1991 WATER QUALITY SURVEY

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Water quality testing for the summer of 1991 included two circuits ot testing, the first from 6/10 through 6/28, and the second from 7/15 through 7/18. Twenty five pools and 2 streams were tested on the refuge.

The Hach Drel 2000 water quality kits used in 1990 and 1991 consist of a conductivity meter, pH meter, digital titrator, and spectrophotometer. Six basic tests were performed on all twenty-seven bodies of water.

Water Areas Tested

A-1	F-1	Upper Goose Pen	T-2 East	Driggs River
B-1	G-1	Lower Goose Pen	T-2 West	Spur Pool #1
C-1	H-1	M-2	Delta Creek	Spur Pool #2
D-1	I-1	A-2	Marsh Creek	Spur Pool #3
E-1	J-1	C-2	Stagnant Pool	Spur Pool #4
		Diversion Ditch	C-3	

Basic Tests Performed

Conductivity Meter
*temperature (C)
*conductivity (mS/cm)
*total dissolved solids (mg/L)

Spectrophotometer
*turbidity (NTU)

Digital Titrator
*alkalinity (mg/L)

pH meter
*pH

Eight priority pools were chosen to undergo nine more specific test.

Priority Pools
A-1, C-1, D-1, F-1, J-1, M-2, A-2, C-3

Priority Tests

Digital Titrator
*total hardness
*calcium
*magnesium
*carbon dioxide

Spectrophotometer
*sulfate
*tannin & lignin
*nitrogen ammonia
*nitrate, low range
*nitrate, high range

The same tests were done in 1990 as well as 1991. In 1989 only conductivity, total dissolved solids, temperature, pH, and alkalinity were performed on selected pools.

WATER QUALITY TESTING DATES
1991

POOL	CIRCUIT #1	CIRCUIT #2
A-1*	6/24	7/15, 7/16
B-1	6/13	7/16
C-1*	6/13, 6/27	7/16, 7/18
D-1*	6/13, 6/27	7/16
E-1	6/10	7/16
F-1*	6/13, 6/27	7/16, 7/18
G-1	6/13	7/16
H-1	6/13	7/16
I-1	6/10	7/16
J-1*	6/10, 6/26	7/16, 7/18
Upper Goose Pen	6/13	7/15
Lower Goose Pen	6/13	7/15
T-2 East	6/24	7/15
T-2 West	6/24	7/15
M-2*	6/24	7/15, 7/16
C-2	6/24	7/16
A-2*	6/24	7/16
Delta Creek Pool	6/28	7/17
Marsh Creek Pool	6/28	7/15
Stagnant Pool	6/28	7/15
Spur Pool #1	6/28	7/17
Spur Pool #2	6/28	7/17
Spur Pool #3	6/28	7/17
Spur Pool #4	6/28	7/17
C-3*	6/28	7/15, 7/17
Driggs River	6/28	7/15
Diversion Ditch	6/28	7/15

* indicates priority pools

* Hach water quality kits
* distilled water
* water sampling bottle
* 2-quart milk jugs
* disposal bottles
* paper towels
* pen and paper
* refuge map
* waders
* instruction booklets
* vehicle

Before beginning any testing read all manuals. Both kits should be checked to insure all batteries are in the machines and all chemicals are present in sufficient amounts. About four gallons of distilled water will be needed for each circuit of testing. Five or six two-quart washed milk jugs will be useful to get priority pool testing water. A vehicle (preferably a truck) is needed, as well as a pair of hip waders.

Once the pool to be tested is reached and the waders have been put on, take a water sampling bottle and the conductivity meter (and a two-quart milk jug if a priority pool), then walk out into the pool until a water depth of about two feet is reached. Wait until the silt and sediment clear away from the area then take the water sampling bottle and rinse with pool water. Fill by holding the bottle upside down and pushing into the water. When the bottle is about halfway between the sediment and surface turn the bottle right side up until it is filled (this way only water from beneath the surface is collected, fill the milk jug with water in the same manner). The water bottle (and jug) can then be thrown to shore. Follow the instructions in the guide to the conductivity meter and perform the temperature, conductivity, and total dissolved solids tests while in the two feet depth of water. Remember to keep accurate records of test results.

