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A BASELINE CHEMICAL ANALYSIS OF SELECTED SPRINGS
IN GLEN CANYON NATIONAL RECREATION AREA

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"HAND"

INTRODUCTION

The purpose of this study was to locate springs in the Waterpocket Fold, Wilson Mesa, and Orange Cliffs areas of Glen Canyon National Recreation Area. Of the springs identified, a select few were chosen for chemical analysis in order to establish the baseline chemical character.

PREVIOUS WORK

Cooley (1965) did a reconnaissance study, prior to the filling of Lake Powell, in which he located springs from the air. He did not report any extensive chemical analyses. Most of the springs located by Cooley have since been flooded by Lake Powell. His findings are not included in this report.

Hand (1979), in his masters thesis identified and chemically analyzed springs in the Orange Cliffs area. Most of the springs included in Hand's report were not flowing at the time of this study. Clyde's Spring (OCA1), French's Spring (OC3), and Hand's spring #17 (OC2) were analyzed both by Hand and in the present study. All spring localities reported by Hand are indicated on the Orange Cliffs and Spur Quadrangle maps included in this report. His chemical data are included in Appendix II.

Laity and Malin (1985) investigated the relationship between groundwater flow and the development of theater headed canyons in the Waterpocket Fold area. In their study they identified numerous seeps and springs in Bown's and Long Canyons. No chemical analyses were performed. The springs located by Laity and Malin are noted on the Rincon Quadrangle map included in this report.

PREPARATORY WORK

Prior to field work, air photos and topographic maps were reviewed, vehicle reconnaissance, and aerial observation trips were made in hopes of locating potential sampling sites.

Air Photo Interpretation

Color air photos were reviewed hoping to locate springs on the basis of enhanced vegetation or the presence of standing water. This approach was not fruitful. Often times vegetation was present owing to minor seeps which were not sampleable, or springs located in this manner were virtually inaccessible.

Vehicle Reconnaissance

A vehicle reconnaissance trip to the Orange Cliffs region was made in mid-June. This approach proved to be unproductive. Vehicle access to known springs was limited and springs were far apart, requiring many days to visit all possible sampling locations.

Aerial Reconnaissance

The most useful method of locating springs proved to be aerial observation. From the air, springs were noted, and access evaluated. The springs chosen for sampling are summarized in Table 1. A brief description of each site, and a plant inventory of selected sites, are included in Appendix I.

Table 1
SUMMARY OF SPRING LOCALITIES

Site	Quadrangle	T.S*	R.E**	Section
BA1	Rincon	39	9	NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec36
BA2	Rincon	39	9	SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec36
BA3	Rincon	39	9	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec25
BA4	Rincon	39	9	SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec36
BA5	Rincon	40	9	NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec1
BA6	Rincon	40	9	NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec1
WMA1	Lake Canyon	40	10	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec25
WMA2	Navajo Mtn.	41	9	NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec12
WMA3	No Mans Mesa	41	10	SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec7
OCA1	The Spur	28	16	NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec1
OC2	The Spur	27	17	NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec4
OC3	Orange Cliffs	30	16	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec3
OC4	Orange Cliffs	29	16	SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec4

* Township South

** Range East

Site Notation: B = Bown's Canyon, WM = Wilson Mesa, OC = Orange Cliffs, A = Alcove

SAMPLING METHOD

The low flow summer season was chosen for sampling in order to provide a true representation of the baseline chemistry of the spring water. This is based on the belief that during times of lowest flow, the chemical species present in the water will be at their maximum concentrations. Sampling was done in late June (6/26-29), late July (7/31), and mid-September (9/14-15).

The collection method of water for this study was based on methodology developed by Riordan (1980). At the site the water was filtered through a 0.1 μ m pore diameter filter using a battery operated portable pump.

