathered by workers in the eleven western states (Map 1). It was intended to inform and assist state, federal, Section 208 planning and management agencies, rangeland and other land managers and the public in understanding the potential water quality impacts associated with grazing, and practices and techniques for minimizing adverse impacts. This document was specifically intended to assist in: (1) the identification of existing and potential hazards to water quality; (2) selection of procedures, practices or methods suitable for preventing, minimizing, or correcting water pollution problem and; rangeland management component of a rangeland watershed's total runoff and pollutant production. It was an aid for dealing with nonpoint source pollution control and also a technical basis to assist managers in making rangeland decisions that minimize impacts on water quality. The specific area for this document comprises the eleven western states. Much of the published state-of-the-art information was gathered by workers within the west where livestock grazing is the major land use in many areas. The specific area of concern for the compilation of this document was the eleven western states (Map 1).

One of the major problem of assessing water quality impacts from grazing and other nonpoint sources of pollution is the lack of adequate criteria. Water quality impacts of grazing are associated with amount, duration and timing of runoff, erosion and sedimentation. All these factors are associated with vegetation cover. Sediment, turbidity, pathogens and nutrients are the major water quality parameters associated with range management.

It is difficult to determine and quantify beneficial and detrimental influences of grazing on runoff and erosion as related to water quality because of the complex interaction of many associated variables. Some of the inter-relationships involved in assessing grazing related impacts were illustrated by Smeins (1975). His concept is broadened to include water quality and is showed figure 1. The potential for water quality impacts from grazing managements and rangeland treatments are dependent upon storm characteristics and local hydrologic characteristics and conditions. Many grazing allotments of the West are drained by ephemeral streams with a few perennial drainages. Numerous small watershed studies have shown runoff events frequency to be of small amount and very irregular in the western portion of the United States. This is due primarily to low annual precipitation and flow losses in the normally dry streambeds. Porous soils, small scale storms, stream alluvium and very large evaporation deficits also contribute to the scarcity of streamflow. In many large watersheds, runoff is produced from only a portion of the area, in response to a high intensity, limited areal extent convective thunderstorm. Snowmelt runoff does not normally contribute an appreciable fraction of the runoff originating from lower elevations on semi-arid rangelands. A very small portion of western grazing lands do have the potential for generating runoff from the more typical storms and transmitting them to a location where this is cause of concern. This, sometimes occurs in areas which have been designated Critical Community Watersheds by the BLM, because annual precipitation and snowmelt runoff is large.



Map 1 - Project Area.

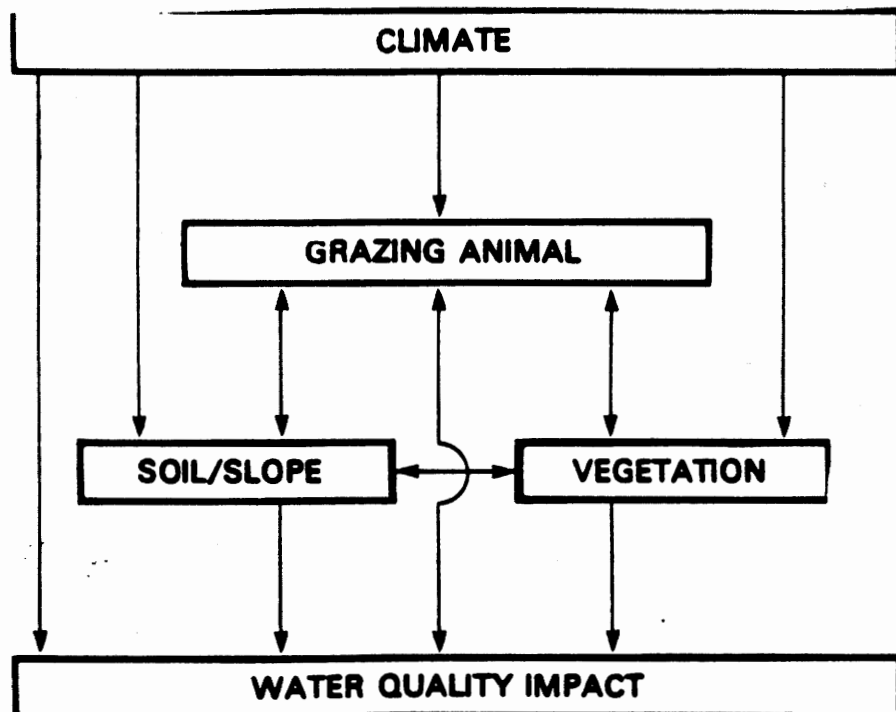


Figure 1 - Variables that influence runoff and erosion (modified from Smeins, 1975).

Landform characteristics are also important to take into account. They include landform features like soil texture and type, surfacial geology, topography, and drainage can influence the risk of pollution from land uses. In a summary of the International Reference Group on Great Lakes Pollution from Land Uses Activities report to the United States- Canadian International Joint Commission, Sonzogni et al (1980) noted that landform rather than land use was the single dominant source of overland runoff in the region. Soil texture was the single most important landform feature. Owing to greater sorption potential in fine-textured soils, the pollution potential of overland runoff was greater on fine than on coarse soils.

a) Predicting Impacts

Water quality monitoring of various types of nonpoint source activities such as forestry, agriculture and livestock grazing is increasingly becoming an activity and responsibility of resource managers. Better water quality data is needed on range management practices such as quantification of impacts associated with various seasons of use, intensities of grazing, cattle distribution, range condition and range improvements. Some of the common needs for water quality monitoring are to: (a) evaluate the presence of pollution; (b) define causes or sources of pollution; (c) evaluate data for development of assessment of preventive measures; (d) determine the natural background quality of water in the watershed, and to be able to distinguish between natural and man-caused sediment, bacteria and other water quality parameters in a system of extreme variability; and (e) document or enforce the application of BMP's as designed by state or areawide 208 plans.

Livestock grazing has short-term impacts during and immediately following use of an area and generally decreasing long-term impacts if grazing is not continuous. The major pollutants are eroded mineral sediments, associated salts, and bacteria. Significant localized pollution problems can be caused by pesticides and nutrient elements (principally nitrogen and phosphorus) from soils, plant and animal matter, and fertilizers. Some important aspects of nonpoint source monitoring that must be recognized in developing a monitoring system are: First, that sediment is the most significant pollutant from nonpoint sources on rangelands in the Western States and secondly, that stream systems naturally produce sediment during certain periods.

Biological monitoring may be especially appropriate and useful in assessing impacts from grazing related activities. The protection and continued propagation of aquatic life is a good indication of water quality. This was recognized in the declaration of goals and policy, 101 (a) P.L. 92-500, which stresses the need to restore and maintain the biological integrity of the nation's waters. Aquatic organisms are very efficient pollution monitors, because they integrate the effects of water quality over periods of time and reflect impacts that may not be detected by using only chemical parameters in monitoring.

The sampling frequency for chemical, physical and biological monitoring must be carefully established so that all the ranges of water quality experienced from grazing and related practices are observed. Monitoring schemes must be built on knowledge of how and when the pollutant is likely to be produced. For example, it is known that sediment enters streams primarily during storm events. It is also documented that bacteria has the greatest potential for entering streams during and immediately after rainfall and runoff. The first major rainfall runoff event of the "season" will generally contain the highest number of bacteria. For water temperature monitoring, the sampling should be geared to diurnal variations, as well as seasonal and annual variations.

b) Sampling approaches

Among those factors which should be assessed in selection of sampling approach are: expected water quality effects; desired accuracy and precision; laboratory expense and

certification requirements; area hydrology; climatology; seasonal variations; and state water quality standards. There are two sampling approaches:

- **Long-term Monitoring:**

This type of monitoring is designed to establish representative water quality and document seasonal and year-to-year fluctuations. The monitoring stations should be on a major drainage within a watershed to adequately represent the combined effects of all activities within a drainage. The information will give an overview of the quality of water within the source area.

Many long-term monitoring stations already exist and are operated by the EPA, U.S. Geological Survey, U.S. Forest Service, Science and Education Administration, State Agencies and universities. In special interest areas such as municipal watersheds or water bodies used for primary contact recreation, if grazing occurs over a period of time, it may be desirable to establish long-term stations to document water quality impacts. The information may be used in developing preventative and corrective measures.

- **Project Monitoring:**

This type is designed to monitor project activities before implementation (to establish a calibration), during implementation (to establish the effect of activity on quality) and after implementation (to establish time frames for return to pre-disturbance conditions) and after implementation (to establish time frames for return to pre-disturbance conditions).

These short term monitoring stations should be located near activities to be assessed. The paired-station approach, one station upstream and one station downstream, is the most convenient and conventional. It is appropriate for monitoring practices such as mechanical land treatment and grazing in riparian areas. The shortest possible time should occur between sampling the two monitoring stations. The potential limitation of the paired-station approach are (a) in-situ changes in pollutant concentration due to past natural or man caused activities; (b) locating downstream stations to insure adequate mixing, yet avoiding unrelated pollutants from instream areas; (c) the approach does not indicate the frequency of changes or their meaning at water use points; (d) in order to achieve any degree of statistical significance in the sampling procedure a number of samples will be required. In addition, it may not be possible to utilize this technique in certain instances. Many small watersheds, where monitoring is desirable, occupy a position in the upper reaches of a drainage system. It may not be possible to establish a station upstream and downstream of an activity in such a situation where a stream originated within the activity area.

It is essential to understand the limitations and applications of any monitoring approach prior to its use. Recognizing its limitations, the paired station approach is still appropriate for monitoring livestock grazing and related practices in many instances.

c) Water Quality Assessment Approaches

There are a number of techniques available for assessing resource problems related to range management. As indicated, most techniques are related to soil and vegetation conditions. Two water quality assessment approaches are summarized that may be used in relating livestock grazing and land treatment to water quality management. The approaches are: (1) EPA Region X's procedure; (2) Panhandle National Forest's Method.

- **Assessment Approach 1 – EPA Region 10's Water Quality Assessment**

One of the difficulties in developing control programs for nonpoint sources that meet water quality goals is the lack of quantification or qualification of the fishable-swimmable concept. Region 10 of EPA developed a water quality assessment approach to assist EPA planners, land management agencies, state and local agencies in identifying probable nonpoint sources of pollution and assessing their general effects upon the fishable-swimmable aspect of regional streams.

The approach is based on displaying existing information related to biological, recreational and water quality status of regional streams. This information is systematically organized on a summary table for use. A flow chart outlining the assessment procedure is presented Figure 2. Storet basin maps are used as base maps for all evaluations. Biological status information is obtained from field biologists representing state and federal fish and game agencies. Their assessment is based upon the criteria shown in Table 1. The biological and recreational status are shown in Map 2 and 3. Recreational status is obtained from field biologist, recreational specialist, fishermen and swimmers utilizing the criteria in Table 2.

Water quality station locations in each segment are also displayed during the assessment. The Storet data system in each segment was used as a basis for all water quality information. Most state and federal agencies and many local agencies and universities store data in the system in Region 10. Data were retrieved utilizing the Storet standards flagging program with EPA's Water Quality Criteria as the threshold levels.

The assessment may be used as a first step for more refined approaches to problem identification, measuring the effectiveness of management practices, and developing control programs. The advantages and limitations of various approaches must be recognized and kept in perspective. The biological and recreational adequacy of water bodies should be a major component in water quality in water quality assessments. Some of the advantages and disadvantages of this method are summarized below:

Advantages

1. It provides a basin-wide perspective of nonpoint source problems for major basins, based on the best data in the Storet system.
2. The greatest potential use of the approach is in broad scale planning as opposed to site specific planning. This is primarily due to water quality data being from larger streams. With adequate water quality data the concept would be applicable to smaller geographical areas.
3. Water quality problem significance is based on uses including biological and recreational status.
4. Available water quality data is assessed on the basis of EPA's water criteria.
5. It illustrates water quality data relationships to percent of land use and ownership for segments.
6. It may be used to develop more specific programs for: (1) identifying monitoring needs, (2) working with such nonpoint source categories as grazing or land use, in terms of significance and control program development, and (3) working with classes of land owners such as federal, state and private in terms of problem significance.

Disadvantages

1. Data are inadequate for many of the segments.
2. There is no sound rationale for relating biological and recreational status (qualitative) to parameter (quantitative) information. For example, there is no procedure for estimating how much turbidity or sediments results in how much destruction of habitat, interruption of food chain and interference with indigenous species.
3. Much of the water quality data for monitoring stations in Storet does not include sediment which is one of the major nonpoint source pollutants.
4. Much of the data have not been adequately validated in the field, especially water uses, biological and recreation information.
5. Data in Storet is taken from many sources with limited quality control of sampling and laboratory procedures.
6. Storet data does not differentiate "natural" conditions from man caused effects.

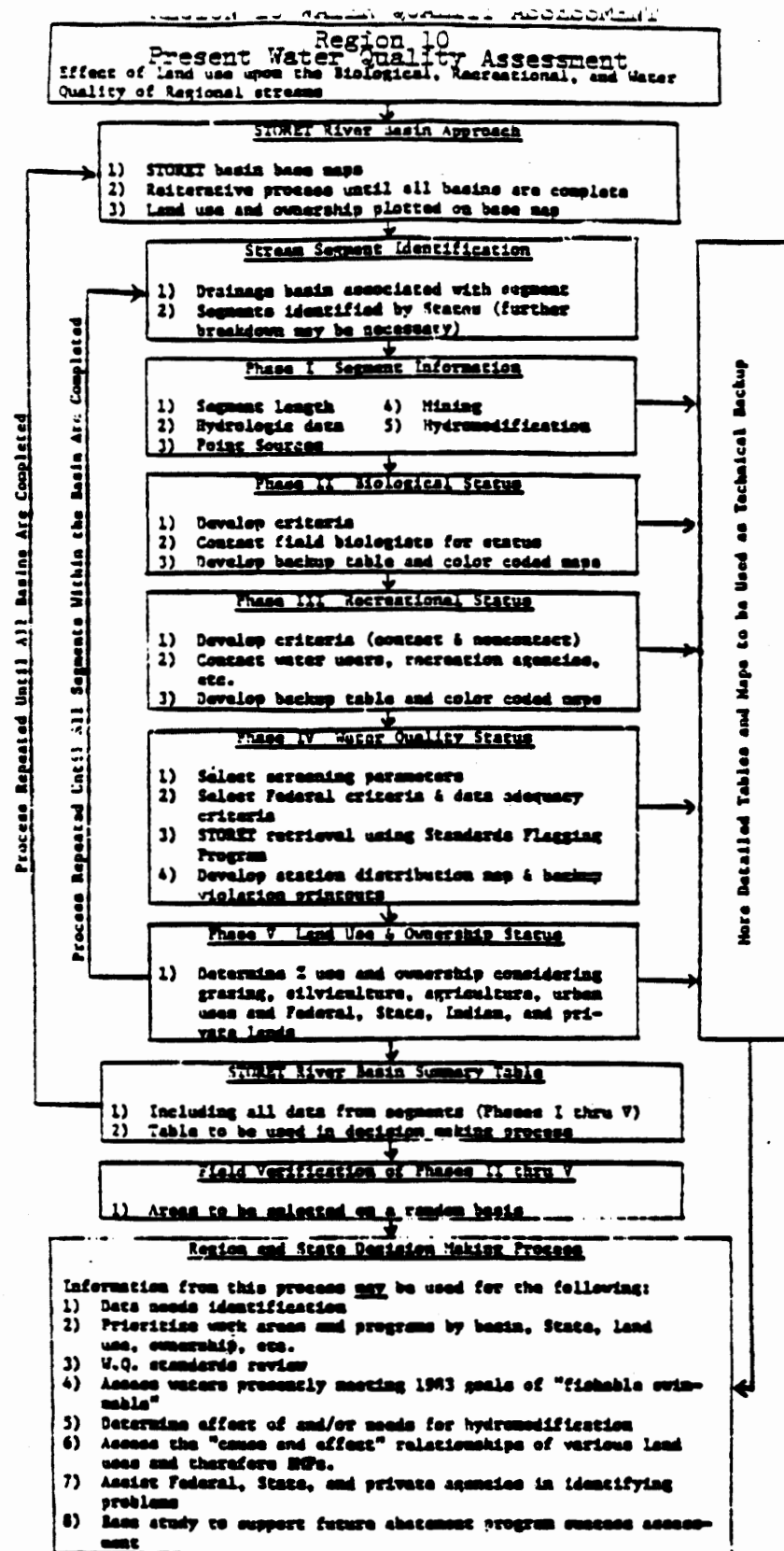


Figure 2 - The assessment procedure.

CRITERIA FOR BIOLOGICAL EVALUATION	TIME & SEVERITY FACTORS			Duration of Adverse Condition			Severity of Adverse Condition			Period of Biological Activity	
				NEVER	INTERMITTENT	CONTINUOUS	LOW		HIGH	NON-CRITICAL	CRITICAL
I. Destruction of habitat for indigenous species - passage, spawning, rearing.	Blue		Red				Blue		Red	Blue/Yellow	Red
II. Interruption of total food chain	Blue		Red				Blue		Red	Yellow	Red
III. Interference with the well being of indigenous species of fish or food chain organisms.	Blue	Red	Red				Yellow		Red	Red	Red

NOTE: The color-code (blue, yellow, and red) is used on the maps (see slides).

On the summary tables, a pattern-code was used to allow for easier duplication.

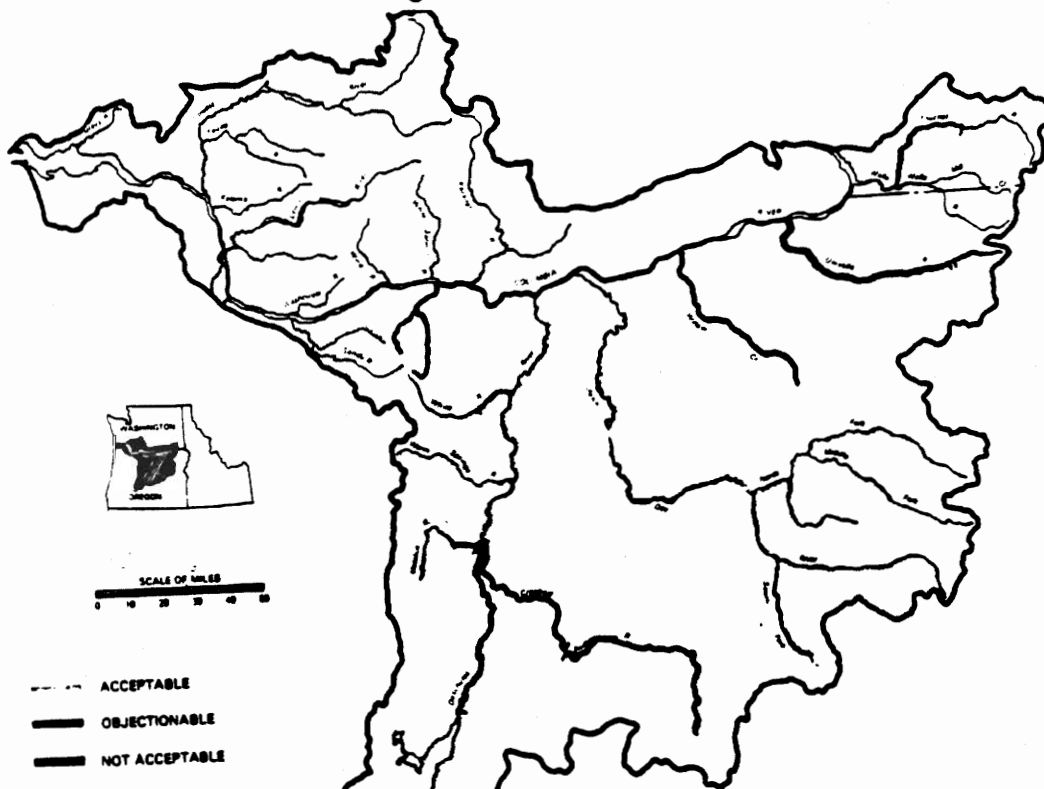
Therefore:

Blue corresponds to: 

Yellow corresponds to: 

Red corresponds to: 

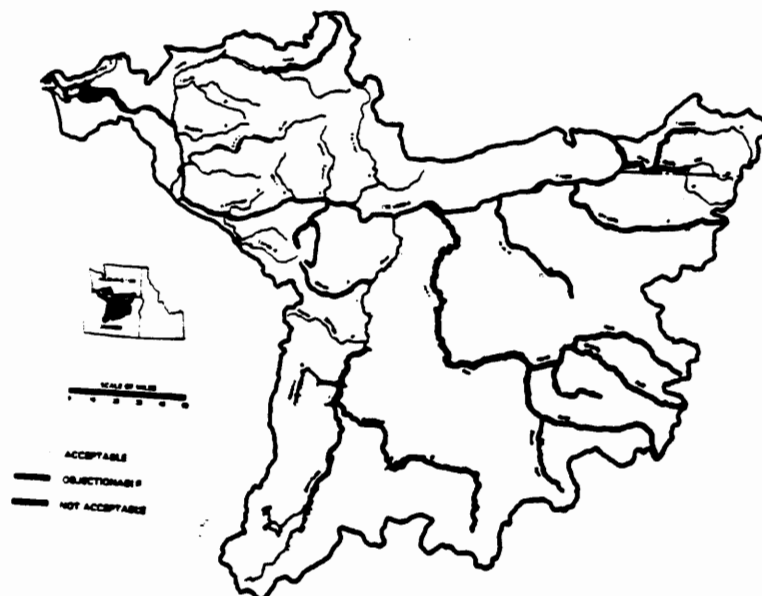
Table 1 - Biological evaluation criteria.



Map 2 - Lower Columbia basin biological status.

BIOLOGICAL STATUS														
River Basin Name <u>Columbia River</u>														
Recorder <u>S.A. Wagner</u> Date <u>8/27/76</u>														
Contact: <u>Errol Claire, Oregon Fisheries & Wildlife Commission, Canyon City</u>														
STREAM NAME	STREAM REACH (River Mile)	SECT	BIOLOGICAL CRITERIA								BIOLOGICAL PROBLEM	BIOLOGICAL EFFECTS	ST.	
Stream north of Columbia River in Washington from Kamasovich to Goodnessville	Various	14-32 -01	Destruction of Habitat			Interruption of Food Chain Well Being			Interference with Species		Overgrazing, poor logging and land management practices, road construction, intermittent, uncontrolled runoff. Eurythermal oligotrophic streams.	Habitat loss, niche quality reduced. Adverse effects to biota because of scouring, temperature, silt, sediment, turbidity, and riparian loss due to bank erosion.	Obj	
			Duration	Severity	Importance of factor	Duration	Severity	Duration	Severity	Duration				Severity
			C	H	Yes	C	H	C	H	C				H
											(No Biological Activity - Natural Condition)			
M.F. John Day source to mouth (confluence with R.F.)	32.3/ 76.2-0	JD-24 -01	C	H	Yes	C	H	C	H		Overgrazing; poor logging, weed and land management practices; road construction and intermittent uncontrolled runoff. Bank loss, scouring effects to stream bed in spring, low flow and high temperatures August thru September. Coarse fish buildup.	Same as above including drastic reduction for fish passage, spawning, and rearing.	Obj	
S = Seldom I = Intermittent C = Continuous														
L = Low M = Medium H = High														
Acc = Acceptable Obj = Objectionable N.A. = Not Acceptable														
5/17														

Table 2 - Biological status.