Once out of the pool pick up the filled water sampling bottle (and milk jug if priority pool) , put the conductivity meter away, and set up the Hach kits on the tailgate (if it is a truck). Alkalinity, turbidity, and pH tests are performed in the field. Put all water with chemicals added into disposal bottle, never dump any chemicals on the ground.

If the pool was one of the priority pools, take the two-quart milk jug of water back to the lab at headquarters and perform the total hardness, calcium, magnesium, carbon dioxide, sulfate, tannin & lignin, nitrogen ammonia, nitrate lr, and nitrate hr tests. Do not rinse any chemicals down the sink, put them in disposal bottles. Priority testing should be performed the same day as the water was collected, do not run tests on water stored overnight.

A-1 259 acres
B-1 243 acres
C-1 302 acres
D-1 197 acres
E-1 490 acres
F-1 258 acres
G-1 202 acres
H-1 111 acres
I-1 129 acres
J-1 214 acres
UGP 27 acres
LGP 93 acres
A-2 282 acres
M-2 863 acres
C-2 501 acres
T-2 410 acres
C-3 702 acres
Marsh Creek Pool 950 acres
Delta Creek Pool 85 acres

Alkalinity
Alkalinity is defined as the quantitative capacity of water to react with hydrogen ions to a preselected pH endpoint. Alkalinity commonly results from carbon dioxide and water attacking sedimentary carbonate rocks and dissolving out some of the carbonate to form bicarbonate solutions (Cole, 1975).

Carbon Dioxide
Carbon dioxide is a common nutrient needed in large quantities for cell development. The daily and seasonal carbon flow in a system can be used to estimate the maximum production at higher trophic levels (Goldman & Horne, 1983).

Conductivity
Electrolytic conductivity is the capacity of ions in a solution to carry electrical current. Current is carried by inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, calcium, magnesium, iron, and aluminum.

Nitrogen and Ammonia
Nitrogen occurs in freshwater systems in several forms including dissolved molecular nitrogen, nitrates, and nitrites. Ammonia is a biologically active nutrient that is present in most waters as a normal degradation product of nitrogenous organic matter (WRFSL, 1984).

pH
pH is a measure of hydrogen ion activity in a water sample.

Sulfate
The sulfate form of sulfur is found almost everywhere in natural waters (WRFSL, 1984).

Tannin & Lignin
Lignin is the skeletal material of leaves.

Temperature
Temperature was recorded in degrees C.

Total Hardness
Water hardness is a measure of metallic ions dissolved in water. Calcium and magnesium are the primary factors, but metals such as iron and manganese may be present (Cole, 1975).

Turbidity

Turbidity is the lack of transparency caused by suspended particles which can be stirred up from the bottom, by dissolved materials leaching from plants, and also by algal growth (Doepke, 1991). A top layer of mud can be easily resuspended by wind and thus causes a high turbidity which can restrict submerged macrophytes and the fish feeding off the bottom fauna (Dokulit, Metz, & Jewson, 1980).

Total Dissolved Solids

The dissolved solids in natural waters primarily consists of carbonate, bicarbonates, chlorides, sulfates, and phosphates, but may also include nitrates of calcium and potassium.

Calcium & Magnesium

Calcium is the predominate compound in most interior waters, magnesium is usually the second most abundant. These two elements make up most of the total hardness.

