Appendix - Maps

Maps displayed in this appendix are listed separately in Table 1.

Table 1. Maps included within Appendix - Maps .	
Figure 1	Subwatershed boundaries within the Echo Reservoir watershed.
Figure 2a	Utah Division of Water Quality monitoring stations located in the northern portion of the Echo Reservoir watershed, including subwatersheds seven, eight, and nine.
Figure 2b	Utah Division of Water Quality monitoring stations located in the southwest portion of the Echo Reservoir watershed, including subwatersheds three through six.
Figure 2c	Utah Division of Water Quality monitoring stations located in the southeast portion of the Echo Reservoir watershed, including portions of subwatersheds one and two.
Figure 3a	Water quality monitoring stations of agencies other than DWQ, located in the northern portion of the Echo Reservoir water including subwatersheds seven, eight, and nine.
Figure 3b	Water quality monitoring stations of agencies other than DWQ located in the southwest portion of the Echo Reservoir watershed, including subwatersheds three through six.
Figure 3c	Water quality monitoring stations of agencies other than DWQ located in the southeast portion of the project area including portions of subwatersheds one and two.

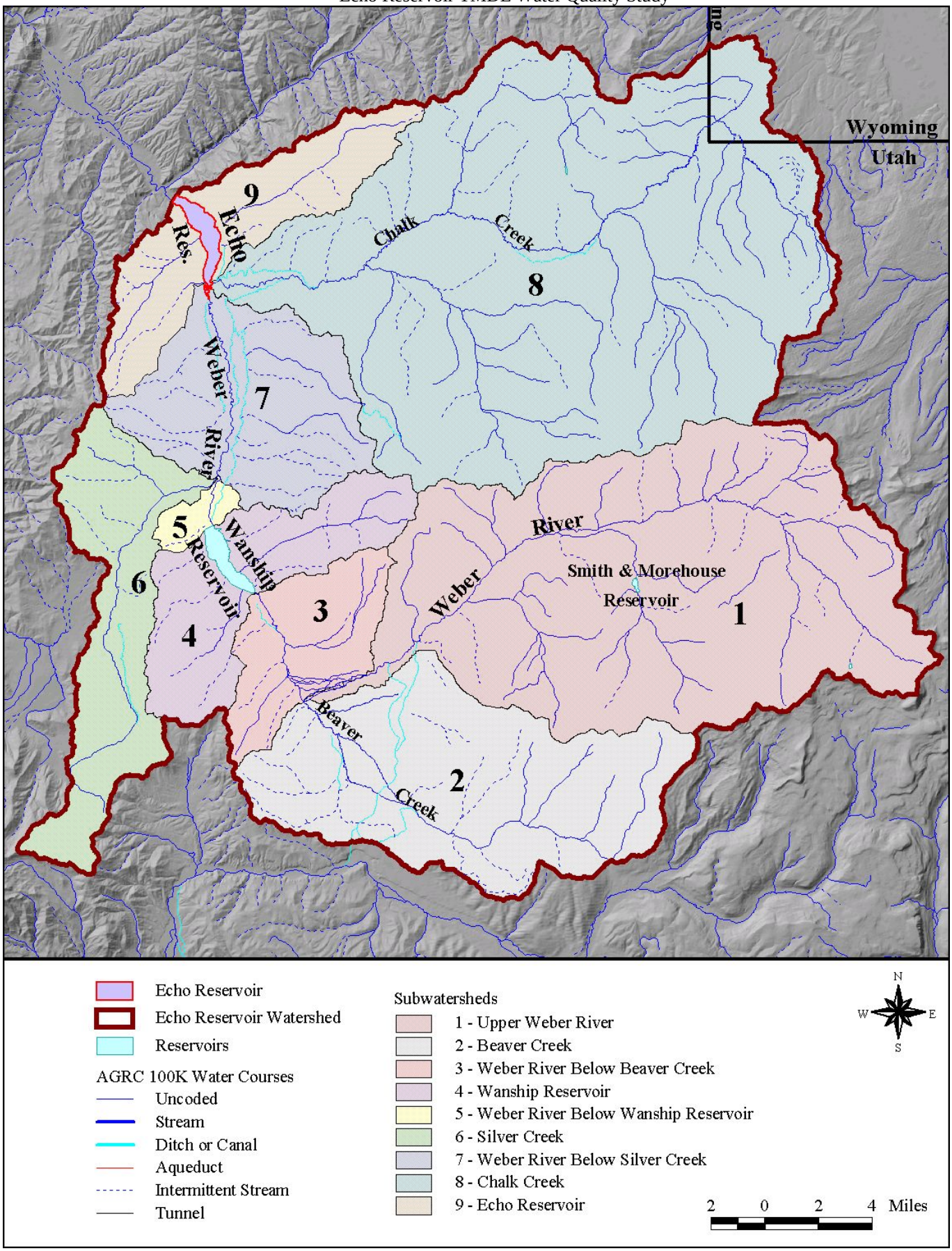


Figure 1. Subwatershed boundaries within the Echo Reservoir watershed.

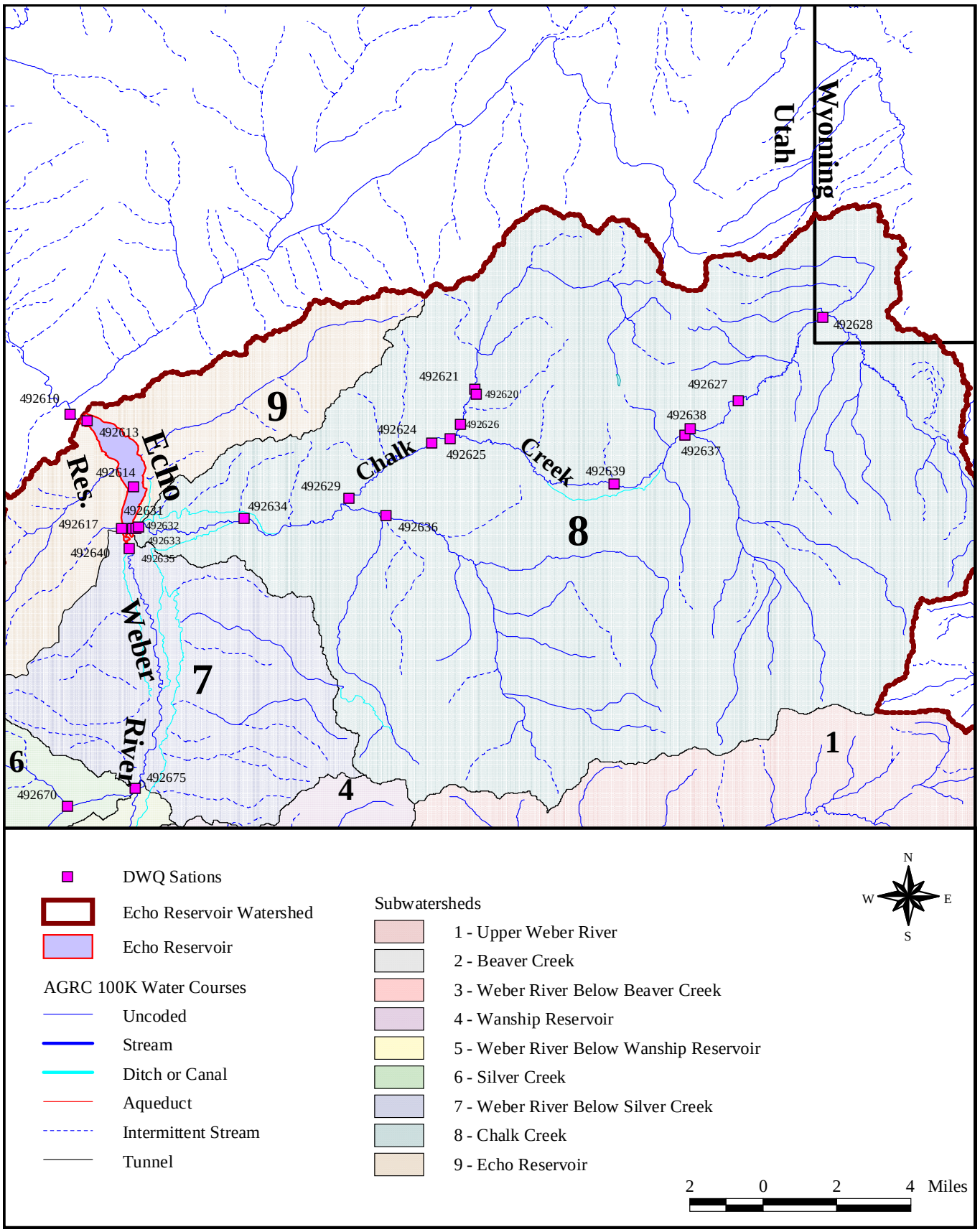


Figure 2a. Utah Division of Water Quality monitoring stations located in the northern portion of the Echo Reservoir watershed, including subwatersheds seven, eight, and nine.

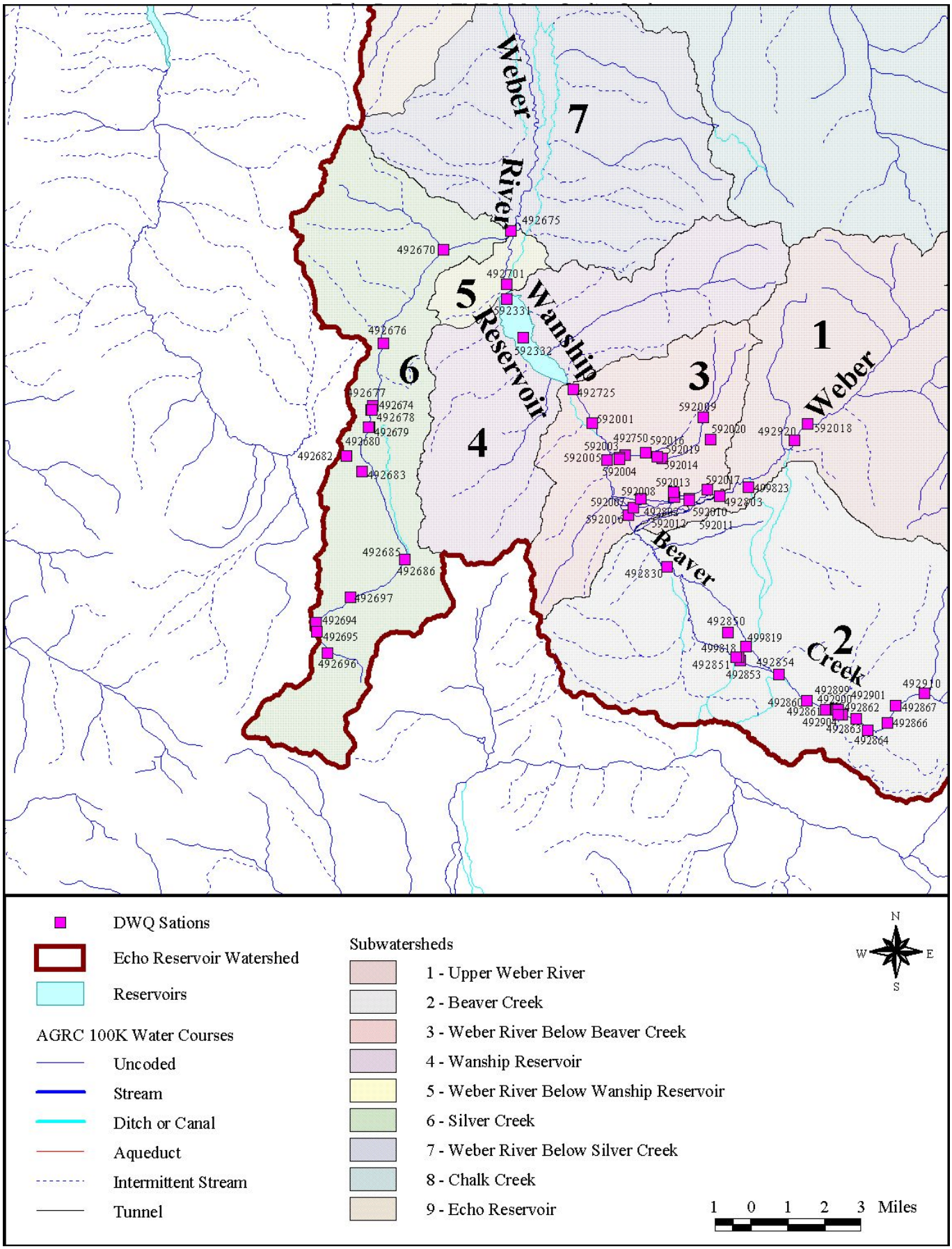


Figure 2b. Utah Division of Water Quality monitoring stations located in the southwest portion of the Echo Reservoir watershed, including subwatersheds three through six.

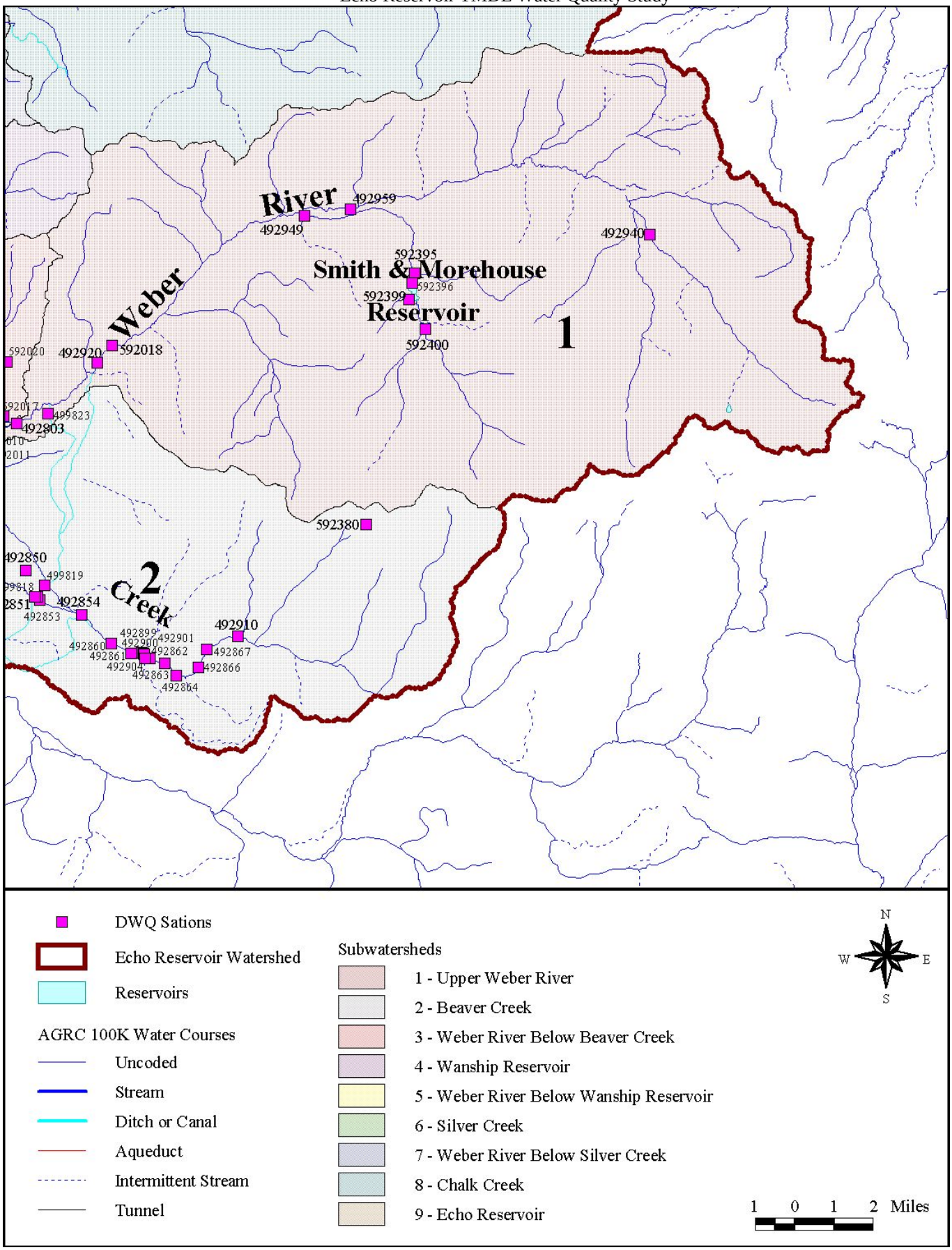


Figure 2c. Utah Division of Water Quality monitoring stations located in the southeast portion of the Echo Reservoir watershed, including portions of subwatersheds one and two.