Map 3 - Lower Columbia basin recreational status.

- Assessment Approach 2 – Panhandle National Forest's Technique

The technique is based on a procedure developed by the Northern Region of the Forest Service for evaluating impacts of increased water yields in stream bank and channel stability (Pfankuch 1975). With minor modification the channel stability assessment has been used to evaluate and predict the impact of grazing on bank and channel stability. Good correlations were found between bank channel stability and ungulate damage. The technique is presented in detail by Cooper (1977). Field data from Wyoming and Idaho was used to validate the method.

The ungulate damage factor or percent of linear bank damage was estimated by observer and added to the form for each stream segment evaluated. Ungulate damage was defined as mass wasting of the upper bank or lower bank cutting that could be attributed to ungulates. Hoof marks, trail and excessive trampling were used in estimating damage.

Rating forms are completed during stream surveys. Information is obtained during stream surveys. Information is obtained for the length of the segment. When items rated on the form change classes, an additional rating is determined. The items rated and found to be most directly related to grazing impacts are upper bank slope, mass wasting debris, vegetation cover, lower bank rock content and cutting.

In the areas evaluated bank vegetation and rock content interacted to reduce grazing index damage. The data suggested that by combining the two variables, a maximum rating figure may be obtained to determine sensitive areas. For areas evaluated, bank vegetation must rate less than 6 to have measurable interaction with rock content for preventing significant damage. Sensitive banks in northern Idaho rated 11 points or more and 10 or more for Wyoming foothills, as illustrated in Figure 3.

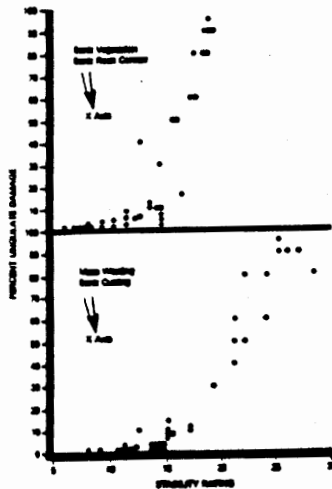


Figure 3 – Mass wasting – bank cutting and bank vegetation- bank rock content. Stability decreases from left to right.

Advantages

1. The technique provides a quick method for evaluating the impact or potential impact of grazing on stream bank stability.
2. The technique may be useful in predicting impacts of various levels of grazing management on bank and channel stability and fish biomass.
3. By reversing the technique, recovery rates for excessively damaged stream channels can be predicted. For example, a 90 percent ungulate damaged stream would have a stability rating of approximately 45. By removing grazing or otherwise protecting stream banks, it would be probable that in a few seasons the rating would improve to about 25. A 20 point change can be significant in northern Idaho (Cooper, 1977).

Disadvantages

1. The method is based on visual estimates of items rated rather than quantitative data, especially for ungulate damage. Cooper emphasizes the need for field training for prospective users before attempting use.
2. The technique is based on relatively limited field evaluations for validation with data from northern Idaho and Wyoming.
3. There is not good correlation of ungulate damage and water quality impact.

d) The Best Management Practices

Best Management Practices imply not only appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) but also means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals (Federal Register Vol. 40, No 230, November 28, 1975). BMPs also refer to a broader process of identifying practices and techniques to reduce water quality impacts. The major emphasis in identifying BMPs was on technical adequacy of practices to reduce water quality impacts. Limited emphasis was placed on economic and institutional acceptability.

Best Management Practices may involve single practices or combinations of practices selected for specific soils, climates or problems areas. Selection of BMPs to be applied should normally be made by the land manager from the appropriate suitable alternatives based on site characteristics, management objectives and water quality requirements.

Current knowledge of BMPs is primarily based on soil erosion control practices that were developed to reduce soil loss and maintain productivity. The inference is made that if soil erosion is minimized, the technique or practice will be effective in substantially reducing water quality impacts if sediment is the problem. For some of the BMPs there are limited research data to validate this inference. Monitoring the effectiveness of practices is a continuing need for land and water quality management agencies.

Some of the principles that should be recognized in selecting BMPs to reduce water quality impacts from grazing are:

1. In many instances, there will be several technically adequate alternatives that may be applied to minimize water quality impacts when problems occur.
2. Exclusion of livestock use because of watershed and site condition may be the BMP in some instances to minimize water quality impacts.
3. Selection of adequate BMPs may require the expertise of interdisciplinary resource specialists.
4. The most effective protection techniques must be based on site specific conditions such as soils, vegetation, geology, climate, proximity of water bodies and management objectives.
5. BMPs may prevent as well as mitigate water quality problems.
6. BMPs reflect the concept that a system or combination of practices may be needed on a particular site or planning area.

7. The frequency of storm events may have an impact on the ability of BMPs to mitigate water quality impacts. BMPs are more effective in controlling frequent storm events than in controlling the unusual storm climate events. The net effect of BMPs will be some reduction in the total volume of sediment produced, with a large reduction in the concentration during more frequent flows.

It is essential to have a good water quality assessment of an area or watershed to assist in making a selection of BMPs to solve existing problems. In many instances, it is not necessary nor appropriate to apply Best Management Practices across the board or throughout a watershed. The emphasis in selection and application of BPMs should be on recognized or potential water quality problem areas. Coordinated interdisciplinary resource planning involving State, Federal and private rangeland managers is an effective tool for minimizing impacts from grazing animal management.

2. The Chino Winds Project

In addition to grazing impacts on water resources, another problem appears that is the multiple on checkerboard pattern of land ownership, made up of an alternating mixture of publicly and privately owned lands. Also, there were multiple jurisdictions and responsibilities of a host of federal, state, local and private agencies and interests. So, the Arizona's Nonpoint Source Program had to be partnership oriented. It sought to find entities that were able and willing to work toward nonpoint source management goals and foster cooperation to get the job done. The Chino Winds Demonstration Project was an example of the strides that can be made when diverse parties develop and carry out a coordinated plan to improve water quality. This project was located on the Yavapai Ranch 26 miles of Seligman. Through the cooperation of 11 agencies and the private owner, the state currently has a project to test a holistic grazing system on multiple ownership lands to improve water quality. The project also evaluates alternative ways to measure watershed conditions and quality in arid regions that lack year-round water flows.

The project sets up of rotational grazing on a 11,000-acre ranch with a checkerboard of public and private lands. Deferred rotational grazing divides the land into numerous fenced paddocks where cattle graze – intensively for short periods of time – from 2 to 30 days- before being moved on to another paddock. The grazed area is then allowed to regenerate for an entire growing season. This system requires a fencing network across the entire land and a distribution system to supply water to each pasture. The distribution of water promotes more uniform rangeland use and, accompanied by the traditional management systems, reduces the extremes of over and under use.

Phase I of the project was started in February 1990 and was completed in September 1993. A coordinated resource management plan was developed over 18 months by numerous groups with diverse and vested interests. Agencies responsible for developing the plan included the U.S. Forest Service, Arizona State Land Department, SCS, and Arizona Department of Environmental Quality. Also included were the University of Arizona School of Renewable and Natural Resources, Cooperative Extension, Chino Winds Natural Resource Conservation District, and the Arizona Department of Game and Fish.

Phase I, funded by a \$90,000 section 319 grant, included installing fencing, pipelines, and a water distribution system for both livestock and wildlife. In-kind services such as labor, equipment, and computer mapping were provided by state, local, and private sources. The university provided watershed monitoring, and conservation groups and private citizens are converting existing fencing that does not restrict the movement of wildlife. A Phase II, \$87,000 section 319 grant has been approved.

Another component of this project is to develop a surrogate system to measure water quality impacts. Because the flow of surface water on Arizona rangelands is intermittent, changes in water quality are difficult to determine. Therefore, measurable improvements from BMPs may be impossible to document. This project correlates coverage vegetation to sediment discharges and extrapolates water quality information by measuring the amount and biodiversity of the vegetation.

The project is being monitored during the Implementation phase to ensure that BMPs are properly installed. Baseline data was collected on initial vegetation and frequency of plant species. A survey was conducted to – determine public attitudes and perceptions of grazing management efforts to improve water quality. Although the complete results may not be seen for 10 years, this project provides an important opportunity to demonstrate the effectiveness of BMPs on arid lands.

3. Final Henry Mountain Grazing Environmental Impact Statement

This report was issued in June 1983 by the Bureau of Land Management of Richfield District. It deals with the Henry Mountain Planning Area which is a part of the Henry Mountain Resource Area, which is administered by the BLM office at Hanksville, Utah. The planning area is located in the southeastern Utah in the Colorado Plateau area (Map 4). Major land use include livestock grazing, uranium mining, and oil and gas exploration. Recreation use includes hunting, camping, sightseeing, hiking and off-road vehicle use. The area provides year-long habitat for deer, bison, antelope, bighorn, sheep and other small and non-game species. The local economy relates directly to the major land uses.

The administration of livestock grazing handled through grazing allotments and a livestock permit system. There are 22 allotments with proposed forage use levels for livestock and big game grazing (Map 5). For this EIS, a total of 1,893,272 acres were analyzed including grazing allotments and unallotted areas.

The purpose of the action – the updating and revising of the grazing management program – was to maintain or improve rangeland resources such as water, soil, and vegetation through the use of grazing management. As required by law (Taylor Grazing Act, Multiple Use Act, Federal Land Policy and Management Act), BLM is responsible for management “in a manner that will protect the land and its resources from destruction or unnecessary injury, stabilize the livestock industry dependent on public lands, and provide for the orderly use, improvement, development, and rehabilitation of the public lands for livestock grazing consistent with multiple use, sustained yield, environmental, economic, and other objectives” (BLM Manual 4100.0-2).

Monitoring studies conducted for more than ten years, supported by a soil-vegetation inventory conducted during 1978-80, indicate that grazing use on some allotments may exceed forage production. Conversely, some allotments have the potential for additional grazing use through modification of current grazing systems and/or rangeland improvements. Other allotments are in good condition under present management.

The program involved authorizing, managing and supervising livestock grazing; providing forage for big game; developing, maintaining, and improving wildlife habitat; implementing and managing rangeland improvements; and protecting rangeland from human-caused and natural abuses.

The steps in BLM's Planning Process are in the (Table 3). The planning documents were updated in 1980-81 in accordance with BLM Manuals 1601-1608. These manuals provide guidance for land use and resource allocation on public lands. The proposed actions and alternatives analyzed in the EIS evolved through the BLM's planning process, as outlined in Figure 4. The EIS was prepared by an interdisciplinary team.

During the planning process, grazing allotments were grouped into three categories based on ecological condition and trend, potential for improvement, resource use conflicts, positive return on investments and effectiveness of present management. These categories and objectives are:

- Category M (Maintain): No special management needs noted – allotments are in satisfactory condition and no major conflicts are evident. Permittees will be encouraged to invest in rangeland improvement projects which would enhance their use of the allotment.
- Category I (Improve): This category will receive first priority for rangeland improvements as funding becomes available. Special management actions are needed – major resource conflicts and/or other grazing problems exist, but allotments have potential for improved productivity and positive return on investments. Permittees will be encouraged to invest in rangeland improvement projects which would enhance their use of the allotments.
- Category C (Custodial): No special management actions feasible – allotments have no or limited improvement or investment potential. Present management appears satisfactory or is the only logic practice under existing resource conditions. Permittees will be encouraged to invest in rangeland improvement projects which would enhance their use of the allotment.

A scoping is the identification of issues, concerns, interrelationships, and possible alternative courses. Furthermore, it is a way for BLM to consult with affected or concerned parties. Significant issues are identified during this process.

Scoping began in 1978 when BLM specialists met to identify significant issues. These issues were refined in 1980 when BLM sent a public involvement guidebook to over 400 organizations and individuals.

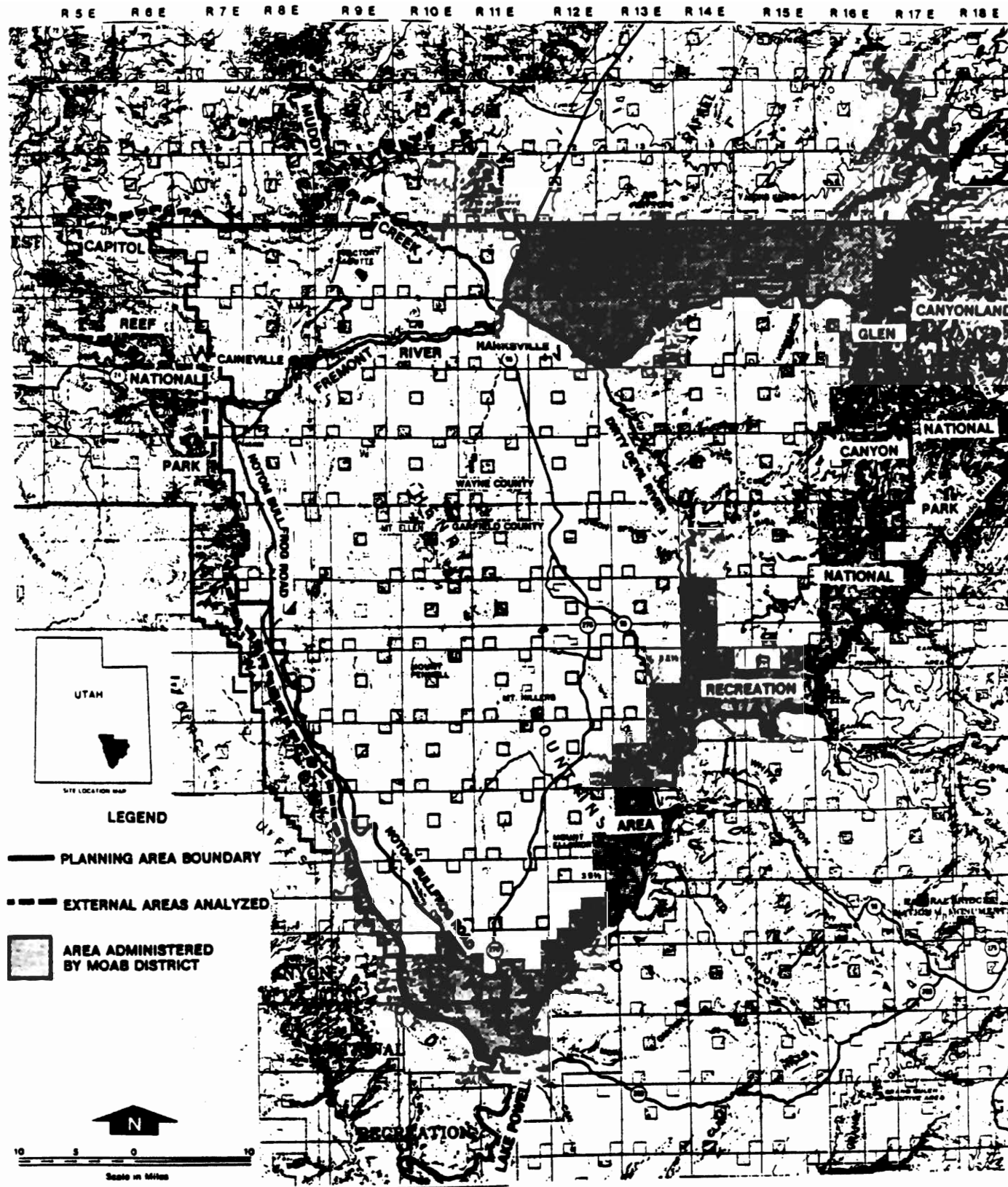
For each resource, several alternatives were emitted and a conclusion was done. Concerning Water Resources, the alternatives were the following:

- Alternative A; Proposed Action- No Change

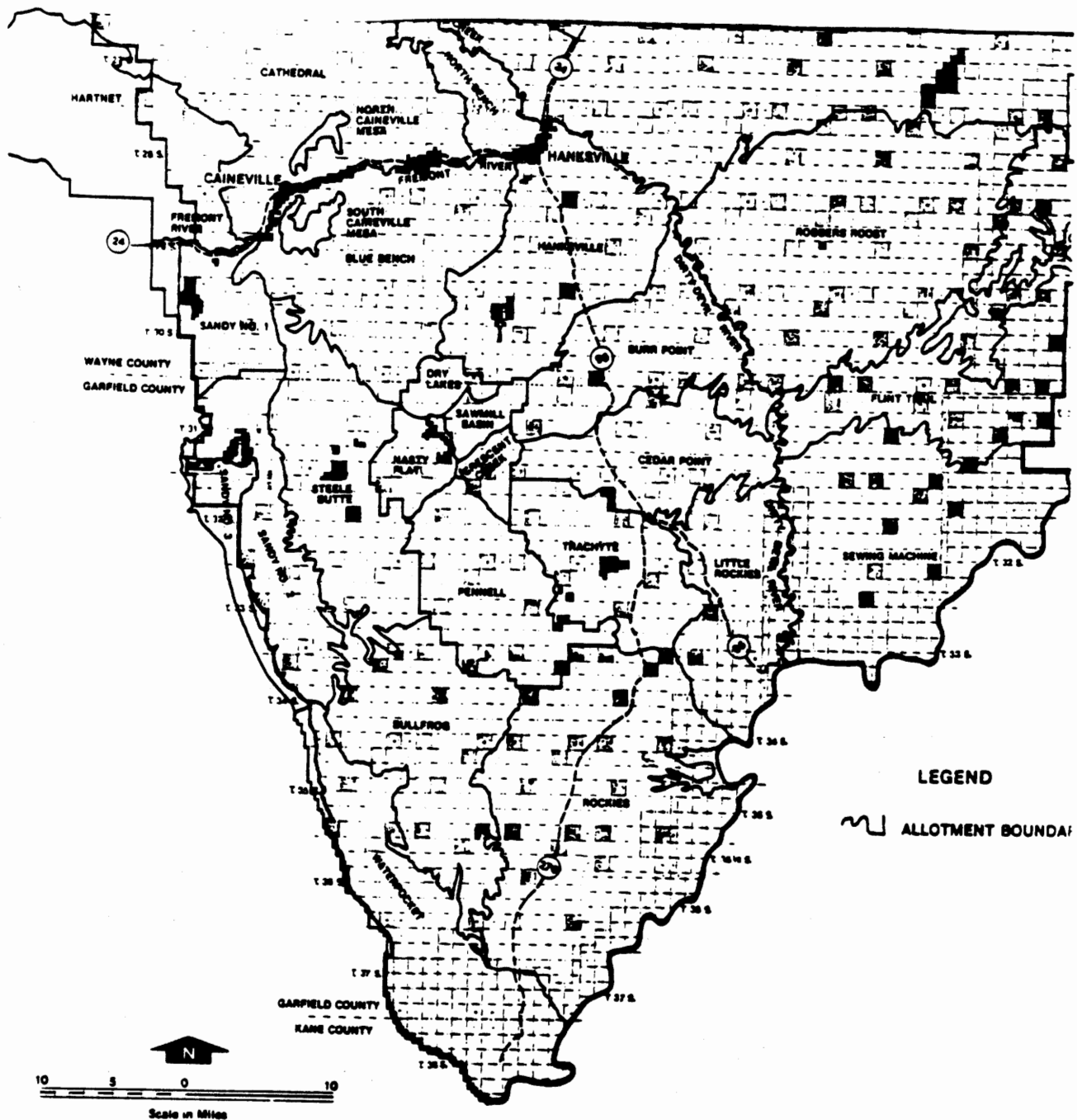
Impacts to the water resource interrelate closely with soils. Where surface disturbance and reduced vegetation occurs, soil erosion rates and sediment yield are affected which, in turn, affect water quality and yield.

Grazing capacity would be exceeded on portions of 11 allotments and one unallotted area (Table 4). This would leave more soil exposed to higher sediment yield and surface runoff on about 14 percent of the planning area. Some deterioration of surface water quality in the vicinity of these allotments could occur.

Numerous studies have shown that moderate and heavy grazing results in increased runoff (Smeins, 1975). The increase in water yield would be expected in the steeper mountain portions. No significant impact on water yield from the drier portions of the planning area would be expected. A study conducted in the planning area by Guisti (1977) found that increased runoff resulting from soil disturbance during construction dissipated a short distance from the site.



Map 4 - Henry Mountain Planning Area.



Map 5 - Grazing allotments.

Steps in BLM's Planning Process

1. *Land and Resource Inventory Data* is collected on current resource supply and production, condition, and trend. Data is collected in the following land use categories: lands, minerals, forest products, rangeland management, watershed, wildlife habitat, recreation, and wilderness. Additional physical data, including topography, climate, geology, soils, vegetation, erosion condition, hazards, developments, and access are also collected.

2. An *Unit Resource Analysis (URA)*, containing a summary of the resource inventories and a discussion of the physical profile (soils, geology, climate, etc.), is prepared next. This document also describes current land uses, forage production, trend, and condition. In addition, projections for potential resource enhancement, improvement, and production are developed.

3. A *Planning Area Analysis (PAA)*, a collection and analysis of socioeconomic data, is prepared simultaneously with the URA. The PAA contains economic demand projections for each resource and social value analyses.

4. A *Management Framework Plan (MFP)* is next developed using resource management opportunities identified in the URA and socioeconomic data presented in the PAA. It is organized around the eight categories listed in the Land and Resource Inventory section.

The first step in developing the MFP is to protect each resource independently, considering resource capability, technical feasibility, physical limitations, laws, regulations, policy, and demand. Conflicts between existing and potential uses are then identified by an interdisciplinary team under the direction of the BLM area manager.

Whenever a conflict is encountered in MFP Step 1 recommendations, the team studies the land use options available. Based on a multiple-use analysis, the area manager selects the option which best meets management objectives and identifies any trade-offs or compromises made as a result of that selection. The product is the MFP Step 2 recommendation. Public input is collected and analyzed (including analysis in the EIS) on all MFP recommendations, and final multiple-use decisions (MFP Step 3) are made. The decisions on all resources except grazing management and wilderness were published in "Multiple-Use Management Decisions—Henry Mountain Planning Area"

The decisions on the grazing management program will be made by the District Manager and Area Manager following the publication of a Final EIS. These decisions will be published in the "Record of Decision/Rangeland Program Summary" which will identify specific objectives, forage use, and rangeland improvement projects by allotment.

Table 3 – Steps in BLM's Planning Process.