A-1*	TEST #1	TEST #2
Con. (mS/cm)	126	132.6
TDS (mg/L)	62.8	66.3
Temp. (C)	21.6	23.6
pH	7.69	8.26
Alk. (mg/L)	39	49
Turb. (NTU)	21	10

B-1	TEST #1	TEST #2
Con. (mS/cm)	74.6	77.4
TDS (mg/L)	37.3	38.7
Temp. (C)	21.9	24.7
pH	7.15	7.48
Alk. (mg/L)	46	28
Turb. (NTU)	18	9

C-1*	TEST #1	TEST #2
Con. (mS/cm)	107.8	124.0
TDS (mg/L)	53.9	62
Temp. (C)	21.5	23.1
pH	8.84	8.52
Alk. (mg/L)	45	54
Turb. (NTU)	15	9

D-1*	TEST #1	TEST #2
Con. (mS/cm)	84.4	80.9
TDS (mg/L)	42.2	40.4
Temp. (C)	22.1	22.7
pH	8.58	8.02
Alk. (mg/L)	36	28
Turb. (NTU)	19	6

E-1	TEST #1	TEST #2
Con. (mS/cm)	89.3	104.9
TDS (mg/L)	44.5	52.4
Temp. (C)	24.5	22.3
pH	7.58	9.02
Alk. (mg/L)	22	42
Turb. (NTU)	8	13

F-1*	TEST #1	TEST #2
Con. (mS/cm)	101.9	94.4
TDS (mg/L)	50.9	47.2
Temp. (C)	19.7	23.2
pH	7.96	9.35
Alk. (mg/L)	50	38
Turb. (NTU)	25	9

G-1	TEST #1	TEST #2
Con. (mS/cm)	140.1	156.6
TDS (mg/L)	67.6	78.3
Temp. (C)	20.9	22.2
pH	8.16	7.69
Alk. (mg/L)	61	65
Turb. (NTU)	13	20

H-1	TEST #1	TEST #2
Con. (mS/cm)	155.8	133.9
TDS (mg/L)	77.9	66.7
Temp. (C)	21.2	23.0
pH	7.60	9.02
Alk. (mg/L)	69	60
Turb. (NTU)	22	12

I-1	TEST #1	TEST #2
Con. (mS/cm)	122.9	103.6
TDS (mg/L)	61.4	52.1
Temp. (C)	22.4	25.1
pH	7.30	8.77
Alk. (mg/L)	55	45
Turb. (NTU)	31	16

J-1*	TEST #1	TEST #2
Con. (mS/cm)	126.3	127.3
TDS (mg/L)	63.1	63.6
Temp. (C)	23.4	23.4
pH	7.54	9.01
Alk. (mg/L)	48	53
Turb. (NTU)	16	13

* indicates priority pools

UGP	TEST #1	TEST #2
Con. (mS/cm)	114.2	132.4
TDS (mg/L)	57.2	66.2
Temp. (C)	22.2	23.4
pH	7.41	8.40
Alk. (mg/L)	47	50
Turb. (NTU)	22	13

LGP	TEST #1	TEST #2
Con. (mS/cm)	90.4	127.1
TDS (mg/L)	45.1	54.0
Temp. (C)	23.4	27.6
pH	8.11	8.77
Alk. (mg/L)	38	48
Turb. (NTU)	14	11

T-2 EAST	TEST #1	TEST #2
Con. (mS/cm)	36.1	35
TDS (mg/L)	18	17.5
Temp. (C)	22.2	23.4
pH	7.00	7.09
Alk. (mg/L)	4	9
Turb. (NTU)	15	12

T-2 WEST	TEST #1	TEST #2
Con. (mS/cm)	23.5	23.3
TDS (mg/L)	11.7	11.7
Temp. (C)	22.2	27.4
pH	6.97	7.21
Alk. (mg/L)	7	8
Turb. (NTU)	9	5

M-2*	TEST #1	TEST #2
Con. (mS/cm)	77	82.6
TDS (mg/L)	38.5	41.4
Temp. (C)	22.1	25.8
pH	7.61	8.26
Alk. (mg/L)	29	29
Turb. (NTU)	10	12

C-2	TEST #1	TEST #2
Con. (mS/cm)	99.2	103.2
TDS (mg/L)	49.6	51.6
Temp. (C)	24.3	24.3
pH	7.94	9.16
Alk. (mg/L)	39	45
Turb. (NTU)	17	22