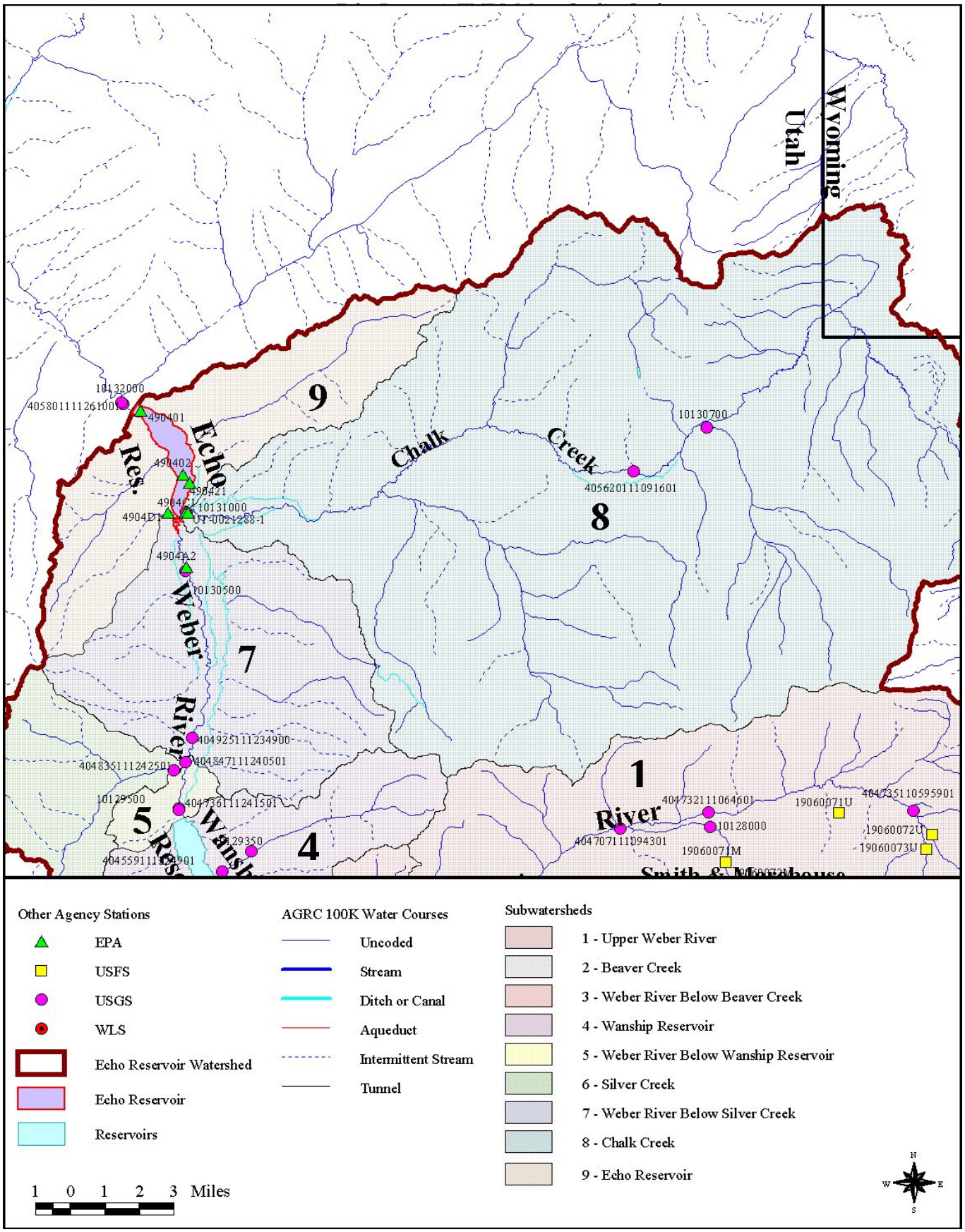
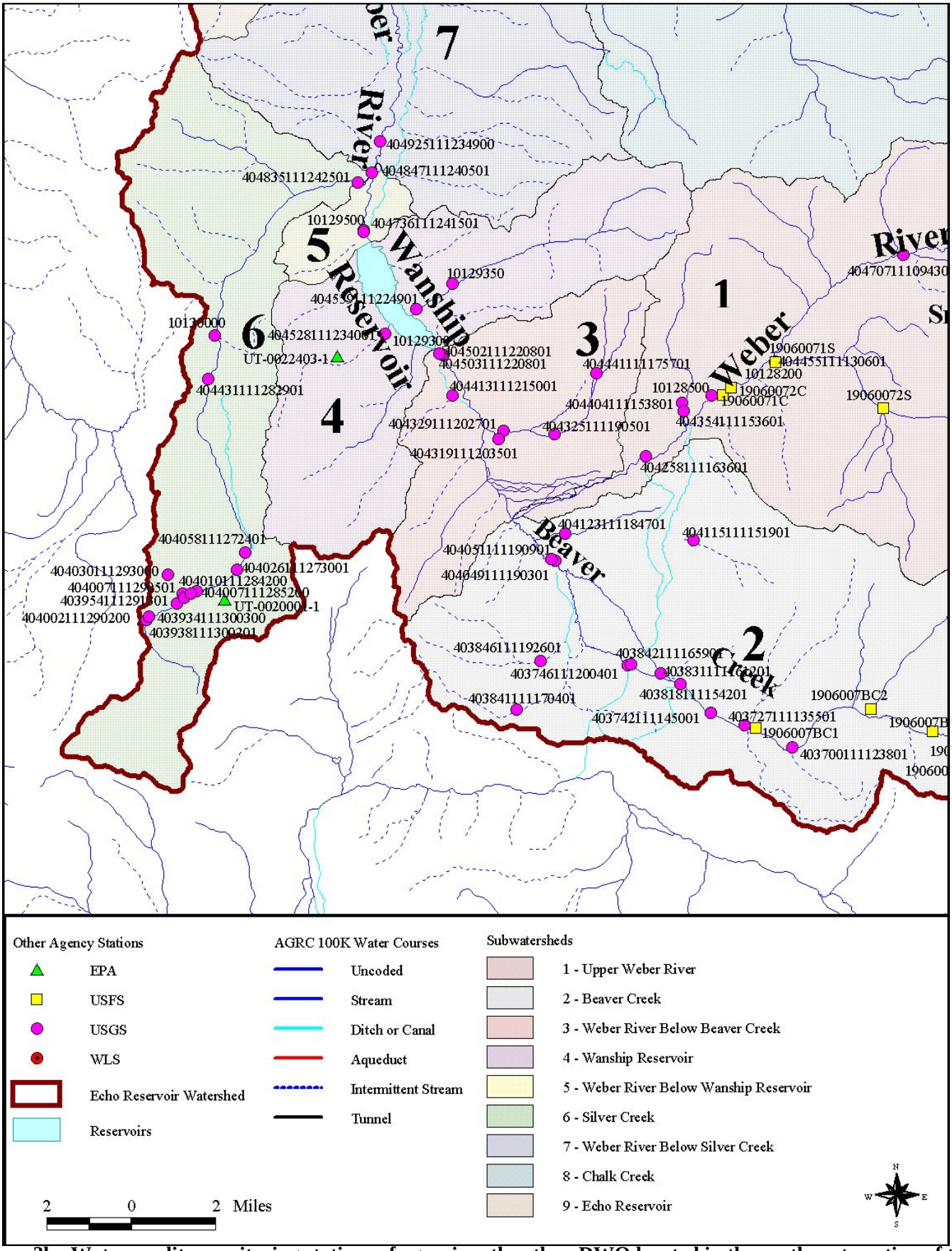


Figure 3a. Water quality monitoring stations of agencies other than DWQ, located in the northern portion of the Echo Reservoir watershed including subwatersheds seven, eight, and nine.



Other Agency Stations
- EPA
- USFS
- USGS
- WLS
- Echo Reservoir Watershed
- Reservoirs

AGRC 100K Water Courses
- Uncoded
- Stream
- Ditch or Canal
- Aqueduct
- Intermittent Stream
- Tunnel

Subwatersheds
- 1 - Upper Weber River
- 2 - Beaver Creek
- 3 - Weber River Below Beaver Creek
- 4 - Wanship Reservoir
- 5 - Weber River Below Wanship Reservoir
- 6 - Silver Creek
- 7 - Weber River Below Silver Creek
- 8 - Chalk Creek
- 9 - Echo Reservoir

2 0 2 Miles

Figure 3b. Water quality monitoring stations of agencies other than DWQ located in the southwest portion of the Echo Reservoir watershed, including subwatersheds three through six.

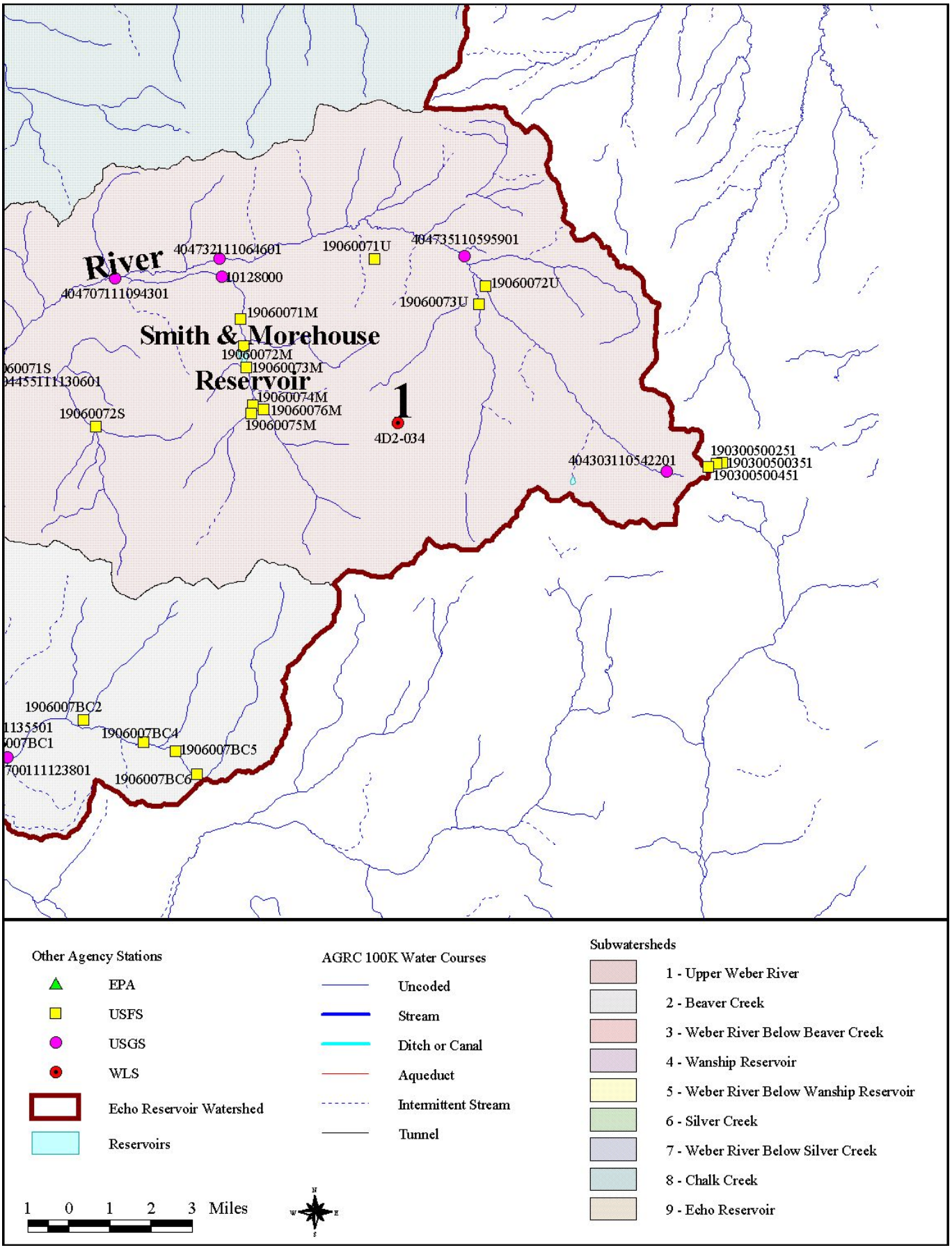


Figure 3c. Water quality monitoring stations of agencies other than DWQ located in the southeast portion of the project area including portions of subwatersheds one and two.

Appendix - Data

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1.0 WATER QUALITY DATA

Water quality data reviewed in this section includes a listing of selected water quality monitoring data used to develop the Echo Reservoir TMDL. A more comprehensive review of all water quality and flow monitoring data can be found in *Echo Reservoir TMDL Water Quality Study – Work Element 1* (DWQ 2003).

1.1 SURFACE WATER QUALITY MONITORING STATIONS

Table 1. Surface water quality monitoring stations located in the TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude	Station Type
USGS	10128000	SMITH AND MOREHOUSE CREEK NEAR OAKLEY, UTAH	40.78578	-111.11240	River/Stream
USGS	10128200	SOUTH FORK WEBER RIVER NEAR OAKLEY, UTAH	40.74856	-111.21963	River/Stream
USGS	10128500	WEBER RIVER NEAR OAKLEY, UT	40.73717	-111.24797	River/Stream
USGS	10129300	WEBER RIVER NEAR PEOA, UTAH	40.75106	-111.37047	River/Stream
USGS	10129350	CRANDALL CREEK NEAR PEOA, UTAH	40.77495	-111.36492	River/Stream
USGS	10129500	WEBER RIVER NEAR WANSHIP, UT	40.79273	-111.40492	River/Stream
USGS	10130000	SILVER CREEK NEAR WANSHIP, UT	40.75689	-111.47159	River/Stream
USGS	10130500	WEBER RIVER NEAR COALVILLE, UT	40.89523	-111.40186	River/Stream
USGS	10130700	EAST FORK CHALK CREEK NEAR COALVILLE, UTAH	40.95773	-111.11463	River/Stream
USGS	10131000	CHALK CREEK AT COALVILLE, UT	40.92050	-111.40159	River/Stream
USGS	10132000	WEBER RIVER AT ECHO, UT	40.96772	-111.43770	River/Stream
113FORS4	190300500251	PEARL LAKE	40.72056	-110.88111	Lake
113FORS4	190300500351	SCOUT LAKE	40.72028	-110.88361	Lake
113FORS4	190300500451	WEST SCOUT LAKE	40.71917	-110.88750	Lake
113FORS4	19060071C	WEBER R. BELOW W/C CAMPGROUND.	40.73750	-111.24278	River/Stream
113FORS4	19060071M	SMITHMOREHOUSE CK-AT FOREST BDRY	40.77111	-111.10361	River/Stream
113FORS4	19060071S	MOUTH OF SW ABOVE CONFL.WL WR.	40.74861	-111.21917	River/Stream
113FORS4	19060071U	WR. AT BRIDGE BELOW HOLIDAY PARK	40.79222	-111.04167	River/Stream
113FORS4	19060072C	WEBER R. ABOVE W/C CAMPGROUND.	40.74000	-111.23917	River/Stream
113FORS4	19060072M	SMITH MOREHOUSE DAM SPILLWAY	40.76167	-111.10222	River/Stream
113FORS4	19060072S	SOUTH WEBER ABOVE SUMMER HOME AR	40.73306	-111.17056	River/Stream
113FORS4	19060072U	UPPER WR. ABOVE BRIDGE.	40.78278	-110.99028	River/Stream
113FORS4	19060073M	SMITH MOREHOUSE DAM INLET	40.75389	-111.10111	River/Stream
113FORS4	19060073U	MIDDLE FK OF WR. ABOVE BRIDGE.	40.77639	-110.99333	River/Stream
113FORS4	19060074M	BELOW CONFL OF SM-AND RED PIN CR	40.74083	-111.09806	River/Stream
113FORS4	19060075M	RED PINE CR. ABOVE GUARD STATION	40.73778	-111.09889	River/Stream
113FORS4	19060076M	SMITH-MREHSE.CR. ABOVE TRLHD.	40.73917	-111.09306	River/Stream
113FORS4	1906007BC1	BEAVER CR. AT FOREST BOUNDARY.	40.62333	-111.22750	River/Stream
113FORS4	1906007BC2	YELLOW PINE CR. AT HWY. CUTVERT.	40.63000	-111.17583	River/Stream
113FORS4	1906007BC4	BEAVER CR. BELOW BEAVER CR. CPGD	40.62222	-111.14833	River/Stream
113FORS4	1906007BC5	BEAVER CR.BELOW SHINGLE CR. CPGD	40.61889	-111.13361	River/Stream
113FORS4	1906007BC6	BEAVER CR. AT BRIDGE ON U-150.	40.61083	-111.12361	River/Stream

Table 1. (cont'd) Surface water quality monitoring stations located in the TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude	Station Type
USGS	403700111123801	BEAVER CREEK ABOVE DIVERSIONS NEAR SAMAK	40.61662	-111.21129	River/Stream
USGS	403727111135501	BEAVER CREEK BELOW FISH HATCHERY	40.62412	-111.23268	River/Stream
USGS	403742111145001	(D- 2- 6)22dca- 1	40.62828	-111.24796	River/Stream
USGS	403746111200401	CITY CREEK NEAR KAMAS, UTAH	40.62940	-111.33518	River/Stream
USGS	403818111154201	BEAVER CREEK ABOVE KAMAS, UT	40.63833	-111.26167	River/Stream
USGS	403831111161201	THORN CREEK NEAR KAMAS	40.64190	-111.27074	River/Stream
USGS	403841111170401	WEBER-PROVO CANAL ABOVE BEAVER CREEK	40.64467	-111.28518	River/Stream
USGS	403842111165901	BEAVER CREEK ABOVE WEBER-PROVO CANAL AT KAMAS	40.64495	-111.28379	River/Stream
USGS	403846111192601	INDIAN HOLLOW NEAR KAMAS	40.64606	-111.32463	River/Stream
USGS	403934111300300	SILVER CRK AT BONANZA DR AT PARK CITY, UT	40.65940	-111.50158	River/Stream
USGS	403938111300201	SILVER CREEK AT BONANZA DR., PARK CITY, UT	40.66056	-111.50056	River/Stream
USGS	403954111291301	SILVER CREEK BELOW PARK CITY	40.66495	-111.48797	River/Stream
USGS	404002111290200	SILVER CRK BL WYATT EARP DR AT PARK CITY, UT	40.66717	-111.48464	River/Stream
USGS	404007111285200	PACE-HOMER DITCH BL PROSPECTOR SQ NR PARK CITY, UT	40.66856	-111.48186	River/Stream
USGS	404007111290501	DORITY SPRING CREEK ABOVE SILVER CREEK	40.66856	-111.48547	River/Stream
USGS	404010111284200	SILVER CRK BL PROSPECTOR SQUARE NR PARK CITY, UT	40.66940	-111.47908	River/Stream
USGS	404026111273001	SILVER CREEK ABOVE RICHARDSON FLAT, UT	40.67678	-111.46133	River/Stream
USGS	404030111293000	PARK MEADOW COLLECTION BOX AT PARK CITY, UT	40.67495	-111.49242	River/Stream
USGS	404049111190301	BEAVER CREEK IN MID KAMAS VALLEY	40.68023	-111.31824	River/Stream
USGS	404051111190901	BEAVER CREEK NEAR MOUTH	40.68078	-111.31991	River/Stream
USGS	404058111272401	SILVER CREEK AT KEETLEY JUNCTION	40.68273	-111.45742	River/Stream
USGS	404115111151901	NORTH FORK HOYT CREEK NEAR MARION, UTAH	40.68745	-111.25602	River/Stream
USGS	404123111184701	CROOKED CREEK AT MOUTH	40.68967	-111.31380	River/Stream
USGS	404258111163601	WEBER RIVER ABOVE WEBER-PROVO DIVERSION	40.71606	-111.27741	River/Stream
USGS	404303110542201	HDWATERS, WEBER RIV BEL REIDS MEADOW NR MIRROR LK	40.71745	-110.90684	River/Stream
USGS	404319111203501	DRAIN AT MARCHANT LANE NEAR PEOA, UTAH	40.72189	-111.34380	River/Stream
USGS	404325111190501	RASMUSSEN CREEK IN PEOA, UTAH	40.72356	-111.31880	River/Stream
USGS	404329111202701	FORT CREEK NEAR MOUTH	40.72467	-111.34158	River/Stream
USGS	404354111153601	WHITES CREEK AT MOUTH	40.73162	-111.26074	River/Stream
USGS	404404111153801	WHITES CREEK NEAR OAKLEY, UTAH	40.73439	-111.26130	River/Stream
USGS	404413111215001	BROWNS CANYON CREEK NEAR PEOA, UTAH	40.73689	-111.36464	River/Stream
USGS	404431111282901	SILVER CREEK NEAR ATKINSON, UT	40.74194	-111.47472	River/Stream
USGS	404441111175701	LOG HOLLOW NEAR OAKLEY, UTAH	40.74467	-111.29991	River/Stream
USGS	404455111130601	SOUTH FORK WEBER RIVER AT MOUTH	40.74856	-111.21908	River/Stream
USGS	404502111220801	WEBER RIVER ABOVE ROCKPORT RESERVOIR, UT	40.75056	-111.36889	River/Stream
USGS	404503111220801	WEBER RIVER ABOVE ROCKPORT RESERVOIR	40.75078	-111.36964	River/Stream
USGS	404528111234001	THREEMILE CANYON CREEK NEAR WANSHIP, UTAH	40.75773	-111.39520	River/Stream