Filtering is a necessary step in the sampling process. It removes colloidal matter that may have been dredged up during collection. Incorporation of this material in the sample may result in an increase in concentrations of dissolved constituents, especially upon acidification of the sample, as the acid dissolves the suspended matter (Riordan, 1980). Suspended materials have the capacity to accept hydrogen ions and may therefore alter alkalinity titration results (Riordan, 1980).

Two 250ml samples were taken from each site. Samples were filtered into, and stored in, polypropelene bottles. Upon collection one sample was preserved by the addition of 0.5 ml 1.0 Phenyl Mercuric Acetate (PMA), in order to inhibit bacterial growth. The other 250 ml sample was preserved by the addition of 1.0 ml concentrated nitric acid. Acidification is necessary to prevent complexation of metal ions, and increases significantly the allowable holding time for the sample prior to analysis (U.S. E.P.A., 1974).

Measurements made at the site include: water and air temperature, pH, and alkalinity. These measurements are compiled in Table 2.

Temperatures were recorded with a glass mercury thermometer, considered accurate to ± 0.1 C. The pH measurements were made using a battery operated pH meter (Sargent-Welch model 5000) equipped with a Corning combination electrode.

The meter was calibrated to pH 4 and pH 7 using commercially prepared buffers cooled to the spring water temperature in a water bath apparatus. The reported pH values (Table 2) are considered accurate to within .01 pH units.

Alkalinity titrations were performed in the field by titration of 50 ml water sample with 0.10 molar hydrochloric acid. The acid was delivered to the water via a 10 ml glass burette. The titration was considered complete at pH 4.00. Bicarbonate content was determined using data from the field alkalinity titration as outlined by Riordan (1980).

Table 2
Summary of Field Data

Site	Date (1985)	Flow* rate	Water T(°C)	pH	Conductivity (μmhos)	Alkalinity (μg/l CaCO ₃)	Notes
BA1	6/26	16	16	7.12	139	—	N, SP, MS
BA2	6/26	undet.	28	7.12	140	—	N,SP,AL
BA3	6/27	20	18	6.23	140	80.08	N,MS,SP
BA3	7/31	17	20	6.20	125	43.68	
BA3	9/15	20	19	7.97	140	80.08	
BA4	6/27	undet.	23.5	6.45	220	152.88	N,AL,SP
BA5	6/27	10	19	6.29	160	50.96	N,AL,P,S
BA5	7/31	10	18	6.04	150	65.52	
BA5	9/15	10	18	7.17	170	87.36	
BA6	6/28	1	18	7.28	232	138.32	N,SP
WMA1	6/29	2	16	9.07	140	131.04	N,P,S,MS
WMA1	7/31	2	19	6.42	225	120.12	N,P,S,MS,SP
WMA1	9/15	2.5	16	7.40	120	61.88	S
WMA2	6/29	20	18	7.40	195	72.80	N,J,P,S
WMA3	7/31	10	18	7.12	135	65.52	N,SP,MS
OCA1	9/14	1	11	6.98	60	152.89	N,AL,SP
OC2	9/14	3	18	7.29	800	360.36	C,SP,MS
OC3	9/14	1	18	7.20	195	72.8	N,AL
OC4	9/14	6	15	7.31	1400	192.92	WR,AL,SP,MS

Key to Notes: N = Navajo Sandstone, C = Chinle formation, WR = White Rim Sandstone, AL = flows through alluvium,
J = flows through joints, SP = sampled from pool, S = sampled source, P = pool present, MS = multiple seeps

Refer to Table 1 for site notation

*Flow rate estimated in liters/minute

ANALYTICAL METHODS

All laboratory analyses were completed at the Ralph M. Bilby Research Center, Northern Arizona University, with the assistance of the technical staff.

Analytical methods employed for chemical analysis in the laboratory include Atomic Absorption Spectrophotometry, colorimetric techniques, and ion chromatography.