A-2*	TEST #1	TEST #2
Con. (mS/cm)	140.9	151.0
TDS (mg/L)	72	75.8
Temp. (C)	23.5	25.7
pH	8.09	8.08
Alk. (mg/L)	55	60
Turb. (NTU)	38	18

DELTA CREEK	TEST #1	TEST #2
Con. (mS/cm)	160.2	202
TDS (mg/L)	80.2	101
Temp. (C)	26.6	23.8
pH	7.55	7.72
Alk. (mg/L)	60	70
Turb. (NTU)	32	36

MARSH CREEK	TEST #1	TEST #2
Con. (mS/cm)	50.6	47.0
TDS (mg/L)	25.3	43.5
Temp. (C)	21.9	26.0
pH	7.10	6.99
Alk. (mg/L)	15	15
Turb. (NTU)	25	16

STAGNANT P.	TEST #1	TEST #2
Con. (mS/cm)	91.9	95.8
TDS (mg/L)	45.8	48.5
Temp. (C)	21.9	21.5
pH	7.28	6.57
Alk. (mg/L)	49	not done
Turb. (NTU)	127	115

* indicates priority pool

SPUR POOL #1	TEST #1	TEST #2
Con. (mS/cm)	156.1	160.7
TDS (mg/L)	78.1	80.3
Temp. (C)	26.1	24.1
pH	7.52	7.23
Alk. (mg/L)	54	69
Turb. (NTU)	46	42

SPUR POOL #2	TEST #1	TEST #2
Con. (mS/cm)	151.8	147
TDS (mg/L)	75.8	73.5
Temp. (C)	27.0	25.1
pH	7.57	7.78
Alk. (mg/L)	46	61
Turb. (NTU)	28	18

SPUR POOL #3	TEST #1	TEST #2
Con. (mS/cm)	111.2	112.9
TDS (mg/L)	55.9	56.5
Temp. (C)	26.8	25.1
pH	7.77	7.96
Alk. (mg/L)	43	52
Turb. (NTU)	10	9

SPUR POOL #4	TEST #1	TEST #2
Con. (mS/cm)	70.2	70.7
TDS (mg/L)	35.1	35.3
Temp. (C)	26.6	22.8
pH	7.23	7.35
Alk. (mg/L)	19	27
Turb. (NTU)	5	15

C-3*	TEST #1	TEST #2
Con. (mS/cm)	104.8	115.0
TDS (mg/L)	52.4	57.5
Temp. (C)	26.1	25.1
pH	8.40	9.26
Alk. (mg/L)	42	37
Turb. (NTU)	13	14

DRIGGS R.	TEST #1	TEST #2
Con. (mS/cm)	140.5	141.6
TDS (mg/L)	70.3	70.7
Temp. (C)	19.6	16.4
pH	7.56	7.37
Alk. (mg/L)	45	55
Turb. (NTU)	41	14

DIVERSION DITCH	TEST #1	TEST #2
Con. (mS/cm)	139.9	140.1
TDS (mg/L)	70.1	70.1
Temp. (C)	20.5	17.7
pH	7.50	7.33
Alk. (mg/L)	47	48
Turb. (NTU)	34	13

* indicates priority pool

ALKALINITY (mg/L)

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	48	39	47	39	49
B-1	44	52	49	46	28
C-1*	54	63	53	45	54
D-1*	45	52	38	36	28
E-1	61.8	65	46	22	42
F-1*	63	56	45	50	38
G-1	84	62	68	61	65
H-1	90	79	71	69	60
I-1	61	72	68	55	45
J-1*	87	----	65	48	53
Upper Goose Pen	----	54	----	47	50
Lower Goose Pen	----	46	32	38	48
T-2 East	15	13	14	4	9
T-2 West	----	----	----	7	8
M-2*	49	41	64	29	29
C-2	61	41	41	39	45
A-2*	70	45	59	55	60
Delta Creek Pool	140	60	110	60	70
Marsh Creek Pool	77	9	30	15	15
Stagnant Pool	----	16	7	49	----
Spur Pool #1	----	84	64	54	69
Spur Pool #2	----	78	52	46	61
Spur Pool #3	----	62	44	43	52
Spur Pool #4	----	35	26	19	27
C-3*	----	36	78	42	37
Driggs River	----	85	67	45	55
Diversion Ditch	----	61	61	47	48