Table 1. (cont'd) Surface water quality monitoring stations located in the TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude	Station Type
USGS	404559111224901	CRANDALL CREEK AT MOUTH	40.76634	-111.38103	River/Stream
USGS	404707111094301	WEBER RIVER BELOW SMITH-MOREHOUSE, UT	40.78528	-111.16194	River/Stream
USGS	404732111064601	WEBER RIVER ABOVE SMITH AND MOREHOUSE CREEK	40.79217	-111.11352	River/Stream
USGS	404735110595901	(A- 1- 8)26daa- 1	40.79300	-111.00045	River/Stream
USGS	404736111241501	WEBER RIVER BELOW ROCKPORT RESERVOIR	40.79328	-111.40492	River/Stream
USGS	404835111242501	SILVER CREEK AT WANSHIP	40.80967	-111.40770	River/Stream
USGS	404847111240501	SILVER CREEK AT WANSHIP, UT	40.81306	-111.40139	River/Stream
USGS	404925111234900	WEBER RIVER NORTHEAST OF WANSHIP	40.82356	-111.39770	River/Stream
USGS	405620111091601	CHALK CREEK ABOVE UPTON	40.93884	-111.15519	River/Stream
USGS	405801111261001	WEBER RIVER BELOW ECHO RESERVOIR	40.96689	-111.43687	River/Stream
11EPALES	490401	ECHO RESERVOIR	40.96417	-111.42694	Lake
11EPALES	490402	ECHO RESERVOIR	40.93694	-111.40333	Lake
11EPALES	490421	COALVILLE	40.93333	-111.40000	River/Stream
11EPALES	4904A2	WEBER RIVER	40.89694	-111.40139	River/Stream
11EPALES	4904C1	CHALK CREEK	40.92056	-111.40194	River/Stream
11EPALES	4904D1	UNNAMED STREAM	40.92028	-111.41167	River/Stream
UTAHDWQ	492610	WEBER R BL ECHO RES	40.96667	-111.43633	River/Stream
UTAHDWQ	492613	ECHO RES AB DAM 01	40.96417	-111.42767	Lake
UTAHDWQ	492614	ECHO RES 2/3 WAY UP LAKE 02	40.93683	-111.40333	Lake
UTAHDWQ	492617	LEWIS CK AB ECHO RES 1.0MI NW OF I80 JCT	40.92017	-111.40933	River/Stream
UTAHDWQ	492626	HUFF CK AB CNFL/ CHALK CK	40.96300	-111.23417	River/Stream
UTAHDWQ	492628	CHALK CREEK AT UT/WYO STATELINE	41.00750	-111.04600	River/Stream
UTAHDWQ	492629	CHALK CREEK AB CNFL/ SOUTH FORK	40.93250	-111.29167	River/Stream
UTAHDWQ	492631	CHALK CK BL COALVILLE WWTP	40.92000	-111.40333	River/Stream
UTAHDWQ	492632	COALVILLE WWTP	40.92000	-111.40350	Facility
UTAHDWQ	492633	CHALK CK AB COALVILLE WWTP	40.92017	-111.40183	River/Stream
UTAHDWQ	492634	CHALK CK AB COALVILLE CITY	40.92417	-111.34600	River/Stream
UTAHDWQ	492635	CHALK CK AT US189 XING	40.92050	-111.40050	River/Stream
UTAHDWQ	492636	CHALK CK S FK 1 MI AB CHALK CK	40.92581	-111.27242	River/Stream
UTAHDWQ	492637	CHALK CK EAST FK AB CNFL/ CHALK CK	40.95883	-111.11750	River/Stream
UTAHDWQ	492638	CHALK CK AT CULVERT 0.8MI AB PINE CLIFF CAMPGROUND	40.96167	-111.11467	River/Stream
UTAHDWQ	492639	CHALK CREEK 4 MILES EAST OF UPTON	40.93883	-111.15433	River/Stream
UTAHDWQ	492640	WEBER R AB ECHO RES	40.91183	-111.40550	River/Stream
UTAHDWQ	492670	ALEXANDER CREEK AT HIGHWAY CROSSING	40.80569	-111.43675	River/Stream
UTAHDWQ	492674	SILVER CK AT FARM XING IN ATKINSON	40.74222	-111.47417	River/Stream
UTAHDWQ	492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	40.81300	-111.40167	River/Stream
UTAHDWQ	492676	SILVER CK 2 MI N OF ATKINSON	40.76850	-111.46767	River/Stream
UTAHDWQ	492677	SILVER CK AT I80 XING AT ATKINSON E OF SILVER CK JCT	40.74383	-111.47300	River/Stream
UTAHDWQ	492678	PACE DAIRY DISCHG NEAR ATKINSON	40.74217	-111.47350	Facility
UTAHDWQ	492679	SILVER CREEK WWTP	40.73517	-111.47467	Facility
UTAHDWQ	492680	SILVER CK AB ATKINSON	40.73517	-111.47517	River/Stream
UTAHDWQ	492682	ROLLS ROYCE EFFLUENT TO SEWER	40.72383	-111.48683	Facility
UTAHDWQ	492683	ROLLS ROYCE 002	40.71767	-111.47833	Facility
UTAHDWQ	492685	SILVER CK AT US40 XING E OF PARK CITY	40.68300	-111.45600	River/Stream

Table 1. (cont'd) Surface water quality monitoring stations located in the TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude	Station Type
UTAHDWQ	492694	SILVER CK AT RR XING BL PARK CITY AB LAND FILL	40.65800	-111.50183	River/Stream
UTAHDWQ	492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	40.65433	-111.50167	River/Stream
UTAHDWQ	492696	ONTARIO CANYON CK AB CNFL / SILVER CK	40.64600	-111.49583	River/Stream
UTAHDWQ	492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	40.66800	-111.48417	River/Stream
UTAHDWQ	492701	WEBER R BL WANSHIP RES	40.79217	-111.40383	River/Stream
UTAHDWQ	492725	WEBER R AB WANSHIP RES	40.75050	-111.36917	River/Stream
UTAHDWQ	492750	FORT CK AB CNFL/ WEBER R	40.72467	-111.34183	River/Stream
UTAHDWQ	492802	OAKLEY LAGOONS	40.70833	-111.31683	Facility
UTAHDWQ	492803	WEBER R AB OAKLEY LAGOONS	40.70850	-111.29300	River/Stream
UTAHDWQ	492830	BEAVER CK AB CROOKED CK	40.68050	-111.32000	River/Stream
UTAHDWQ	492850	KAMAS LAGOONS	40.65467	-111.28850	Facility
UTAHDWQ	492851	BEAVER CK AB KAMAS LAGOONS	40.64383	-111.28183	River/Stream
UTAHDWQ	492853	BEAVER CREEK AB0VE WEBER-PROVO CANAL	40.64500	-111.28300	River/Stream
UTAHDWQ	492854	BEAVER CK AT BRIDGE TO LUMBER MILL 1MI AB KAMAS 19	40.63833	-111.26167	River/Stream
UTAHDWQ	492860	BEAVER CK AT BRIDGE NEAR THE PINES 18	40.62800	-111.24717	River/Stream
UTAHDWQ	492861	BEAVER CK AT BRIDGE TO PRIVATE HOMES 17	40.62433	-111.23767	River/Stream
UTAHDWQ	492862	BEAVER CK AT BRIDGE NEAR RICE HOME 15	40.62250	-111.22883	River/Stream
UTAHDWQ	492863	BEAVER CK NEAR BEAR R SERVICE STATION SIGN 14	40.62083	-111.22167	River/Stream
UTAHDWQ	492864	BEAVER CK BEHIND DEVOS RANCH 13	40.61633	-111.21583	River/Stream
UTAHDWQ	492866	BEAVER CK 1MI BL BUNKERVILLE RANCH	40.61933	-111.20550	River/Stream
UTAHDWQ	492867	BEAVER CK NEAR BUNKERVILLE RANCH 11	40.62600	-111.20133	River/Stream
UTAHDWQ	492899	BEAVER CK AT BRIDGE TO WILLOW SPNGS FH (BL KAMAS FH) 16	40.62467	-111.23250	River/Stream
UTAHDWQ	492900	KAMAS FISH HATCHERY EFFLUENT	40.62433	-111.23183	Facility
UTAHDWQ	492901	BEAVER CK AB KAMAS FH	40.62417	-111.23133	River/Stream
UTAHDWQ	492904	WILLOW SPRINGS TROUT FARM	40.62250	-111.23100	Facility
UTAHDWQ	492910	BEAVER CK AT USFS BOUNDARY 10	40.63083	-111.18633	River/Stream
UTAHDWQ	492920	WEBER R AB WEBER/PROVO DIVERSION	40.73083	-111.25417	River/Stream
UTAHDWQ	492940	WEBER R AB HOLIDAY PARK DEVELOPMENT	40.77800	-110.98850	River/Stream
UTAHDWQ	492949	SMITH MOREHOUSE CK AB CNFL/ WEBER R	40.78500	-111.15467	River/Stream
UTAHDWQ	492959	WEBER R AB CNFL/ SMITH MOREHOUSE CK	40.78750	-111.13267	River/Stream
UTAHDWQ	499818	WEBER-PROVO CNL BL DIVERSION FROM BEAVER CK	40.64500	-111.28417	River/Stream
UTAHDWQ	499819	WEBER-PROVO CNL AB DIVERSION FROM BEAVER CK	40.64917	-111.27917	River/Stream
UTAHDWQ	499823	WEBER-PROVO CNL INLET BL DIVERSION FROM WEBER R	40.71217	-111.27800	River/Stream
12WLS1	4D2-034	RHOADS LAKE	40.73444	-111.03111	Lake
UTAHDWQ	592001	WEBER RIVER AT CROSSING OF STATE ROUTE 196 NW OF PEOA	40.73717	-111.35933	River/Stream
UTAHDWQ	592003	FORT CK ABOVE CNFL / SPRING CK	40.72383	-111.34500	River/Stream
UTAHDWQ	592004	SPRING CREEK ABOVE CNFL / FORT CREEK	40.72300	-111.34517	River/Stream
UTAHDWQ	592005	WEBER RIVER ABOVE CNFL / FORT CK	40.72267	-111.35133	River/Stream
UTAHDWQ	592006	BEAVER CK ABOVE CNFL / WEBER RIVER	40.70100	-111.34000	River/Stream

Table 1. (cont'd) Surface water quality monitoring stations located in the TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude	Station Type
UTAHDWQ	592007	WEBER RIVER ABOVE CNFL / BEAVER CK	40.70383	-111.33767	River/Stream
UTAHDWQ	592008	WOODEN SHOE DITCH AT XING OF WOODEN SHOE ROAD	40.70750	-111.33383	River/Stream
UTAHDWQ	592009	RASMUSSEN CK JUST AB SMALL STORAGE RES 1.5 MI N OF OAKLEY	40.73967	-111.30167	River/Stream
UTAHDWQ	592010	MILL RACE CK AB CNFL / WEBER RIVER	40.70750	-111.30850	River/Stream
UTAHDWQ	592011	WEBER RIVER AB CNFL / MILL RACE CK	40.70683	-111.30850	River/Stream
UTAHDWQ	592012	MARCH CK .1 MI S OF STATION 113	40.70833	-111.31633	River/Stream
UTAHDWQ	592013	JACK HOLLOW CK AT END OF LANE 1 MI SW OF OAKLEY	40.71000	-111.31667	River/Stream
UTAHDWQ	592014	RASMUSSEN CK ABOVE FIPSH FARM ON US 189	40.72350	-111.32300	River/Stream
UTAHDWQ	592016	FORT CK NEAR LANE 0.7 MI E OF CNFL / SPRING CK	40.72583	-111.33133	River/Stream
UTAHDWQ	592017	MILL RACE CK AT ROAD XING JUST SO OF OAKLEY	40.71133	-111.29933	River/Stream
UTAHDWQ	592018	WEBER RIVER AT GAGING STATION 3.2 MI NE OF OAKLEY	40.73717	-111.24717	River/Stream
UTAHDWQ	592019	RASMUSSEN CK BL FISH FARM ON US 189	40.72417	-111.32517	River/Stream
UTAHDWQ	592020	IRR CNL BDG E OF RASMUSSEN CK 1MI N OF OAKLEY	40.73100	-111.29767	River/Stream
UTAHDWQ	592331	WANSHIP RES AB DAM 01	40.78633	-111.40383	Lake
UTAHDWQ	592332	WANSHIP RES MIDLAKE 02	40.77083	-111.39517	Lake
UTAHDWQ	592380	CASTLE LAKE 01 DEEPEST POINT	40.67167	-111.12467	Lake
UTAHDWQ	592395	SMITH AND MOREHOUSE CK BL SMITH AND MOREHOUSE RES	40.76383	-111.10167	River/Stream
UTAHDWQ	592396	SMITH AND MOREHOUSE RES AB DAM 01	40.76017	-111.10300	Lake
UTAHDWQ	592399	BEAR TRAP CK AB SMITH AND MOREHOUSE RES	40.75433	-111.10433	River/Stream
UTAHDWQ	592400	SMITH AND MOREHOUSE CK AB SMITH AND MOREHOUSE RES	40.74333	-111.09633	River/Stream
1118EPA8	UT-0020001-1	PARK CITY STP	40.66667	-111.46667	Facility
1118EPA8	UT-0021288-1	COALVILLE CITY CORP WWTP	40.92056	-111.40083	Facility
1118EPA8	UT-0022403-1	NORANDA MINING INC.-PARK CITY	40.75000	-111.41667	Facility

1.2 WATER QUALITY STATISTICS

The water quality statistics shown below include only DWQ stations visited during intensive monitoring cycles in the TMDL study area. The specific time period associated with water quality statistics are shown in each table and only include data collected after 1990. A more extensive review of water quality data is included in *Echo Reservoir TMDL Water Quality Study – Work Element 1* (DWQ 2003).

Data from each monitoring site is associated with a separate table. Due to the large amount of information, tables presented in this section are not numbered individually. Tables are listed in ascending order according to the DWQ station ID assigned to each monitoring site.

492610 - WEBER R BL ECHO RES				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	187.9	187	15.47	239.321	187.3	159	221
FLOW, STREAM, INSTANTANEOUS CFS	31	0	1993 - 1999	410.4	282	374.7	140400	253	9.3	1480
HARDNESS, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	218	223.6	24.8	615.04	216.6	171.2	271
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	29	3	1993 - 1999	0.211	0.1626	0.1891	0.03576	0.159	<BDL>	0.819
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	29	15	1993 - 1999	0.051	0.0454	0.02714	0.00074	0.0454	<BDL>	0.133
OXYGEN, DISSOLVED MG/L	31	0	1993 - 1999	8.395	8.7	2.08	4.3264	8.111	3.66	11.6
PH (STANDARD UNITS)	30	0	1993 - 1999	8.331	8.3	0.2343	0.0549	8.327	7.9	8.8
PH, LAB, STANDARD UNITS SU	31	0	1993 - 1999	8.052	8.06	0.3384	0.11451	8.045	7.2	8.72
PHOSPHORUS, DISSOLVED (MG/L AS P)	29	5	1993 - 1999	0.024	0.023	0.00849	7.2E-05	0.02299	<BDL>	0.04
PHOSPHORUS, TOTAL (MG/L AS P)	31	3	1993 - 1999	0.046	0.043	0.02079	0.00043	0.04151	<BDL>	0.087
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	31	0	1993 - 1999	267.9	268	35.72	1275.92	265.7	200	356
RESIDUE, TOTAL FIXED (MG/L)	17	4	1993 - 1994	11.8	5	23.62	557.904	4.506	<BDL>	100
RESIDUE, TOTAL NONFILTRABLE (MG/L)	31	10	1993 - 1999	14.17	6.8	23.31	543.356	5.919	<BDL>	115
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	31	0	1993 - 1999	466.5	470	61.84	3824.19	462.6	373	609
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	30	0	1993 - 1999	457.5	456	127.4	16230.8	445.7	320	1054
TEMPERATURE, WATER (DEGREES CENTIGRADE)	31	0	1993 - 1999	8.883	8.7	4.079	16.6382	7.919	2.72	16.36
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	31	0	1993 - 1999	7.901	4.99	8.167	66.6999	4.787	0.65	31.7

492613 - ECHO RES AB DAM 01				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	14	0	1990 - 2002	186.7	190.5	17.09	292.068	186	159	212
CHLOROPHYLL A UG/L FLUOROMETRIC UNCORRECTED	14	0	1990 - 2002	2.114	2.35	1.385	1.91823	1.396	0.2	4.3
HARDNESS, TOTAL (MG/L AS CACO3)	17	0	1990 - 1998	208.4	214.7	21.55	464.403	207.4	178.5	247.8
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	51	26	1992 - 2002	0.051	0.0221	0.0653	0.00426	0.0221	<BDL>	0.24
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	59	48	1990 - 2002	0.047	0.04487	0.01427	0.0002	0.04487	<BDL>	0.082
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	16	1	1990 - 1992	0.306	0.25	0.2341	0.0548	0.2389	<BDL>	1
OXYGEN, DISSOLVED MG/L	64	0	1990 - 2002	5.95	6.505	2.23	4.9729	5.329	0.9	9
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	24	0	2000 - 2002	73.93	76.65	29.88	892.814	65.71	11	113.5
PH (STANDARD UNITS)	64	0	1990 - 2002	8.174	8.2	0.288	0.08294	8.169	7.43	8.9
PH, LAB, STANDARD UNITS SU	10	0	1990 - 2002	8.393	8.42	0.1404	0.01971	8.392	8.1	8.57
PHOSPHORUS, DISSOLVED (MG/L AS P)	55	30	1990 - 2002	0.016	0.01128	0.01318	0.00017	0.01128	<BDL>	0.062

492613 - ECHO RES AB DAM 01 (cont'd) — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
PHOSPHORUS, TOTAL (MG/L AS P)	59	23	1990 - 2002	0.028	0.016	0.03137	0.00098	0.01543	<BDL>	0.143
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	14	0	1990 - 2002	259	256	32.01	1024.64	257.2	210	316
RESIDUE, TOTAL FIXED (MG/L)	12	10	1992 - 2002	1.841	1.632	0.9635	0.92833	1.629	<BDL>	4
RESIDUE, TOTAL NONFILTRABLE (MG/L)	14	13								
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	63	0	1990 - 2002	458.6	463	51.21	2622.46	455.8	370	563
TEMPERATURE, WATER (DEGREES CENTIGRADE)	64	0	1990 - 2002	16.99	17.68	3.664	13.4249	16.54	8.57	24.44
TRANSPARENCY, SECCHI DISC (METERS)	16	0	1990 - 2002	3.506	3.3	1.888	3.56454	2.89	0.7	6.6
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	12	0	1990 - 2002	1.025	0.9345	0.3091	0.09554	0.9873	0.65	1.8