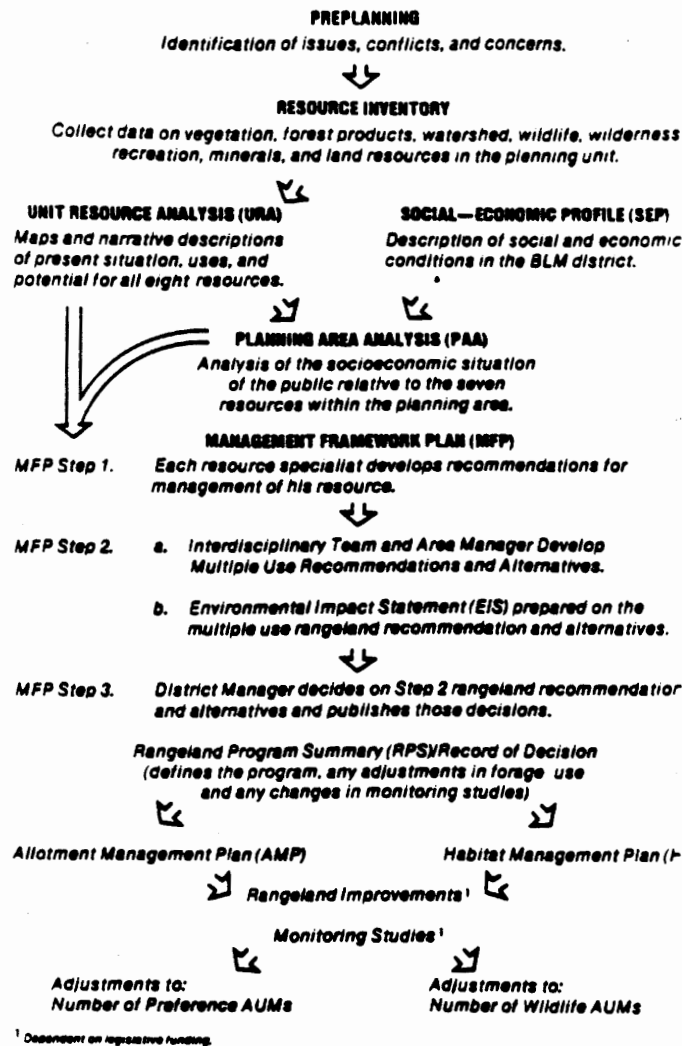


Figure 4 – BLM Planning Process.

Comparison of Grazing Use to Forage Production^a

Allotments	Alternative A				Alternative B			
	Average Licensed Livestock Use Exceeds Grazing Capacity	Percent of Grazing Capacity Used	Big Game Use Exceeds Grazing Capacity ^b	Percent of Grazing Capacity Used	Livestock Use at Preference would Exceed Grazing Capacity	Percent of Grazing Capacity Used	Big Game Use at Full Reservation would Exceed Grazing Capacity	Percent of Grazing Capacity Used
Blue Bench	No	--	Yes (B) ^c	160	Yes	167	Yes (B)	320
Bullfrog ^d	No	--	Yes (B)	131	Yes	134	No	--
Burr Point ^d	No	--	Yes (D) ^e	109	Yes	114	Yes (D)	203
Cathedral	No	--	No	--	Yes	134	No	--
Cedar Point	No	--	Yes (B)	188	Yes	146	Yes (B)	125
Crescent Creek	Yes	184	No	--	Yes	183	No	--
Hanksville ^d	No	--	No	--	No	--	No	--
Hartnet	No	--	No	--	Yes	106	No	--
Hasty Flat	Yes	158	Yes (D)	103	Yes	160	Yes (D)	248
North Bench	No	--	No	--	Yes	149	No	--
Pennell ^d	No	--	Yes (B)	101	Yes	110	No	--
Robbers Roost ^d	No	--	No	--	No	--	No	--
Rockies ^d	No	--	Yes (D)	109	Yes	129	Yes (D)	136
Sandy 1 ^d	Yes	116	No	--	Yes	139	No	--
Sandy 2	Yes	176	Yes (B)	127	Yes	312	Yes (B)	107
Sandy 3	No	--	No	--	Yes	101	No	--
Sawmill Basin	No	--	No	--	Yes	259	No	--
Sewing Machine	No	--	No	--	No	--	No	--
Steele Butte	Yes	142	Yes (B)	143	Yes	267	Yes (B)	126
Trachyte ^d	Yes	103	No	--	Yes	180	No	--
Waterpocket ^d	No	--	No	--	No	--	No	--
Wild Horse	No	--	No	--	No	--	No	--
<u>Unallotted Areas</u>								
Dry Lakes	--	--	Yes (B)	226	--	--	Yes (B)	190
Flint Trail	--	--	No	--	--	--	No	--
Little Rockies	--	--	No	--	--	--	No	--
North Caineville Mesa	--	--	No	--	--	--	No	--
South Caineville Mesa	--	--	No	--	--	--	No	--

Source: These figures were derived from the soil-vegetation inventory conducted by USOI, BLM and Earth Environmental Consultants, Inc. (1980)

^aSee Table 2-2, Alternative A, for numbers of livestock and big game involved.

^bEstimated big game use exceeds grazing capacity based on optimum big game diets. The acreage involved is limited, see Tables 3-6 and 3-8.

^c(B) = Bison use.

^dTo determine if overutilization is occurring or would occur, total cattle use was added to total sheep use and compared to the total of both sheep and cattle forage. There are differences in competitive forage between sheep and cattle from allotment to allotment which are caused by differences in plant composition. See footnotes g and h on Table 2-2, Alternative E for explanation of specific situations on common use (sheep and cattle) allotments

^e(D) = Deer use.

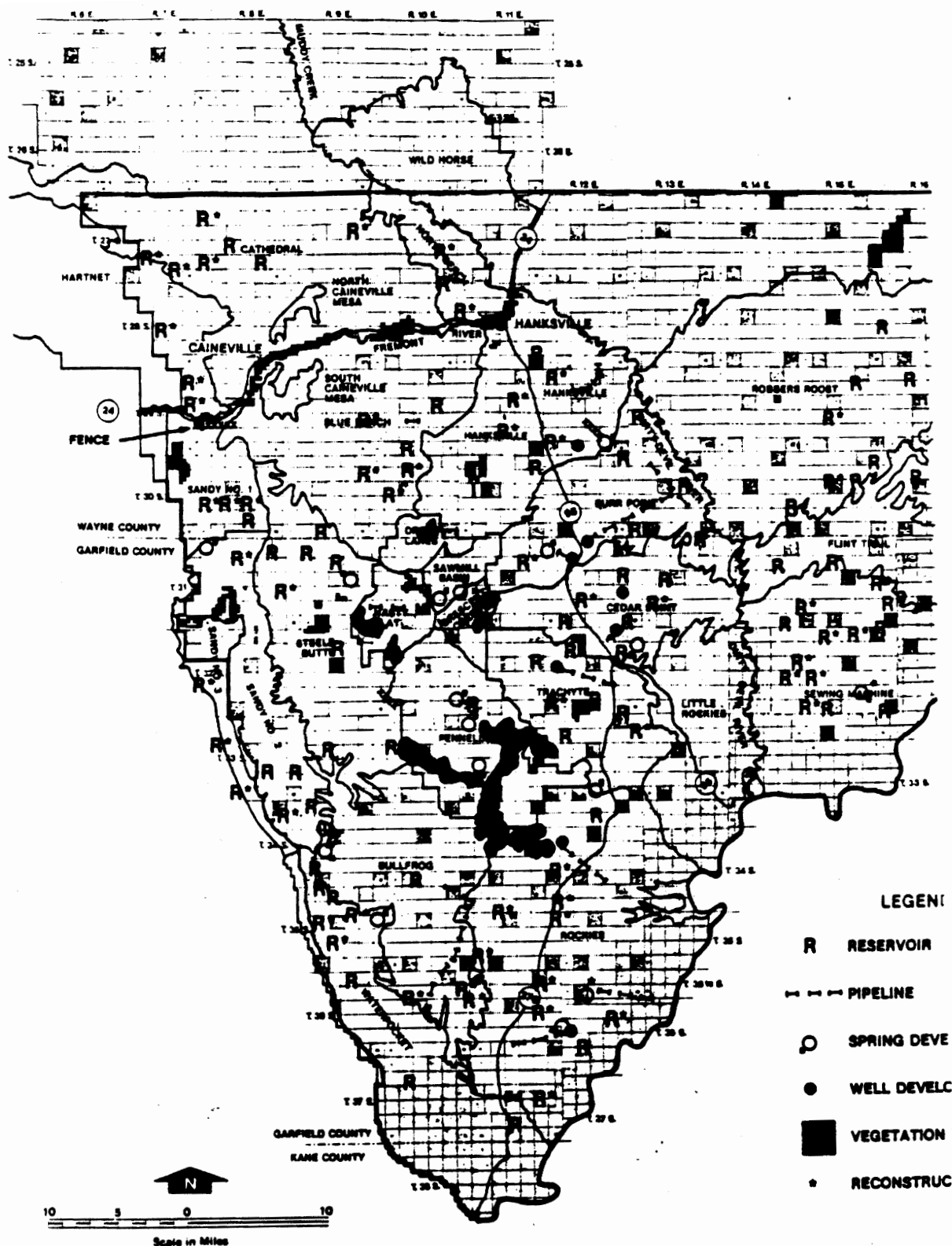
Table 4 - Comparison of grazing use to forage production.

<u>Grazing Management</u>	
Practices	Number of Allotments and Unallotted Areas
1. Continue Present Grazing System	10
2. Implement a Grazing System	7
3. Continue Season-long Grazing	4
4. Implement Season-long Grazing	1
5. No Livestock Grazing	5

Alternative	<u>Land Treatments</u>				
	Number of Allotments and Unallotted Areas	Acres	Livestock AUMs	Big Game AUMs	Total AUMs
Alternative C	10	24,300	423	2,552	2,975
Alternative D	10	24,300	2,815	160	2,975
Alternative E	10	24,300	2,415	560	2,975

<u>Rangeland Developments</u>		
Type	Number of Allotments and Unallotted Areas	Units
Springs		
Redevelop	3	3
New	10	15
Reservoir		
Recondition	17	60
New	17	59
Pipelines (miles)	8	37
Troughs	13	38
Wells		
Vertical	3	6
Horizontal	1	2
Corrals	1	1
Fences (miles)	5	17
Cattle Guards	2	2

Table 5 - Proposed Rangeland Improvements and Grazing Management
Practices under Alternatives C, D, and E.



Map 6 - Proposed rangeland improvements for alternatives C, D and E.

Alternative B: No Action

Impacts to the water resource would be as described in Alternative A, except portions of 21 allotments and one unallotted area would be affected where grazing capacity was exceeded (Table 5). Sediment yield could increase on about 56 percent of the planning area, decreasing surface water quality from overland flow.

- Alternative C: Optimize Big Game

There could be a short-term, localized decrease to surface water quality from disturbance caused by land treatments on nine allotments and one unallotted area (Table 5). In the long-term, sediment yield would decrease as vegetation became reestablished. Water quality would improve and surface runoff would be reduced on 9 allotments and one unallotted area (24,300 acres).

- Alternative D: Optimize Livestock

Impacts to the water resource would be similar to those described in Alternative C.

- Alternative E: Preferred Alternative – Planning Recommendation

Impacts to the water resource would be similar to those discussed in Alternative C.

Conclusion:

Alternatives C, D and E (Map 6) would result in a beneficial impact to water resources because land treatments on 24,300 acres would increase vegetation cover, thereby decreasing sediment yield and improving surface quality. Alternative A could cause a decrease in surface water quality as sediment yield increased on portions of 11 allotments and one unallotted area. Under Alternative B, surface water quality would decrease on 21 allotments and one unallotted area. This would result from decreased vegetation cover caused by overgrazing.

VI. CONCLUSION

This overview showed that from the Clean Water Act, point sources pollution as easier to jugulate through the NPDES because easier to assess whereas nonpoint source pollution was considered of less importance and later, because of the difficulty to assess it. Nonetheless, the three examples of study gave different methods to approach a non point source pollution due to grazing and depending on that method, the agencies involved, the result in treating grazing will vary. The following table summarizes the strengths and weaknesses of each method:

Project name	Strengths	Weaknesses
EPA Region 10's Water Quality Assessment	- basin wide approach - water quality based on recreational and biological which are significant	- no link between biological and recreational status and water quality parameters like sediment - data from the monitoring station don't give measurement of sediment - data come from different origin sources - data don't differentiate natural conditions from man caused effects
Panhandle National Forest Technique	- quick method for evaluating the impact of grazing on stream bank stability - prediction of impact of various levels of grazing management on the bank	- based on visual estimates of items rather than quantitative data, so need to train the observer - no good relations exist between ungulate damage and water quality parameters - limited field evaluation
Chino Wind Project	- partnership oriented - evaluates ways to measure watershed conditions and water quality in arid regions that don't have year round water stream - rotational grazing - reduce the extremes of over and under use - fencing network and distribution water system - more uniform rangeland	- complete results in ten years
Final Henry Mountain Environmental Impact Statement	- based on data obtained from a ten year monitoring	- overview of the situation in grazing allotments which are classified into three groups regarding the grazing impact - solutions are several alternatives for each resource and the actions are just analyzed in the report

GLOSSARY

Acre: surface of 0.4047 hectares or 4,047 m².

Acre feet: volume made by a surface of one acre on an height of one foot. To convert an acre-feet into cubic meters, multiply by 1,234.0.

Allotment: the act of assigning to a particular person or thing for a particular use.

AU: Animal Unit, 1,000 pounds of grazing animal. For example, a 1,000 pounds cow equals one AU.

AUM: Animal Unit Month, amount of forage an AU can eat in a month. Most grazing animals eat 2% of their body weight each day; thus the amount of forage an AU eat in a month is about 600 pounds.

Badland: land characterized by the intricate and sharp erosional sculpture of generally weak rock forming nearly horizontal bed and generally developing in decomposed granite, loess or soft material lacking or having scanty vegetation. It is rather barren land.

Cattle: horned, hoofed mammals as cows, bulls, oxen especially those domesticated for meat and dairy products.

Corrals: an enclosure for confining livestock.

Deferred Rotation Grazing: discontinuance of livestock grazing on various parts of a range in succeeding years, allowing each part to successively rest during the growing season. Permit seed production, seedling establishment, or restoration of plant vigor. Two, but often three or more, separate pastures are required.

Environmental assessment (EA): a concise public document prepared by a federal agency that serves (a) to determine whether to prepare an EIS or a finding of no significant impact; (b) aid an agency's compliance with the National Environmental Policy Act when no EIS is necessary; and (c) facilitate preparation of an EIS when one is necessary.

Environmental impact statement (EIS): a detailed written statement by a federal agency prior to deciding to take a proposed action that may have a significant environmental impact.

Forb: it is characterized by leaves attached with a petiole to the stem.

Grass: it is characterized by leaves attached with a sheath to the stem.

Livestock: domestic animals such as cattle or horse, raised for home use or for profit.

Line shacks: housing of a cattle guardian.

Rangeland: open land on which livestock wander and graze.

Rest Rotation Grazing: generally, a three or four pasture grazing system in which one pasture receives a year of rest while others are grazed.

Seep: spot where water contained in the ground oozes slowly to the surface, often forms a pool and is not permanently running.

Slickrock: smooth slippery rock.

Stocking rate: the # of AUs/acre/year or acres/AU/year. It can also be expressed as a number of AUMs per acre.

Talus: slope formed especially by an accumulation of rock debris at the base of a cliff or slope chiefly as the result of gravitational roll or slide.

Winter-Summer: grazing is done at low elevation during winter and at high elevation during summer

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APPENDIX A – Legislation and Agreements

Public Law 92-583

An Act to establish the Glen Canyon National Recreation Area in the States of Arizona and Utah. (88 Stat. 1311)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to provide for public outdoor recreation use and enjoyment of Lake Powell and lands adjacent thereto in the States of Arizona and Utah and to preserve scenic, scientific, and historic features contributing to public enjoyment of the area, there is established the Glen Canyon National Recreation Area (hereafter referred to as the "recreation area") to comprise the area generally depicted on the drawing entitled "Boundary Map Glen Canyon National Recreation Area," numbered GLC-01,000 and dated August 1972, which is on file and available for public inspection in the office of the National Park Service, Department of the Interior. The Secretary of the Interior (hereafter referred to as the "Secretary") may revise the boundaries of the recreation area from time to time by publication in the Federal Register of a revised drawing or other boundary description, but the total acreage of the national recreation area may not exceed one million two hundred and thirty-six thousand eight hundred and eighty acres.

Sec. 2. (a) Within the boundaries of the recreation area, the Secretary may acquire lands and interests in lands by donation, purchase, or exchange. Any lands owned by the States of Utah or Arizona, or any State, political subdivisions thereof, may be acquired only by donation or exchange. No lands held in trust for any Indian tribe may be acquired except with the concurrence of the tribal council.

(b) Nothing in this Act shall be construed to affect the mineral rights reserved to the Navajo Indian Tribe under section 2 of the Act of September 2, 1906 (73 Stat. 1686), or the rights reserved to the Navajo Indian Tribal Council in said section 2 with respect to the use of the lands there described under the heading "PARCEL B".

Sec. 2. (a) The lands within the recreation area, subject to valid existing rights, are withdrawn from location, entry, and patent under the United States mining laws. Under such regulations as he deems appropriate, the Secretary shall permit the removal of the nonleasable minerals from lands or interests in lands within the national recreation area in the manner prescribed by section 10 of the Act of August 4, 1936, as amended (53 Stat. 1196; 48 U.S.C. 397 et seq.), and he shall permit the removal of leasable minerals from lands or interests in lands within the recreation area in accordance with the Mineral Leasing Act of February 25, 1935, as amended (30 U.S.C. 181 et seq.), or the Acquired Lands Mineral Leasing Act of August 7, 1947 (30 U.S.C. 351 et seq.), if he finds that such disposition would not have signif-

cant adverse effects on the Glen Canyon project or on the administration of the national recreation area pursuant to this Act.

(b) All receipts derived from permits and leases issued on lands in the recreation area under the Mineral Leasing Act of February 25, 1920, as amended, or the Act of August 7, 1947, shall be disposed of as provided in the applicable Act; and receipts from the disposition on non-leaseable minerals within the recreation area shall be disposed of in the same manner as moneys received from the sale of public lands.

Sec. 4. The Secretary shall administer, protect, and develop the recreation area in accordance with the provisions of the Act of August 25, 1916 (39 Stat. 535; 16 U.S.C. 1 et seq.), as amended and supplemented, and with any other statutory authority available to him for the conservation and management of natural resources to the extent he finds such authority will further the purpose of this Act: *Provided, However,* That nothing in this Act shall affect or interfere with the authority of the Secretary granted by Public Law 485, Eighty-fourth Congress, second session, to operate Glen Canyon Dam and reservoir in accordance with the purposes of the Colorado River Storage Project Act for river regulation, irrigation, flood control, and generation of hydroelectric power.

Sec. 5. The Secretary shall permit hunting, fishing, and trapping on lands and waters under his jurisdiction within the boundaries of the recreation area in accordance with applicable laws of the United States and the States of Utah and Arizona, except that the Secretary may designate zones where, and establish periods when, no hunting, fishing, or trapping shall be permitted for reasons of public safety, administration, or public use and enjoyment. Except in emergencies, any regulation of the Secretary pursuant to this section shall be put into effect only after consultation with the appropriate State fish and game department.

Sec. 6. The administration of mineral and grazing leases within the recreation area shall be by the Bureau of Land Management. The same policies followed by the Bureau of Land Management in issuing and administering mineral and grazing leases on other lands under its jurisdiction shall be followed in regard to the lands within the boundaries of the recreation area, subject to the provisions of sections 3(a) and 4 of this Act.

Sec. 7. The Secretary shall grant easements and rights-of-way on a nondiscriminatory basis upon, over, under, across, or along any component of the recreation area unless he finds that the route of such easements and rights-of-way would have significant adverse effects on the administration of the recreation area.

Sec. 8. (a) The Secretary together with the Highway Department of the State of Utah, shall conduct a study of proposed road alignments within and adjacent to the recreation area. Such study shall locate the specific route of a scenic, low-speed road, hereby authorized, from

Glen Canyon City to Bullfrog Basin, crossing the Escalante River south of the point where the river has entered Lake Powell when the lake is at the three thousand seven hundred-foot level. In determining the route for this road, special care shall be taken to minimize any adverse environmental impact and said road is not required to meet ordinary secondary road standards as to grade, alinement, and curvature. Turnouts, overlooks, and scenic vistas may be included in the road plan. In no event shall said route cross the Escalante River north of Stephens Arch.

(b) The study shall include a reasonable timetable for the engineering, planning, and construction of the road authorized in section 8(a) and the Secretary of the Interior shall adhere to said timetable in every way feasible to him.

(c) The Secretary is authorized to construct and maintain markers and other interpretive devices consistent with highway safety standards.

(d) The study specified in section 8(a) hereof shall designate what additional roads are appropriate and necessary for full utilization of the area for the purposes of this Act and to connect with all roads of ingress to, and egress from the recreation area.

(e) The findings and conclusions of the Secretary and the Highway Department of the State of Utah, specified in section 8(a), shall be submitted to Congress within two years of the date of enactment of this Act, and shall include recommendations for any further legislation necessary to implement the findings and conclusions. It shall specify the funds necessary for appropriation in order to meet the timetable fixed in section 8(b).

Sec. 9. Within two years from the date of enactment of this Act, the Secretary shall report to the President, in accordance with subsections 8(c) and 3(d) of the Wilderness Act (78 Stat. 890; 16 U.S.C. 1133 (c) and (d)), his recommendations as to the suitability or nonsuitability of any area within the recreation area for preservation as wilderness, and any designation of any such area as wilderness shall be in accordance with said Wilderness Act.

Sec. 10. There are hereby authorized to be appropriated such sums as may be necessary to carry out the purposes of this Act, not to exceed, however, \$400,000 for the acquisition of lands and interests in lands and not to exceed \$37,385,400 for development. The sums authorized in this section shall be available for acquisition and development undertaken subsequent to the approval of this Act.

Approved October 27, 1972.

Legislative History
House Report No. 95-1446 accompanying H.R. 18718 (Committee on Interior and Insular Affairs).
Senate Report No. 95-156 (Committee on Interior and Insular Affairs).
Committee Print:
Vol. 117 (1971): June 21, considered and passed Senate.
Vol. 118 (1972):
Oct. 12, considered and passed House, amended, in lieu of H.R. 18718.
Oct. 14, Senate concurred in House amendment, with amendments; House concurred in Senate amendment.
Weekly Compilation of Presidential Documents: Vol. 8, No. 66 (1972):
Oct. 25, Presidential statement.

APPENDIX B – Plates of plants

- A- Indian Ricegrass
- B- Sand dropseed
- C- Galleta grass
- D- Mormon teas
- E- Winterfat
- F- Four-wing saltbush
- G- Needle-and-Thread



A- Indian Ricegrass (*Oryzopsis hymenoides*).

This grass is highly palatable to all classes of livestock. It cures exceptionally well and is valued as a winter feed for cattle, sheep, and horses. The seeds, which stay on the plant, are large and high in protein. They are responsible to a considerable degree for the value of the grass as a winter feed.