* indicates priority pool
\- indicates no information available

CONDUCTIVITY (mS/cm)

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	129.0	80.6	122.3	126	132.6
B-1	113.7	71.8	74.8	74.6	77.4
C-1*	124.2	119.0	128.3	107.8	124.0
D-1*	99.0	75.6	85.9	84.4	80.9
E-1	146.0	88.8	93.0	89.3	104.9
F-1*	140.5	118.5	114.1	101.9	94.4
G-1	174.6	139.5	144.3	140.1	156.6
H-1	186.3	157.9	148.7	155.8	133.9
I-1	137.5	130.4	147.3	122.9	103.6
J-1*	177.7	123.3	125.8	126.3	127.3
Upper Goose Pen	-----	97.3	125.1	114.2	132.4
Lower Goose Pen	-----	95.9	94.2	90.4	127.1
T-2 East	39.0	29.8	25.8	36.1	35
T-2 West	-----	-----	-----	23.5	23.3
M-2*	109.7	71.7	74.7	77	82.6
C-2	133.3	88.4	91.8	99.2	103.2
A-2*	188.8	116.9	119.4	140.9	151.0
Delta Creek Pool	187.5	142.2	230.0	160.2	202
Marsh Creek Pool	64.4	50.6	51.9	50.6	47.0
Stagnant Pool	-----	33.5	33.8	91.9	95.8
Spur Pool #1	-----	145.2	162.9	156.1	160.7
Spur Pool #2	-----	142.9	156.2	151.8	147
Spur Pool #3	-----	109.5	118.9	111.2	112.9
Spur Pool #4	-----	67.9	73.6	70.2	70.7
C-3*	-----	113.4	164.7	104.8	115.0
Driggs River	-----	133.8	133.9	140.5	141.6
Diversion Ditch	-----	129.4	137.1	139.9	140.1

*indicates priority pool

-indicates no information available

For Tests Performed

pH

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	8.0	8.48	7.65	7.69	8.26
B-1	-----	7.16	8.26	7.15	7.48
C-1*	8.25	9.06	7.57	8.84	8.52
D-1*	8.25	8.21	8.62	8.58	8.02
E-1	8.3	7.14	7.67	7.58	9.02
F-1*	8.2	7.32	7.36	7.96	9.35
G-1	8.25	8.02	8.27	8.16	7.69
H-1	8.0	7.39	8.60	7.60	9.02
I-1	-----	8.13	7.95	7.30	8.77
J-1*	8.25	8.27	8.79	7.54	9.01
Upper Goose Pen	-----	7.77	7.48	7.41	8.40
Lower Goose Pen	-----	8.38	8.98	8.11	8.77
T-2 East	7.0	7.18	7.51	7.00	7.09
T-2 West	-----	-----	-----	6.97	7.21
M-2*	-----	8.22	8.35	7.61	8.26
C-2	-----	8.24	8.34	7.94	9.16
A-2*	8.0	7.75	8.18	8.09	8.08
Delta Creek Pool	-----	6.78	7.64	7.55	7.72
Marsh Creek Pool	-----	7.08	-----	7.10	6.99
Stagnant Pool	-----	6.67	-----	7.28	-----
Spur Pool #1	-----	7.73	7.65	7.52	7.23
Spur Pool #2	-----	7.77	7.82	7.57	7.78
Spur Pool #3	-----	7.87	7.38	7.77	7.96
Spur Pool #4	-----	7.08	7.38	7.23	7.35
C-3*	8.5	8.36	7.84	8.40	9.26
Driggs River	7.5	7.55	7.48	7.56	7.37
Diversion Ditch	-----	7.27	7.39	7.50	7.33

* indicates priority pool
\- indicates no information available

WATER QUALITY [illegible]
For Tests Performed [illegible]