492614 - ECHO RES 2/3 WAY UP LAKE 02 — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
CHLOROPHYLL A UG/L FLUOROMETRIC UNCORRECTED	11	0	1990 - 2002	3.236	3.3	2.214	4.9018	2.385	0.2	8.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	23	15	1992 - 2002	0.06	0.03604	0.06471	0.00419	0.03604	<BDL>	0.24
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	31	29	1990 - 2002	0.017	0.01117	0.01653	0.00027	0.01117	<BDL>	0.078
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	10	1	1990 - 1992	0.36	0.3	0.1643	0.02699	0.3372	<BDL>	0.8
OXYGEN, DISSOLVED MG/L	32	0	1990 - 2002	7.2	7.4	1.285	1.65123	7.077	4.2	9.31
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	10	0	2000 - 2002	101.1	105.8	16.77	281.233	99.75	72.8	119.9
PH (STANDARD UNITS)	32	0	1990 - 2002	8.289	8.335	0.1922	0.03694	8.287	8	8.6
PHOSPHORUS, DISSOLVED (MG/L AS P)	27	14	1990 - 2002	0.01	0.00646	0.01019	0.0001	0.006456	<BDL>	0.041
PHOSPHORUS, TOTAL (MG/L AS P)	31	4	1990 - 2002	0.031	0.024	0.02805	0.00079	0.02199	<BDL>	0.126
RESIDUE, TOTAL FIXED (MG/L)	10	7	1994 - 2002	3.14	2.333	2.616	6.84346	2.32	<BDL>	9
RESIDUE, TOTAL NONFILTRABLE (MG/L)	12	8	1990 - 2002	3.661	1.092	5.974	35.6887	1.073	<BDL>	17.6
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	32	0	1990 - 2002	447.6	462	42.92	1842.13	445.5	378	525
TEMPERATURE, WATER (DEGREES CENTIGRADE)	32	0	1990 - 2002	18	19.14	3.974	15.7927	17.55	10.9	25.5
TRANSPARENCY, SECCHI DISC (METERS)	13	0	1990 - 2002	2.665	2.7	1.617	2.61469	2.181	0.7	5.7

492626 - HUFF CK AB CNFL/ CHALK CK — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	32	0	1993 - 1999	249.6	257	34.7	1204.09	247.1	174	320
FLOW, STREAM, INSTANTANEOUS CFS	30	0	1993 - 1999	9.568	2.75	28.05	786.803	2.949	0.2	155

492626 - HUFF CK AB CNFL/ CHALK CK (cont'd) — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
HARDNESS, TOTAL (MG/L AS CACO3)	32	0	1993 - 1999	277.7	285.9	38.49	1481.48	274.9	194	353.7
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	30	8	1993 - 1999	0.114	0.0845	0.1518	0.02304	0.06617	<BDL>	0.8355
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	32	26	1993 - 1999	0.041	0.03907	0.01353	0.00018	0.03907	<BDL>	0.08
OXYGEN, DISSOLVED MG/L	31	0	1993 - 1999	8.737	8.7	1.479	2.18744	8.618	6	11.6
PH (STANDARD UNITS)	32	0	1993 - 1999	8.312	8.3	0.2353	0.05537	8.309	7.8	9
PH, LAB, STANDARD UNITS SU	32	0	1993 - 1999	8.117	8.185	0.3127	0.09778	8.111	7.5	8.78
PHOSPHORUS, DISSOLVED (MG/L AS P)	30	0	1993 - 1999	0.044	0.041	0.01923	0.00037	0.04075	0.02	0.097
PHOSPHORUS, TOTAL (MG/L AS P)	32	0	1993 - 1999	0.202	0.1485	0.1818	0.03305	0.1503	0.053	0.782
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	32	0	1993 - 1999	349.1	357	43.28	1873.16	346.3	240	418
RESIDUE, TOTAL FIXED (MG/L)	17	0	1993 - 1994	78.94	49	90.37	8166.74	41.36	4	303
RESIDUE, TOTAL NONFILTRABLE (MG/L)	32	0	1993 - 1999	111.8	60.9	160.3	25696.1	56.74	6	832
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	32	0	1993 - 1999	590.5	606	75.03	5629.5	585.4	410	724
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	32	0	1993 - 1999	552.3	565	88.55	7841.1	544.6	324	720
TEMPERATURE, WATER (DEGREES CENTIGRADE)	32	0	1993 - 1999	10.28	10.36	6.509	42.3671	5.761	0.1	21.1
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	32	0	1993 - 1999	53.32	30.9	79.35	6296.42	26.3	3.7	405

492628 - CHALK CREEK AT UT/WYO STATELINE — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	12	0	1998 - 1999	249.4	237	48.7	2371.69	245.2	182	338
FLOW, STREAM, INSTANTANEOUS CFS	53	8	1990 - 1999	21.17	7.7	29.51	870.84	5.625	<BDL>	139.2
HARDNESS, TOTAL (MG/L AS CACO3)	12	0	1998 - 1999	303.2	293	60.56	3667.51	297.6	209.7	414
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	41	22	1991 - 1999	0.037	0.00871	0.08126	0.0066	0.00871	<BDL>	0.462
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	47	43	1990 - 1999	0.013	0.00079	0.05325	0.00284	0.000787	<BDL>	0.36
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	35	2	1990 - 1994	0.577	0.52	0.3282	0.10772	0.4924	<BDL>	1.77
OXYGEN, DISSOLVED MG/L	48	0	1990 - 1999	8.721	8.65	0.9617	0.92487	8.669	7	10.9
PH (STANDARD UNITS)	48	0	1990 - 1999	8.32	8.35	0.3191	0.10182	8.313	7.48	8.9
PH, LAB, STANDARD UNITS SU	12	0	1998 - 1999	8.378	8.36	0.1104	0.01219	8.377	8.2	8.56
PHOSPHORUS, DISSOLVED (MG/L AS P)	42	12	1991 - 1999	0.039	0.023	0.05524	0.00305	0.02209	<BDL>	0.321
PHOSPHORUS, TOTAL (MG/L AS P)	48	4	1990 - 1999	0.092	0.066	0.08751	0.00766	0.06089	<BDL>	0.399
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	12	0	1998 - 1999	374.8	384	79.78	6364.85	366.2	218	490
RESIDUE, TOTAL NONFILTRABLE (MG/L)	47	5	1990 - 1999	57.38	26	75.13	5644.52	23.64	<BDL>	310
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	12	0	1998 - 1999	649.8	660	145.4	21141.2	633.4	389	877

492628 - CHALK CREEK AT UT/WYO STATELINE (cont'd) — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	48	0	1990 - 1999	541.3	541.5	144.2	20793.6	521.3	220	866
TEMPERATURE, WATER (DEGREES CENTIGRADE)	48	2	1990 - 1999	10.06	9.8	6.169	38.0566	6.469	<BDL>	23.3
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	12	0	1998 - 1999	27.81	8.92	43.63	1903.58	11.1	2.42	155

492629 - CHALK CREEK AB CNFL/ SOUTH FORK — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	43	0	1992 - 2000	235.4	241	24.13	582.257	234.2	172	292
FLOW, STREAM, INSTANTANEOUS CFS	60	0	1990 - 2000	66.48	32.7	91.51	8374.08	33.42	3	500
HARDNESS, TOTAL (MG/L AS CACO3)	42	0	1992 - 1999	259.1	260.2	38.69	1496.92	256.2	175.7	335.7
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	59	28	1991 - 2000	0.07	0.021	0.1089	0.01186	0.02697	<BDL>	0.633
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	69	65	1990 - 2000	0.027	0.0222	0.01723	0.0003	0.0222	<BDL>	0.095
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	49	4	1990 - 1995	0.539	0.37	0.759	0.57608	0.3665	<BDL>	5.17
OXYGEN, DISSOLVED MG/L	69	0	1990 - 2000	9.458	9.1	1.669	2.78556	9.325	6.9	16.5
PH (STANDARD UNITS)	70	0	1990 - 2000	8.368	8.4	0.2722	0.07409	8.363	7.6	9
PH, LAB, STANDARD UNITS SU	43	0	1992 - 2000	8.142	8.2	0.2651	0.07028	8.138	7.5	8.47
PHOSPHORUS, DISSOLVED (MG/L AS P)	59	24	1990 - 2000	0.018	0.012	0.0156	0.00024	0.01285	<BDL>	0.075
PHOSPHORUS, TOTAL (MG/L AS P)	68	6	1990 - 2000	0.085	0.039	0.123	0.01513	0.04202	<BDL>	0.669
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	43	0	1992 - 2000	314.9	306	61.08	3730.77	309.2	196	456
RESIDUE, TOTAL FIXED (MG/L)	16	2	1993 - 1994	101.9	22.5	192.9	37210.4	17.71	<BDL>	740
RESIDUE, TOTAL NONFILTRABLE (MG/L)	69	8	1990 - 2000	71.36	15	149.8	22440	17.48	<BDL>	805
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	43	0	1992 - 2000	541.4	537	98.65	9731.82	532.6	355	715
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	70	0	1990 - 2000	518.2	510.5	99.57	9914.18	509	332	842
TEMPERATURE, WATER (DEGREES CENTIGRADE)	70	2	1990 - 2000	9.872	9.16	6.341	40.2083	6.32	<BDL>	23
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	43	0	1992 - 2000	26.16	7.27	45.79	2096.72	8.564	1	225

492632 - COALVILLE WWTP — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	25	0	1990 - 1993	298.2	299	17.46	304.852	297.7	266	326
BOD, 5 DAY, 20 DEG C MG/L	91	60	1990 - 2002	3.223	0.4287	19.06	363.284	0.4287	<BDL>	182
FLOW, IN CONDUIT OR THRU A TREATMENT PLANT MGD	48	0	1990 - 2002	0.431	0.265	0.6224	0.38738	0.3062	0.1	4.1

492632 - COALVILLE WWTP (cont'd)	Summary Statistics									
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
FLOW, RATE, INSTANTANEOUS GALLONS/MIN	33	0	1991 - 2002	192.4	170	68.69	4718.32	181.2	90	335
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	20	0	1991 - 1999	3.397	3.027	2.113	4.46477	2.357	0.05	7.954
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	93	47	1990 - 2002	0.274	0.0326	0.6873	0.47238	0.0326	<BDL>	3.856
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	25	0	1990 - 1993	1.085	0.56	1.382	1.90992	0.6884	0.15	6.01
OXYGEN, DISSOLVED MG/L	98	0	1990 - 2002	7.286	7.2	1.137	1.29277	7.203	5.1	12
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	18	0	2000 - 2002	80.86	81.25	7.854	61.6853	80.47	61.2	90.8
PH (STANDARD UNITS)	97	0	1990 - 2002	7.74	7.7	0.2945	0.08673	7.734	6.3	8.9
PH, LAB, STANDARD UNITS SU	16	0	1990 - 1992	7.989	8	0.2465	0.06076	7.986	7.23	8.4
PHOSPHORUS, DISSOLVED (MG/L AS P)	22	0	1990 - 1999	1.564	1.594	0.8571	0.73462	1.192	0.091	3.42
PHOSPHORUS, TOTAL (MG/L AS P)	39	0	1990 - 1999	1.837	1.74	0.9114	0.83065	1.511	0.111	3.819
RESIDUE, TOTAL NONFILTRABLE (MG/L)	93	68	1990 - 2002	2.84	1.177	4.627	21.4091	1.177	<BDL>	30
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	98	0	1990 - 2002	1159	1158	188.7	35607.7	1133	123	1521
TEMPERATURE, WATER (DEGREES CENTIGRADE)	98	0	1990 - 2002	11.3	11.3	3.648	13.3079	10.67	4.54	18.05

492635 - CHALK CK AT US189 XING	Summary Statistics									
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	111	0	1990 - 2002	257.3	256	28.62	819.104	255.7	173	349
BOD, 5 DAY, 20 DEG C MG/L	57	41	1990 - 2002	1.024	0.5209	1.522	2.31648	0.5209	<BDL>	10
FLOW, STREAM, INSTANTANEOUS CFS	130	0	1990 - 2002	97.88	40	147.9	21874.4	49.48	7	897
HARDNESS, TOTAL (MG/L AS CACO3)	94	0	1990 - 1999	281.7	287.5	38	1444	279	183.2	366.2
NITRATE NITROGEN, DISSOLVED (MG/L AS N)	11	0	1990 - 1990	0.402	0.41	0.1973	0.03893	0.3546	0.16	0.67
NITRITE NITROGEN, DISSOLVED (MG/L AS N)	11	11								
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	104	2	1991 - 2002	0.339	0.2625	0.267	0.07129	0.2511	<BDL>	1.34
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	26	0	1991 - 1999	0.434	0.345	0.306	0.09364	0.3416	0.066	1.16
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	139	115	1990 - 2002	0.031	0.02544	0.02226	0.0005	0.02544	<BDL>	0.157
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	62	5	1990 - 1997	0.426	0.325	0.3366	0.1133	0.3228	<BDL>	1.4715
OXYGEN, DISSOLVED MG/L	144	0	1990 - 2002	9.44	9.385	1.504	2.26202	9.322	6.1	15.2
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	20	0	2000 - 2002	98.62	96.15	10.43	108.785	98.14	83.9	130.9
PH (STANDARD UNITS)	143	0	1990 - 2002	8.128	8.17	0.3639	0.13242	8.12	7.2	9.6
PH, LAB, STANDARD UNITS SU	111	0	1990 - 2002	8.063	8.12	0.3344	0.11182	8.056	6.1	8.72
PHOSPHORUS, DISSOLVED (MG/L AS P)	97	33	1990 - 2002	0.024	0.017	0.02082	0.00043	0.01638	<BDL>	0.102
PHOSPHORUS, TOTAL (MG/L AS P)	130	14	1990 - 2002	0.112	0.046	0.1872	0.03504	0.04957	<BDL>	1.31

492635 - CHALK CK AT US189 XING (cont'd) — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	113	0	1990 - 2002	370.9	374	73.33	5377.29	364.7	204	868
RESIDUE, TOTAL FIXED (MG/L)	20	1	1993 - 1997	121.5	21.5	265.1	70278	25.25	<BDL>	1199
RESIDUE, TOTAL NONFILTRABLE (MG/L)	139	23	1990 - 2002	83.03	16.8	176.7	31222.9	17.51	<BDL>	1314
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	111	0	1990 - 2002	630.8	644	99.71	9942.08	622.4	364	862
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	144	0	1990 - 2002	608.3	621	118.6	14066	594.9	218	825
TEMPERATURE, WATER (DEGREES CENTIGRADE)	144	1	1990 - 2002	8.686	8.575	5.15	26.5225	6.693	<BDL>	19.13
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	111	0	1990 - 2002	28.35	4.3	58.52	3424.59	7.079	0.5	325

492636 - CHALK CK S FK 1 MI AB CHALK CK — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	33	0	1993 - 1999	217.6	223	19.41	376.748	216.8	175	248
FLOW, STREAM, INSTANTANEOUS CFS	30	0	1993 - 1999	42.3	16.95	50.03	2503	22.12	2.8	169.3
HARDNESS, TOTAL (MG/L AS CACO3)	33	0	1993 - 1999	236.5	233	25.8	665.64	235.2	190	285.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	33	12	1993 - 1999	0.169	0.083	0.5045	0.25452	0.0511	<BDL>	2.949
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	35	33	1993 - 1999	0.02	0.01288	0.02065	0.00043	0.01288	<BDL>	0.101
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	21	3	1993 - 1994	0.45	0.37	0.2649	0.07017	0.3787	<BDL>	1.06
OXYGEN, DISSOLVED MG/L	35	0	1993 - 1999	9.301	8.8	1.932	3.73262	9.129	6.7	16.5
PH (STANDARD UNITS)	36	0	1993 - 1999	8.434	8.48	0.3154	0.09948	8.429	7.5	9
PH, LAB, STANDARD UNITS SU	33	0	1993 - 1999	8.074	8.16	0.315	0.09923	8.068	7.2	8.65
PHOSPHORUS, DISSOLVED (MG/L AS P)	34	16	1993 - 1999	0.019	0.013	0.01614	0.00026	0.0142	<BDL>	0.079
PHOSPHORUS, TOTAL (MG/L AS P)	36	5	1993 - 1999	0.128	0.03027	0.1988	0.03952	0.04061	<BDL>	0.701
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	33	0	1993 - 1999	275.5	276	40.85	1668.72	272.5	202	364
RESIDUE, TOTAL FIXED (MG/L)	18	2	1993 - 1994	116.6	28	192.2	36940.8	27.78	<BDL>	649
RESIDUE, TOTAL NONFILTRABLE (MG/L)	36	4	1993 - 1999	112.9	34.7	174.5	30450.3	31.94	<BDL>	701
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	33	0	1993 - 1999	478.3	464	66.3	4395.69	474	369	602
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	36	0	1993 - 1999	477.3	465	76.08	5788.17	471.4	352	620
TEMPERATURE, WATER (DEGREES CENTIGRADE)	36	1	1993 - 1999	9.015	8.915	6.285	39.5012	4.384	<BDL>	20.8
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	33	0	1993 - 1999	41.07	6.9	64.63	4177.04	11.73	1.1	225

492637 - CHALK CK EAST FK AB CNFL/ CHALK CK — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	37	0	1993 - 2000	209.8	213	20.56	422.714	208.8	171	271
FLOW, STREAM, INSTANTANEOUS CFS	33	0	1993 - 2000	44.41	17	65.43	4281.08	22.24	2.5	289
HARDNESS, TOTAL (MG/L AS CACO3)	36	0	1993 - 1999	213.7	214.7	34.86	1215.22	211.3	162.1	366.8
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	37	14	1993 - 2000	0.25	0.025	1.111	1.23432	0.02556	<BDL>	6.8
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	39	39								
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	22	4	1993 - 1996	0.288	0.255	0.1476	0.02179	0.2501	<BDL>	0.57
OXYGEN, DISSOLVED MG/L	38	0	1993 - 2000	9.192	9.2	1.372	1.88238	9.092	7	11.7
PH (STANDARD UNITS)	39	0	1993 - 2000	8.424	8.4	0.3792	0.14379	8.415	6.7	9
PH, LAB, STANDARD UNITS SU	37	0	1993 - 2000	8.122	8.2	0.3069	0.09419	8.116	7.2	8.68
PHOSPHORUS, DISSOLVED (MG/L AS P)	37	24	1993 - 2000	0.012	0.00546	0.01628	0.00027	0.005462	<BDL>	0.069
PHOSPHORUS, TOTAL (MG/L AS P)	39	11	1993 - 2000	0.035	0.018	0.04197	0.00176	0.01885	<BDL>	0.219
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	37	0	1993 - 2000	228.9	232	46.82	2192.11	225.1	158	450
RESIDUE, TOTAL FIXED (MG/L)	18	4	1993 - 1994	33.34	10	64	4096	9.715	<BDL>	268
RESIDUE, TOTAL NONFILTRABLE (MG/L)	40	11	1993 - 2000	27.01	11.5	52.64	2770.97	9.414	<BDL>	295
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	37	0	1993 - 2000	410.9	400	96.19	9252.52	402.8	317	803
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	39	0	1993 - 2000	384.3	399	56.51	3193.38	380.2	279	485
TEMPERATURE, WATER (DEGREES CENTIGRADE)	39	3	1993 - 2000	6.705	6.2	5.091	25.9183	3.455	<BDL>	17.1
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	37	0	1993 - 2000	11.76	3.51	19.51	380.64	5.157	0.983	95