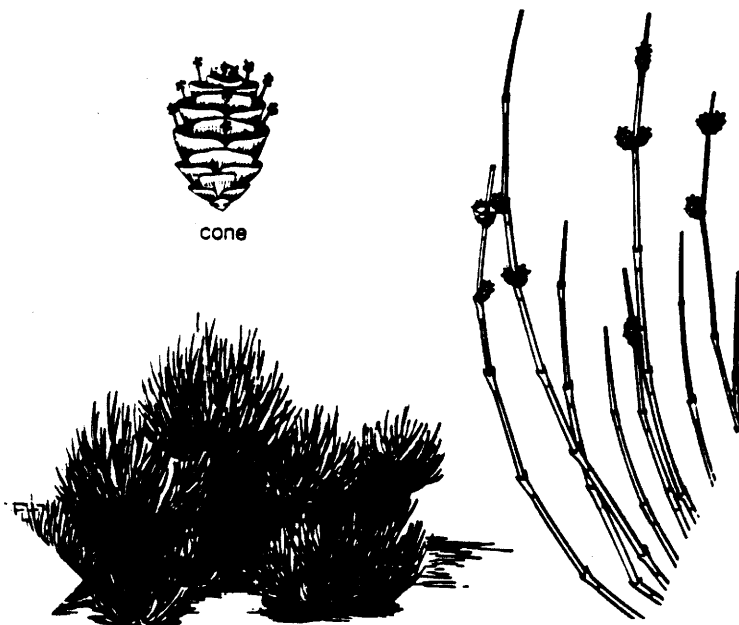
B- Sand dropseed (*Sporobollus cryptandrus*).

Sand dropseed varies in palatability from one region to another. In most of Arizona, it is generally classed as fair to good feed for cattle and horses and fair for sheep when green. After it is mature it is poor forage for all classes of stock. It begins growth later than most of the grasses with which it grows. Some of the lighter soil areas in southeastern Arizona support a mixture of sand dropseed and blue grama which has higher palatability.



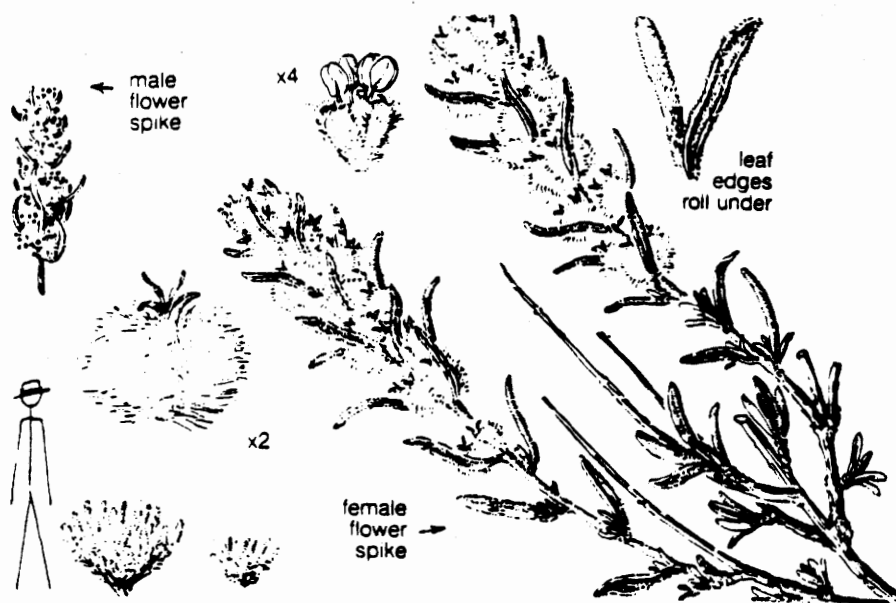
C- Galleta (*Hilaria jamesii*).

Because of its abundance this grass is one of the most important forage plants in the northeastern part of the state. When actively growing, it is classed as good to excellent feed for cattle and horses and fair for sheep. When dry, it is almost worthless for all classes of livestock.



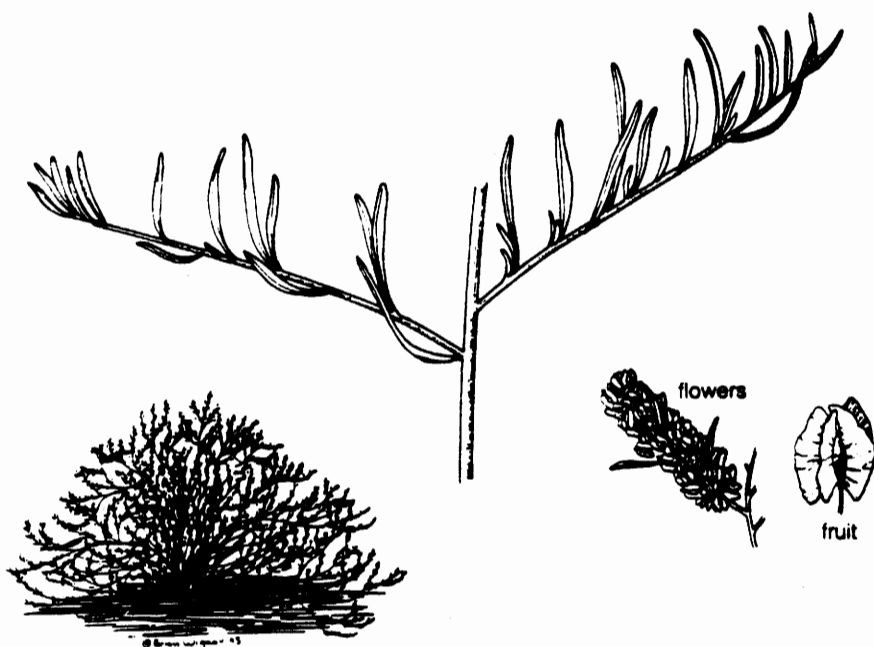
D- Mexican mormon tea (*Ephedra trifurca*).

Mexican mormon tea is a five-foot-tall-shrub common on gravelly plains, rocky slopes, and even stable dunes. Unlike conifers, it bears cones instead of fruits but that's where the resemblance ends. Mormon tea cones are flimsy, not stiff, and the plants are desert shrubs.



E- Winter-fat (*Eurotia lanata*).

Winter-fat is rich in protein and has been touted as the most valuable forage plant of the region, particularly in winter, when few herbaceous plants are available, thus the common name.



F- Four-wing saltbush (*Atriplex canescens*).

Four-wing saltbush, a stiffly-branched shrub about four or five feet tall, gets its name from the winged fruits. The wings, formed flower bracts, are designed for wind dispersal. Each fruit contains a single seed.



G- Needle-and-thread (*Stipa comata*).

**APPENDIX C – Description of the four management zones
defined for Glen Canyon National Recreation Area – General
Management Plan**

The Natural Zone includes Glen Canyon NRA's most outstanding scenic resources, relatively undisturbed areas, isolated and remote from the activities of man, or areas bordering on places with established land-use practices complementary to those of the zone. The management strategy for this zone is the maintenance of isolation and natural processes and consumption of renewable resources subject to protection of recreational area values. Grazing is allowed. Generally, management practices necessary to sustain grazing are limited to non-mechanical means.

The RRU Zone consists of areas possessing somewhat less scenic value, greater susceptibility to the activities of man, potential or actual mineral resources, or value for utility rights-of-way or development. Management strategy for this zone is the maintenance of natural processes while allowing to the extent possible, both mineral leasing and grazing. Enhancement of fish and game populations and consumption of renewable and nonrenewable resources are subject to protection of recreation area values. Grazing and mining may be prohibited in portions of this zone to protect recreation area values and resources. Permitted activities are grazing, mining, utility rights-of-ways, transportation systems, riding mountain bikes and scenic touring (autos, legal 4-wheeled-drive, and boats). The use of all vehicles (includes off-road vehicles and bicycles) is restricted to open roads and designated off-road vehicle use areas. Unpaved roads and primitive trailhead facilities such as parking and sanitary devices are allowed, with required NEPA clearance.

The Cultural Zone was delineated to focus on the preservation, interpretation, and restoration (where deemed appropriate by professional analysis) of historic and archeological resources. This zone embraces cultural or historic resources, with the management strategy geared to interpretation and preservation. Permitted activities include scholarly study, access to resources, trail establishment, placement of protective enclosures, and interpretive facilities. Grazing may be permitted, however, mining is prohibited.

The final management zone is the Development Zone, which provides for visitor services and maintenance of facilities, and where the existing developed areas exist. This zone permits the development and placement of relatively elaborate, permanent structures necessary to support recreational activities, and allows the full range of recreational uses described above in the Natural Zone, as well as management of dam structures and utilities. Hunting and mining are prohibited within the entire zone, and grazing is prohibited only in the developed areas of the zone.

APPENDIX D – Resources values, goals and objectives

- A- Vegetation**
- B- Soils**
- C- Water Quality**
- D- Wildlife**
- E- Cultural Resources**
- F- Paleontological and Quaternary Resources**
- G- Scenic Resources**
- H- Recreational Resources**

A. VEGETATION

Value Statement

Vegetation provides the basis for wildlife habitat, and produces the necessary forage for livestock. Healthy vegetation (with adequate cover and composition) inhibits soil erosion, maintains high water quality, regulates water quantity, and maintains the nutrient cycling

essential for both plant and animal life. Native vegetation is of great scientific value, and provides for scenic and aesthetic enjoyment by recreation area visitors.

Resource Condition

Glen Canyon NRA contains an outstanding array of Colorado Plateau vegetation communities, a diverse flora, and several state rare and federally listed species. Unusual and interesting plant communities occur in Glen Canyon NRA, many of which are of great scientific and scenic value. Hanging gardens, which are wetlands existing in undercut alcoves and on cliffs and fed by a perched aquifer, are prominent around Lake Powell and in its side canyons. The largest and best developed alcove gardens in the world occur within the recreation area. These unique communities support many rare and endemic plant species. Another scientifically important community that may have been more widespread prior to the formation of Lake Powell is the mixed deciduous woodland, which occurs in shaded and well-watered side canyons. Extensive wetland and riparian communities are also found in side canyons with permanent streams and springs. Above the canyons, large tracts of desert shrubland, grassland, and pinyon-juniper woodland occur.

A total of 780 species are currently known from Glen Canyon NRA (Spence and Zimmerman 1994). Two of these are federally listed, Pediocactus bradyi and Cycladenia jonesii. Several species are listed as state rare by the Utah Heritage Program, of which at least three are restricted in the state to the recreation area (see Appendix D).

Currently, relatively little is known about the recent status and trend of vegetation that is subject to livestock grazing in Glen Canyon NRA. Grazing occurs on about 762,361 acres out of 882,678 acres within allotments in Glen Canyon. The BLM maintains and surveys trend plots on and adjacent to recreation area lands as part of their general monitoring program on BLM lands. Ecological trend and status data are available for some but not all grazed areas of Glen Canyon NRA (see appendix B).

Resource goal and objectives

Goal: Maintain naturally diverse plant communities and species populations similar to Potential Natural Community composition (see Appendix C). These include a full complement of native species, plant vigor and health, natural structure for wildlife habitat, dynamic changes, reproductive success, and populational genetic and evolutionary responses.

The objectives and various actions to be taken to meet the objectives are listed below. The particular action taken will depend on the characteristics of the vegetation and location. Generally, if an allotment is in Maintenance condition, then the proposed actions for each objective may not be needed. However, if the allotment is not in the Maintenance category, one or more of the following objectives and actions may be necessary.

Objective 1: Maintain in upland (dry site) plant communities, as natural a community as possible, including the full range of native species, a viable seedbank, and minimal presence of increasing undesirable species (BLM/NPS).

Desirable Conditions. Potential natural community (PNC) composition for major plant communities is based on standard descriptions in the Natural Resource Conservation Service (NRCS) O-35 Green River resource area and field work done in Glen Canyon NRA (see Appendix C). These composition values provide the target requirements in most cases for vegetation condition within Glen Canyon NRA. Unless otherwise stated, the PNC is the desired plant community (DPC). In certain situations, such as in the case of maintaining a special status species, or where fire plays a role, desirable vegetation status may depart from the PNC or late seral requirements. Biomass and cover values for

key species and life form groups in these tables should be considered approximate and somewhat idealized. It is unlikely that vegetation exactly corresponding to the values in these tables exists. Furthermore, many land site descriptions are based on examples elsewhere in the NRCS Green River Resource Area, and are not specifically based on sites in Glen Canyon NRA. The reported values should be used in conjunction with information on site conditions (landforms, elevation, slope, fire history, other disturbances) that can cause variation in the abundances of many species. Undesirable species that occur in Glen Canyon NRA are also listed in Appendix C.

It is recognized that there are alternative theories to the traditional PNC concept. In particular, recent work has validated the "state and transition" approach which suggests that traditional techniques of vegetation manipulation through stocking rates may be inadequate in many plant communities. Some vegetation has been altered to such an extent by past disturbances (e.g., fire, grazing, construction, establishment of exotics) that simply adjusting stocking rates or even removal of livestock will not cause a shift in community composition towards the PNC stage. Currently the NPS is conducting field studies in Glen Canyon NRA on the utility of these newer approaches to grazing management. Until this work is finished, the PNC condition will be retained as a useful goal, recognizing that in some cases reduction in stocking rates or removal of livestock may not lead to the desired future condition.

1. Establish maximum utilization levels of 45% for Indian ricegrass in all key areas in allotments within Glen Canyon NRA, and also for other key species as necessary, until vegetation meets desirable community composition (PNC).
2. In allotments or pastures that are grazed in spring, utilization of Indian ricegrass and other key species will not exceed 25%.
3. In non-maintenance or other high-priority allotments, utilization of Indian ricegrass and other key species will not exceed 25% in spring.

The established utilization level is based on key areas, selected in consultation with the BLM. Key areas are those that, 1) are representative of the area's vegetation, 2) support sufficient amounts of the key species, and 3) are utilized but are not areas of congregation (e.g., such as happens around watering sources). Generally, key areas are situated at least from 1/2 to 1 mile from areas of heavy use (such as around stock ponds). The principal key species utilized in Glen Canyon NRA is Indian ricegrass (*Stipa hymenoides*) but at higher elevations needle-and-thread (*Stipa comata*) and sand dropseed (*Sporobolus cryptandrus*) are also important. Other species that can be used as indicators include Galleta grass (*Hilaria jamesii*), mormon teas (*Ephedra cutleri* and *E. viridis*), winterfat (*Eurotia lanata*), and four-wing saltbush (*Atriplex confertifolia*; see Appendix C). In addition to these key areas for forage utilization, others may be chosen, in consultation with the BLM, near areas with recreational activities or in areas where important resources (natural or cultural) occur that are of importance to Glen Canyon NRA.

Utilization levels are based on standards used by the BLM. Utilization in spring and fall should not exceed 50%, and 60% in the winter. C. Wayne Cook (National Wildlife Federation vs. BLM 1993) suggests that yearly utilization at 60% in winter on the Colorado Plateau is probably too high. He also pointed out that in pastures grazed every year spring utilization of 50% was too high, and that in order to allow for reproduction 25% was the maximum allowable utilization. Levels have been set at 45% in key areas in this plan for all grazing periods. Once 45% utilization of Indian Ricegrass, and if deemed necessary other key species has been reached, livestock will be moved from the area.

4. Adjust grazing seasons for Glen Canyon NRA allotments until vegetation meets desirable community composition (PNC).

Season and Elevation ¹	Grazing Season
Fall Period - Low elevation (<5000')	9/30 - 11/15
Fall Period - High elevation (>5000')	10/1 - 11/15
Winter Period - Low Elevation (<5000')	11/16 - 2/28
Winter Period - High Elevation (>5000')	11/16 - 3/15
Spring Period - Low elevation (<5000')	3/1 - 4/15
Spring period - High elevation (>5000')	3/16 - 5/1
Summer period - Low elevation (<5000')	None
Summer period - High elevation (>5000')	None

¹ Elevations are approximate and may be adjusted depending on site and vegetation

Grazing seasons are defined above for low (below 5000') and high (above 5000') elevations. In general, pastures or allotments with both elevational zones will be managed for the more sensitive communities, usually those below 5000'. Seasons of use may deviate from the table if utilization is below 45%, a grazing system is in place, and ecological trend is stable or improving. The spring grazing season has been somewhat shortened in order to allow for adequate reproduction by Indian ricegrass. Key species are listed by resource area and allotment in Appendix C.

5. Maintain or increase amounts of desirable plant species and keep low or reduce numbers of undesirable increasing species (PNC; see Appendix C).

Butler et. al. (1994) note that snakeweed (*Gutierrezia* species) is a good indicator of range in poor condition in the recreation area. Since snakeweed can be an increaser (or sometimes an invader) on Glen Canyon NRA range that has been overgrazed, it can serve as an indicator of range in poor condition. However, snakeweed also has a strong cyclic nature dependent on climate, and increases in abundance on a site may reflect factors other than grazing. Any use of the species as an indicator must take this into account. Natural levels of snakeweed can be found in the PNC composition tables for the communities in Glen Canyon NRA. Other groups of species that appear to be related to overgrazing are the locoweeds (selected *Astragalus* species), principally *A. lentiginosus* and *A. praelongus*, and the larkspurs (*Delphinium*). These species may be poisonous to livestock, as many contain toxic levels of chemicals like selenium, nitrotoxins, locoine, and delphinine. These three groups can be used as indicators of change in areas where they occur. Increases in populations of these taxa in selected key areas, in combination with decreases in desirable or key species, will be used to indicate that changes in grazing activity may be needed. In some cases, particular climate events can trigger heavy growth and flowering in many locoweeds, so presence and abundance must be used with care in evaluating range conditions.

6. Establish trend plots in key areas to determine successional trend and ecological status.

7. Establish grazing exclosures in key areas through consultation with the BLM to determine long term effects and recovery from livestock grazing, as well as how climate affects species growth and abundance.

Exclosures of sufficient size (a minimum of 30 m X 30 m) provide valuable baseline data on how climate and other factors affect vegetation independently of livestock grazing. Such baseline data can be used to determine if declines in selected species (e.g., key species) result from climate change (drought), grazing, or a combination of these as well as other factors. The number of exclosures or transects depends on the level of precision needed to detect change in monitored species. Brady et. al. (1995) provide a useful summary of sample sizes for the point-count transect method, which is similar to some BLM monitoring techniques.

8. Adjust stocking rates or change grazing prescription until key areas meet late seral or potential natural community composition criteria (see Appendix C). For specially designated areas (Research and Protected Natural Areas; see objective 3), conditions must meet potential natural community composition criteria, as set forth above.

Objective 2: To protect healthy populations of special status species, including federally listed threatened and endangered species, federal candidate C1 and former C2 species, and state heritage ranked rare and sensitive species (NPS/USFWS).

Appendix D lists 17 special status species that occur within Glen Canyon NRA. Of the two federally protected species, one (Pediocactus bradyi) occurs in an area not currently grazed, but the second (Cycladenia jonesii) occurs in an active allotment. However, this latter species prefers habitats that are largely inaccessible to livestock, and the species appears to currently sustain little or no impact through grazing activities. A biological assessment of the potential impacts of grazing on C. jonesii has not been completed.

Of the former federal C2 candidates (now NPS sensitive), four occur in or near hanging gardens (Erigeron kachinensis, E. zothecinus, Habenaria zothecina, and Perityle specuicola), two are found on or near the Tropic Shale in the Warm Creek area (Camissonia atwoodii and Cymopterus higginsii), and two occur in sandy and rocky desert shrublands in the middle part of the recreation area. (Dalea flavescens var. epica and Psoralea thompsonae var. whitingii).

Finally, seven proposed Utah state sensitive species are included. All but one of these species occur in riparian zones and hanging gardens (Viguiera soliceps occurs on Tropic Shale badlands). Two species (Imperata brevifolia and Aralia racemosa) are known from only one locality each within Glen Canyon NRA.

Objective 3: Manage and protect scientifically important areas and hanging gardens to prevent grazing induced changes (NPS).

Appendix E lists known scientifically important areas within Glen Canyon NRA other than hanging gardens. Studies by the NPS and The Nature Conservancy have documented that these areas support important plant communities, including ungrazed relicts, and often include sensitive plant species. At present, none are established Research Natural Areas. No grazing will be allowed in the identified relict areas (approximately 12,000 acres) because of their importance to Glen Canyon NRA resource values, management, or scientific research. No range developments will be authorized in scientifically important areas. The NPS will seek Research Natural Area (RNA) designation for all eligible relict and near relict (relict areas that have been grazed but not severely altered) areas. Two additional categories, Protected Natural Area (PNA) and Experimental Research Area (ERA), may be used as they provide additional important management options for areas that do not meet RNA criteria. PNA's are based on important natural features that are generally smaller in size than areas with an RNA designation, or they protect single important resources (such as a specific patch of vegetation). ERA's are already disturbed but are useful for comparisons and for research on the impacts of various kinds of disturbances, including grazing.

Desirable Conditions. Sensitive plant communities of importance for scientific research will not be subject to livestock grazing impacts.

1. Prioritize areas according to immediacy of threats, and importance of resource to Glen Canyon NRA.
2. Determine if RNA, PNA or ERA designation, and/or fencing is most appropriate to protect the site.
3. Prepare ERA, PNA or RNA justification report.
4. Consult with BLM on ways to exclude livestock from PNA or RNA areas.

Objective 4: Protect wetlands, riparian zones, and spring and seep vegetation (NPS/BLM).

These communities support much of the biodiversity in Glen Canyon NRA (Spence 1995). They also provide critical habitat for the majority of the wildlife species in the recreation area (cf. Johnson 1989). Many riparian communities in Glen Canyon NRA are of major scientific importance (Spence 1995). Baseline data on riparian vegetation is lacking from much of Glen Canyon NRA. Desirable conditions can be developed from data supplied by Spence (1995), who surveyed and classified permanent riparian zones in side canyons of Lake Powell (see Appendix C). Inventory techniques and terminology are derived from Platts et. al. (1987; also see Myers 1989, pp. 16-23). Key riparian species are listed in Appendix C. Riparian reaches (zones or sections of stream) to monitor will be selected in consultation with the BLM. Principal monitoring techniques include Proper Functioning Condition assessment (BLM 1993) and Greenline Riparian and Wetland monitoring (Cagney 1993). Other techniques and approaches will be developed in consultation with the BLM and where possible with BLM inventory and monitoring protocols (Myers 1989).

For key riparian reaches in high priority or non-M allotments, maintain populations of all native species and specific conditions detailed below.

1. Streambank alteration (e.g., bank collapse, loss of vegetation) shall not exceed 25% for streambanks and 30% for vegetation in key areas (see Platts et. al. 1987; pp. 75-83; Myers 1989, pp. 16-23 for definitions and methods).
2. Browse (of previous years growth) and forage utilization (of current years growth) shall not exceed 30% in key areas.
3. Reduce abundance of undesirable species to low levels (<5%) in areas where present (show declines through monitoring), and prevent establishment of undesirable species in areas where they are currently not present (see Table 9; Appendix C).
4. Establish monitoring transects for vegetation status and trend determination in areas currently not meeting desirable conditions.
5. Adjust stocking rates, rest periods, reduce length of season, change season of use, or remove livestock until desirable conditions are met.