TEMPERATURE (C)

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	25.1	25.5	23.2	21.6	23.6
B-1	23.3	23.2	23.6	21.9	24.7
C-1*	25.9	23.7	22.9	21.5	23.1
D-1*	27.1	21.8	24.0	22.1	22.7
E-1	25.1	21.6	24.6	24.5	22.3
F-1*	-----	16.6	24.3	19.7	23.2
G-1	29.9	19.9	25.4	20.9	22.2
H-1	28.9	17.3	22.3	21.2	23.0
I-1	24.1	16.1	23.3	22.4	25.1
J-1*	27.2	24.5	22.4	23.4	23.4
Upper Goose Pen	-----	24.7	23.0	22.2	23.4
Lower Goose Pen	-----	24.2	23.8	23.4	27.6
T-2 East	21.3	25.0	24.8	22.2	23.4
T-2 West	-----	-----	-----	22.2	27.4
M-2*	20.1	22.7	23.1	22.1	25.8
C-2	20.7	24.1	23.0	24.3	24.3
A-2*	19.4	23.3	22.7	23.5	25.7
Delta Creek Pool	23.1	21.9	24.1	26.6	23.8
Marsh Creek Pool	23.3	23.4	26.9	21.9	26.0
Stagnant Pool	-----	22.0	24.9	21.9	21.5
Spur Pool #1	-----	20.3	20.6	26.1	24.1
Spur Pool #2	-----	22.8	24.5	27.0	25.1
Spur Pool #3	-----	22.9	24.2	26.8	25.1
Spur Pool #4	-----	22.6	24.7	26.6	22.8
C-3*	-----	23.1	23.3	26.1	25.1
Driggs River	-----	13.9	17.8	19.6	16.4
Diversion Ditch	-----	14.4	18.9	20.5	17.7

* indicates priority pool
\- indicates no information available

WATER QUALITY
For Tests Performed on

TOTAL DISSOLVED SOLIDS (mg/L)

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	65.5	40.1	60.9	62.8	66.3
B-1	56.8	36.1	37.3	37.3	38.7
C-1*	62.3	59.6	64.1	53.9	62
D-1*	49.5	37.8	42.9	42.2	40.4
E-1	73.0	91.5	46.5	44.5	52.4
F-1*	70.2	57.4	56.8	50.9	47.2
G-1	87.3	69.5	71.9	67.6	78.3
H-1	93.0	55.1	74.2	77.9	66.7
I-1	69.8	55.8	73.7	61.4	52.1
J-1*	88.8	64.0	62.9	63.1	63.6
Upper Goose Pen	-----	48.6	62.5	57.2	66.2
Lower Goose Pen	-----	47.9	47.0	45.1	54.0
T-2 East	19.3	14.8	12.8	18	17.5
T-2 West	-----	-----	-----	11.7	11.7
M-2*	54.8	35.9	37.4	38.5	41.4
C-2	67.7	44.1	46.0	49.6	51.6
A-2*	94.4	58.5	59.9	72	75.8
Delta Creek Pool	94.1	71.1	115.2	80.2	101
Marsh Creek Pool	32.2	25.2	25.7	25.3	43.5
Stagnant Pool	-----	16.8	16.8	45.8	48.5
Spur Pool #1	-----	72.7	81.7	78.1	80.3
Spur Pool #2	-----	71.7	78.0	75.8	73.5
Spur Pool #3	-----	54.8	59.6	55.9	56.5
Spur Pool #4	-----	33.9	36.8	35.1	35.3
C-3*	-----	56.7	82.4	52.4	57.5
Driggs River	-----	66.9	67.2	70.3	70.7
Diversion Ditch	-----	64.8	67.7	70.1	70.1

* indicates priority pool
\- indicates no information available

WATER QUALITY STATISTICS FOR 1989, 1990, AND 1991
For Tests Performed On All Pools

TURBIDITY (NTU)