492638 - Chalk CK at Culvert 0.8MI AB Pine Cliff CMPGRND — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	35	0	1992 - 1999	258.5	259	41.23	1699.91	255.1	154	333
FLOW, STREAM, INSTANTANEOUS CFS	57	4	1990 - 1999	22.55	8	32.14	1032.98	6.21	<BDL>	145
HARDNESS, TOTAL (MG/L AS CACO3)	35	0	1992 - 1999	306	302.3	63.73	4061.51	299.2	165.8	429.3
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	50	23	1991 - 1999	0.058	0.0185	0.09864	0.00973	0.01898	<BDL>	0.553
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	56	53	1990 - 1999	0.04	0.03991	0.00575	3.3E-05	0.03991	<BDL>	0.055
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	42	3	1990 - 1994	0.478	0.47	0.2362	0.05579	0.4121	<BDL>	1.02
OXYGEN, DISSOLVED MG/L	56	0	1990 - 1999	8.553	8.6	1.33	1.7689	8.452	6	12
PH (STANDARD UNITS)	57	0	1990 - 1999	8.115	8.2	0.3576	0.12788	8.107	7.3	8.9
PH, LAB, STANDARD UNITS SU	35	0	1992 - 1999	8.033	8.1	0.3286	0.10798	8.026	6.9	8.49
PHOSPHORUS, DISSOLVED (MG/L AS P)	51	14	1991 - 1999	0.025	0.016	0.0254	0.00065	0.01673	<BDL>	0.108

492638 - Chalk CK at Culvert 0.8MI AB Pine Cliff CMPGRND (cont'd)

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
	Summary Statistics									
PHOSPHORUS, TOTAL (MG/L AS P)	57	8	1990 - 1999	0.091	0.048	0.1007	0.01014	0.04732	<BDL>	0.529
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	35	0	1992 - 1999	385.9	408	92.74	8600.71	373.6	192	530
RESIDUE, TOTAL FIXED (MG/L)	18	3	1993 - 1994	47.68	15	69.92	4888.81	13.53	<BDL>	239
RESIDUE, TOTAL NONFILTRABLE (MG/L)	57	15	1990 - 1999	63.81	22	95.66	9150.84	20.16	<BDL>	548
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	35	0	1992 - 1999	664.3	694	159.4	25408.4	643.9	337	962
SPECIFIC CONDUCTANCE, FIELD (UMHOS/CM @ 25C)	57	0	1990 - 1999	610.6	603	162.5	26406.3	587.8	309	947
TEMPERATURE, WATER (DEGREES CENTIGRADE)	57	1	1990 - 1999	9.301	8.72	5.717	32.6841	6.59	<BDL>	20.9
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	35	0	1992 - 1999	29.02	8.8	54.07	2923.56	8.03	0.771	295

492639 - CHALK CREEK 4 MILES EAST OF UPTON

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
	Summary Statistics									
ALKALINITY, TOTAL (MG/L AS CACO3)	33	0	1993 - 1999	223.7	226	26.91	724.148	222.1	165	277
FLOW, STREAM, INSTANTANEOUS CFS	53	0	1990 - 1999	70.68	35	96.37	9287.18	34.19	2.1	500
HARDNESS, TOTAL (MG/L AS CACO3)	33	0	1993 - 1999	247.2	246.1	44.55	1984.7	243.4	170.8	343.4
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	50	24	1991 - 1999	0.063	0.021	0.09156	0.00838	0.03251	<BDL>	0.592
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	58	55	1990 - 1999	0.012	0.00572	0.01813	0.00033	0.005716	<BDL>	0.111
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	45	3	1990 - 1996	0.412	0.35	0.2947	0.08685	0.3189	<BDL>	1.43
OXYGEN, DISSOLVED MG/L	58	0	1990 - 1999	9.069	9.05	1.246	1.55252	8.988	6.8	12.4
PH (STANDARD UNITS)	59	0	1990 - 1999	8.381	8.4	0.2971	0.08827	8.376	7.5	9
PH, LAB, STANDARD UNITS SU	33	0	1993 - 1999	8.13	8.2	0.3332	0.11102	8.123	7.2	8.53
PHOSPHORUS, DISSOLVED (MG/L AS P)	53	22	1990 - 1999	0.024	0.012	0.03633	0.00132	0.01138	<BDL>	0.195
PHOSPHORUS, TOTAL (MG/L AS P)	59	7	1990 - 1999	0.082	0.042	0.1048	0.01098	0.03847	<BDL>	0.446
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	33	0	1993 - 1999	285.6	288	70.67	4994.25	277.3	184	416
RESIDUE, TOTAL FIXED (MG/L)	18	4	1993 - 1994	57.48	25.5	95.61	9141.27	17.45	<BDL>	381
RESIDUE, TOTAL NONFILTRABLE (MG/L)	59	5	1990 - 1999	61.63	21	90.88	8259.17	20.59	<BDL>	414
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	33	0	1993 - 1999	499.8	500	120.9	14616.8	486.3	333	737
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	59	0	1990 - 1999	459.2	449	122.8	15079.8	440.7	88	753
TEMPERATURE, WATER (DEGREES CENTIGRADE)	58	1	1990 - 1999	9.691	8.85	6.029	36.3488	6.15	<BDL>	22.7
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	33	0	1993 - 1999	24.9	9.5	37.47	1404	8.898	1.14	165

492640 - WEBER R AB ECHO RES — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	58	0	1990 - 1999	177.7	182	24.97	623.501	175.9	125	228
FLOW, STREAM, INSTANTANEOUS CFS	62	0	1990 - 2002	219.4	174	245.4	60221.2	151.5	22	1220
HARDNESS, TOTAL (MG/L AS CACO3)	58	0	1990 - 1999	209.2	206.9	42.56	1811.35	205.4	142.4	402.3
NITRATE NITROGEN, DISSOLVED (MG/L AS N)	10	1	1990 - 1990	0.146	0.0925	0.1338	0.0179	0.09856	<BDL>	0.43
NITRITE NITROGEN, DISSOLVED (MG/L AS N)	10	10								
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	57	6	1991 - 2002	0.195	0.128	0.1986	0.03944	0.1286	<BDL>	1.149
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	69	57	1990 - 2002	0.029	0.01755	0.03361	0.00113	0.01755	<BDL>	0.173
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	27	2	1990 - 1993	0.428	0.3	0.3724	0.13868	0.326	<BDL>	1.84
OXYGEN, DISSOLVED MG/L	72	0	1990 - 2002	10.13	9.95	1.642	2.69616	10.01	7.7	16.22
PH (STANDARD UNITS)	73	0	1990 - 2002	8.439	8.5	0.347	0.12041	8.432	6.9	9.12
PH, LAB, STANDARD UNITS SU	58	0	1990 - 1999	8.154	8.2	0.324	0.10498	8.147	7.3	8.97
PHOSPHORUS, DISSOLVED (MG/L AS P)	62	5	1990 - 2002	0.04	0.037	0.02108	0.00044	0.03476	<BDL>	0.11
PHOSPHORUS, TOTAL (MG/L AS P)	70	1	1990 - 2002	0.073	0.062	0.06792	0.00461	0.06171	<BDL>	0.58
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	70	0	1990 - 2002	259.4	250	72.21	5214.28	251.2	126	622
RESIDUE, TOTAL FIXED (MG/L)	30	16	1992 - 2002	7.075	2.294	14.39	207.072	2.289	<BDL>	68
RESIDUE, TOTAL NONFILTRABLE (MG/L)	68	11	1990 - 2002	10.73	6.8	13.8	190.44	6.772	<BDL>	75
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	56	0	1990 - 1999	439.9	431	91.66	8401.56	431.3	284	751
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	73	0	1990 - 2002	419.3	410	99.75	9950.06	408.2	218	765
TEMPERATURE, WATER (DEGREES CENTIGRADE)	73	0	1990 - 2002	10.34	10.9	5.825	33.9306	7.653	0.2	21
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	58	0	1990 - 1999	4.109	3	4.377	19.1581	3.168	1	28

492674 - SILVER CK AT FARM XING IN ATKINSON — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	10	0	2001 - 2002	146.8	148.5	9.235	85.2852	146.5	132	164
BOD, 5 DAY, 20 DEG C MG/L	42	26	1993 - 2002	1.91	1.447	1.48	2.1904	1.447	<BDL>	6
FLOW, STREAM, INSTANTANEOUS CFS	49	0	1991 - 2002	5.892	4	5.613	31.5058	4.341	0.5	32.8
HARDNESS, TOTAL (MG/L AS CACO3)	15	0	1996 - 1999	460	455.1	51.44	2646.07	457.3	356.4	538.9
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	10	0	2001 - 2002	7.768	7.065	4.302	18.5072	5.146	0.1	14.4
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	55	36	1990 - 2002	0.085	0.0214	0.1937	0.03752	0.0214	<BDL>	1.22
OXYGEN, DISSOLVED MG/L	53	0	1991 - 2002	9.251	9.3	1.706	2.91044	9.097	4.99	16
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	16	0	2000 - 2002	89.61	89.15	20.44	417.794	87.36	57.9	123.7
PH (STANDARD UNITS)	53	0	1991 - 2002	7.844	7.87	0.3306	0.1093	7.837	7.18	8.6

492674 - SILVER CK AT FARM XING IN ATKINSON (cont'd) — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
PH, LAB, STANDARD UNITS SU	10	0	2001 - 2002	7.867	7.845	0.3783	0.14311	7.859	7.43	8.8
PHOSPHORUS, DISSOLVED (MG/L AS P)	10	0	2001 - 2002	1.452	1.205	0.5909	0.34916	1.355	0.8	2.46
PHOSPHORUS, TOTAL (MG/L AS P)	10	0	2001 - 2002	1.482	1.465	0.4876	0.23775	1.408	0.719	2.43
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	10	0	2001 - 2002	1015	1050	95.54	9127.89	1011	878	1134
RESIDUE, TOTAL NONFILTRABLE (MG/L)	21	9	1998 - 2002	9.954	5.6	12.65	160.023	5.348	<BDL>	48
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	10	0	2001 - 2002	1370	1540	455.5	207480	1187	147	1660
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	49	0	1993 - 2002	1328	1327	196.5	38612.3	1313	937	1701
TEMPERATURE, WATER (DEGREES CENTIGRADE)	53	0	1991 - 2002	9.736	9.57	6.224	38.7382	7.243	0.5	22.18
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	10	0	2001 - 2002	3.542	2.505	2.695	7.26303	2.846	1.1	9.79

492675 - SILVER CK AT WANSHIP AB CNFL / WEBER R — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	66	0	1990 - 2002	169.1	180.5	36.19	1309.72	164.6	87	226
FLOW, STREAM, INSTANTANEOUS CFS	64	0	1990 - 2002	11.46	5.7	15.93	253.765	7.035	1.2	86.9
HARDNESS, TOTAL (MG/L AS CACO3)	55	0	1990 - 1999	347.7	365	76.55	5859.9	338.4	177.5	555.6
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	55	2	1991 - 2002	1.5	0.965	1.453	2.11121	0.8748	<BDL>	6.05
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	64	58	1990 - 2002	0.019	0.00654	0.03648	0.00133	0.00654	<BDL>	0.25
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	22	0	1990 - 1993	0.466	0.49	0.1702	0.02897	0.4227	0.1	0.8
OXYGEN, DISSOLVED MG/L	65	0	1990 - 2002	9.556	9.1	1.579	2.49324	9.433	6.8	13.5
PH (STANDARD UNITS)	64	0	1990 - 2002	8.297	8.3	0.301	0.0906	8.292	7.5	9.3
PH, LAB, STANDARD UNITS SU	66	0	1990 - 2002	7.988	8.1	0.4261	0.18156	7.976	6.3	8.9
PHOSPHORUS, DISSOLVED (MG/L AS P)	58	0	1990 - 2002	0.289	0.244	0.1983	0.03932	0.2312	0.059	0.955
PHOSPHORUS, TOTAL (MG/L AS P)	65	0	1990 - 2002	0.386	0.316	0.2429	0.059	0.3191	0.032	1.03
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	66	0	1990 - 2002	610.5	626	136.7	18686.9	593.4	308	886
RESIDUE, TOTAL FIXED (MG/L)	17	6	1993 - 1994	9.972	6	12.38	153.264	5.314	<BDL>	49
RESIDUE, TOTAL NONFILTRABLE (MG/L)	65	7	1990 - 2002	19.17	10	35.03	1227.1	9.541	<BDL>	222.7
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	66	0	1990 - 2002	949.8	986	206.6	42683.6	925.6	485	1530
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	65	0	1990 - 2002	926.5	945	234.9	55178	892.8	311	1383
TEMPERATURE, WATER (DEGREES CENTIGRADE)	65	0	1990 - 2002	9.065	7.9	5.796	33.5936	6.32	0.18	20
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	66	0	1990 - 2002	7.077	3.34	14.09	198.528	3.664	0.4	92.4

492679 - SILVER CREEK WWTP	Summary Statistics									
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	35	0	1990 - 2002	142.1	136	21.15	447.323	140.6	102	190
BOD, 5 DAY, 20 DEG C MG/L	76	18	1990 - 2002	3.394	2	3.226	10.4071	2.317	<BDL>	22
FLOW, IN CONDUIT OR THRU A TREATMENT PLANT MGD	99	0	1990 - 2002	1.361	1.33	0.5083	0.25837	1.263	0.33	3.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	17	0	1998 - 2002	11.52	11.6	4.815	23.1842	7.846	0.14	16.6
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	100	53	1990 - 2002	0.195	0.02767	0.5823	0.33907	0.02766	<BDL>	3.74
OXYGEN, DISSOLVED MG/L	103	0	1990 - 2002	7.477	7.5	1.004	1.00802	7.406	4.4	9.9
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	21	0	2000 - 2002	85.63	87.1	7.379	54.4496	85.32	72.3	99.1
PH (STANDARD UNITS)	101	0	1990 - 2002	7.568	7.51	0.3124	0.09759	7.562	6.9	8.8
PH, LAB, STANDARD UNITS SU	24	0	1990 - 2002	7.678	7.7	0.3172	0.10062	7.672	6.9	8.2
PHOSPHORUS, DISSOLVED (MG/L AS P)	17	0	1998 - 2002	2.533	2.58	0.8012	0.64192	2.259	0.208	3.41
PHOSPHORUS, TOTAL (MG/L AS P)	21	0	1994 - 2002	2.432	2.45	0.927	0.85933	2.135	0.263	4.35
RESIDUE, TOTAL NONFILTRABLE (MG/L)	94	60	1990 - 2002	4.335	2.342	9.976	99.5206	2.341	<BDL>	95.6
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	99	0	1990 - 2002	1401	1445	312	97344	1355	319	2082
TEMPERATURE, WATER (DEGREES CENTIGRADE)	103	0	1990 - 2002	12.1	11.06	3.472	12.0548	11.5	1	18.3

492680 - SILVER CK AB ATKINSON	Summary Statistics									
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	19	0	1990 - 2002	163.7	162	14.74	217.268	163.1	138	194
BOD, 5 DAY, 20 DEG C MG/L	24	16	1990 - 2002	1.197	0.7725	1.175	1.38063	0.7715	<BDL>	4
FLOW, STREAM, INSTANTANEOUS CFS	30	5	1990 - 2002	2.421	1.7	2.444	5.97314	1.38	<BDL>	10.4
HARDNESS, TOTAL (MG/L AS CACO3)	12	0	1990 - 1999	521.4	516.2	44.34	1966.04	519.7	460.1	630.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	13	7	1991 - 2002	0.219	0.01187	0.4058	0.16467	0.01187	<BDL>	1.26
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	28	25	1990 - 2002	0.028	0.02476	0.01405	0.0002	0.02476	<BDL>	0.07
OXYGEN, DISSOLVED MG/L	28	0	1990 - 2002	9.089	8.895	1.848	3.4151	8.888	4	14
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	12	0	2000 - 2002	83.37	84.95	10.88	118.374	82.7	67.5	99.4
PH (STANDARD UNITS)	28	0	1990 - 2002	7.925	7.95	0.409	0.16728	7.915	6.98	8.8
PH, LAB, STANDARD UNITS SU	19	0	1990 - 2002	7.896	7.9	0.2755	0.0759	7.891	7.4	8.39
PHOSPHORUS, DISSOLVED (MG/L AS P)	15	4	1990 - 2002	0.026	0.021	0.0166	0.00028	0.02111	<BDL>	0.062
PHOSPHORUS, TOTAL (MG/L AS P)	18	3	1990 - 2002	0.045	0.0385	0.02587	0.00067	0.03794	<BDL>	0.099
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	18	0	1990 - 2002	998.8	919	258.2	66667.2	968.7	662	1534
RESIDUE, TOTAL NONFILTRABLE (MG/L)	27	16	1990 - 2002	10.36	2.958	17.69	312.936	2.958	<BDL>	58
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	18	0	1990 - 2002	1345	1175	343.1	117718	1306	980	2030

492680 - SILVER CK AB ATKINSON (cont'd)				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	28	0	1990 - 2002	1266	1240	462.5	213906	1182	405	2265
TEMPERATURE, WATER (DEGREES CENTIGRADE)	28	0	1990 - 2002	8.989	8.185	6.917	47.8449	4.055	0.03	22.9
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	18	0	1990 - 2002	2.661	1.9	2.322	5.39168	1.999	0.591	9.38