Flame atomic absorption was used to analyze for major cations (Ca, Mg, Na, K). Analyses were carried out on a Perkin-Elmer model 560 spectrophotometer. In order to control chemical and ionization interferences, lanthanum (1000 ppm) was added to samples when analyzed for calcium and magnesium, and cesium (1000 ppm) was added to samples being analyzed for sodium and potassium. (American Public Health Association, et.al., 1971). The reported values (Table 3) are considered accurate to ± 0.01 ppm.

Graphite furnace atomic absorption (Perkin-Elmer model HGA 400) was utilized for trace metal analyses, using methods developed at the Ralph M. Bilby Research Center, and methods of known addition (Perkin-Elmer, 1982).

Nitrate levels were determined colorimetrically using a Technicon Autoanalyzer II, following Technicon industrial method 100-70W. (Technicon, 1973). Samples preserved with PMA were used for this analysis. Reported levels of Nitrate (Table 4) are considered accurate to within 10% of this value.

Ion chromatography was used to determine the concentration of chloride and sulfate. Analyses were carried out on a Wescan model 266-100 ion chromatography module equipped with model 269-030 guard column and model 269-029 anion column, following methods developed by Wescan (Wescan, 1975).

Table 3
CATION ANALYSES
(ppm)

Site	Date (1985)	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺
BA1	6/26	19.00	9.70	1.50	0.95
BA2	6/26	17.30	7.80	1.90	1.10
BA3	6/27	15.10	9.00	1.80	0.55
BA3	7/31	12.60	7.70	1.10	1.20
BA3	9/15	10.50	6.60	1.35	1.30
BA4	6/27	22.00	12.50	2.35	0.90
BA5	6/27	17.10	9.70	2.90	1.00
BA5	7/31	14.60	9.20	1.35	1.30
BA5	9/15	15.00	9.20	1.65	1.70
BA6	6/28	31.00	15.60	3.10	0.40
WMA1	6/29	17.00	8.60	3.20	0.80
WMA1	7/31	17.10	8.80	1.50	1.35
WMA1	9/15	18.20	11.20	1.55	1.40
WMA2	6/29	20.10	8.60	1.85	1.35
WMA3	7/31	15.80	10.00	2.50	2.25
OCA1	9/14	27.40	22.00	4.35	3.55
OC2	9/14	32.20	42.50	130.50	15.95
OC3	9/14	41.30	12.20	8.45	3.10
OC4	9/14	212.00	121.00	90.00	19.95

Table 4
ANION ANALYSES

Site	Date (1985)	HCO ₃ ⁻ (ppm)	NO ₃ ⁻ (ppb)	Cl ⁻	SO ₄ ⁻²
BA3	6/27	4.88	—		
BA3	7/31	2.66	56.2		
BA3	9/15	4.88	141.3		
BA4	6/27	9.33	—		
BA5	6/27	3.11	—		
BA5	7/31	4.00	738.5		
BA5	9/15	5.33	785.4		
BA6	6/28	8.44	—		
WMA1	6/29	7.99	—		
WMA1	7/31	7.33	549.5		
WMA1	9/15	3.77	339.5		
WMA2	6/29	4.44	—		
WMA3	7/31	4.00	339.5		
OCA1	9/14	9.33	277.2		
OC2	9/14	21.98	41.1		
OC3	9/14	4.44	814.2		
OC4	9/14	11.77	88.3		