	1989	1990, #1	1990, #2	1991, #1	1991, #2
A-1*	----	------	18.0	21	10
B-1	----	9.0	12.0	18	9
C-1*	----	7.0	11.0	15	9
D-1*	----	11.0	7.0	19	6
E-1	----	21.0	14.0	8	13
F-1*	----	41.0	23.0	25	9
G-1	----	12.0	14.0	13	20
H-1	----	21.0	11.0	22	12
I-1	----	21.0	38.0	31	16
J-1*	----	15.0	12.0	16	13
Upper Goose Pen	----	15.0	21.0	22	13
Lower Goose Pen	----	13.0	12.0	14	11
T-2 East	----	23.0	12.0	15	12
T-2 West	----	-----	-----	9	5
M-2*	----	11.0	9.0	10	12
C-2	----	16.0	11.0	17	22
A-2*	----	27.0	19.0	38	18
Delta Creek Pool	----	28.0	69.0	32	36
Marsh Creek Pool	----	24.0	22.0	25	16
Stagnant Pool	----	37.0	50.0	127	115
Spur Pool #1	----	69.0	67.0	46	42
Spur Pool #2	----	34.0	31.0	28	18
Spur Pool #3	----	10.0	5.0	10	9
Spur Pool #4	----	13.0	4.0	5	15
C-3*	----	22.0	27.0	13	14
Driggs River	----	17.0	14.0	41	14
Diversion Ditch	----	21.0	16.0	34	13

* indicates priority pool
\- indicates no information available

PRIORITY TESTS PERFORMED ON SELECTED POOLS IN 1991

Arranged By Test Performed

	TOTAL HARDNESS		CALCIUM		MAGNESIUM	
	TEST #1	TEST #2	TEST #1	TEST #2	TEST #1	TEST #2
A-1	58	65	42	52	6	13
C-1	57	60	32	37	25	23
D-1	49	45	32	30	17	15
F-1	51	52	35	37	16	15
J-1	65	70	46	50	19	20
A-2	92	85	62	60	30	25
M-2	60	58	36	32	24	26
C-3	72	68	57	49	15	19

	CARBON DIOXIDE		SULFATE		TANNIN & LIGNIN	
	TEST #1	TEST #2	TEST #1	TEST #2	TEST #1	TEST #2
A-1	49	51	0.0	0.0	2.8	2.6
C-1	32	32	0.0	0.0	1.6	1.6
D-1	12	19	0.0	0.0	0.5	1.3
F-1	29	26	1.0	0.0	0.3	2.1
J-1	21	23	1.0	1.0	0.4	1.2
A-2	37	41	0.0	0.0	1.1	1.2
M-2	24	28	1.0	1.0	0.7	2.2
C-3	36	20	0.0	0.0	1.0	0.8

	NITROGEN AMMONIA		NITRATE, LR		NITRATE, HR	
	TEST #1	TEST #2	TEST #1	TEST #2	TEST #1	TEST #2
A-1	0.04	0.04	0.10	0.01	1.2	0.3
C-1	0.07	0.07	0.04	0.03	1.1	0.2
D-1	0.00	0.15	0.04	0.01	0.5	0.4
F-1	0.07	0.03	0.01	0.07	0.1	0.5
J-1	0.00	0.00	0.04	0.01	0.3	0.7
A-2	0.00	0.21	0.03	0.02	0.8	0.6
M-2	0.04	0.01	0.03	0.02	0.7	0.7
C-3	0.15	0.12	0.02	0.01	0.1	0.2

PRIORITY TESTS OF 1990 AND 1991

Arranged By Test Performed

TOTAL HARDNESS

	1990	1991, Test #1	1991, Test #2
A-1	52	58	65
C-1	110	57	60
D-1	114	49	45
F-1	94	51	52
J-1	73	65	70
A-2	88	92	85
M-2	64	60	58
C-3	95	72	68

CALCIUM

	1990	1991, Test #1	1991, Test #2
A-1	41	42	52
C-1	62	32	37
D-1	34	32	30
F-1	52	35	37
J-1	57	46	50
A-2	62	62	60
M-2	46	36	32
C-3	76	57	49