Objective 5: Determine the current status and trend of the grazed rangelands in Glen Canyon NRA (NPS/BLM).

Baseline data are not available for all grazed portions of Glen Canyon NRA. This objective is designed to provide data essential for proper management of grazing activities and proper use of annual forage production. The results of this work may indicate changes are necessary in potential natural community composition.

Complete classification and inventory of the ecological status and successional trend of the upland vegetation in Glen Canyon NRA, using the methods and steps outlined below.

1. Compile and analyze existing data.
2. Inventory the current status of the upland arid and semi-arid vegetation, including species richness, diversity, structure, and successional status.
3. Establish permanent monitoring transects to determine future trends.
4. Establish permanent photographic points in association with permanent transects.
5. Revise the current vegetation classification for the recreation area, incorporating new data.
6. Establish baseline community classification criteria to direct management of grazing.

B. SOILS

Value Statement

The evolutionary and ecological processes of the soil (abiotic) ecosystem, which includes surface cover, microbial populations, soil nutrient cycling and physical/chemical transformations, are critical to the protection of scientific processes and scenic values within Glen Canyon NRA.

Resource Condition

The percentage of soil impacted by grazing activities versus recreational or vehicle activities, within Glen Canyon NRA, is not available. Trend data collected over the past several years does not address the various impacts on the soil. There is no data available from the trend plots that provides information on "normal" rates of soil development or levels of organic deposition.

Most of Glen Canyon NRA is considered to be arid rangeland. Remote mesa tops may hold the key to understanding existing natural plant community potential for similar areas. These remote areas, far from developed water sources and subject to minimal grazing pressure, may be used to assess current trend and site stability for larger areas within Glen Canyon NRA. Studying and monitoring these sites may provide necessary information on the greater area's plant communities in regards to soil development, nutrient availability, and "average" litter and plant cover values. Development and monitoring of livestock grazing "exclosures" could help to determine other factors that have an effect on various soil activities, outside of grazing. This information can be useful to the grazing program by providing answers on the recovery rate of the vegetation after a disturbance; what is the successional direction or trend; or what is the recovery rate of cryptobiotic populations.

Resource Goal and Objectives

Goal: Maintain the evolutionary and ecological processes of the soil ecosystem.

Objective 1: Collect data on rates of soil erosion on various grazed and ungrazed plots, targeting areas showing excessive erosion, such as rills, soil pedestals, or actively eroding gullies (NPS).

Use a combination of rangeland monitoring and sedimentation studies to quantify annual losses or gains from selected, established trend and riparian plots. Determine values from plots and compare to expected erosion rates developed by the Natural Resources Conservation Service (NRCS) in all sample areas, through the year 2005.

Objective 2: Enhance soil productivity and surface cover by promoting deposition of sufficient cover and litter to protect the soil from excessive water and wind erosion, and to promote infiltration (NPS).

Note: Field data may be collected during routine trend plot monitoring or plant utilization studies, etc., or incorporated into other studies conducted by other resource disciplines.

C. WATER QUALITY

Value Statement

Glen Canyon NRA was established, "...to provide for public outdoor recreation use and enjoyment of Lake Powell and lands adjacent thereto...and to protect and preserve the scenic, scientific and historic resources...". Water resources within Glen Canyon NRA are essential to support complex and diverse biological communities, riparian vegetation, fish and wildlife, which are often isolated by vast expanses of desert. Visitors come to enjoy water related recreation at Lake Powell and intriguing hikes into remote canyons. Backcountry hikers rely upon local springs and seeps to supply drinking water, and enjoy the aesthetic value of natural free flowing water. Maintaining high water quality and instream flows are management priorities for sustainability of water and water-dependent resources.

Resource Condition

Surface water resources include Lake Powell, springs and seeps, intermittent and perennial streams and five major rivers that flow into Glen Canyon NRA, four of which enter upstream of Glen Canyon Dam to form Lake Powell: the Colorado, Dirty Devil, San Juan, and Escalante Rivers. Lake Powell is the dominant water resource within Glen Canyon NRA, as one of the nation's largest reservoirs, it expands over 180 miles in length, and results in over 1900 miles of shoreline. Little baseline data exists on water quality and quantity for most water sources away from Lake Powell. Little is known about aquatic wildlife in side canyons and streams around Lake Powell, or in other natural bodies of water such as waterpockets.

Goal: Maintain water quality in all natural bodies of water and sources of water (does not include stock ponds or reservoirs) and maintain natural flows to preserve water dependent resources. At a minimum, water quality standards will meet the Utah state water requirements of 303(d) and 317 (e) as defined in the S&Gs (appendix B).

Objective 1: In all natural surface waters accessible for public use, water quantity and quality including physical/chemical parameters of flow, temperature, conductivity, pH, turbidity, salinity, dissolved oxygen, suspended and dissolved solids, and nutrients will not be degraded (NPS).

Objective 2: Bacteriological levels for fecal coliform in natural surface waters will not exceed standards for recreational use (NPS).

Objective 3: Preserve naturally occurring aquatic species diversity, composition and abundance (NPS).

Objective 4: Maintain integrity of stream morphology, instream flows, riparian zone, and springs' natural emergence (NPS/BLM).

Objective 5: Preserve the aesthetic value of natural water. Instream flows will be maintained in natural, unaltered condition (NPS).

Objective 6: Ensure access to water sources for wildlife and recreational uses (NPS).

D. WILDLIFE

Value Statement

The terrestrial and aquatic wildlife resources of Glen Canyon NRA are an integral part of the desert ecosystem to be experienced and enjoyed by visitors to the recreation area. These wildlife resources, which the NPS is charged to protect and preserve for the enjoyment of future generations, have intrinsic and scientific value.

Resource Condition

Glen Canyon NRA supports nine species of special status wildlife, which includes federal threatened and endangered species and Utah and Arizona state listed candidate species: Peregrine Falcon, Mexican Spotted Owl, Southwestern Willow Flycatcher, Bald Eagle, Colorado Squawfish, Humpback Chub, Bonytail Chub, Razorback Sucker, and Flannelmouth Sucker. Other species include a variety of mammals, reptiles and amphibians. Currently, 282 species of birds have been reported from the recreation area. Surveys for small mammals have not been done, although at least 13 species of bats are present. Other mammals include desert bighorn, mule deer, and a variety of smaller species. At least 30 reptiles and amphibians are known, but others may be found with more survey work. Virtually no work has been done on invertebrates in the recreation area.

Little is known about grazing effects on most wildlife in Glen Canyon NRA. Some work has been done in adjacent areas, such as in Capitol Reef National Park (e.g., Willey 1994). Within the recreation area, Bich (1992) noted differences in rodent species composition and abundances in several sites on Grand Bench.

Goal: Maintain components and processes of natural ecosystems, including the natural abundance, diversity and ecological integrity of the wildlife and fish.

Objective 1 (see also Objective 7): Protect Special Status Species and their habitat (NPS/USFWS).

Objective 2: Minimize the competition between livestock and wildlife. Consider livestock interactions and disease transmission (NPS/BLM).

Objective 3: Maintain the natural abundance and diversity of bird species (NPS).

Objective 4: Maintain or establish populations of wild mammals where suitable habitat exists (NPS).

Objective 5: Maintain the abundance and diversity of herpetofauna (NPS).

Objective 6: Maintain the natural abundance and diversity of insects.

Objective 7: Protect state and federally listed threatened and endangered aquatic species, species of special concern, and critical or required habitat (NPS/USFWS).

Four endemic fish are federally listed endangered species: Colorado squawfish (Ptychocheilus lucius), Humpback chub (Gila cypha), Bonytail chub (Gila elegans), and Razorback sucker (Xyrauchen texanus). Flannelmouth sucker (Catostomus latipinnis), is a native species of special concern. Kanab ambersnail (Oxyloma haydeni kanabensis) is a federally listed species that has not been identified within Glen Canyon NRA, however, surveys for it have not been conducted.

Local populations of other aquatic species, such as northern leopard frogs (Rana pipens), warrant special consideration (NPS).

Objective 8: General predator control activities will not be permitted.

Based on documented predator activity that identifies an individual animal, or limited number of individual animals, a specific control action may be authorized by the NPS. (NPS)

Objective 9: Feral or trespass animals will be removed (BLM/NPS).

E. CULTURAL RESOURCES

Value Statement

Cultural resource properties are irreplaceable and non-renewable resources with scientific, cultural, educational, and interpretive value.

This value statement is reflected in the management directives contained in NPS Management Policies, NPS 28 (1988). These policies prohibit any actions which might result in unmitigated site destruction: "The NPS will not take or allow any action that reduces the research potential of cultural resources without an appropriate level of research and documented data recovery." It further requires that, "Any action that will affect cultural resources adversely will be undertaken only if the following additional criteria are also met: 1) There is no reasonable alternative; and 2) All reasonable measures to limit adverse effect will be taken, including recovery of data and salvage of materials, as appropriate."

Resource Condition

Nearly 2300 cultural resource sites have been recorded within the boundaries of Glen Canyon NRA, most of which date to the prehistoric period. Much of the survey work was completed prior to the filling of Lake Powell. Since that time, about 2 percent of the 1 million acres surrounding Lake Powell within the recreation area have been intensively surveyed. Site densities in those surveys have ranged from 5 to 108 sites per square mile. Assuming an average 14 sites/square mile, potentially over 19,000 sites have not yet been identified and recorded on the 882,500 acres open to grazing.

Approximately 900 of the 2300 total sites were recorded by the University of Utah and the Museum of Northern Arizona during the pre-inundation studies of the late 1950s. The remaining 1400 sites have been recorded during surveys and studies conducted since that time.

It is estimated that approximately 60 percent of the 900 sites recorded during the preinundation studies (about 550 sites) were destroyed by the rising waters of Lake Powell, leaving about 350 of those sites still in existence today. With the addition of the 1400 sites recorded after the preinundation work, approximately 1750 sites remain in the present pool of recorded sites.

The majority of the prehistoric sites recorded within Glen Canyon NRA date to the Pre-Formative and Formative periods (AD 600 - 1300) of the Anasazi and Fremont cultures, although evidence for Paleo-Indian (9500 - 7000 BC) and Archaic (7000 - 200 BC) period occupations have been observed in limited sections of the recreation area. A small number of protohistoric remains (post-AD 1300) are also present, characterized mostly by ephemeral open sherd and lithic scatters, brush shelters, and diagnostic rock art panels. Historic cultural resources are also present in relatively small numbers.

In Glen Canyon NRA, five general site type categories are recognized. These include alcove sites, open surface sites, historic sites, rock art sites, and Traditional Cultural Properties.

Alcove sites are generally located in concave recesses in the sides or heads of steep-walled canyons, and can occur as well under tilted talus boulders, and in overhanging cliff faces, crevices, and shallow concave holes in the canyon walls. Specialized types of alcoves include rockshelters and caves, with varying degrees of protection from the elements. Alcove sites often contain both above-ground and subterranean structural remains, and they can accommodate other archaeological features as well including but not limited to storage cists, granaries, rock alignments, hearths, rock art, and middens (prehistoric trash dumps), along with associated artifacts and perishable materials.

Open surface sites are characterized by their lack of any natural shelter such as overhanging cliff faces or ledges. They contain the same kinds of archaeological features described for alcove sites, and may show evidence of agricultural features as well.

Historic sites must be at least 50 years old and contain cultural material deposited after 1540, the year the Spanish entered the area for the first time. Types of historic sites within the recreation area include those related to mining, ranching, pioneering, and recreational activities as well as Native American use of the land. Features found at historic sites include many objects related to the history of grazing and its way of life as well as other activities such as structures, corrals, dumps, trails, roads, inscriptions, boats, and historic paraphernalia such as tin cans, glass, china, metal, and milled wood. Historic sites are located in alcoves as well as on open surfaces.

Rock art is a specialized feature that occurs in alcoves, on vertical cliff faces, and on boulders. Both prehistoric pictographs (painted elements) and petroglyphs (pecked elements) are known to exist in the recreation area. Historic inscriptions, along with Navajo and other Native American rock drawings, are considered rock art as well. Rock art becomes a site type category only when it is the only feature present at a given location. When rock art is associated with other prehistoric and/or historic features, then it is a feature within one of the other three site type categories.

Traditional Cultural Properties include those locations associated with the cultural practices or beliefs of a living community, rooted in the community's history and are important in maintaining the continuing cultural identity of the community.

Resource Goal and Objectives

Goal: Protect and preserve the scientific value, and foster appreciation for, the cultural resources and their settings within Glen Canyon NRA. This protection and preservation extends to both prehistoric and historic cultural resources as well as Traditional Cultural Properties.

Objective 1: Protect cultural resources within the Primary and Secondary AOI. (NPS)

A cultural resources inventory of the Primary Area of Impact (AOI) will be conducted on high priority projects and ground disturbing activities. The Primary AOI is the area directly affected by a proposed activity, and includes an additional buffer area to account for possible resource damage experienced during implementation of the proposed activity. If the proposed activity in the Primary AOI is a water development project, a Secondary AOI will also be inventoried. This Secondary AOI includes a minimum of up to a 2 mile radius around the water development site, which is the average daily range of livestock from their water source in cool weather.

The inventory will include both a Class I literature search for previously identified cultural resources, and a Class III intensive survey of the impact areas. Transects, fifteen to 20 meter wide, will be walked until the entire Primary, and if necessary, the Secondary AOI has been inspected. Located sites will be plotted on appropriate 7.5 minute topographic quads and recorded using a Global Positioning System to ensure accurate georeferencing.

Objective 2: All alcove sites identified within the Primary and Secondary AOI will be protected from damage or loss due to livestock grazing activities (fenced). (NPS)

All alcove sites identified within the Primary and Secondary AOI will be documented using the appropriate Intermountain Antiquities Computer System (IMACS) forms. Site condition evaluation, photo documentation, field and feature sketches, site mapping, artifact collections, and topographic plotting will be performed as appropriate. Alcove sites may be fenced or other action taken to prevent access to livestock. Prior to beginning any fencing activity, a Section 106 compliance will be required.

Objective 3: All open surface sites identified within the Primary and Secondary AOI will be protected from damage or loss due to livestock grazing activities. (NPS)

All open surface sites identified within the Primary and Secondary AOI will be documented using the appropriate IMACS forms. Site condition evaluation, photo documentation, field and feature sketches, site mapping, artifact collections, and topographic plotting will be performed as appropriate. Open surface sites may be fenced or other action taken to prevent access to livestock. Prior to beginning any fencing activity, a Section 106 compliance will be required.

Objective 4: All historic sites identified within the primary and secondary areas of impact will be protected from damage or loss due to livestock grazing activities. (NPS)

All historic sites identified within the Primary and Secondary AOI will be documented using the appropriate IMACS forms. Site condition evaluation, photo documentation, field and feature sketches, site mapping, artifact collections, and topographic plotting will be performed as appropriate. Historic sites may be fenced on other action taken to prevent access to livestock. Prior to beginning any fencing activity, a Section 106 compliance will be required.

Objective 5: All rock art sites identified within the primary and secondary areas of impact will be protected from damage or loss due to livestock grazing activities. (NPS)

All rock art sites identified within the Primary and Secondary AOI will be documented using the appropriate IMACS forms. Site condition evaluation, photo documentation, field and feature sketches, site mapping, artifact collections, and topographic plotting will be performed as appropriate. Rock art sites may be fenced to prevent access by livestock. Prior to beginning any fencing activity, a Section 106 compliance will be required.

Objective 6: Mitigate potential impacts to cultural resources not protected in situ. This mitigation includes the curation of artifacts and other materials collected during mitigation efforts. (NPS)

Objective 7: American Indian traditional, cultural, or ceremonial sites will be identified and protected. (NPS)

No ground disturbing activities will be authorized until a determination has been made that no traditional cultural properties (TCP) will be affected. If potential impacts to a TCP occur, formal consultation with Native American tribes will be done.

E. PALEONTOLOGICAL AND QUATERNARY RESOURCES

Value Statement

Dinosaur trackways found in the Morrison formation, shark teeth in the Mancos Shale, and Quaternary Period resources including packrat middens and preserved faunal and floral remains are irreplaceable scientific resources.

Resource Condition

Limited reconnaissance level surveys have documented the presence of single tracks and trackways in the recreation area. Formations containing fossilized resources are widely distributed. Existing range improvements may or may not have been surveyed for paleontological resources prior to construction.

Only reconnaissance level quaternary resource surveys have been completed. These surveys have demonstrated that the semi-arid environment of Glen Canyon NRA has preserved packrat middens, alluvial deposits of floral and faunal remains, skeletal material, and other diagnostic materials in settings that allow for accurate aging of deposits. These resources are critical to understanding past environments and environmental change. Grazing impacts to quaternary resource sites may include erosion and loss of provenience.

Resource Goal and Objectives

Goal: Preserve paleontological and quaternary resources in-situ or insure full data recovery and curation of recovered specimens.

Objective 1: A literature search and first order survey to locate and record paleontological and quaternary resources will be completed prior to ground disturbing activities. (NPS)

Objective 2: Paleontological and quaternary resources will be protected in-situ whenever possible. Removal will occur only when necessary to safeguard resources from impacts that cannot be administratively controlled. (NPS/BLM)

G. SCENIC RESOURCES

Value Statement

Glen Canyon NRA contains magnificent scenic vistas. Deep canyons, sheer cliffs, distant mountain ranges, colorful soils and vegetation, and a unique collection of mesas, buttes, and spires all form a mosaic of visual enchantment for the visitor specifically identified for protection in the enabling legislation.

Scenic values are those elements of a landscape which contribute positively, both through the senses and the emotions, to the overall quality of a visitor's enjoyment and use of the recreation area. Visitor studies demonstrate the importance placed on preservation of the scenic resource (Wood, et.al., 1989).

Resource Condition

Visitor surveys have consistently shown that enjoying scenic vistas is one of the most important activities while visiting national park areas. At Glen Canyon NRA, viewing scenery has rated as important, very important, or extremely important by both lakeshore and backcountry visitors.

Scenic resources include a variety of tangible elements such as landforms, color, vegetation, uniqueness, and absence of development or modification which are obvious and, to some degree, quantifiable while also creating emotional responses which may be provoked by the landscape. Some emotional responses may not be directly tied to visual/sensual apprehension but to memories, pleasures, and associations accumulated over time.

Determining scenic values utilizes the BLM Visual Resource Management Guidelines, NPS Guidelines, Policies and Management Plans as well as the U.S. Forest Service Visual Assessment Program.

The following elements make up scenic value:

1. **Landforms** -- Topography; the Colorado Plateau is characteristically known for its varied and unique skyline of buttes, mesas, spires, arches, mountains, etc. Topography featuring high vertical relief, highly eroded landforms, rock outcrops, spires, and other interesting landforms have high scenic value. Large dune formations, eroded badlands, deep canyons, and the like would also rate highly. The degree to which these landforms dominate the view would determine, to some extent, the value of the view. Landforms with little or no relief, flat or with low rolling hills, and few remarkable details or interesting features would have lower scenic value.
2. **Vegetation** -- A variety of natural or native vegetation with an interesting relationship of form, pattern, and texture has high scenic value. Areas with less variety would tend to be rated lower. Areas of little or no vegetation may generally have lower value.
3. **Water** -- Where it is present, water which is clear and clean, either still or running, has high scenic value. In Glen Canyon NRA, the absence of water or a water source does not lower the scenic value.
4. **Color** -- Combinations of rich colors or a smaller variety of especially vivid colors. Pleasing contrasts in rock, soil, and vegetation. Colors might be dependent on time of day (e.g. sunrise or sunset). Extremely muted colors or generally monochromatic landscapes may have less scenic value.
5. **Proximity** -- What is in the immediate proximity. Adjacent scenery may enhance the view contributing to a higher value than if the adjacent area were neutral or detracting.
6. **Uniqueness** -- Is the view one of a kind? What are the opportunities for duplicating a scenic view such as this? Is the scenic view of a unique feature or combination of features. Value would also be enhanced if there was a unique opportunity for plant or wildlife viewing. The more "typical" a view is determined to be within its region, the lower the value.
7. **Modification** -- To what extent will an activity modify the scenic view from its natural state? Aesthetically undesirable or discordant sights, influences, or modifications degrade scenic values. This addresses the extent to which the hand of man is visible in the scene and to what extent, if any, this disrupts the scene. Some modification, especially if it is in harmony with the natural scene, could be acceptable, perhaps, even enhancing the view (e.g. Anasazi ruins). What extent does the modification itself disrupt the scene and the visitor's reaction to its presence.

While large landforms are not directly affected by grazing impacts, viewsheds may be impacted visually by the presence of water tanks, fence lines, roads related to grazing, stock trails, etc., which break up the natural flow of the eye across the landscape, reminding the visitor that man has modified the natural scene. Vegetation utilization can reduce the amount and kind of vegetation, reducing the variety of texture, color and pattern.

Existing recreation area scenic inventories divide viewsheds into four categories: signed or designated overlooks, existing and proposed marinas, major travel routes along the lake surface, and access roads to the recreation area and backcountry areas.

Resource Goal and Objectives

Goal: Maintain scenic resources.

Objective 1: No long-term loss of scenic resources. (NPS)

Potential impacts to scenic views will be evaluated based on the seven elements. Required mitigation such as location of improvements so they do not affect the scene may be utilized.

Determine "Visual Absorption Capability" and "Visual Vulnerability" of the affected scenic resources and do not permit impacts that diminish visual quality to include a determination of the area's ability to recover from the impact. (Desert landscapes are fragile and susceptible to long-term degradation from short-term activities).

Objective 2: Identify and protect cultural landscapes. (NPS)

Objective 3: Protect critical scenic resources in areas of heavy recreation use such as access road corridors, trailheads, major backcountry vehicle routes, boat accessible beach camping locations and developed scenic overlook viewsheds. In these critical scenic resource areas effects of grazing will be minimized so that vegetative components of the scene will be maintained. (NPS)

H. RECREATIONAL RESOURCES

Resource Value Statement

Glen Canyon NRA was established "... in order to provide for public outdoor recreation use and enjoyment of Lake Powell and lands adjacent thereto in the States of Arizona and Utah". Millions of visitors use the recreation area each year. There are millions of recreation overnights on the shores of Lake Powell and in the backcountry. Recreation use ranges from those activities which require solitude and an undisturbed setting to very mechanical recreation such as power boating and four-wheel driving. Recreation area management zoning has addressed these diverse activities.

Resource Condition

Some of the more popular backcountry activities include backpacking and camping, day hiking, mountain biking, and driving unpaved roads. While in the backcountry visitors enjoy viewing scenery, taking pictures, studying nature, solitude, and viewing archeological or historical resources. Backcountry users are willing to expend the extra time, effort, and planning it takes for a backcountry trip in order to reap what they feel are the "rewards" of the backcountry: pristine scenery, solitude, wildness, and remoteness.

Glen Canyon NRA has a significant and unique backcountry which offers a distinctive recreational opportunity for visitors. Grazing related impacts may have a negative impact on the recreational values and desired experiences of visitors within Glen Canyon NRA.