Table 5

Trace Metal Analyses

Sample		PPB As	PPB Ba	PPB Cd	PPB Cr	PPB Cu	PPB Fe	PPB Mn	PPB Ni	PPB Pb	PPB Se	PPB Zn
BA1*	6/26	<.5	73	.5	<.1	<1	4	1.3	<1	<.5	<1	5
BA2*	6/26	<.5	28	.6	.2	4	69	2.6	<1	.5	<1	16
BA3*	6/27	<.5	95	.1	.1	<1	14	9.7	<1	<.5	<1	4
BA3*	7/31	<.5	84	.2	.1	2	2.7	1.7	<1	<.5	<1	9
BA3*	9/15	<.5	87	<.1	<.1	<1	16	2.9	<1	<.5	2	4
BA4*	6/27	.6	88	<.1	<.1	<1	23	87.5	<1	<.5	<1	4
BA5*	6/27	<.5	85	<.1	<.1	<1	1	1.6	<1	<.5	<1	8
BA5*	7/31	<.5	86	<.1	<.1	1	<1	1.3	<1	<.5	<1	6
BA5*	9/15	1.9	80	<.1	<.1	<1	<1	<.5	<1	<.5	<1	4
BA6*	6/28	<.5	84	.2	.2	<1	11	16.8	<1	<.5	<1	6
OCA1*	9/14	2.3	885	1.1	.4	1	9	3.3	<1	<.5	<1	4
OC2*	9/14	9.1	258	1.1	<.1	1	4	37.0	<1	<.5	4	<1
OC3*	9/14	<.5	330	<.1	<.1	<1	9	154.4	<1	<.5	<1	6
OC4*	9/14	.9	113	.2	<.1	1	29	32.8	<1	.8	<1	<1
WMA1*	6/29	<.5	134	<.1	.2	<1	5	1.4	<1	<.5	<1	4
WMA1*	7/31	1.6	173	.5	.1	4	9	7.8	<1	1.8	<1	19
WMA1*	9/15	3.5	188	.5	.1	<1	1	0.9	<1	<.5	<1	3
WMA2*	6/29	.7	190	<.1	.1	1	9	2.1	<1	1.3	<1	18
WMA3*	7/31	<.5	156	.2	<.1	2	13	12.1	<1	<.5	<1	6

RESULTS

Field and laboratory data are summarized in tables 2-5. All of the waters analyzed in this study show concentrations well within the common range for dissolved constituents of groundwater (Hem, 1970).

The relatively high concentrations of calcium and magnesium observed in the water of OC4 may be attributed to extended residence time of the water in the aquifer, and the depth at which the White Rim sandstone aquifer occurs in the stratigraphic section. Long residence times allow for extended chemical interaction between the water and the aquifer in which it is contained, resulting in greater concentrations of dissolved constituents (Brownlow, 1979). Hand (1979) reported an increase in the dissolved constituents of groundwater in this region, with increasing depth in the stratigraphic section. The water from this spring, while high in calcium and magnesium concentrations relative to other spring waters analyzed in this study, are not anomalous when compared to average water compositions (Hem, 1970).

The results of the present study compare rather well with those of Hand (1979), included in Appendix II. Collection and analytical methodologies were not discussed in his report, and may account for minor discrepancies between the two data sets.

SUGGESTIONS FOR FUTURE STUDIES

The establishment of a baseline chemical character for spring waters in the Glen Canyon National Recreation Area allows the evaluation of future changes in the water chemistry owing to human interference. This study provides valuable information as to the nature of the natural waters in the Waterpocket Fold, Wilson Mesa, and Orange Cliffs areas, however, much more information, in the form of chemical analyses of these and other springs, is necessary to fully accomplish the objectives of this study.

In order to establish a broader data base, additional springs in these three areas should be located and sampled for chemical analysis. The springs that were sampled in this study, and any additional springs analyzed in future studies, should be sampled during other seasons of the year in order to observe any seasonal variations in their chemistry. The field and analytical methods employed for the present study should be utilized in future studies to preserve continuity of analyses, thereby giving validity to data comparison.

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APPENDIX I
SITE DESCRIPTION AND VEGETATION INVENTORY

SITE DESCRIPTION AND VEGETATION INVENTORY*

*Vegetation inventories were made by Jim Holland, Natural Resource Management Specialist, during the September water sampling trip.

BA1

Alcove spring issuing from Navajo sandstone bedding plane seeps. Some water may be contributed by runoff over the cliff above. Pool is approximately 50'X 20'X 2'deep. Dense vegetation, abundant aquatic life present.

BA2

Alcove spring issuing from Navajo sandstone bedding plane seeps, minor shallow pool present. Receives direct sun throughout the afternoon.