492685 - SILVER CK AT US40 XING E OF PARK CITY				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	52	0	1991 - 2002	167.8	174	23.3	542.89	166.1	105	231
BOD, 5 DAY, 20 DEG C MG/L	32	17	1991 - 1998	1.718	1.363	1.25	1.5625	1.363	<BDL>	5
FLOW, STREAM, INSTANTANEOUS CFS	65	3	1991 - 2002	3.771	2.1	4.301	18.4986	2.076	<BDL>	19.4
HARDNESS, TOTAL (MG/L AS CACO3)	52	0	1991 - 1999	491	514.1	88.55	7841.1	481.7	202.3	771.3
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	50	3	1991 - 2002	0.579	0.4095	0.5433	0.29517	0.3932	<BDL>	2.513
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	68	56	1990 - 2002	0.031	0.01728	0.03878	0.0015	0.01728	<BDL>	0.19
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	11	1	1991 - 1994	0.44	0.4	0.3587	0.12867	0.302	<BDL>	1.14
OXYGEN, DISSOLVED MG/L	68	0	1991 - 2002	8.864	8.95	1.757	3.08705	8.697	5.1	14.8
PH (STANDARD UNITS)	69	0	1991 - 2002	7.841	7.82	0.3522	0.12404	7.833	6.5	8.4
PH, LAB, STANDARD UNITS SU	52	0	1991 - 2002	7.814	7.805	0.3006	0.09036	7.808	7	8.38
PHOSPHORUS, DISSOLVED (MG/L AS P)	50	15	1991 - 2002	0.018	0.014	0.01235	0.00015	0.0145	<BDL>	0.062
PHOSPHORUS, TOTAL (MG/L AS P)	52	8	1991 - 2002	0.053	0.0385	0.09951	0.0099	0.03582	<BDL>	0.741
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	52	0	1991 - 2002	805.1	785	186.8	34894.2	781.8	240	1400
RESIDUE, TOTAL FIXED (MG/L)	18	10	1993 - 1994	27.49	0.7634	109	11881	0.7514	<BDL>	464
RESIDUE, TOTAL NONFILTRABLE (MG/L)	52	18	1991 - 2002	17.3	4	73.67	5427.27	3.84	<BDL>	534
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	52	0	1991 - 2002	1235	1183	274.7	75460.1	1210	875	2350
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	67	0	1991 - 2002	1194	1162	286.1	81853.2	1165	702	2280
TEMPERATURE, WATER (DEGREES CENTIGRADE)	69	2	1991 - 2002	8.036	7.94	6.185	38.2542	4.31	<BDL>	18.7
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	52	0	1991 - 2002	10.01	2.325	44.79	2006.14	2.933	0.95	325

492695 - SILVER CK @ CITY PARK AB PROSPECTOR SQR — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	27	0	1998 - 2002	122	120	23.98	575.04	119.7	82	169
FLOW, STREAM, INSTANTANEOUS CFS	37	4	1997 - 2002	1.773	0.5	3.222	10.3813	0.4803	<BDL>	15
HARDNESS, TOTAL (MG/L AS CACO3)	15	0	1997 - 1999	360.6	384.8	99.11	9822.79	346.1	188.5	524.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	25	6	1998 - 2002	0.428	0.3	0.5062	0.25624	0.2529	<BDL>	2.5268
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	26	23	1998 - 2002	0.021	0.00113	0.06897	0.00476	0.001122	<BDL>	0.349
OXYGEN, DISSOLVED MG/L	34	0	1997 - 2002	9.276	9.06	1.421	2.01924	9.173	6.83	12.93
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	15	0	2001 - 2002	84.86	83.9	10.26	105.268	84.32	70.6	111.7
PH (STANDARD UNITS)	34	0	1997 - 2002	8.081	8.1	0.4041	0.1633	8.071	6.6	8.87
PH, LAB, STANDARD UNITS SU	27	0	1998 - 2002	7.963	8.06	0.3378	0.11411	7.955	6.91	8.37
PHOSPHORUS, DISSOLVED (MG/L AS P)	25	5	1998 - 2002	0.064	0.039	0.08256	0.00682	0.03754	<BDL>	0.347
PHOSPHORUS, TOTAL (MG/L AS P)	27	0	1998 - 2002	0.12	0.071	0.1099	0.01208	0.08443	0.02	0.371
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	27	0	1998 - 2002	2107	894	3429	1.2E+07	1164	246	16434
RESIDUE, TOTAL NONFILTRABLE (MG/L)	27	10	1998 - 2002	41.87	9.2	69.38	4813.58	9.422	<BDL>	266
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	27	0	1998 - 2002	3329	1570	5049	2.5E+07	1905	292	24000
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	33	0	1997 - 2002	3953	1798	6291	4E+07	1973	215	26212
TEMPERATURE, WATER (DEGREES CENTIGRADE)	34	3	1997 - 2002	6.761	5.145	5.997	35.964	2.744	<BDL>	17.88
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	27	0	1998 - 2002	36.92	9.69	59.2	3504.64	12.88	1.56	224

492697 - Park Meadow Drain CK from Golf Course AB Silver CK — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	13	0	1998 - 1999	177.2	177	12.16	147.866	176.8	162	194
FLOW, STREAM, INSTANTANEOUS CFS	13	0	1998 - 1999	6.146	3.1	4.949	24.4926	4.192	0.4	16
HARDNESS, TOTAL (MG/L AS CACO3)	13	0	1998 - 1999	433.1	441.3	42.42	1799.46	431.2	373	496.5
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	11	0	1998 - 1999	0.812	0.8	0.1951	0.03806	0.7895	0.51	1.0783
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	11	5	1998 - 1999	0.091	0.0759	0.06115	0.00374	0.07546	<BDL>	0.238
OXYGEN, DISSOLVED MG/L	13	0	1998 - 1999	10.23	10.13	2.45	6.0025	9.971	7	15.3
PH (STANDARD UNITS)	13	0	1998 - 1999	7.766	7.79	0.2852	0.08134	7.761	7.2	8.29
PH, LAB, STANDARD UNITS SU	13	0	1998 - 1999	8.023	8.07	0.1677	0.02812	8.021	7.72	8.23
PHOSPHORUS, DISSOLVED (MG/L AS P)	11	2	1998 - 1999	0.039	0.027	0.03921	0.00154	0.02864	<BDL>	0.148
PHOSPHORUS, TOTAL (MG/L AS P)	13	1	1998 - 1999	0.08	0.065	0.06123	0.00375	0.06278	<BDL>	0.211

492697 - Park Meadow Drain CK from Golf Course AB Silver CK (cont'd)

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
				Summary Statistics						
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	13	0	1998 - 1999	607.5	602	57.87	3348.94	604.9	506	692
RESIDUE, TOTAL NONFILTRABLE (MG/L)	13	1	1998 - 1999	14.57	10.4	14.92	222.606	10.51	<BDL>	60
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	13	0	1998 - 1999	926.6	977	103.3	10670.9	921.2	777	1060
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	13	0	1998 - 1999	863.6	829	110.8	12276.6	856.9	649	1025
TEMPERATURE, WATER (DEGREES CENTIGRADE)	13	0	1998 - 1999	11.03	11.89	5.986	35.8322	8.796	1.46	20.5
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	13	0	1998 - 1999	6.785	3.58	9.007	81.126	4.548	1.85	35.8

492701 - WEBER R BL WANSHIP RES

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
				Summary Statistics						
ALKALINITY, TOTAL (MG/L AS CACO3)	32	0	1993 - 1999	161.8	171.5	27.09	733.868	159.4	105	195
FLOW, STREAM, INSTANTANEOUS CFS	32	0	1993 - 1999	261.4	200	305.3	93208.1	175.6	29	1330
HARDNESS, TOTAL (MG/L AS CACO3)	32	0	1993 - 1999	174.4	188.8	28.71	824.264	171.8	111.4	206
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	30	4	1993 - 1999	0.188	0.139	0.1803	0.03251	0.1335	<BDL>	0.72253
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	31	25	1993 - 1999	0.036	0.02469	0.03403	0.00116	0.02469	<BDL>	0.133
OXYGEN, DISSOLVED MG/L	32	0	1993 - 1999	8.114	8.435	1.763	3.10817	7.891	3.8	11.3
PH (STANDARD UNITS)	31	0	1993 - 1999	8.337	8.3	0.2753	0.07579	8.333	7.7	8.91
PH, LAB, STANDARD UNITS SU	32	0	1993 - 1999	7.996	8.1	0.3673	0.13491	7.988	7.2	8.64
PHOSPHORUS, DISSOLVED (MG/L AS P)	30	5	1993 - 1999	0.025	0.023	0.01678	0.00028	0.02045	<BDL>	0.067
PHOSPHORUS, TOTAL (MG/L AS P)	32	2	1993 - 1999	0.041	0.037	0.02222	0.00049	0.03636	<BDL>	0.115
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	32	0	1993 - 1999	198.9	212	32.16	1034.27	196	132	246
RESIDUE, TOTAL FIXED (MG/L)	18	10	1993 - 1994	3.23	2.311	2.93	8.5849	2.307	<BDL>	12
RESIDUE, TOTAL NONFILTRABLE (MG/L)	32	10	1993 - 1999	4.73	4	3.679	13.535	3.729	<BDL>	18
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	32	0	1993 - 1999	351.8	380	59.78	3573.65	346.3	225	430
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	32	0	1993 - 1999	335.6	366	67.02	4491.68	328.1	179	457
TEMPERATURE, WATER (DEGREES CENTIGRADE)	32	0	1993 - 1999	8.145	7.61	3.596	12.9312	7.312	2.82	15.1
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	32	0	1993 - 1999	2.894	2.46	1.524	2.32258	2.545	0.98	6.5

492725 - WEBER R AB WANSHIP RES				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	110	0	1990 - 2002	179.9	188	33.08	1094.29	176	70	233
BOD, 5 DAY, 20 DEG C MG/L	18	6	1990 - 1993	1.724	1	1.149	1.3202	1.364	<BDL>	4
FLOW, STREAM, INSTANTANEOUS CFS	94	0	1990 - 2002	178.6	118	255.8	65433.6	117.2	7.4	1639
HARDNESS, TOTAL (MG/L AS CACO3)	94	0	1990 - 1999	188.3	196.9	34.19	1168.96	184.2	73.3	234.6
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	73	9	1991 - 2002	0.183	0.116	0.2365	0.05593	0.1102	<BDL>	1.573
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	42	3	1991 - 2002	0.202	0.16	0.132	0.01742	0.1638	<BDL>	0.52
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	103	88	1990 - 2002	0.024	0.01172	0.04985	0.00249	0.01172	<BDL>	0.478
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	38	6	1990 - 1997	0.484	0.335	0.7878	0.62063	0.2838	<BDL>	4.931
OXYGEN, DISSOLVED MG/L	124	0	1990 - 2002	10.07	9.9	1.419	2.01356	9.97	6.52	13.44
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	21	0	2000 - 2002	103.9	102.7	12.5	156.25	103.2	80.3	135.8
PH (STANDARD UNITS)	123	0	1990 - 2002	8.447	8.43	0.3239	0.10491	8.441	7.2	9.78
PH, LAB, STANDARD UNITS SU	111	0	1990 - 2002	8.209	8.25	0.326	0.10628	8.203	7.2	8.96
PHOSPHORUS, DISSOLVED (MG/L AS P)	72	9	1990 - 2002	0.025	0.022	0.01689	0.00029	0.02066	<BDL>	0.09007
PHOSPHORUS, TOTAL (MG/L AS P)	116	8	1990 - 2002	0.043	0.0355	0.02919	0.00085	0.03638	<BDL>	0.2
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	121	0	1990 - 2002	222.4	232	41.1	1689.21	217.6	82	316
RESIDUE, TOTAL FIXED (MG/L)	25	13	1992 - 2002	4.055	2.69	3.841	14.7533	2.69	<BDL>	15
RESIDUE, TOTAL NONFILTRABLE (MG/L)	121	30	1990 - 2002	10.66	6.8	12.32	151.782	6.468	<BDL>	70
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	108	0	1990 - 2002	381.4	392	68.47	4688.14	373.7	145	535
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	124	0	1990 - 2002	378.5	385	115.7	13386.5	365.1	147	1355
TEMPERATURE, WATER (DEGREES CENTIGRADE)	123	1	1990 - 2002	8.758	8.43	5.529	30.5698	6.1	<BDL>	19.3
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	110	0	1990 - 2002	3.877	2.39	4.622	21.3629	2.665	0.41	32.4

492802 - OAKLEY LAGOONS				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	24	0	1990 - 2000	213.5	202	34.46	1187.49	210.8	158	281
BOD, 5 DAY, 20 DEG C MG/L	53	0	1990 - 2002	14.45	12	8.846	78.2517	12.7	6	54
FLOW, IN CONDUIT OR THRU A TREATMENT PLANT MGD	25	1	1990 - 1996	0.201	0.1	0.2546	0.06482	0.102	<BDL>	1.2
FLOW, RATE, INSTANTANEOUS GALLONS/MIN	25	0	1991 - 2002	65.01	55.5	39.12	1530.37	51.59	5.5	138
FLOW, STREAM, INSTANTANEOUS CFS	25	20	1990 - 2002	0.159	0.00075	0.5832	0.34012	0.000755	<BDL>	2.9
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	48	3	1990 - 2002	3.398	1.741	3.213	10.3234	1.862	<BDL>	10.8
OXYGEN, DISSOLVED MG/L	57	0	1990 - 2002	6.925	3.4	6.508	42.3541	3.911	0.1	21.9

492802 - OAKLEY LAGOONS (cont'd)

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	10	0	2000 - 2002	43.11	25.2	44.51	1981.14	30.79	11.6	151.3
PH (STANDARD UNITS)	58	0	1990 - 2002	8.039	7.75	0.9756	0.9518	7.982	6.6	10.1
PH, LAB, STANDARD UNITS SU	17	0	1990 - 2000	7.668	7.7	0.4173	0.17414	7.658	7.1	8.26
RESIDUE, TOTAL NONFILTRABLE (MG/L)	55	2	1990 - 2002	18.11	13	13.53	183.061	14.15	<BDL>	58
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	58	0	1990 - 2002	539.9	552.5	143	20449	516.5	115	803
TEMPERATURE, WATER (DEGREES CENTIGRADE)	58	0	1990 - 2002	10.42	10.82	4.316	18.6279	9.157	0.83	18.02

492830 - BEAVER CK AB CROOKED CK

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	176.8	193	35.94	1291.68	173	109	230
FLOW, STREAM, INSTANTANEOUS CFS	28	0	1993 - 1999	101.9	88.3	92.63	8580.32	72.45	9	445
HARDNESS, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	193	203.2	38.15	1455.42	189.2	123.5	263.2
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	29	0	1993 - 1999	0.358	0.245	0.2216	0.04911	0.2965	0.1	0.90442
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	30	27	1993 - 1999	0.029	0.00023	0.1241	0.0154	0.00023	<BDL>	0.68
OXYGEN, DISSOLVED MG/L	30	0	1993 - 1999	9.625	9.55	1.378	1.89888	9.53	7.1	12.2
PH (STANDARD UNITS)	31	0	1993 - 1999	8.259	8.21	0.4679	0.21893	8.245	6.5	9.01
PH, LAB, STANDARD UNITS SU	31	0	1993 - 1999	7.976	8.1	0.4493	0.20187	7.963	7	8.76
PHOSPHORUS, DISSOLVED (MG/L AS P)	29	5	1993 - 1999	0.033	0.028	0.01877	0.00035	0.0274	<BDL>	0.074
PHOSPHORUS, TOTAL (MG/L AS P)	31	0	1993 - 1999	0.062	0.06	0.03051	0.00093	0.05446	0.019	0.148
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	31	0	1993 - 1999	226.8	236	40.5	1640.25	223.2	162	300
RESIDUE, TOTAL FIXED (MG/L)	18	1	1993 - 1994	12.61	10.5	11.81	139.476	9.14	<BDL>	53
RESIDUE, TOTAL NONFILTRABLE (MG/L)	31	1	1993 - 1999	18.13	16	15.41	237.468	14.07	<BDL>	73.2
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	31	0	1993 - 1999	394	408	78.54	6168.53	386.5	277	587
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	31	0	1993 - 1999	422.7	403	215.1	46268	392	245	1340
TEMPERATURE, WATER (DEGREES CENTIGRADE)	31	0	1993 - 1999	8.767	9	5.591	31.2593	6.336	0.6	21.4
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	31	0	1993 - 1999	6.874	5.79	5.849	34.2108	5.398	1.7	32.3

492850 - KAMAS LAGOONS

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	10	0	1990 - 1993	191.2	190.5	38.56	1486.87	187.6	131	258
BOD, 5 DAY, 20 DEG C MG/L	57	14	1990 - 2002	9.287	6	9.082	82.4827	5.401	<BDL>	37

492850 - KAMAS LAGOONS (cont'd)				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
FLOW, IN CONDUIT OR THRU A TREATMENT PLANT MGD	19	0	1992 - 1999	0.64	0.5	0.5751	0.33074	0.4555	0.1	2.4
FLOW, RATE, INSTANTANEOUS GALLONS/MIN	33	0	1992 - 2002	210.6	150	237.5	56406.3	105.1	0.9	1100
FLOW, STREAM, INSTANTANEOUS CFS	25	21	1990 - 2002	0.319	0.00085	1.221	1.49084	0.000853	<BDL>	6
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	60	9	1990 - 2002	1.81	1.115	2.678	7.17168	0.5599	<BDL>	11.4
OXYGEN, DISSOLVED MG/L	64	0	1990 - 2002	7.718	7.005	2.424	5.87578	7.365	4.1	15.01
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	15	0	2000 - 2002	78.76	73.8	18.93	358.345	76.7	53.7	117.1
PH (STANDARD UNITS)	64	0	1990 - 2002	8.447	8.35	0.7735	0.5983	8.412	7.1	10.13
RESIDUE, TOTAL NONFILTRABLE (MG/L)	61	28	1990 - 2002	11.35	4.4	11.06	122.324	6.731	<BDL>	37
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	63	0	1990 - 2002	634.6	617	142.7	20363.3	617.6	223	1043
TEMPERATURE, WATER (DEGREES CENTIGRADE)	64	0	1990 - 2002	11	11.5	5.892	34.7157	8.916	1.4	22.1