Much of the backcountry use in Glen Canyon NRA is made up of day hikers from boats on Lake Powell and river runners while most overnight backcountry use occurs in the Natural Zone, primarily in the Orange Cliffs, Escalante, and Halls Crossing/San Juan areas. Conflicts between livestock impacts and recreational use have occurred. Conflicts or negative impacts on the recreational experience may occur from the presence of livestock or as a result of associated impacts.

Although cattle (and other livestock) have historically grazed the lands of Glen Canyon NRA, cattle are not normally considered a part of the backcountry experience of a unit of the National Park Service. Backcountry users tend to have both strong expectations for their recreational experience, as well as strong opinions as to what is and is not appropriate backcountry activity.

Resource Goal and Objectives

Goal: Protect recreation resources and the visitor experience (enjoyment and use) by reducing or mitigating recreation/livestock conflicts.

Objective 1: Prevent or reduce livestock/recreation conflicts so that recreational use and enjoyment of the recreation area is not impaired. (NPS/BLM)

APPENDIX E – Preparation of reagents, media and bacteria cultures.

PREPARATION OF REAGENTS:

*** Final buffered dilution water or sterile water**

- Add 1.25 ml of 0.3M KH_2PO_4 and 5.0ml of 0.85M $\text{MgCl}_2 \cdot (6\text{H}_2\text{O})$ to one liter of deionized water and mix thoroughly,
- Sterilize in the autoclave for 30 minutes at 121°C ,
- Adjust final pH of solution at 25°C to 7.2 ± 0.2 using NaOH.

*** Rosolic acid**

To prepare a 1% solution of Rosolic acid in 0.2 NaOH, dissolve 1 g of Rosolic acid (dehydrated) in 100 ml of 10 N NaOH. This stock solution must be stored at $2-10^\circ\text{C}$, preferably in an amber polypropylene Nalgene bottle.

PREPARATION OF MEDIA:

*** Lauryl Sulfate Tryptose broth (LST broth)**

- Mix 35.6 g of Lauryl Sulfate Tryptose (dehydrated) in one liter of deionized water and warm slightly to dissolve completely,
- Pour 10ml in each test tube,
- Place inverted fermentation tube in each test tube and place a loose closure on tubes and sterilize them in the autoclave for 15 minutes at 15 pounds pressure at 121°C .

*** mFC broth for fecal coliform tests (for 50 plates of medium)**

- Suspend 3.7mg mFC broth base (dehydrated) per 100 ml sterile deionized water measured with a sterile graduated cylinder, then transfer to a sterile Erlenmeyer flask,
- Add 1ml of 1% solution of Rosolic Acid in 0.2N NaOH,
- Heat to boiling on the VWR Dylatherm hotplate (heat setting 2-3) making sure to stir frequently,
- After broth is heated to boiling, promptly remove from heat and cool to near 25°C before taking pH reading,

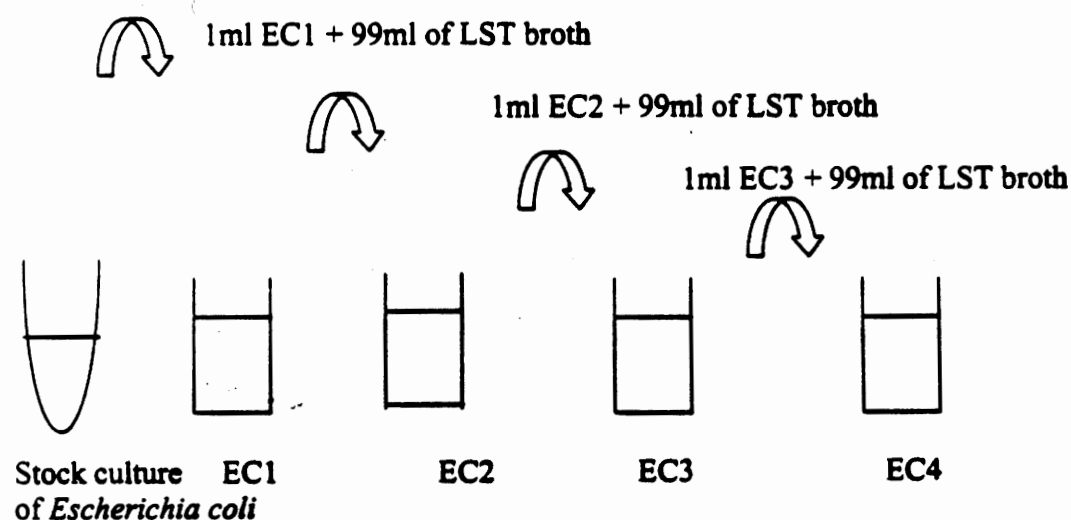
- Check pH of broth by dispensing a small portion into a beaker so as not to contaminate media to be used with pH probe. Acceptable pH for the broth at 25°C is 7.4 $\pm$ 0.2. Also, pipette 2ml broth onto a petri-pad and check pH media, then dispose of the plate. Record both results in media log. Do not adjust pH. If mFC broth is outside of pH range, discard solution and start over,
- Pipette 2ml mFC broth onto each prelabeled millipore disposable plastic (50x12mm) petri plate containing pad.
- Store unused or excess media in refrigerator, and discard after 96 hours.

PREPARATION OF BACTERIAN CULTURES

* Preparation of the positive controls EC2, EC3, EC4

A stock culture for preparation of the EC series was a culture of *Escherichia coli* that had been developing for one up to 14 days at 6C in the fridge in a test tube containing LST broth (Appendix F) and a loop (10 μ l) from a previous stock culture. An EC1 was prepared by adding a loop of a stock culture after agitation to a fresh tube of LST broth. An EC2 was prepared by adding 1 ml of EC1 after agitation to 99 ml of LST broth. An EC3 was prepared by adding 1 ml of EC2 after agitation to 99 ml of LST broth. It was the same for preparing an EC4.

One loop + 100ml of LST broth

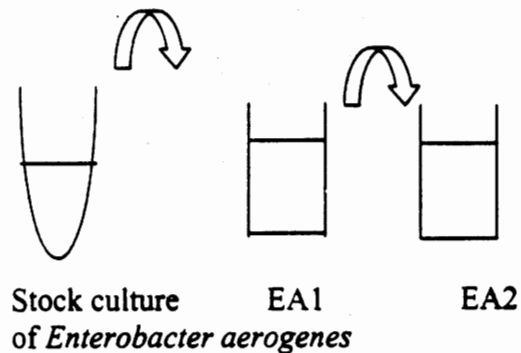


*** Preparation of the negative controls EA1, EA2**

A stock culture for EA series preparation was a culture of *Enterobacter aerogenes* that had been developing for one up to 14 days at 6C in the fridge in a test tube containing LST broth (Appendix F) that received a loop (10UI) from a previous stock culture. An EA1 was prepared by adding a loop of a stock culture after agitation to a fresh tube of LST broth. An EA2 was prepared by adding 1 ml of EC1 after agitation to 99 ml deionized water.

One loop + 100ml LST broth

1ml EC1 + 99ml LST broth



**APPENDIX F – EPA methods for total nutrients, dissolved
nutrients, chemical analysis and total metals**

METALS:

Parameter (Method)	Method reference
Aluminum (ICP)	EPA 600/4-79-020 200-7
Arsenic (GFAA, ICP)	EPA 600/4-79-020 206.2, 200-7A
Barium (ICP)	EPA 600/4-79-020 200-7A
Beryllium (ICP)	EPA 600/4-79-020 200-7
Cadmium (GFAA, ICP)	EPA 600/4-79-020 213.2, 200-7A
Chromium (GFAA, ICP)	EPA 600/4-79-020 218.2 200-7A
Cobalt (ICP)	EPA 600/4-79-020 200-7
Copper (ICP)	EPA 600/4-79-020 200-7
Iron (ICP)	EPA 600/4-79-020 200-7
Lead (GFAA, ICP, AA)	EPA 600/4-79-020 239.2, 200-7A, 239.1
Manganese (ICP)	EPA 600/4-79-020 200-7
Mercury (CVAA)	EPA 600/4-79-020 245.1
Selenium (GFAA, Hydride ICP)	EPA 600/4-79-020 270.3, 200-7
Silver (GFAA, ICP)	EPA 600/4-79-020 272.2, 200-7
Zinc	EPA 600/4-79-020 200-7

CHEMICALS:

Parameter (Method)	Method reference
pH (Electrometric)	EPA 600/4-79-020 150.1
Specific Conductance (umhos at 25 C)	EPA 600/4-79-020 120.1
Total Hardness (calculated)	Standard Methods 16 th Ed 314A p.209
Chloride (Argentometric)	Standard Methods 16 th Ed 407A p.287
Sulfate (Spectro)	EPA 600/4-79-020 375.2
Bicarbonate (Calc.)	Standard Methods 15 th Ed 406C p.285
Carbon Dioxide (Calc.)	Standard Methods 15 th Ed 406C p.285
Carbonate (Calc.)	Standard Methods 15 th Ed 406C p.285
Hydroxide (Calc.)	Standard Methods 15 th Ed 406C p.286
TDS (Gravimetric)	EPA 600/4-79-020 160.1
TSS (Gravimetric)	EPA 600/4-79-020 160.2
Turbidity	EPA 600/4-79-020 180.1

NUTRIENTS:

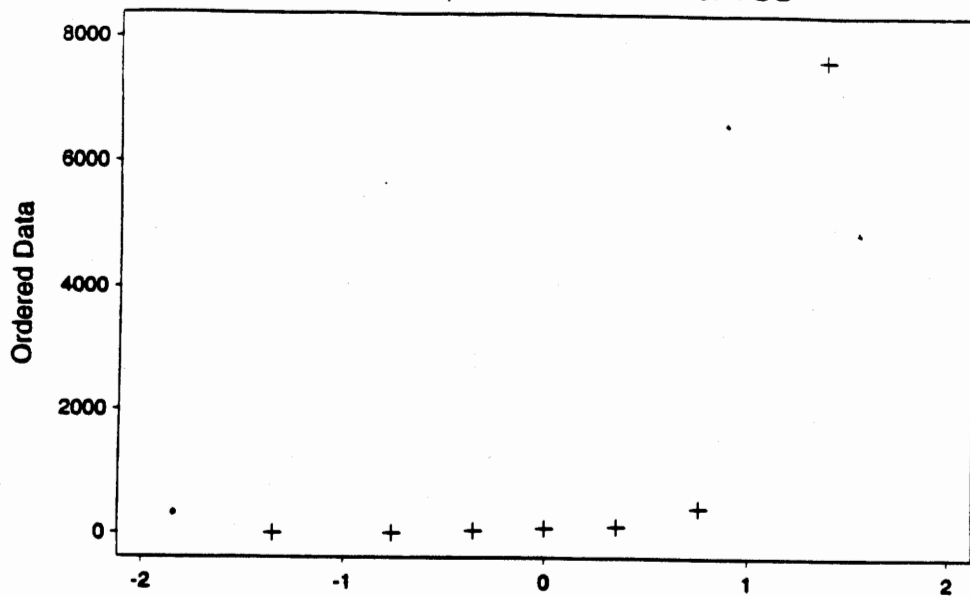
Parameter (Method)	Method reference
Ammonia (Electrode)	EPA 600/4-79-020 350.3
Nitrate (Cadmium Reduction)	EPA 600/4-79-020 353.2
Nitrite (Spectro.)	EPA 600/4-79-020 353.2
Total Phosphorus (Colorimetric)	EPA 600/4-79-020 365.1
Calcium (ICP)	EPA 600/4-79-020 200-7
Magnesium (ICP)	EPA 600/4-79-020 200-7
Sodium (ICP)	EPA 600/4-79-020 200-7
Potassium (ICP)	EPA 600/4-79-020 200-7

APPENDIX G –

- A- Results for the Wilk Shapiro test for the water parameters.
- B- Results of the water sample analysis
done by Utah State Laboratory
- C- Number of insects per sweep (13cmx18cmx100cm)
- D- Feeding groups for the aquatic insects
- E- Water quality parameters measured
- F- Concentration of zooplankton (number of zooplankton/ liter filtered)
- G- Quantiles of the Spearman test statistic