MAGNESIUM

	1990	1991, Test #1	1991, Test #2
A-1	11	6	13
C-1	48	25	23
D-1	80	17	15
F-1	42	16	15
J-1	16	19	20
A-2	26	30	25
M-2	18	24	26
C-3	19	15	19

CARBON DIOXIDE

	1990	1991, Test #1	1991, Test #2
A-1	37	49	51
C-1	45	32	32
D-1	11	12	19
F-1	37	29	26
J-1	23	21	23
A-2	38	37	41
M-2	25	24	28
C-3	42	36	20

Arranged By Test Performed

SULFATE

	1990	1991, Test #1	1991, Test #2
A-1	1.0	0.0	0.0
C-1	0.0	0.0	0.0
D-1	0.0	0.0	0.0
F-1	0.0	1.0	0.0
J-1	0.0	1.0	1.0
A-2	0.0	0.0	0.0
M-2	0.0	1.0	1.0
C-3	0.0	0.0	0.0

TANNIN & LIGNIN

	1990	1991, Test #1	1991, Test #2
A-1	3.4	2.8	2.6
C-1	0.9	1.6	1.6
D-1	0.6	0.5	1.3
F-1	0.9	0.3	2.1
J-1	0.4	0.4	1.2
A-2	1.0	1.1	1.2
M-2	0.7	0.7	2.2
C-3	0.9	1.0	0.8

NITROGEN AMMONIA

	1990	1991, Test #1	1991, Test #2
A-1	0.05	0.04	0.04
C-1	0.28	0.07	0.07
D-1	0.18	0.00	0.15
F-1	0.02	0.07	0.03
J-1	0.00	0.00	0.00
A-2	0.00	0.00	0.21
M-2	0.05	0.04	0.01
C-3	0.02	0.15	0.12

NITRATE, LOW RANGE

	1990	1991, Test #1	1991, Test #2
A-1	0.12	0.10	0.01
C-1	0.03	0.04	0.03
D-1	0.04	0.04	0.01
F-1	0.02	0.01	0.07
J-1	0.04	0.04	0.01
A-2	0.02	0.03	0.02
M-2	0.02	0.03	0.02
C-3	0.01	0.02	0.01

PRIORITY TEST OF 1990 AND 1991

Arranged By Test Performed

NITRATE, HIGH RANGE

	1990	1991, Test #1	1991, Test #2
A-1	1.5	1.2	0.3
C-1	0.3	1.1	0.2
D-1	0.7	0.5	0.4
F-1	0.2	0.1	0.5
J-1	0.9	0.3	0.7
A-2	0.7	0.8	0.6
M-2	0.7	0.7	0.7
C-3	0.5	0.1	0.2

Recommendations

The usefulness of the water quality statistics for the purpose of measuring the productivity in the pools is questionable. A search for some guidelines and information which could correlate the tests performed with productivity was started, but yielded few results. Many suggestions were encountered which may lead to a better way to measure productivity such as measuring invertebrates or the dissolved oxygen levels in the pools. A further search by a person more knowledgeable in the area of water quality and production is strongly recommended.

A concern about iron boosting the conductivity readings of the pools was voiced. Iron is necessary to photosynthetic plants, it is the metal part of at least two plant chromosomes that function in the transfer of electrons during photosynthesis (Cole, 1975). Philip Doepke, a professor at Northern Michigan University that teaches limnology believes that iron is probably not a major portion of conductivity (1991).

A second concern about the quick changes in turbidity was also discussed. Turbidity can reduce photosynthesis and primary production, it can have an effect on the dissolved oxygen and also modify vision in fish (Wilber, 1983). The rapid changes may be caused by wind, animals and fish stirring up the sediments, waterways which spill into the pools may be more turbid, and the growth of some algae and phytoplankton.

Since almost every pool of water on the refuge is tested, it would probably be a good idea to include the show pools also. Many geese and other birds feed on the show pools, so they may also be of interest.

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