492853 - BEAVER CREEK AB0VE WEBER-PROVO CANAL				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	12	0	1998 - 1999	120.4	112	54.85	3008.52	107.7	45	194
BOD, 5 DAY, 20 DEG C MG/L	13	8	1990 - 1998	1.01	0.6219	1.093	1.19465	0.6219	<BDL>	4
FLOW, STREAM, INSTANTANEOUS CFS	47	0	1990 - 1999	11.46	5.3	13.84	191.546	6.126	0.67	58.9
HARDNESS, TOTAL (MG/L AS CACO3)	16	0	1991 - 1999	128.8	125	58.73	3449.21	114.7	48.9	211.9
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	29	1	1991 - 1999	0.149	0.1184	0.1022	0.01044	0.1162	<BDL>	0.436
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	45	44								
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	12	0	1991 - 1992	0.304	0.22	0.2368	0.05607	0.2535	0.1	1
OXYGEN, DISSOLVED MG/L	48	0	1990 - 1999	9.591	9.25	1.458	2.12576	9.487	7.05	14.3
PH (STANDARD UNITS)	46	0	1990 - 1999	8.348	8.4	0.3851	0.1483	8.339	7.3	9.1
PH, LAB, STANDARD UNITS SU	22	0	1990 - 1999	7.805	7.865	0.5413	0.29301	7.787	6.8	8.43
PHOSPHORUS, DISSOLVED (MG/L AS P)	34	19	1990 - 1999	0.013	0.0089	0.01457	0.00021	0.008894	<BDL>	0.079
PHOSPHORUS, TOTAL (MG/L AS P)	47	7	1990 - 1999	0.037	0.022	0.04249	0.00181	0.02557	<BDL>	0.248
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	38	1	1990 - 1999	143.2	142	49.7	2470.09	133.4	<BDL>	240
RESIDUE, TOTAL NONFILTRABLE (MG/L)	47	11	1990 - 1999	13.75	8.4	25.07	628.505	7.119	<BDL>	169
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	12	0	1998 - 1999	276	279	103.2	10650.2	255.3	103	411
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	48	0	1990 - 1999	255.2	221.5	178.7	31933.7	221.7	91	1303
TEMPERATURE, WATER (DEGREES CENTIGRADE)	47	0	1990 - 1999	8.924	8.6	4.375	19.1406	7.579	1.3	17.9
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	12	0	1998 - 1999	7.287	3.305	8.111	65.7883	4.062	0.798	28.4

492854 - Beaver CK at Bridge to Lumber Mill 1MI AB Kamas 19

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
				Summary Statistics						
ALKALINITY, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	110	98.5	53.59	2871.89	97.24	41	195
FLOW, STREAM, INSTANTANEOUS CFS	26	0	1993 - 1999	33.99	27	27.28	744.198	24.15	4.5	105
HARDNESS, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	120	113.4	55.98	3133.76	106.8	41.8	208.7
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	28	3	1993 - 1999	0.194	0.139	0.1376	0.01893	0.1547	<BDL>	0.61584
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	29	27	1993 - 1999	0.022	0.01909	0.01367	0.00019	0.01909	<BDL>	0.065
OXYGEN, DISSOLVED MG/L	30	0	1993 - 1999	8.724	8.75	0.9841	0.96845	8.669	6.9	10.48
PH (STANDARD UNITS)	28	0	1993 - 1999	8.337	8.31	0.2991	0.08946	8.332	7.4	8.98
PH, LAB, STANDARD UNITS SU	30	0	1993 - 1999	7.917	7.955	0.5219	0.27238	7.899	6.2	8.48
PHOSPHORUS, DISSOLVED (MG/L AS P)	28	10	1993 - 1999	0.013	0.0115	0.005571	3.1E-05	0.01167	<BDL>	0.031
PHOSPHORUS, TOTAL (MG/L AS P)	30	6	1993 - 1999	0.03	0.022	0.04141	0.00171	0.02057	<BDL>	0.239
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	30	0	1993 - 1999	140.9	137	50.36	2536.13	131.1	56	216
RESIDUE, TOTAL FIXED (MG/L)	17	6	1993 - 1994	7.389	5	6.797	46.1992	5.046	<BDL>	25
RESIDUE, TOTAL NONFILTRABLE (MG/L)	30	6	1993 - 1999	10.23	7.7	8.683	75.3945	7.165	<BDL>	33
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	30	0	1993 - 1999	248.6	238	101.9	10383.6	226.8	101	411
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	30	0	1993 - 1999	230.9	215	94.18	8869.87	211.6	93	409
TEMPERATURE, WATER (DEGREES CENTIGRADE)	30	0	1993 - 1999	8.414	7.99	4.122	16.9909	7.465	3.1	16.13
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	30	0	1993 - 1999	7.695	6.9	6.327	40.0309	5.408	1.2	27.2

492900 - KAMAS FISH HATCHERY EFFLUENT

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
				Summary Statistics						
ALKALINITY, TOTAL (MG/L AS CACO3)	21	0	1994 - 2002	217.9	221	18.82	354.192	217.1	177	238
BOD, 5 DAY, 20 DEG C MG/L	102	27	1990 - 1995	2.096	2	1.256	1.57754	1.739	<BDL>	6
FLOW, RATE, INSTANTANEOUS GALLONS/MIN	44	0	2000 - 2002	1754	1693	523.1	273634	1621	170	2948
FLOW, STREAM, INSTANTANEOUS CFS	153	3	1990 - 2000	5.118	5	1.475	2.17563	4.896	<BDL>	12.2
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	72	3	1991 - 2002	0.493	0.445	0.1803	0.03251	0.4672	<BDL>	1.191
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	92	22	1990 - 2002	0.148	0.13	0.0866	0.0075	0.124	<BDL>	0.39
OXYGEN, DISSOLVED MG/L	209	0	1990 - 2002	7.471	7.3	0.9636	0.92852	7.409	4.1	10.7
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	18	0	2000 - 2002	82.47	83.15	12.04	144.962	81.66	62.9	114.8
PH (STANDARD UNITS)	212	0	1990 - 2002	7.944	7.6	4.711	22.1935	7.695	6.4	76
PH, LAB, STANDARD UNITS SU	49	0	1990 - 2002	7.441	7.43	0.3484	0.12138	7.433	6.7	8.09

492900 - KAMAS FISH HATCHERY EFFLUENT (cont'd) — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
PHOSPHORUS, DISSOLVED (MG/L AS P)	67	7	1990 - 2002	0.053	0.043	0.03592	0.00129	0.04198	<BDL>	0.164
PHOSPHORUS, TOTAL (MG/L AS P)	87	7	1990 - 2002	0.083	0.059	0.07385	0.00545	0.0638	<BDL>	0.54
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	40	0	1990 - 2002	229.8	236	23.21	538.704	228.5	166	268
RESIDUE, TOTAL NONFILTRABLE (MG/L)	214	188	1990 - 2002	1.319	0.6192	2.272	5.16198	0.6192	<BDL>	23
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	94	0	1990 - 2002	444.4	425	240.8	57984.6	420.9	142	2636
TEMPERATURE, WATER (DEGREES CENTIGRADE)	212	0	1990 - 2002	11.15	10.7	2.078	4.31808	10.96	6	18.83

492910 - BEAVER CK AT USFS BOUNDARY 10 — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	34.37	31	25.54	652.292	30.15	13	160
FLOW, STREAM, INSTANTANEOUS CFS	27	0	1993 - 1999	28.05	18	25.66	658.436	16.97	2	100
HARDNESS, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	36.83	36.75	14.79	218.744	33.7	14.5	60.2
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	28	16	1993 - 1999	0.207	0.01378	0.8199	0.67224	0.0137	<BDL>	4.352
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	29	28								
OXYGEN, DISSOLVED MG/L	30	0	1993 - 1999	8.981	8.85	1.212	1.46894	8.902	7	11.38
PH (STANDARD UNITS)	29	0	1993 - 1999	8.119	8.19	0.4193	0.17581	8.108	7.3	8.95
PH, LAB, STANDARD UNITS SU	30	0	1993 - 1999	7.286	7.3	0.4563	0.20821	7.271	5.7	8.39
PHOSPHORUS, DISSOLVED (MG/L AS P)	28	19	1993 - 1999	0.01	0.00734	0.007586	5.8E-05	0.007339	<BDL>	0.035
PHOSPHORUS, TOTAL (MG/L AS P)	30	12	1993 - 1999	0.015	0.013	0.00831	6.9E-05	0.01306	<BDL>	0.033
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	30	0	1993 - 1999	63.4	63	22.74	517.108	59.2	28	102
RESIDUE, TOTAL FIXED (MG/L)	18	7	1993 - 1994	6.157	3	8.65	74.8225	2.853	<BDL>	31
RESIDUE, TOTAL NONFILTRABLE (MG/L)	30	9	1993 - 1999	7.524	5.1	8.022	64.3525	5.084	<BDL>	37
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	30	0	1993 - 1999	94.64	88.2	39.64	1571.33	86.23	35.9	181
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	30	0	1993 - 1999	107.1	100	85.62	7330.78	85.76	13	494
TEMPERATURE, WATER (DEGREES CENTIGRADE)	29	1	1993 - 1999	7.226	7.5	5.491	30.1511	3.935	<BDL>	17.28
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	30	0	1993 - 1999	8.703	6.135	5.496	30.206	7.404	2.04	28

492920 - WEBER R AB WEBER/PROVO DIVERSION — Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	120.8	121	34.02	1157.36	115.3	51	190
FLOW, STREAM, INSTANTANEOUS CFS	31	0	1993 - 1999	358	199	474.3	224960	196.5	44	1890

492920 - WEBER R AB WEBER/PROVO DIVERSION (cont'd) — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
HARDNESS, TOTAL (MG/L AS CACO3)	31	0	1993 - 1999	128.8	130.2	36.93	1363.82	122.8	57	183.5
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	29	7	1993 - 1999	0.104	0.071	0.1648	0.02716	0.05758	<BDL>	0.913
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	30	29								
OXYGEN, DISSOLVED MG/L	31	0	1993 - 1999	9.275	9.2	1.328	1.76358	9.184	6.9	11.9
PH (STANDARD UNITS)	31	0	1993 - 1999	8.439	8.43	0.2996	0.08976	8.434	8	9.11
PH, LAB, STANDARD UNITS SU	31	0	1993 - 1999	7.973	8.1	0.4617	0.21317	7.959	6.7	8.65
PHOSPHORUS, DISSOLVED (MG/L AS P)	29	21	1993 - 1999	0.009	0.00818	0.004812	2.3E-05	0.008183	<BDL>	0.022
PHOSPHORUS, TOTAL (MG/L AS P)	31	12	1993 - 1999	0.021	0.011	0.03588	0.00129	0.01065	<BDL>	0.187
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	31	0	1993 - 1999	139.7	148	34.57	1195.08	134.7	60	182
RESIDUE, TOTAL FIXED (MG/L)	18	11	1993 - 1994	5.394	1.078	12.84	164.866	1.068	<BDL>	55
RESIDUE, TOTAL NONFILTRABLE (MG/L)	31	10	1993 - 1999	7.431	4	12.18	148.352	3.797	<BDL>	64
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	31	0	1993 - 1999	247.2	253	67.21	4517.18	236.6	103	339
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	31	0	1993 - 1999	228.2	237	65.26	4258.87	217.9	101	341
TEMPERATURE, WATER (DEGREES CENTIGRADE)	31	2	1993 - 1999	6.484	5.52	4.893	23.9414	3.649	<BDL>	17.8
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	31	0	1993 - 1999	3.847	2.3	5.092	25.9285	2.22	0.4	24

492949 - SMITH MOREHOUSE CK AB CNFL/ WEBER R — **Summary Statistics**

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	86	84	39.58	1566.58	75.52	24	144
FLOW, STREAM, INSTANTANEOUS CFS	25	0	1993 - 1999	42.47	32.3	40.82	1666.27	30.25	8	154.7
HARDNESS, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	98.22	95.5	48.83	2384.37	84.38	26.8	176.7
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	28	6	1993 - 1999	0.075	0.0755	0.05672	0.00322	0.05335	<BDL>	0.199
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	29	28								
OXYGEN, DISSOLVED MG/L	30	0	1993 - 1999	9.139	8.955	1.32	1.7424	9.049	7	11.9
PH (STANDARD UNITS)	29	0	1993 - 1999	8.34	8.38	0.3382	0.11438	8.333	7.8	9.36
PH, LAB, STANDARD UNITS SU	30	0	1993 - 1999	7.836	7.875	0.4003	0.16024	7.826	6.9	8.48
PHOSPHORUS, DISSOLVED (MG/L AS P)	28	21	1993 - 1999	0.01	0.00837	0.005872	3.4E-05	0.008362	<BDL>	0.024
PHOSPHORUS, TOTAL (MG/L AS P)	30	20	1993 - 1999	0.011	0.00749	0.01197	0.00014	0.007488	<BDL>	0.063
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	30	0	1993 - 1999	110.4	120	44.04	1939.52	100.7	36	176
RESIDUE, TOTAL FIXED (MG/L)	17	11	1993 - 1994	3.216	1.133	5.325	28.3556	1.133	<BDL>	20
RESIDUE, TOTAL NONFILTRABLE (MG/L)	30	20	1993 - 1999	3.852	2.038	5.116	26.1735	2.035	<BDL>	24
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	30	0	1993 - 1999	190.7	194	86.21	7432.16	168.4	55.4	321

492949 - SMITH MOREHOUSE CK AB CNFL/ WEBER R (cont'd)

Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	30	0	1993 - 1999	175.7	185.5	81.43	6630.84	153.5	36	318
TEMPERATURE, WATER (DEGREES CENTIGRADE)	30	2	1993 - 1999	6.252	5.65	4.356	18.9747	4.049	<BDL>	15.9
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	30	0	1993 - 1999	3.046	1.75	3.472	12.0548	1.872	0.353	14

492959 - WEBER R AB CNFL/ SMITH MOREHOUSE CK

Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	109.3	115	30.73	944.333	104.3	46	149
FLOW, STREAM, INSTANTANEOUS CFS	24	0	1993 - 1999	135.6	82.5	128.3	16460.9	96.96	35	550
HARDNESS, TOTAL (MG/L AS CACO3)	30	0	1993 - 1999	117.2	120.2	35.02	1226.4	111.2	51.5	171
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	28	7	1993 - 1999	0.173	0.1	0.2947	0.08685	0.08605	<BDL>	1.541
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	29	28								
OXYGEN, DISSOLVED MG/L	30	0	1993 - 1999	8.939	8.715	1.356	1.83874	8.837	5.81	11.1
PH (STANDARD UNITS)	29	0	1993 - 1999	8.288	8.26	0.37	0.1369	8.28	7.5	9.21
PH, LAB, STANDARD UNITS SU	30	0	1993 - 1999	7.812	8.01	0.5748	0.3304	7.79	6.2	8.39
PHOSPHORUS, DISSOLVED (MG/L AS P)	28	18	1993 - 1999	0.011	0.01014	0.00539	2.9E-05	0.01013	<BDL>	0.023
PHOSPHORUS, TOTAL (MG/L AS P)	30	16	1993 - 1999	0.013	0.00879	0.0135	0.00018	0.008781	<BDL>	0.063
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	30	0	1993 - 1999	127.5	136	32.72	1070.6	122.8	54	184
RESIDUE, TOTAL FIXED (MG/L)	17	10	1993 - 1994	3.423	1.5	5.376	28.9014	1.5	<BDL>	22
RESIDUE, TOTAL NONFILTRABLE (MG/L)	30	12	1993 - 1999	5.783	4.5	5.767	33.2583	4.077	<BDL>	30
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	30	0	1993 - 1999	223.8	238.5	62.23	3872.57	213.9	97.7	308
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	30	0	1993 - 1999	210.1	221.5	65.02	4227.6	198.4	77	324
TEMPERATURE, WATER (DEGREES CENTIGRADE)	30	0	1993 - 1999	6.287	4.75	4.799	23.0304	3.968	0.3	15.4
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	30	0	1993 - 1999	2.981	2.46	2.899	8.4042	2.077	0.44	14

592331 - WANSHIP RES AB DAM 01

Summary Statistics

Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	13	0	1990 - 2002	156.5	164	24.5	600.25	154.5	108	187
CHLOROPHYLL A UG/L FLUOROMETRIC UNCORRECTED	13	0	1990 - 2002	2.615	3	1.48	2.1904	1.908	0.2	5.5
HARDNESS, TOTAL (MG/L AS CACO3)	17	0	1990 - 1998	162.2	174.1	32.9	1082.41	158.5	87.8	197.3
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	42	20	1992 - 2002	0.087	0.0355	0.0784	0.00615	0.05813	<BDL>	0.355

592331 - WANSHIP RES AB DAM 01 (cont'd)				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	50	40	1990 - 2002	0.036	0.0115	0.07938	0.0063	0.0115	<BDL>	0.5
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	16	0	1990 - 1992	0.384	0.295	0.3083	0.09505	0.3017	0.1	1.21
OXYGEN, DISSOLVED MG/L	56	0	1990 - 2002	5.725	6.75	2.745	7.53503	4.367	0.1	10.19
OXYGEN, DISSOLVED, PERCENT OF SATURATION %	16	0	2000 - 2002	64.16	59.9	40.68	1654.86	46.42	5	128.2
PH (STANDARD UNITS)	56	0	1990 - 2002	8.063	8.16	0.3733	0.13935	8.054	7.28	8.6
PHOSPHORUS, DISSOLVED (MG/L AS P)	46	21	1990 - 2002	0.034	0.01	0.06195	0.00384	0.009622	<BDL>	0.249
PHOSPHORUS, TOTAL (MG/L AS P)	50	13	1990 - 2002	0.047	0.0205	0.08298	0.00689	0.01844	<BDL>	0.385
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	13	0	1990 - 2002	195.5	200	34.02	1157.36	192.5	128	244
RESIDUE, TOTAL FIXED (MG/L)	11	8	1992 - 2002	2.339	2.225	0.785	0.61623	2.225	<BDL>	4
RESIDUE, TOTAL NONFILTRABLE (MG/L)	13	12								
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	56	0	1990 - 2002	339.2	345	59.83	3579.63	333.4	158	503
TEMPERATURE, WATER (DEGREES CENTIGRADE)	56	0	1990 - 2002	14.95	15.95	4.032	16.257	14.37	7.5	21.5
TRANSPARENCY, SECCHI DISC (METERS)	14	0	1990 - 2002	3	3	0.6816	0.46458	2.92	1.8	4
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	11	0	1990 - 2002	1.386	1.44	0.4886	0.23873	1.307	0.74	2.33

592332 - WANSHIP RES MIDLAKE 02				Summary Statistics						
Parameter	No. of Obs	No. Censored	Range Of Dates	Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
CHLOROPHYLL A UG/L FLUOROMETRIC UNCORRECTED	11	0	1990 - 2002	3.573	2.7	3.559	12.6665	2.107	0.2	13.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	22	11	1992 - 2002	0.068	0.03776	0.05687	0.00323	0.04786	<BDL>	0.225
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	30	27	1990 - 2002	0.04	0.03773	0.01277	0.00016	0.03772	<BDL>	0.0745
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	12	0	1990 - 1992	0.433	0.335	0.2772	0.07684	0.3653	0.2	1
OXYGEN, DISSOLVED MG/L	32	0	1990 - 2002	6.822	7.24	1.573	2.47433	6.614	3.3	9.74
PH (STANDARD UNITS)	32	0	1990 - 2002	8.195	8.2	0.3148	0.0991	8.189	7.4	8.62
PHOSPHORUS, DISSOLVED (MG/L AS P)	26	12	1990 - 2002	0.015	0.01	0.01251	0.00016	0.01125	<BDL>	0.048
PHOSPHORUS, TOTAL (MG/L AS P)	30	8	1990 - 2002	0.028	0.0195	0.03804	0.00145	0.01828	<BDL>	0.214
RESIDUE, TOTAL NONFILTRABLE (MG/L)	11	10								
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	31	0	1990 - 2002	337.5	337	67.18	4513.15	331.6	208	601
TEMPERATURE, WATER (DEGREES CENTIGRADE)	32	0	1990 - 2002	16.44	16.92	3.791	14.3717	15.97	9.4	22.55
TRANSPARENCY, SECCHI DISC (METERS)	14	0	1990 - 2002	2.493	2.75	0.9817	0.96373	2.276	0.8	4.1