BA3

Very impressive alcove spring at the head of the west fork of Bown's canyon. Spring issues from Navajo sandstone bedding plane seeps and is collected in a large pool approximately 30'X 50'X 7' maximum depth. Abundant aquatic life is present and deer were sighted here as well. The alcove faces south and is exposed to direct mid-day sun. The surrounding area supports a variety of mesic perennial plants:

Populus fremontii
Baccharis glutinosa
Rhamnus betulaeifolia
Celtis reticulata
Clematis ligusticifolia
Rhus trilobata
Quercus gambelli
Juncus acutus
Cirsium rydbergii
Lobelia cardinalis
Mimulus cardinalis
Aquilegia micrantha

Hydrocotyle verticillata
Oenothera longissima
Parthenocissus inserta
Conyza canadensis
Adiantum capillus-veneris
Calamagrostis scopulorum
Typha angustifolia
Aster frondosus
Agropyron barbinoides
Solidago sparsiflora
Panicum lanciginosum

BA4

Large stagnant pool approximately 35'X 20'X 6'deep. Spring issues from the Navajo sandstone, however, the source is not visible, and the pool is fed through sandy alluvium. In the valley below there are many down cottonwood trees felled by beaver.

BA5

Alcove spring issuing from the Navajo sandstone just above the Navajo/Kayenta contact. Water runs through Navajo talus. Collection was from running stream above the pool. The size of the pool did not vary throughout the summer, remaining approximately 15'X 20'X 8''deep. Abundant aquatic life present. The slope is vegetated with primarily woody species with a herbaceous understory.

Plant inventory:

Populus fremontii	Phragmites australis
Ptelea trifoliata	Veronica anagallis-aquatica
Rhamnus betulaeifolia	Clematis ligusticifolia
Tamarix ramosissima	Parthenocissus inserta
Cercis occidentalis	Lepidium montana
Juncus acutis	Plantago major
Solidago sparsiflora	Rhus trilobata
Baccaris	Conyza canadensis
Poa annua	Querus gambelii
Salix exigua	Artemisia ludoviciana
Typha angustifolia	Erigeron divergens
Celtis reticulata	

BA6

Alcove spring issuing from the Navajo sandstone just above the Navajo/Kayenta contact. No pool is present, well developed soils and abundant vegetation apparently take up the majority of the flow. Collection was from a small stream near the source. Access is easy.

WMA1

Large alcove with numerous seeps draining into a shallow pool floored by sand derived from the Navajo sandstone from which the seeps issue. Collection was from the eastern most seep at the source in June and September. Owing to an inoperable pump the July collection was from the pool. Abundant aquatic life is present, including "crawfish". Deer were also sighted here. The entire alcove supports perennial mesic vegetation.

WMA1, continued

The community composition is primarily herbaceous with a few scattered trees.

Plant inventory:

Poa bigelovii
Aquilegia micrantha
Adiantum capillus-veneris
Cirsium rydbergii
Ptelea trifoliata
Rhamnus betulaefolia
Juncus bufonius
Brickellia longifolia
Mimulus cardinalis
Calamagrostis scopulorum

Parthaenocissus inserta
Equisetum variegatum
Muhlenbergia curtifolia
Xanthium strumarium
Populus fremontii
Cercis occidentalis
Solidago sparsiflora
Carex sp.
Bromus tectorum

WMA2

Alcove spring issuing from joints within the Navajo sandstone just above the Navajo/Kayenta contact (contact is visible here). A small shallow pool is present in the center of the alcove. Grasses and reeds are abundant. The spring appears to be frequented by visitors from the lake, as access is easy and trails are well worn.

WMA3

Large alcove in the Navajo sandstone. Numerous bedding plane seeps drain into a long narrow pool located at the base of the cliff. An additional spring, located on the ledge above this spring, was cited from the air, however, it is inaccessible from air and land.