A – Results for the Wilk-Shapiro test for the water parameters

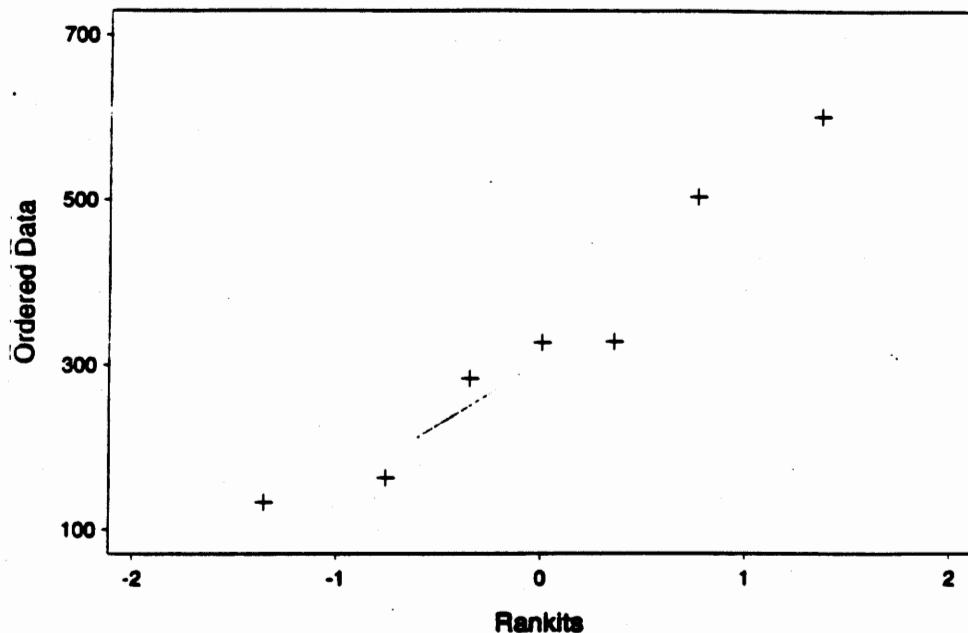
Wilk-Shapiro / Rankit Plot of TSS



*TOTAL SUSPENDED SOLIDS

Approximate Wilk-Shapiro 0.4830 7 cases

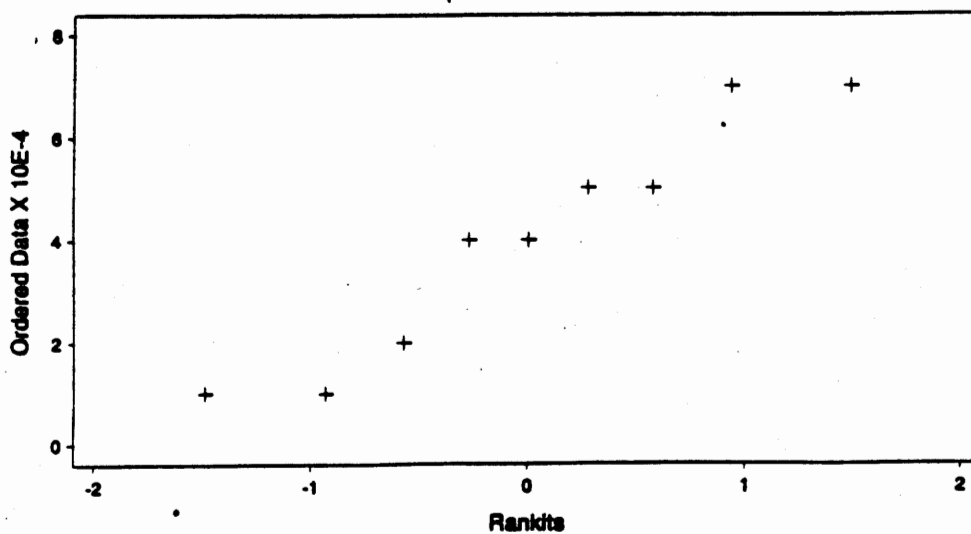
Wilk-Shapiro / Rankit Plot of TDS *

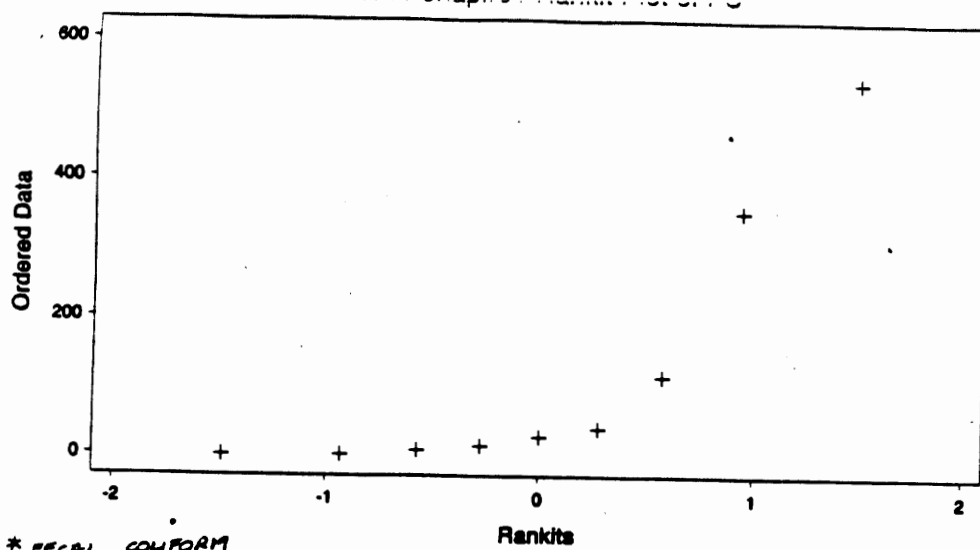


*TOTAL DISSOLVED SOLIDS

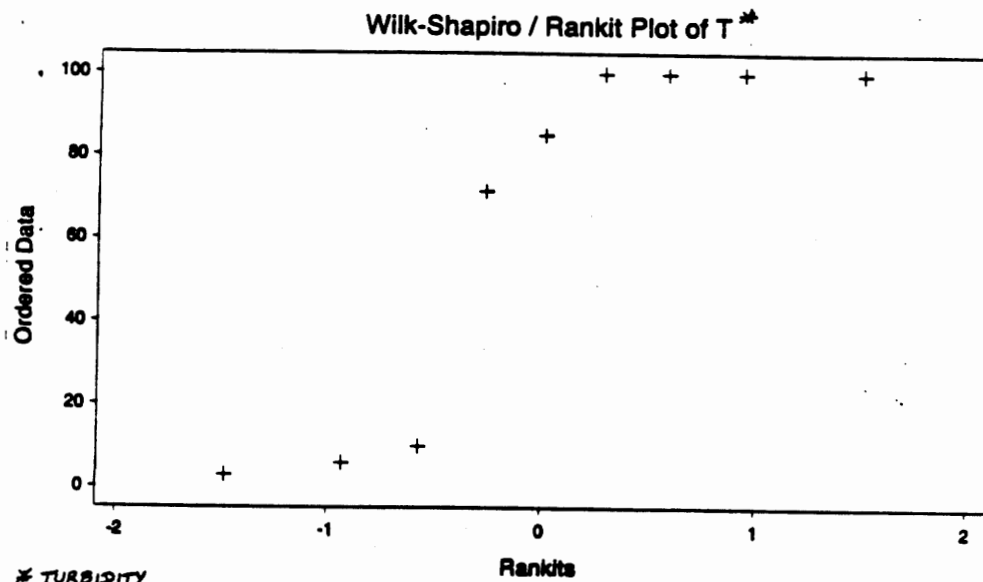
Approximate Wilk-Shapiro 0.9433 7 cases

Wilk-Shapiro / Rankit Plot of PH *

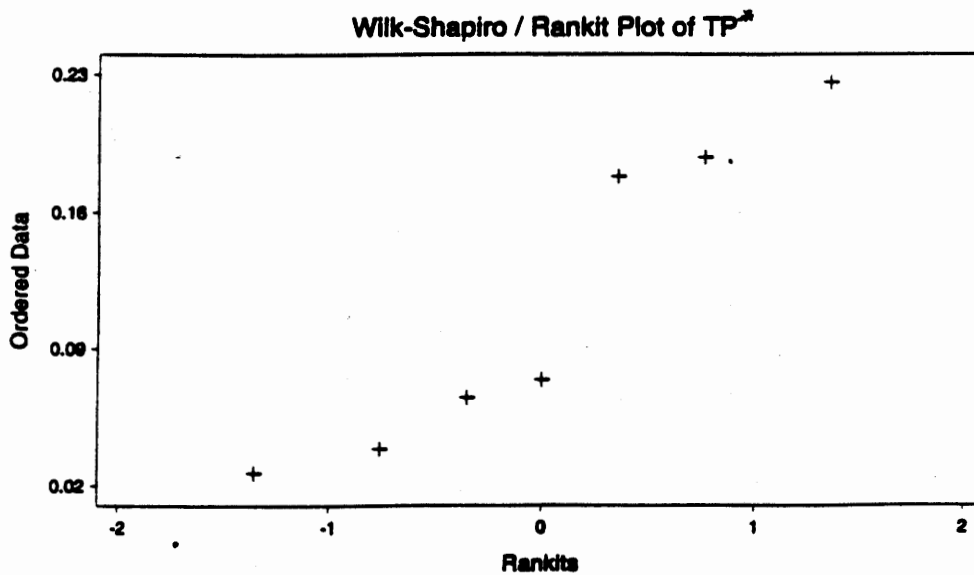




Approximate Wilk-Shapiro 0.6834 9 cases

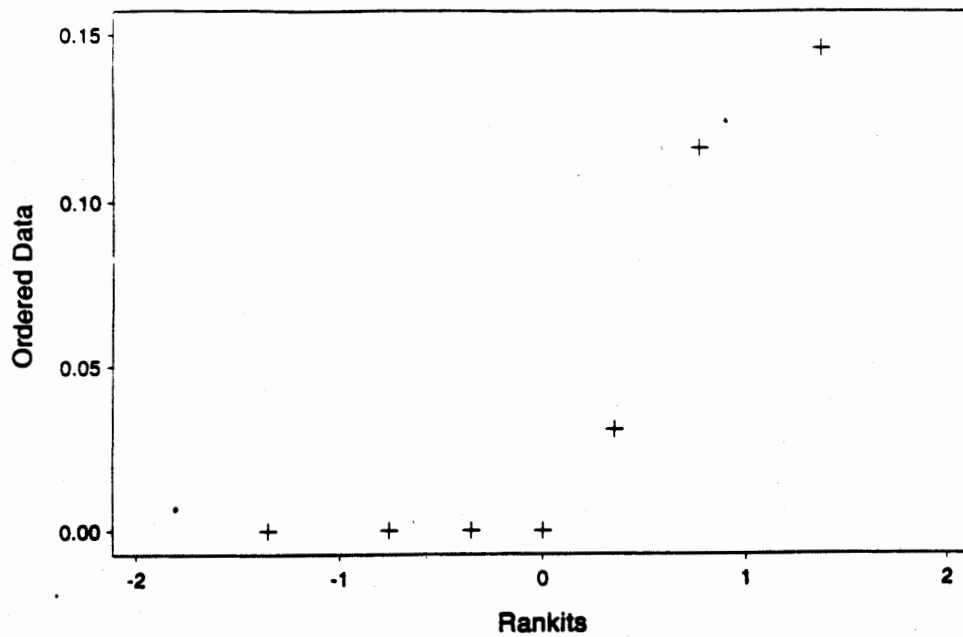


Approximate Wilk-Shapiro 0.7763 9 cases



Approximate Wilk-Shapiro 0.8865 7 cases

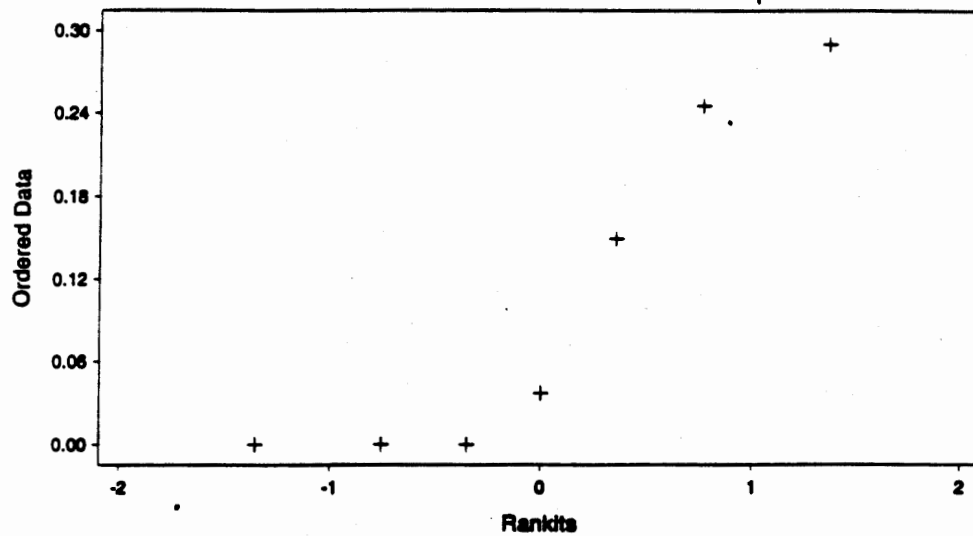
Wilk-Shapiro / Rankit Plot of NO_3^-



Approximate Wilk-Shapiro 0.7391 7 cases

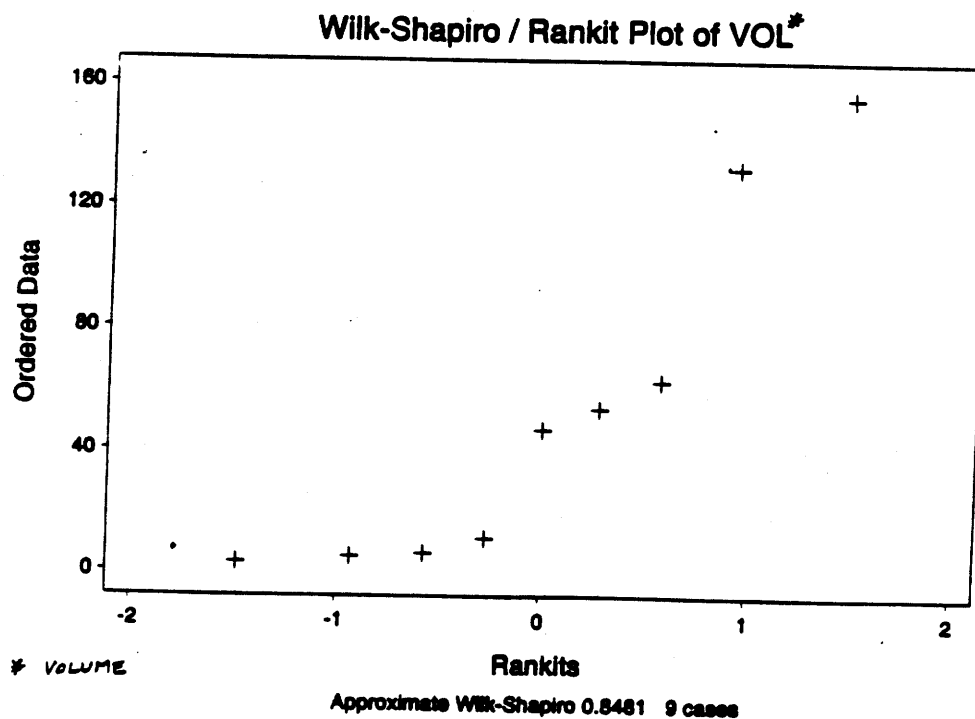
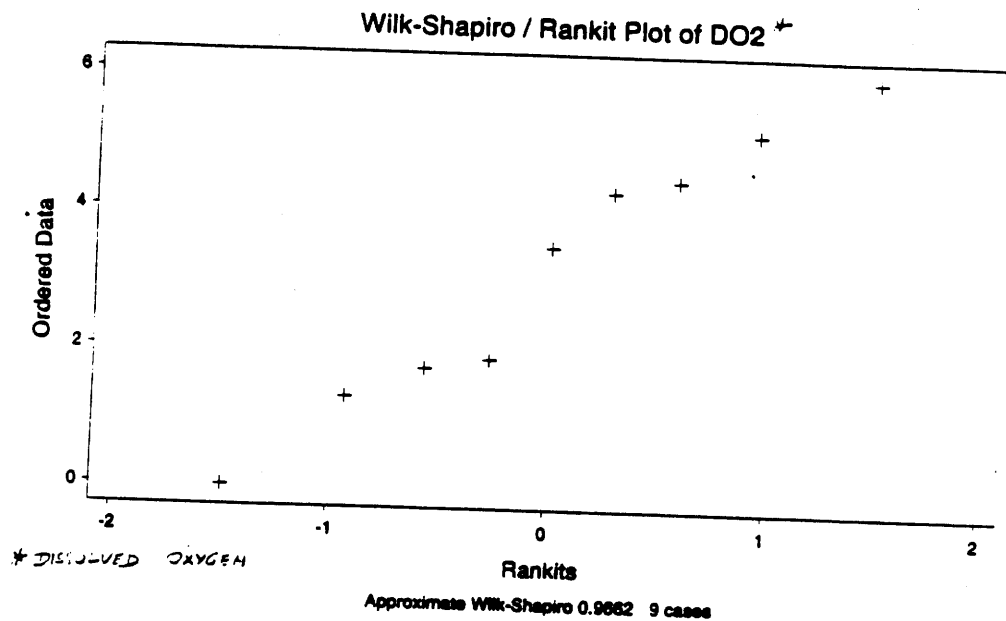
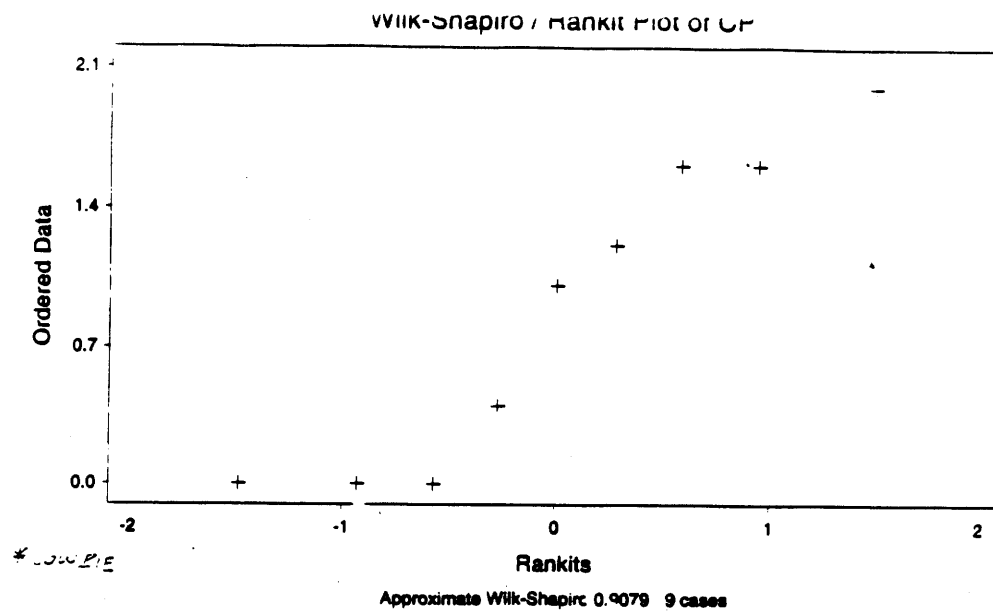
* NITRATE

Wilk-Shapiro / Rankit Plot of NH_4^+



Approximate Wilk-Shapiro 0.8412 7 cases

* AMMONIA



B – Results of the water samples analysis done by the Utah State Laboratory

2A 113 #1

Lab Number 199906943		Indicator I	
Davis Site #1			199922331
PH	8.35	L-PH	199921604
TSS	4.8	T.Sus.Sol	199922507
NO2+	<0.1	NO2+NO3, N	199923614
NH3	<0.05	Ammonia N	199922402
D-CA	55.5	D-Calcium	199922404
D-MG	26	D-Magnesium	199922405
D-K	3.06	D-Potassium	199922401
D-NA	3.66	D-Sodium	199922331
BICB	290	Bicarbonate	199922331
CO2	2	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	<3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	<20	Sulfate	199923208
TPO4	0.028	T. Phos.	199923112
ALK	238	Tot. Alk.	199922331
HARD	245.4	T. Hardns.	199922331
TURB	4.64	Turbidity	199921610
COND	451	L-Sp. Cond	199922211
TDS	284	TDS @ 180C	199921814
H+AL	66	H+Aluminum	199922311
H+AS	6.8	H+Arsenic	199922321
H+BA	0.34	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	<5	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	0.418	H+Iron	199922406
H+PB	<3	H+Lead	199922325
H+MN	164	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	143	CO3 Solids	199922331

DAVIS #2

Lab Number 199906944		Indicator I	
Davis Site #2			
PH	8.26	L-pH	199922331
TSS	4.4	T.Sus.Sol	199921604
NO2+	<0.1	NO2+NO3, N	199922507
NH3	<0.05	Ammonia N	199923614
D-CA	55.7	D-Calcium	199922402
D-MG	25.9	D-Magnesium	199922404
D-K	2.88	D-Potassium	199922405
D-NA	3.55	D-Sodium	199922401
BICB	294	Bicarbonate	199922331
CO2	3	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	<3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	<20	Sulfate	199923208
TPO4	0.03	T. Phos.	199923112
ALK	241	Tot. Alk.	199922331
HARD	245.5	T. Hardns.	199922331
TURB	3.71	Turbidity	199921610
COND	449	L-Sp. Cond	199922211
TDS	284	TDS @ 180C	199921814
H+AL	38	H+Aluminum	199922311
H+AS	7	H+Arsenic	199922321
H+BA	0.36	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	6	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	0.324	H+Iron	199922406
H+PB	<3	H+Lead	199922325
H+MN	148	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	145	CO3 Solids	199922331

DAVIS #3

Lab Number 199906945		Indicator I	
Davis Site #3			199922331
PH	8.31	L-pH	199921604
TSS	5.2	T.Sus.Sol	199922507
NO2+	<0.1	NO2+NO3, N	199923614
NH3	<0.05	Ammonia N	199922402
D-CA	55.9	D-Calcium	199922404
D-MG	25.9	D-Magnesium	199922405
D-K	3	D-Potassium	199922401
D-NA	3.58	D-Sodium	199922331
BICB	288	Bicarbonate	199922331
CO2	2	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	<3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	<20	Sulfate	199923208
TPO4	0.024	T. Phos.	199923112
ALK	236	Tot. Alk.	199922331
HARD	246	T. Hardns.	199922331
TURB	4.37	Turbidity	199921610
COND	449	L-Sp. Cond	199922211
TDS	282	TDS @ 180C	199921814
H+AL	50	H+Aluminum	199922311
H+AS	6.4	H+Arsenic	199922321
H+BA	0.34	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	7	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	0.345	H+Iron	199922406
H+PB	<3	H+Lead	199922325
H+MN	126	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	142	CO3 Solids	199922331

FIFTY MILE #1

Lab Number 199906940		Indicator I	
Fifty Mile Site #1			
PH	7.81	L-pH	199922331
TSS	9540	T.Sus.Sol	199921604
NO2+	0.3	NO2+NO3, N	199923204
NH3	<0.05	Ammonia N	199923614
D-CA	135	D-Calcium	199922402
D-MG	25.9	D-Magnesium	199922404
D-K	7.13	D-Potassium	199922405
D-NA	19.8	D-Sodium	199922401
BICB	206	Bicarbonate	199922331
CO2	5	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	5.5	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	284	Sulfate	1999223208
TPO4	<0.02	T. Phos.	199923112
ALK	169	Tot. Alk.	199922331
HARD	443.4	T. Hardns.	199922331
TURB	6298	Turbidity	199921610
COND	881	L-Sp. Cond	199922211
TDS	626	TDS @ 180C	199921704
H+AL	<30	H+Aluminum	199922311
H+AS	<5	H+Arsenic	199922321
H+BA	0.42	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	38	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	0.418	H+Iron	199922406
H+PB	<3	H+Lead	199922325
H+MN	1080	H+Mangan	199922317
H+HG	0.459	H+Mercury	199922504
H+SE	2.2	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	101	CO3 Solids	199922331

FIFTY MILE #2

Lab Number 199906941		Indicator I	
Fifty Mile Site #2			
PH	7.83	L-pH	199922331
TSS	12860	T.Sus.Sol	199921604
NO2+	0.3	NO2+NO3, N	199923204
NH3	<0.05	Ammonia N	199923614
D-CA	129	D-Calcium	199922402
D-MG	24.6	D-Magnesium	199922404
D-K	6.76	D-Potassium	199922405
D-NA	18.5	D-Sodium	199922401
BICB	212	Bicarbonate	199922331
CO2	5	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	4	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	277	Sulfate	199923208
TPO4	<0.02	T. Phos.	199923112
ALK	174	Tot. Alk.	199922331
HARD	423.1	T. Hardns.	199922331
TURB	9294	Turbidity	199921610
COND	887	L-Sp. Cond	199922211
TDS	616	TDS @ 180C	199921704
H+AL	10500	H+Aluminum	199922311
H+AS	5	H+Arsenic	199922321
H+BA	0.425	H+Barium	199922324
H+CD	2.9	H+Cadmium	199922323
H+CR	45.5	H+Chromium	199922316
H+CU	25.5	H+Copper	199922319
H+FE	9.91	H+Iron	199922406
H+PB	32	H+Lead	199922325
H+MN	1100	H+Mangan	199922317
H+HG	0.399	H+Mercury	199922504
H+SE	2.3	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	80	H+Zinc	199922320
CO3	104	CO3 Solids	199922331

FIFTY MILE #3

Lab Number 199906942		Indicator I	
Fifty Mile Site #3			
PH	7.98	L-pH	199922331
TSS	540	T.Sus.Sol	199921604
NO2+	0.2	NO2+NO3, N	199923204
NH3	<0.05	Ammonia N	199923614
D-CA	117	D-Calcium	199922402
D-MG	27.6	D-Magnesium	199922404
D-K	5.82	D-Potassium	199922405
D-NA	18.1	D-Sodium	199922401
BICB	230	Bicarbonate	199922331
CO2	4	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	232	Sulfate	199923208
TPO4	0.195	T. Phos.	199923112
ALK	189	Tot. Alk.	199922331
HARD	405.5	T. Hardns.	199922331
TURB	309	Turbidity	199921610
COND	809	L-Sp. Cond	199922211
TDS	564	TDS @ 180C	199921704
H+AL	4000	H+Aluminum	199922311
H+AS	<5	H+Arsenic	199922321
H+BA	0.168	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	14.4	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	2.31	H+Iron	199922406
H+PB	5.4	H+Lead	199922325
H+MN	280	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	113	CO3 Solids	199922331

BIG POND #1

Lab Number 199906937		Indicator I	
Big pond site #1			
PH	7.67	L-PH	199922331
TSS	134	T.Sus.Sol	199921604
NO2+	<0.1	NO2+NO3, N	199922507
NH3	<0.05	Ammonia N	199923614
D-CA	42.3	D-Calcium	199922402
D-MG	12.3	D-Magnesium	199922404
D-K	22	D-Potassium	199922405
D-NA	4.12	D-Sodium	199922401
BICB	173	Bicarbonate	199922331
CO2	6	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	3.5	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	20.2	Sulfate	199923208
TPO4	0.146	T. Phos.	199923112
ALK	142	Tot. Alk.	199922331
HARD	156.1	T. Hardns.	199922331
TURB	361	Turbidity	199921605
COND	302	L-Sp. Cond	199922211
TDS	336	TDS @ 180C	199921704
H+AL	3000	H+Aluminum	199922311
H+AS	16.4	H+Arsenic	199922321
H+BA	0.44	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	6.6	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	2.15	H+Iron	199922406
H+PB	10.2	H+Lead	199922325
H+MN	360	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	85	CO3 Solids	199922331

36 Pond #2

Lab Number 199906938		Indicator I	
Big Pond Site #2			
PH	7.73	L-pH	199922331
TSS	948	T.Sus.Sol	199921604
NO2+	<0.1	NO2+NO3, N	199922507
NH3	<0.05	Ammonia N	199923614
D-CA	42.7	D-Calcium	199922402
D-MG	11.5	D-Magnesium	199922404
D-K	19.7	D-Potassium	199922405
D-NA	4.08	D-Sodium	199922401
BICB	179	Bicarbonate	199922331
CO2	5	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	<3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	25.1	Sulfate	199923208
TPO4	0.369	T. Phos.	199923112
ALK	147	Tot. Alk.	199922331
HARD	153.9	T. Hardns.	199922331
TURB	567	Turbidity	199921605
COND	313	L-Sp. Cond	199922211
TDS	300	TDS @ 180C	199921704
H+AL	3200	H+Aluminum	199922311
H+AS	17.4	H+Arsenic	199922321
H+BA	0.52	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	7.4	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	2.39	H+Iron	199922406
H+PB	13.2	H+Lead	199922325
H+MN	520	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	88	CO3 Solids	199922331

Big Pond #3

Lab Number 199906939		Indicator I	
Big pond Site #3			199922331
PH	7.9	L-PH	199921604
TSS	200	T.Sus.Sol	199923204
NO2+	0.1	NO2+NO3, N	199923614
NH3	<0.05	Ammonia N	199922402
D-CA	40.6	D-Calcium	199922404
D-MG	13.2	D-Magnesium	199922405
D-K	23.8	D-Potassium	199922401
D-NA	3.9	D-Sodium	199922331
BICB	155	Bicarbonate	199922331
CO2	3	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199923613
CL	3.5	Chloride	199922331
OH	0.0000000	Hydroxide	199923208
SO4	<20	Sulfate	199923112
TPO4	0.05	T. Phos.	199922331
ALK	127	Tot. Alk.	199922331
HARD	155.6	T. Hardns.	199922331
TURB	468	Turbidity	199921605
COND	276	L-Sp. Cond	199922211
TDS	348	TDS @ 180C	199921704
H+AL	3200	H+Aluminum	199922311
H+AS	16.4	H+Arsenic	199922321
H+BA	0.46	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	6.2	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	2.29	H+Iron	199922406
H+PB	11.4	H+Lead	199922325
H+MN	420	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	76	CO3 Solids	199922331

Small Pond #1

Lab Number 199906946		Indicator I	
Small Pond Site			
PH	8.15	L-pH	199922331
TSS	67.6	T.Sus.Sol	199921604
NO2+	<0.1	NO2+NO3, N	199922507
NH3	<0.05	Ammonia N	199923614
D-CA	22.1	D-Calcium	199922402
D-MG	8.35	D-Magnesium	199922404
D-K	7.34	D-Potassium	199922405
D-NA	2.8	D-Sodium	199922401
BICB	106	Bicarbonate	199922331
CO2	1	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199923613
CL	3	Chloride	199922331
OH	0.0000000	Hydroxide	199923208
SO4	<20	Sulfate	199923112
TPO4	0.035	T. Phos.	199922331
ALK	87	Tot. Alk.	199922331
HARD	89.5	T. Hardns.	199921605
TURB	91.8	Turbidity	199922211
COND	189	L-Sp. Cond	199921704
TDS	132	TDS @ 180C	199922311
H+AL	420	H+Aluminum	199922321
H+AS	12	H+Arsenic	199922324
H+BA	0.17	H+Barium	199922323
H+CD	<1	H+Cadmium	199922316
H+CR	<5	H+Chromium	199922319
H+CU	<12	H+Copper	199922406
H+FE	0.288	H+Iron	199922325
H+PB	<3	H+Lead	199922317
H+MN	42	H+Mangan	199922109
H+HG	<0.2	H+Mercury	199922322
H+SE	<1	H+Selenium	199922326
H+AG	<2	H+Silver	199922320
H+ZN	<30	H+Zinc	199922331
CO3	52	CO3 Solids	

Small Pond #2

Lab Number 199906947		Indicator I	
Small Pond Site #2			
PH	8.12	L-pH	199922331
TSS	42.4	T.Sus.Sol	199921604
NO2+	<0.1	NO2+NO3, N	199922507
NH3	<0.05	Ammonia N	199923614
D-CA	22.4	D-Calcium	199922402
D-MG	8.72	D-Magnesium	199922404
D-K	8.03	D-Potassium	199922405
D-NA	2.9	D-Sodium	199922401
BICB	105	Bicarbonate	199922331
CO2	1	Carb. Diox	199922331
CARB	0.0000000	Carbonate	199922331
CL	<3	Chloride	199923613
OH	0.0000000	Hydroxide	199922331
SO4	<20	Sulfate	199923208
TPO4	0.044	T. Phos.	199923609
ALK	86	Tot. Alk.	199922331
HARD	91.8	T. Hardns.	199922331
TURB	73.5	Turbidity	199921605
COND	189	L-Sp. Cond	199922211
TDS	134	TDS @ 180C	199921704
H+AL	410	H+Aluminum	199922311
H+AS	11.6	H+Arsenic	199922321
H+BA	0.164	H+Barium	199922324
H+CD	<1	H+Cadmium	199922323
H+CR	<5	H+Chromium	199922316
H+CU	<12	H+Copper	199922319
H+FE	0.299	H+Iron	199922406
H+PB	<3	H+Lead	199922325
H+MN	38	H+Mangan	199922317
H+HG	<0.2	H+Mercury	199922109
H+SE	<1	H+Selenium	199922322
H+AG	<2	H+Silver	199922326
H+ZN	<30	H+Zinc	199922320
CO3	52	CO3 Solids	199922331

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907187 Sample Type: 04 Cost Code: 358
Description: WATERHOLE #1

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.53	T.Sus.Sol	27.6 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	0.0921 mg/l
D-Calcium	39.5 mg/l	D-Magnesium	5.43 mg/l
D-Potassium	8.41 mg/l	D-Sodium	1.64 mg/l
Bicarbonate	147 mg/l	Carb. Diox	7 mg/l
Carbonate	0 mg/l	Chloride	<3 mg/l
Hydroxide	0 mg/l	Sulfate	<20.0 mg/l
T. Phos.	0.089 mg/l	Tot. Alk.	120 mg/l
T. Hardns.	120.9 mg/l	Turbidity	5.39 NTU
L-Sp. Cond	243 umhos	TDS @ 180C	164 mg/l
H+Aluminum	52 ug/l	H+Arsenic	5.8 ug/l
H+Barium	0.066 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	0.76 mg/l	H+Lead	<3.0 ug/l
H+Mangan	132.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	<1.0 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	72 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
238 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907188 Sample Type: 04 Cost Code: 358
Description: WATERHOLE #2

Site ID: Source No: 00
Sample Date: 08/05/99 Time: -----

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.58	T.Sus.Sol	<4.0 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	<0.05 mg/l
D-Calcium	39.4 mg/l	D-Magnesium	5.43 mg/l
D-Potassium	8.82 mg/l	D-Sodium	1.65 mg/l
Bicarbonate	145 mg/l	Carb. Diox	6 mg/l
Carbonate	0 mg/l	Chloride	<3 mg/l
Hydroxide	0 mg/l	Sulfate	<20.0 mg/l
T. Phos.	0.07 mg/l	Tot. Alk.	119 mg/l
T. Hardns.	120.6 mg/l	Turbidity	2.02 NTU
L-Sp. Cond	243 umhos	TDS @ 180C	166 mg/l
H+Aluminum	<30 ug/l	H+Arsenic	5.4 ug/l
H+Barium	0.06 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	0.703 mg/l	H+Lead	<3.0 ug/l
H+Mangan	78.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	<1.0 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	71 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907189 Sample Type: 04 Cost Code: 353
Description: WATERHOLE #3

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.74	T.Sus.Sol	6.0 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	<0.05 mg/l
D-Calcium	38.9 mg/l	D-Magnesium	5.39 mg/l
D-Potassium	8.27 mg/l	D-Sodium	1.57 mg/l
Bicarbonate	145 mg/l	Carb. Diox	4 mg/l
Carbonate	0 mg/l	Chloride	<3 mg/l
Hydroxide	0 mg/l	Sulfate	<20.0 mg/l
T. Phos.	0.063 mg/l	Tot. Alk.	119 mg/l
T. Hardns.	119.2 mg/l	Turbidity	1.97 NTU
L-Sp. Cond	239 umhos	TDS @ 180C	158 mg/l
H+Aluminum	44 ug/l	H+Arsenic	5.4 ug/l
H+Barium	0.062 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	0.692 mg/l	H+Lead	<3.0 ug/l
H+Mangan	70.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	<1.0 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	71 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907184 Sample Type: 04 Cost Code: 358
Description: RED POND A #1

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.71	T.Sus.Sol	179.0 mg/l
NO2+NO3, N	0.25663 mg/l	Ammonia N	0.0644 mg/l
D-Calcium	38.4 mg/l	D-Magnesium	10.2 mg/l
D-Potassium	14.1 mg/l	D-Sodium	5.72 mg/l
Bicarbonate	110 mg/l	Carb. Diox	3 mg/l
Carbonate	0 mg/l	Chloride	3.5 mg/l
Hydroxide	0 mg/l	Sulfate	47.1 mg/l
T. Phos.	0.189 mg/l	Tot. Alk.	91 mg/l
T. Hardns.	137.8 mg/l	Turbidity	281.0 NTU
L-Sp. Cond	306 umhos	TDS @ 180C	328 mg/l
H+Aluminum	2400 ug/l	H+Arsenic	<5.0 ug/l
H+Barium	0.3 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.61 mg/l	H+Lead	5.0 ug/l
H+Mangan	134.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	1.26 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	54 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 81114-4870

801-538-6146

Lab Number: 199907185 Sample Type: 04 Cost Code: 358
Description: RED POND A #2

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.72	T.Sus.Sol	105.0 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	<0.05 mg/l
D-Calcium	37.3 mg/l	D-Magnesium	9.94 mg/l
D-Potassium	12.9 mg/l	D-Sodium	5.42 mg/l
Bicarbonate	105 mg/l	Carb. Diox	3 mg/l
Carbonate	0 mg/l	Chloride	4 mg/l
Hydroxide	0 mg/l	Sulfate	56.0 mg/l
T. Phos.	0.253 mg/l	Tot. Alk.	86 mg/l
T. Hardns.	134.0 mg/l	Turbidity	273.0 NTU
L-Sp. Cond	300 umhos	TDS @ 180C	336 mg/l
H+Aluminum	2000 ug/l	H+Arsenic	10.0 ug/l
H+Barium	0.174 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.65 mg/l	H+Lead	4.4 ug/l
H+Mangan	64.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	2.2 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	52 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907186 Sample Type: 04 Cost Code: 358
Description: RED POND A #3

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	7.74	T.Sus.Sol	82.0 mg/l
NO2+NO3, N	0.48112 mg/l	Ammonia N	0.375 mg/l
D-Calcium	37.2 mg/l	D-Magnesium	9.9 mg/l
D-Potassium	13.1 mg/l	D-Sodium	4.88 mg/l
Bicarbonate	106 mg/l	Carb. Diox	3 mg/l
Carbonate	0 mg/l	Chloride	3 mg/l
Hydroxide	0 mg/l	Sulfate	56.0 mg/l
T. Phos.	0.094 mg/l	Tot. Alk.	87 mg/l
T. Hardns.	133.5 mg/l	Turbidity	278.0 NTU
L-Sp. Cond	302 umhos	TDS @ 180C	318 mg/l
H+Aluminum	2200 ug/l	H+Arsenic	<5.0 ug/l
H+Barium	0.3 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.87 mg/l	H+Lead	4.4 ug/l
H+Mangan	116.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	1.2 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 solids	52 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-533-6146

Lab Number: 199907181 Sample Type: 04 Cost Code: 358
Description: RED POND B #1

Site ID: Source No: 00 Organic Review:
Sample Date: 08/05/99 Time: Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	8.39	T.Sus.Sol	170.0 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	<0.05 mg/l
D-Calcium	18.8 mg/l	D-Magnesium	8 mg/l
D-Potassium	15.7 mg/l	D-Sodium	71.5 mg/l
Bicarbonate	128 mg/l	Carb. Diox	1 mg/l
Carbonate	0 mg/l	Chloride	6.5 mg/l
Hydroxide	0 mg/l	Sulfate	93.6 mg/l
T. Phos.	0.363 mg/l	Tot. Alk.	105 mg/l
T. Hardns.	79.8 mg/l	Turbidity	295.0 NTU
L-Sp. Cond	442 umhos	TDS @ 180C	548 mg/l
H+Aluminum	3520 ug/l	H+Arsenic	10.8 ug/l
H+Barium	0.2 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.49 mg/l	H+Lead	6.0 ug/l
H+Mangan	80.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	2.2 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	63 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
298 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907192 Sample Type: 04 Cost Code: 359
Description: RED POND B #2

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	8.68	T.Sus.Sol	54.0 mg/l
NO2+NO3, N	0.14898 mg/l	Ammonia N	0.0589 mg/l
D-Calcium	19 mg/l	D-Magnesium	7.69 mg/l
D-Potassium	14.6 mg/l	D-Sodium	69.6 mg/l
Bicarbonate	125 mg/l	Carb. Diox	0 mg/l
Carbonate	0 mg/l	Chloride	7 mg/l
Hydroxide	0 mg/l	Sulfate	93.7 mg/l
T. Phos.	0.176 mg/l	Tot. Alk.	103 mg/l
T. Hardns.	79.0 mg/l	Turbidity	278.0 NTU
L-Sp. Cond	439 umhos	TDS @ 180C	496 mg/l
H+Aluminum	2200 ug/l	H+Arsenic	<5.0 ug/l
H+Barium	0.3 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.87 mg/l	H+Lead	4.6 ug/l
H+Mangan	120.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	1.3 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	62 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

UTAH STATE DEPARTMENT OF HEALTH
DIVISION OF LABORATORY SERVICES
Environmental Chemistry Analysis Report

UDEQ - DWQ
ARNE HULTQUIST
288 N 1460 W
PO BOX 144870
SALT LAKE CITY

UT 84114-4870

801-538-6146

Lab Number: 199907183 Sample Type: 04 Cost Code: 359
Description: RED POND B #3

Site ID: Source No: 00
Sample Date: 08/05/99 Time:

Organic Review:
Inorganic Review:
Radiochemistry Review:
Microbiology Review:

TEST RESULTS:

L-pH	8.59	T.Sus.Sol	35.0 mg/l
NO2+NO3, N	<0.1 mg/l	Ammonia N	0.29 mg/l
D-Calcium	19.5 mg/l	D-Magnesium	7.42 mg/l
D-Potassium	13.5 mg/l	D-Sodium	67.6 mg/l
Bicarbonate	123 mg/l	Carb. Diox	1 mg/l
Carbonate	0 mg/l	Chloride	7 mg/l
Hydroxide	0 mg/l	Sulfate	90.9 mg/l
T. Phos.	0.139 mg/l	Tot. Alk.	101 mg/l
T. Hardns.	79.2 mg/l	Turbidity	260.0 NTU
L-Sp. Cond	437 umhos	TDS @ 180C	468 mg/l
H+Aluminum	1800 ug/l	H+Arsenic	10.0 ug/l
H+Barium	0.17 mg/l	H+Cadmium	<1 ug/l
H+Chromium	<5.0 ug/l	H+Copper	<12.0 ug/l
H+Iron	1.01 mg/l	H+Lead	4.0 ug/l
H+Mangan	60.0 ug/l	H+Mercury	<0.2 ug/l
H+Selenium	2.2 ug/l	H+Silver	<2.0 ug/l
H+Zinc	<30.0 ug/l	CO3 Solids	61 mg/l

QUALIFYING COMMENTS (*) on test results: NO COMMENTS

END OF REPORT

C - Number of insects per sweep (18cmx12cmx100cm) (cont.)

Taxa	Small Pond		Red Point A		Red Point B		Waterhole	
	M	STD	M	STD	M	STD	M	STD
Insecta	0	0	0	0	0	0	0	0
Ephemotpera	0	0	0	0	0	0	0	0
Baetidae	0	0	0	0	0	0	4.67	8.083
Unidentified	0	0	0	0	0	0	1.33	2.309
Odanata	0	0	0	0	0	0	0	0
Lestidae	0	0	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0	0	0
Corixidae	1	0	0	0	1	1.732	1.33	2.309
Gerridae	0	0	0	0	0	0	0	0
Lygaeidae	0	0	0	0	0	0	0	0
Coleoptera	0	0	0	0	0	0	0	0
Dytiscidae	0	0	0	0	1	0	0.67	0.577
Hydrophilida	0	0	0	0	0.67	0.577	0	0
Gyrindae	0	0	0	0	0	0	0	0
Larvae	0	0	0	0	0	0	7.33	10.21
Diptera	0	0	0	0	0	0	0	0
Adults	0	0	0	0	0	0	0	0
Larvae	0	0	0	0	0	0	31.3	37.58
Unidentified	0	0	0	0	0	0	0.33	0.577
Crustacea	0	0	0	0	0	0	0	0
Anostraca	114.5	146.37	10.333	5.03	0	0	0.33	0.577
Notostraca	0	0	0	0	0	0	0	0
Triopsidae	0	0	6	0	0	0	0	0
Triops Larva	0	0	0	0	0	0	0	0
Decapoda	0	0	0	0	0	0	0	0
Astacidae	0	0	0	0	0	0	0	0
Vertabrate	0	0	0	0	0	0	0	0
Amphibia	0	0	0	0	0	0	0	0
Salientia	0	0	0	0	0	0	0	0
Fish	0	0	0	0	0	0	0	0
Small green sun fis	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

* M: Mean (n=3), STD: Standard Deviation (n=3)

C - Number of insects per sweep (18cmx12cmx100cm)

Pond		Cottonwood		Garden Canal		Davis Gulch		Fifty-mile Creek		Big Pond	
Taxa		M*	STD*	M	STD	M	STD	M	STD	M	STD
Insecta		0	0	0	0	0	0	0	0	0	0
	Ephemotpera	0	0	0	0	0	0	0	0	0	0
	Baetidae	0	0	0	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0	0	0	0
	Odanata	0	0	0	0	0	0	0	0	0	0
	Lestidae	0	0	1.333	0.577	0	0	0	0	0	0
	Hemiptera	0	0	0	0	0	0	0	0	0	0
	Corixidae	0	0	0	0	0	0	0	0	1	0
	Gerridae	0.333	0.577	0	0	0	0	0.667	1.1547	0	0
	Lygaeidae	0	0	0	0	0	0	0	0	0	0
	Coleoptera	0	0	0	0	0	0	0	0	0	0
	Dytiscidae	0	0	0	0	0	0	0.333	0.5774	0	0
	Hydrophilidae	0	0	0	0	0	0	0	0	0	0
	Gyrinidae	0	0	0	0	0	0	0	0	0	0
	Larvae	0	0	0	0	0	0	0	0	0	0
	Diptera	0	0	0	0	0	0	0	0	0	0
	Adults	0	0	0	0	0	0	0	0	0	0
	Larvae	0	0	0	0	0	0	1	0	0	0
	Unidentified	0	0	0	0	0	0	0	0	0	0
Crustacea		0	0	0	0	0	0	0	0	0	0
	Anostraca	0	0	0	0	0	0	0	0	31.6667	31.533
	Notostraca	0	0	0	0	0	0	0	0	0	0
	Triopsidae	0	0	0	0	0	0	0	0	0	0
	Triops Larvae	0	0	0	0	0	0	0	0	0	0
	Decapoda	0	0	0	0	0	0	0	0	0	0
	Astacidae	0	0	0.333	0.577	0	0	0	0	0	0
Vertabrate		0	0	0	0	0	0	0	0	0	0
Amphibia		0	0	0	0	0	0	0	0	0	0
	Salientia	0	0	0	0	0	0	0.667	1.1547	0	0
Fish		0	0	0	0	0	0	0	0	0	0
	Small green sun fish	1.333	2.309	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0

* M: Mean (n=3), STD: Standard Deviation (n=3)

D - Feeding groups of the aquatic insects sampled

Taxa	common name	dominant food	functional group	feeding mechanism
Phylum				
Class				
Order				
family				
Arthropoda				
Insecta				
Ephemeroptera				
Baetidae	mayfly	plant tissue coarse particulates organic matter	shredder	detritivore
Odonata				
Lestidae	dragonfly	periphyton-attached algae and associated material	scraper	herbivore
Hemiptera				
Corixidae	water boatmen	periphyton-attached algae and associated material	scraper	herbivore
Gerridae	water strider	living animal tissue	predator	piercer-carnivore
Coleoptera				
Dytiscidae	diving beetle	living animal tissue	predator	engulfier
Hydrophilidae	water scavenger beetle	living animal tissue	predator	engulfier
Gyrinidae	whirlig beetle	living animal tissue	predator	engulfier
Larvae	beetle	living animal tissue	predator	piercer
Diptera				
Larvae	midge	periphyton-attached algae and associated material	scraper	herbivore
	mosquito	phytoplankton	collector	detritivore filterer or suspension feeder
Crustacea				
Anostraca	fairy shrimp	phytoplankton	collector	detritivore filterer or suspension feeder
Notostraca	tadpole shrimp	plant tissue coarse particulates organic matter, phytoplankton	collector	detritivore filterer or suspension feeder
Decapoda				
Asiaticidae	crayfish	plant, animal	omnivorous	engulfier
Vertebrata				
Amphibia				
Saltatoria	tadpole	periphyton-attached algae and associated material	scraper	herbivore

E - Water quality parameters measured

Pond	garden canyon		cottonwood canyon drill hole				big pond	
	M*	STD*	M	STD	M	STD	M	STD
T P**	.	.	.	.	.	.	0.18833	0.16366
NH4+	.	.	.	.	.	.	0.037	0.06409
NO3-	.	.	.	.	.	.	0	0
TSS**	.	.	.	.	.	.	427.333	452.117
TDS**	.	.	.	.	.	.	328	24.98
T**	12	8.18	8.33	1.1	100	52.72	465.333	103.026
pH	.	.	8.09	.	.	.	7.78667	0.37314
(H3O+)	0.00073	0.00018	0.00031	0.00035	0.00017	2.5E-05	0.00044	0.00017
DO2**	4.3	0.36056	2	1.76667	0	0	5.16667	1.44338
C**	.	.	.	.	390.667	49.5614	256.667	11.0151
FC**	13.5	2.7	0	0	349.667	563.232	1000	0

*M: Mean (n=3), STD:Standard deviation (n=3)

**TSS: Total Suspended Solids, TDS: Total Dissolved Solids, T: Turbidity, DO2: Dissolved Oxygen, C: Conductivity, FC: Fecal Coliform

E - Water quality parameters measured (continued)

Pond	small pond		fiftymile		davis		redpointA	
	M	STD	M	STD	M	STD	M	STD
T P**	0.0395	0.00636	0.065	0.11258	0.02733	0.00306	0.17867	0.08
NH4+	0	0	0.29367	0.05488	0	0	0.24567	0.24067
NO3-	0	0	0	0	0	0	0.14633	0.2006
TSS**	55	17.8191	7646.67	6374.49	4.8	0.4	122	50.6853
TDS**	133	1.41421	602	33.2866	283.333	1.1547	327.333	9.0185
T**	82.65	12.9401	5300.33	4574.83	4.24	0.47843	277.333	4.04145
pH	8.905	0.13435	7.26	0.12124	7.81	0.03	.	.
(H3O+)	0.00014	1.8E-05	0.00071	8.7E-05	0.00041	1.2E-05	0.00053	1.1E-05
DO2**	3.5	0.70711	1.33333	1.61658	6.06667	0.20817	1.86667	0.20817
C**	188.5	9.19239	830.333	34.0637	441	5.56776	305	8.7178
FC**	7	5.65685	538.667	400.308	26.6667	20.1329	115.067	90.5606

*M: Mean (n=3), STD:Standard deviation (n=3)

**TSS: Total Suspended Solids, TDS: Total Dissolved Solids, T: Turbidity, DO2: Dissolved Oxygen, C: Conductivity, FC: Fecal Coliform

E - Water quality parameters measured (continued)

Pond	redpoint B		waterhole	
	M	STD	M	STD
T P**	0.226	0.12008	0.07467	0.01266
NO3-	0.11633	0.15327	0.0307	0.05317
TSS**	87.3333	72.037	11.2	14.5162
TDS**	504	40.5956	162.667	4.16333
T**	277.667	17.5024	3.12667	1.96026
pH	8.87	0.13528	7.55667	0.09018
(H3O+)	0.00014	1.9E-05	0.00052	4.7E-05
DO2**	4.46667	0.25166	1.73333	0.35119
C**	411.333	25.1462	252.667	10.504
FC**	39.3	6.38514	0	0

*M: Mean (n=3), STD:Standard deviation (n=3)

**TSS: Total Suspended Solids, TDS: Total Dissolved Solids, T: Turbidity, DO2: Dissolved Oxygen, C: Conductivity, FC: Fecal Coliform

F - Concentration of zooplankton (number of zooplankton/liter filtered)

Taxa	Pond		Small Pond		Davis Gulch		Fifty mile		Cottonwood	
	M*	STD*	M	STD	M	STD	M	STD	M	STD
Crustacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astacidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda	0.0	0.0	0.0	0.0	1.2	0.9	0.1	0.2	0.0	0.0
Ostrocoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cladocera	23.1	8.4	3.0	3.1	0.2	0.3	0.0	0.0	0.0	0.0
Clam shrimp	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.3	0.5
Anostraca	0.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tadpole	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Annelida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oligocheate	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Horsehair worm	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0

* M: Mean (for n=3), STD: Standard Deviation (for n=3)

F - Concentration of zooplankton (number of zooplankton/liter filtered)

Taxa	Pond		Garden Canyon		Red Point A		Red Point B		Waterhole	
	M	STD	M	STD	M	STD	M	STD	M	STD
Crustacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astacidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostrocoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cladocera	0.3	0.5	7.2	1.7	0.1	0.2	0.1	0.2	14.1	4.4
Clam shrimp	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.0	0.0
Anostraca	0.0	0.0	0.2	0.3	5.8	6.7	0.0	0.0	0.0	0.0
Tadpole	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Annelida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oligocheate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Horsehair worm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* M: Mean (for n=3), STD: Standard Deviation (for n=3)

G – QUANTILES OF THE SPEARMAN TEST STATISTIC

Table A10 QUANTILES OF THE SPEARMAN TEST STATISTIC^a

<i>n</i>	<i>p</i> = .900	.950	.975	.990	.995	.999
4	.8000	.8000				
5	.7000	.8000	.9000	.9000		
6	.6000	.7714	.8286	.8857	.9429	
7	.5357	.6786	.7450	.8571	.8929	.9643
8	.5000	.6190	.7143	.8095	.8571	.9286
9	.4667	.5833	.6833	.7667	.8167	.9000
10	.4424	.5515	.6364	.7333	.7818	.8667
11	.4182	.5273	.6091	.7000	.7455	.8364
12	.3986	.4965	.5804	.6713	.7273	.8182
13	.3791	.4780	.5549	.6429	.6978	.7912
14	.3626	.4593	.5341	.6220	.6747	.7670
15	.3500	.4429	.5179	.6000	.6536	.7464
16	.3382	.4265	.5000	.5824	.6324	.7265
17	.3260	.4118	.4853	.5637	.6152	.7083
18	.3148	.3994	.4716	.5480	.5975	.6904
19	.3070	.3895	.4579	.5333	.5825	.6737
20	.2977	.3789	.4451	.5203	.5684	.6586
21	.2909	.3688	.4351	.5078	.5545	.6455
22	.2829	.3597	.4241	.4963	.5426	.6318
23	.2767	.3518	.4150	.4852	.5306	.6186
24	.2704	.3435	.4061	.4748	.5200	.6070
25	.2646	.3362	.3977	.4654	.5100	.5962
26	.2588	.3299	.3894	.4564	.5002	.5856
27	.2540	.3236	.3822	.4481	.4915	.5757
28	.2490	.3175	.3749	.4401	.4828	.5660
29	.2443	.3113	.3685	.4320	.4744	.5567
30	.2400	.3059	.3620	.4251	.4665	.5479

For *n* greater than 30 the approximate quantiles of *p* may be obtained from

$$w_p = \frac{x_p}{\sqrt{n-1}}$$

where *x_p* is the *p* quantile of a standard normal random variable obtained from Table 1.

SOURCE. Adapted from Glasser and Winter (1961), with corrections, with permission from the *Biometrika* Trustees.

^a The entries in this table are selected quantiles *w_p* of the Spearman rank correlation coefficient *p* when used as a test statistic. The lower quantiles may be obtained from the equation

$$w_p = -w_{1-p}$$

The critical region corresponds to values of *p* smaller than (or greater than) but not including the appropriate quantile. Note that the median of *p* is 0.