OCA1

"Clyde's Spring" located in a north facing alcove, the spring issues from bedding planes and possible joints in the Navajo sandstone, just above the Navajo/Kayenta contact. Water runs through Navajo talus and alluvium before collecting in a small pool. Flow rate is quite low and the source was inaccessible, thus collection was from the pool. This spring has previously been developed as evidenced by a storage tank and collapsed wooden structure. The alcove contains perennial mesic vegetation composed primarily of herbaceous species with some woody species interspersed.

OCA1 continued

Plant inventory:

Rhamnus betulaefolia
 Salix exigua
 Cercis occidentalis
 Toxicodendron rydbergii
 Quercus gambelii
 Aster frondosus
 Ribes montigenum
 Clematis ligusticifolia

Epipactis gigantea
 Shepherdia rotundifolia
 Pinus edulis
 Salix gooddingii
 Artemisia ludoviciana
 Muhlenbergia curtifolia
 Aquilegia micrantha

OC2

Spring is located in the floor of Horsethief Canyon. It issues from a conglomeratic unit near the top of the Chinle formation. The canyon is walled by the Wingate sandstone.

Plant inventory:

Oxytenia acerosa
 Solidago sparsiflora
 Cirsium rydbergii
 Epipactis gigantea
 Carex aurea
 Equisetum variegatum
 Phragmites australis
 Machaeranthera canescens

Tamarix ramosissima
 Thelypodopsis divaricata
 Gutierrezia microcephaea
 Hedysarum borale
 Chrysothamnus nauseosus
 Rhus trilobata
 Muhlenbergia curtifolia

OC3

"French's Spring" issues from the top of the Navajo sandstone at the contact with the overburden. It is used for cattle, and in one area has been developed by means of a pipe and trough. No pool is present. The perennial mesic flora consists of:

Rosa woodsii
 Chrysothamnus nauseosus
 Solanum trifoliatum
 Pinum edulis
 Gutierrezia microcephaea
 Juniperus osteosperma
 Amelanchier utahensis
 Quercus gambelii
 Marrubium vulgare
 Amaranthus graecicus

Polygonum aviculare
 Sonchus aspera
 Conyza canadensis
 Berberis fremontii
 Senecio multilobatus
 Clematis ligusticifolia
 Senecio spartioides
 Bouleloua gracilis
 Tiquilia lator
 Astragalus lonchocarpus

OC4

"Big Water Spring" issues from the White Rim sandstone member of the Cutler formation and flows through a vegetated slope into a small creek. The source is inaccessible for sampling, therefore the samples were collected from the stream. Cattle are present in the area.

The lands surrounding Big Water Spring support arid land vegetation typical of the lower elevations of the Colorado Plateau. The mesic vegetation is conspicuous in contrast. The adjacent lands support primarily a blackbrush/mixed shrub community.

Plant inventory:

Coleogyne ramosissima
Cowainia mexicana
Hilaria jamesii
Eriogonum alatum
Rhus trilobata
Juniperus osteosperma
Berberis fremontii
Opuntia phaeacantha
Astragalus amphioxys
Senecio multilobatus
Penstemon utahensis
Cryptantha confertifolia
Fraxinus anomala
Yucca angustifolia
Bouteloua curtipendula
Artemisia ludoviciana
Haplopappus acaulis
Cordylanthus wrightii
Fraseria paniculata
Machaeranthera grindelioides
Artemisia bigelovii
Oxybaphus linearis

Aristida purpurea
Bouteloua curtipendula
Arenaria eastwoodiae
Euphorbia fendleri
Oenothera caespitosa
Thelosperma subnudum
Sporobolus cryptandrus
Heterotheca villosa
Astragalus lonchocarpus
Machaeranthera canescens
Atriplex canescens
Delphinium scaposum
Sclerocactus whipplei
Townsendia incana
Hymenoxys richardsonii
Cryptantha flavoculata
Oenothera coronopifolia
Ambrosia acanthicarpa
Atriplex canescens
Psoralea canescens
Eriogonum corymbosum
Brickellia microphylla

APPENDIX II

Chemical data from Hand, 1979

Spring Localities (Hard, 1979)

Spring No.	Location*	Aquifer
1	27-13-bad, Horseshoe Canyon	Navajo/Kayenta
2	27-16-4-bdc, Horseshoe Canyon	"
3	27-16-19-aad, Horseshoe Canyon	"
4	27-16-36-cda, Big Spring	"
5	28-15-36-cad, Upper Pasture spring	"
6	28-16-1-adc, Clyde's spring	"
7	28-16-28-cbb, 3 Fingers spring	"
8	29-15-24-aba, Wildcat spring	"
9	29-15-24-aba	"
10	29-16-19-add	"
11	29-16-30-aab	"
12	29-16-20-add, Burro seep	"
13	30-16-3, French's spring	"
14	30-16-4-dcb Fr. spring fork spring	"
15	27-17-20-cbb, Horsethief Canyon	Wingate
16	27-17-20-bbd, Horsethief Canyon	"
17	27-17-4-dcd, Horsethief Canyon	Chinle
18	27-17-20-abc, Horsethief Canyon	"
19	28-17-23-bad, Anderson Bottom spg.	White Rim mbr- Cutler fm.
20	29-16-28-cbc, Hans Flat well	Cedar Mesa mbr-Cutler fm.
21	29-18-20-cod, Horse Canyon Spring	"
22	30-17-23-occ, South Fork spring	"
23	30-18-6-dbc, Pictograph Spring	"
24	30-18-9-bbd, Jasper Canyon spring	"
25	30-18-15-cca, Water Canyon spring	"
26	30 $\frac{1}{2}$ -17-28-cdb, Sheep's spring	"

* Township south-range east-section-quarter section-quarter quarter section, etc.

Chemical Analyses of Spring Waters (Hard, 1979)

Spring No.	Date (1978)	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	HCO ₃ ⁻	SO ₄ ⁻²	Cl ⁻	NO ₃ ⁻
1	7/10	31	38	17	7.8	280	38	9.0	5.1
2	8/1	27	36	17	7.6	240	67	14	3.1
3	6/10	44	25	4.3	3.0	210	22	26	1.8
4	6/10	29	25	9.9	5.5	190	24	16	6.2
5	6/15	49	34	9.6	3.3	320	19	23	1.3
6	6/10	42	7.9	0.8	5.0	160	13	5.2	4.4
7	6/17	52	8.1	3.0	4.3	190	11	11	4.0
8	6/13	53	31	7.3	2.5	300	24	8.5	.4
9	6/14	33	22	4.9	1.9	200	17	8.1	2.2
10	6/14	40	23	5.8	1.7	210	25	11	3.1
11	6/14	26	18	4.0	1.2	170	11	7.8	0.9
12	6/18	43	22	6.9	2.2	200	13	8.5	4.0
13	7/14	49	15	24	2.1	190	41	22	23.0
14	8/02	36	21	11	2.2	190	34	3.7	2.7
15	7/10	26	34	32	6.2	290	27	7.1	5.3
16	7/10	23	30	29	6.6	260	23	0.0	8.0
17	7/10	20	37	210	17	410	180	62.0	1.3
18	7/10	40	41	41	8.8	400	36	8.5	0.9
19	8/12	34	10	18	5.8	150	42	2.2	0.4
20	11/25	230	51	180	47.0	230	960	52	0.0
21	7/25	110	58	46	10	280	380	20	3.1
22	7/29	58	28	13	3.8	300	51	14	0.4
23	7/26	51	50	30	4.6	340	89	8.5	1.3
24	7/27	82	29	12	2.6	360	8.0	10	0.7
25	8/02	74	16	26	2.1	300	49	15	1.3
26	7/24	33	17	7.1	2.7	180	25	2.2	3.5

Analyses by Wyoming department of Agriculture, Division of Laboratories, Laramie Wyoming.