592396 - SMITH AND MOREHOUSE RES AB DAM 01

Parameter	No. of Obs	No. Censored	Range Of Dates	Summary Statistics Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	14	0	1991 - 2001	16.5	17	6.466	41.8092	13.94	1	25
CHLOROPHYLL A UG/L FLUOROMETRIC UNCORRECTED	12	0	1991 - 2001	2.717	2.35	1.934	3.74036	1.946	0.2	5.8
HARDNESS, TOTAL (MG/L AS CACO3)	16	0	1991 - 1999	19.31	19.5	5.434	29.5284	18.59	11.1	32.1
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	46	31	1991 - 2001	0.026	0.00862	0.05786	0.00335	0.008615	<BDL>	0.37
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	46	43	1991 - 2001	0.029	0.02597	0.01512	0.00023	0.02596	<BDL>	0.0775
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	12	7	1991 - 1997	0.183	0.05204	0.3062	0.09376	0.05108	<BDL>	1
OXYGEN, DISSOLVED MG/L	46	0	1991 - 2001	8.636	7.71	8.529	72.7438	7.406	1.1	63.9
PH (STANDARD UNITS)	46	0	1991 - 2001	7.494	7.4	0.7646	0.58461	7.457	5.95	9.2
PH, LAB, STANDARD UNITS SU	10	0	1991 - 2001	6.913	7.065	0.5012	0.2512	6.895	5.69	7.35
PHOSPHORUS, DISSOLVED (MG/L AS P)	38	33	1991 - 2001	0.007	0.00688	0.002013	4.1E-06	0.006882	<BDL>	0.013
PHOSPHORUS, TOTAL (MG/L AS P)	46	37	1991 - 2001	0.01	0.00295	0.0178	0.00032	0.002947	<BDL>	0.0974
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	12	1	1991 - 2001	33.25	33	8.374	70.1239	32.29	<BDL>	50
RESIDUE, TOTAL FIXED (MG/L)	12	10	1991 - 2001	3	3	0	0	3	<BDL>	3
RESIDUE, TOTAL NONFILTRABLE (MG/L)	11	9	1991 - 2001	3.497	3.418	0.7883	0.62142	3.418	<BDL>	5
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	45	0	1991 - 2001	39.58	38	23.13	534.997	31.43	1	148
TEMPERATURE, WATER (DEGREES CENTIGRADE)	46	0	1991 - 2001	9.875	8.5	4.674	21.8463	8.835	3.4	17.9
TRANSPARENCY, SECCHI DISC (METERS)	11	0	1991 - 2001	2.377	2	1.443	2.08225	1.998	0.9	5
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	14	0	1991 - 2001	4.092	4.3	2.868	8.22542	2.911	0.63	8.55

592400 - Smith & Morehouse CK AB Smith & Morehouse Res

Parameter	No. of Obs	No. Censored	Range Of Dates	Summary Statistics Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
ALKALINITY, TOTAL (MG/L AS CACO3)	16	0	1993 - 1999	20.81	18.5	9.847	96.9634	18.72	10	39
FLOW, STREAM, INSTANTANEOUS CFS	26	0	1991 - 2001	24.12	9.5	29.63	877.937	11.28	1	90
HARDNESS, TOTAL (MG/L AS CACO3)	16	0	1993 - 1999	22.42	19.1	10.51	110.46	20.15	11.1	38.9
NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	26	18	1991 - 2001	0.052	0.01771	0.08343	0.00696	0.01765	<BDL>	0.36
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	28	27								
OXYGEN, DISSOLVED MG/L	28	0	1991 - 2001	8.794	8.7	1.191	1.41848	8.718	7.1	11.8
PH (STANDARD UNITS)	27	0	1991 - 2001	8.116	8.1	0.6374	0.40628	8.091	6.75	9.4
PH, LAB, STANDARD UNITS SU	16	0	1993 - 1999	7.199	7.025	0.4612	0.21271	7.186	6.7	8.6
PHOSPHORUS, DISSOLVED (MG/L AS P)	24	21	1991 - 2001	0.004	0.00134	0.006728	4.5E-05	0.001336	<BDL>	0.031

592400 - Smith & Morehouse CK AB Smith & Morehouse Res (cont'd)

Parameter	No. of Obs	No. Censored	Range Of Dates	Summary Statistics Mean	Median	Standard Deviation	Variance	Geometric Mean	Min	Max
PHOSPHORUS, TOTAL (MG/L AS P)	28	23	1991 - 2001	0.007	0.00355	0.0107	0.00011	0.003543	<BDL>	0.05032
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	28	2	1991 - 2001	40.56	36	22.13	489.737	35.62	<BDL>	120
RESIDUE, TOTAL FIXED (MG/L)	21	15	1991 - 2001	1.707	0.05216	3.937	15.5	0.05216	<BDL>	16
RESIDUE, TOTAL NONFILTRABLE (MG/L)	27	19	1991 - 2001	3.991	1.749	5.637	31.7758	1.749	<BDL>	21.6
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	16	0	1993 - 1999	114.4	48.8	189.4	35872.4	64.75	24.3	784
SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	26	0	1991 - 2001	55.72	41	36.15	1306.82	45.32	8.5	146
TEMPERATURE, WATER (DEGREES CENTIGRADE)	28	0	1991 - 2001	7.806	9.15	4.839	23.4159	4.874	0.04	15.95
TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	16	0	1993 - 1999	3.964	1.935	4.268	18.2158	2.122	0.25	14

1.3 BACKGROUND CONCENTRATIONS OF TOTAL PHOSPHORUS

This section contains an assessment of water quality monitoring data collected at springs and upper headwater stream monitoring locations. This assessment was completed in order to review concentrations of total phosphorus at locations where water quality conditions are the result of natural geomorphologic processes such as weathering or dissolution. Anthropogenic or human-caused influences are assumed to be minimal at the locations included in this assessment.

Table 2. Total phosphorus concentration at upper headwater stream monitoring locations in the Echo TMDL study area.

	No. of Obs.	No. BDL	Range Of Dates	Mean	Median	Standard Deviation	Geometric Mean	Min.	Max.	% exceedance
Chalk Creek Streams										
Group assessment	170	26	1990 - 2003	0.10	0.057	0.14	0.05	<BDL>	0.782	54.7
Stations included in grouped assessment										
492626 - HUFF CK AB CNFL/ CHALK CK	37	0	1993 - 2003	0.19	0.145	0.17	0.14	0.053	0.782	100
492628 - CHALK CREEK AT UT/WYO STATELINE	48	4	1990 - 1999	0.09	0.066	0.09	0.06	<BDL>	0.399	62.5
492636 - CHALK CK S FK 1 MI AB CHALK CK	41	7	1993 - 2003	0.12	0.029	0.19	0.04	<BDL>	0.701	39
492637 - CHALK CK EAST FK AB CNFL/ CHALK CK	64	12	1990 - 2003	0.08	0.03	0.10	0.03	<BDL>	0.446	22.7
Upper Weber Streams										
Group assessment	74	49	1981 - 2003	0.01	0.0065	0.01	0.01	<BDL>	0.063	2.7
Stations included in grouped assessment										
492940 - WEBER R AB HOLIDAY PARK DEVELOPMENT	8	5	1993 - 1994	0.01	0.0056	0.01	0.01	<BDL>	0.033	0
492959 - WEBER R AB CNFL/ SMITH MOREHOUSE CK	35	21	1993 - 2003	0.01	0.0075	0.01	0.01	<BDL>	0.063	2.9
592400 - SMITH AND MOREHOUSE CK AB SMITH AND MOREHOUSE RES	31	23	1981 - 2001	0.01	0.0056	0.01	0.01	<BDL>	0.0503	3.2
Beaver Creek Streams										
Group assessment	78	34	1979 - 2003	0.02	0.01	0.02	0.01	<BDL>	0.09	3.8
Stations included in grouped assessment										
403818111154201 - BEAVER CREEK AB KAMAS, UT	2	0	2000 - 2000	0.02	0.018	0.00	0.02	0.015	0.021	0
492910 - BEAVER CK AT USFS BOUNDARY 10	51	23	1979 - 2003	0.02	0.01	0.02	0.01	<BDL>	0.09	5.9
492867 - BEAVER CK NEAR BUNKERVILLE RANCH 11	2	1	1979 - 1979					<BDL>	0.02	0
492866 - BEAVER CK 1MI BL BUNKERVILLE RANCH	12	5	1979 - 1981	0.01	0.01	0.01	0.01	<BDL>	0.02	0

Table 2. (cont'd) Total phosphorus concentration at upper headwater stream monitoring locations in the Echo TMDL study area.

	No. of Obs.	No. BDL	Range Of Dates	Mean	Median	Standard Deviation	Geometric Mean	Min.	Max.	% exceedance
492864 - BEAVER CK BEHIND DEVOS RANCH 13	11	5	1979 - 1981	0.01	0.01	0.01	0.01	<BDL>	0.03	0
Silver Creek Streams										
Group assessment	47	0	1979 - 2003	0.11	0.06	0.16	0.07	0.02	0.967	63.8
Stations included in grouped assessment										
492695 - SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	35	0	1998 - 2003	0.13	0.063	0.18	0.08	0.02	0.967	68.6
492696 - ONTARIO CANYON CK AB CNFL / SILVER CK	1	0	1979 - 1979	0.07	0.07			0.07	0.07	100
492670 - ALEXANDER CK @ HIGHWAY XING	11	0	2001 - 2002	0.05	0.039	0.02	0.05	0.02	0.091	45.5

Table 3. Total phosphorus (TP) and dissolved phosphorus (DP) concentrations at spring monitoring locations in the Echo TMDL study area.

All Springs with TP data	No. of Obs.	No. BDL	Range Of Dates	Mean	Median	Standard Deviation	Geometric Mean	Min.	Max.	% exceedance
Group assessment	50	14	1988 - 1991	0.02	0.0095	0.04	0.01	<BDL>	0.25	4
Stations included in grouped assessment.										
492902 - KAMAS FH INFLOW 2 EAST SPRINGS	25	9	1988 - 1991	0.02	0.008	0.05	0.01	<BDL>	0.25	4
492903 - KAMAS FH INFLOW 1 NORTH SPRINGS	25	5	1988 - 1991	0.02	0.01	0.03	0.01	<BDL>	0.141	0
All Springs with DP data										
Group assessment	10	0	1983 - 1991	0.07	0.03	0.07	0.04	0.01	0.19	40
Stations included in grouped assessment										
404048111272201 - (D-2-4) 2aac-S1	1		8/23/1983	0.03	0.03			0.03	0.03	0
404114111274501 - (D-1-4)35cad-S1	1		8/14/1983	0.15	0.15			0.15	0.15	100
404100111284101 - (D-1-4)34dcd-S1	1		8/23/1983	0.19	0.19			0.19	0.19	100
404133111272901 - (D-1-4)35aca-S1	1		7/18/1983	0.11	0.11			0.11	0.11	100
404150111293601 - (D-1-4)33aab-S1	1		8/23/1983	0.12	0.12			0.12	0.12	100
404013111294801 - (D-2-4)4dca-S1	1		8/22/1983	0.03	0.03			0.03	0.03	0
492902 - KAMAS FH INFLOW 2 EAST SPRINGS	2	0	1990 - 1991	0.02	0.016	0.01	0.01	0.01	0.022	0
492903 - KAMAS FH INFLOW 1 NORTH SPRINGS	2	0	1990 - 1991	0.01	0.014	0.01	0.01	0.01	0.018	0

Table 4. Upper Weber River above Weber-Provo Diversion. Monthly average flows from USGS Gage 10128500 (Weber River Near Oakley, UT) 1904-2003. Monthly average total phosphorus (TP) concentrations were estimated using the grouped statistical assessment for stations 492940, 492959, and 592400 1981-2003.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	56.3	0.010[1]	43
February	28	56.5	0.010[1]	39
March	31	67.3	0.013[2]	66
April	30	177.7	0.020	257
May	31	683.4	0.022	1,151
June	30	901.4	0.008	551
July	31	264.0	0.014[2]	280
August	31	114.0	0.013	113
September	30	85.1	0.031[2]	194
October	31	79.8	0.012	73
November	30	69.7	0.010[1]	51
December	31	60.6	0.021	97
Annual Total:				2,914

[1]All data below the detection limit - value of 0.01 mg/L used.
[2]Only one value above the detection limit.

Table 5. Beaver Creek near Mouth. Streamflow estimated from observations at station 492830 1993-1999. Monthly average total phosphorus (TP) concentrations were estimated using the grouped statistical assessment for stations 492910, 492867, 492866, 492864, 403818111154201 1979-2003.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	52.5	0.022[1]	88
February	28	10.5	0.041	29
March	31	96.3	0.039	282
April	30	82.6	0.017	102
May	31	222.8	0.015	253
June	30	125.1	0.013	117
July	31	76.0	0.013[1]	75
August	31	62.3	0.018	84
September	30	55.5	0.010	41
October	31	32.3	0.019	47
November	30	30.0	0.023	51
December	31	41.3	0.020	63
Annual Total:				1,231

[1]Only one value above the detection limit.

Table 6. Weber River above Wanship Reservoir. Monthly average flow estimates from USGS Gage 10129300 (Weber River Near Peoa, Ut) 1957-1977. Monthly average total phosphorus (TP) concentrations are the flow weighted averages of the Beaver Creek and Upper Weber River values.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	80.5	0.016	96
February	28	83.4	0.015	85
March	31	119.6	0.028	255
April	30	158.5	0.019	219
May	31	419.3	0.020	649
June	30	729.0	0.009	474
July	31	211.2	0.014	221
August	31	96.2	0.015	108
September	30	102.6	0.023	171
October	31	114.4	0.014	122
November	30	102.7	0.014	105
December	31	89.5	0.021	140
Annual Total:				2,645

Table 7. Weber River Below Wanship Reservoir. Monthly average flow estimates from USGS Gage 10129500 1988-2003. Monthly average total phosphorus (TP) concentrations are those from the Weber River above Wanship Reservoir.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	76.9	0.016	92
February	28	81.8	0.015	83
March	31	100.7	0.028	215
April	30	118.2	0.019	163
May	31	241.4	0.020	374
June	30	477.4	0.009	310
July	31	282.1	0.014	295
August	31	217.8	0.015	244
September	30	179.6	0.023	299
October	31	150.0	0.014	160
November	30	133.6	0.014	137
December	31	107.0	0.021	168
Annual Total:				2,540

Table 8. Silver Creek near Mouth. Monthly average flow estimates from UDWQ monitoring station 492675 1981-2003. Monthly average total phosphorus (TP) concentrations were estimated using the grouped statistical assessment for stations 492695, 492696, and 492670 1979-2003.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	9.68	0.059	43
February	28	11.22	0.123	95
March	31	27.58	0.224	468
April	30	25.49	0.073	136
May	31	51.57	0.080	314
June	30	10.99	0.038	30
July	31	7.85	0.043	26
August	31	6.536	0.055	27
September	30	5.454	0.061	24
October	31	9.815	0.229	171
November	30	16.6	0.148	181
December	31	7.833	0.107	63
Annual Total:				1,578

Table 9. Weber River above Echo Reservoir. Monthly average flow estimates from USGS gage 10130500 1970-2003. Monthly average total phosphorus (TP) concentrations are the flow weighted average values of the Silver Creek and Weber River below Wanship Reservoir values.

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	136.6	0.021	214
February	28	134.4	0.028	257
March	31	158.5	0.070	843
April	30	201.3	0.028	419
May	31	355.5	0.031	835
June	30	583.3	0.010	407
July	31	273.8	0.015	303
August	31	189.4	0.016	229
September	30	181.5	0.024	317
October	31	183.0	0.027	378
November	30	165.7	0.029	351
December	31	152.1	0.027	306
Annual Total:				4,859

Table 10. Chalk Creek near Mouth. Monthly average flows from USGS gage 10131000 1927-2003. Monthly average total phosphorus (TP) concentrations were estimated using the grouped statistical assessment for Chalk Creek Stations 492626, 492628, 492636, 492637, and 492638 1990-2003

Month	Number of Days	Average Flow (cfs)	Average TP Concentration (mg/L)	Total Load (kg)
January	31	20.8	0.034	53
February	28	23.7	0.024	39
March	31	40.5	0.145	445
April	30	115.7	0.157	1,334
May	31	279.4	0.184	3,906
June	30	176.3	0.085	1,104
July	31	47.1	0.052	186
August	31	23.6	0.039	70
September	30	21.5	0.085	134
October	31	21.8	0.025	41
November	30	23.9	0.024	42
December	31	21.1	0.028	45
Annual Total:				7,399

1.4 STREAMFLOW DATA

The information presented below summarizes streamflow data available at USGS stream monitoring sites located in the Echo Reservoir TMLD study area. For a more detailed review of data, see *Echo Reservoir TMDL Water Quality Study – Work Element 1* (DWQ 2003).

Table 11. USGS streamflow gage stations located in the Echo Reservoir TMDL study area.

Agency Code	Station	Station Name	Latitude	Longitude
USGS	10127500	Weber River Above Smith and Morehouse Creek Near Oakley	40.8	-111.1
USGS	10128000	Smith and Morehouse Creek Near Oakley UT	40.7858	-111.1117
USGS	10128200	South Fork Weber River Near Oakley UT	40.7486	-111.2189
USGS	10128500	Weber River Near Oakley UT	40.7372	-111.2472
USGS	10129000	Weber-Provo Diversion Canal at Oakley UT	40.7083	-111.275
USGS	10129300	Weber River Near Peoa UT	40.7511	-111.3697
USGS	10129350	Crandall Creek Near Peoa UT	40.775	-111.3642
USGS	10129500	Weber River Near Wanship UT	40.7928	-111.4042
USGS	10129900	Silver Creek Near Silver Creek Junction, UT	40.7353	-111.4753
USGS	10130000	Silver Creek Near Wanship UT	40.7569	-111.4708
USGS	10130500	Weber River Near Coalville UT	40.8953	-111.4011
USGS	10130700	East Fork Chalk Creek Near Coalville UT	40.9578	-111.1139
USGS	10131000	Chalk Creek at Coalville UT	40.9206	-111.4008
USGS	10132000	Weber River at Echo UT	40.9678	-111.4369
USGS	10154000	Shingle Creek Near Kamas UT	40.6125	-111.1158
USGS	10154500	Weber-Provo Diversion Canal Near Woodland UT	40.6139	-111.3042
USGS	403846111192601	Indian Hollow Near Kamas	40.6461	-111.3239
USGS	404019111295001	Dority Spring Weir Near Park City UT	40.6719	-111.4972

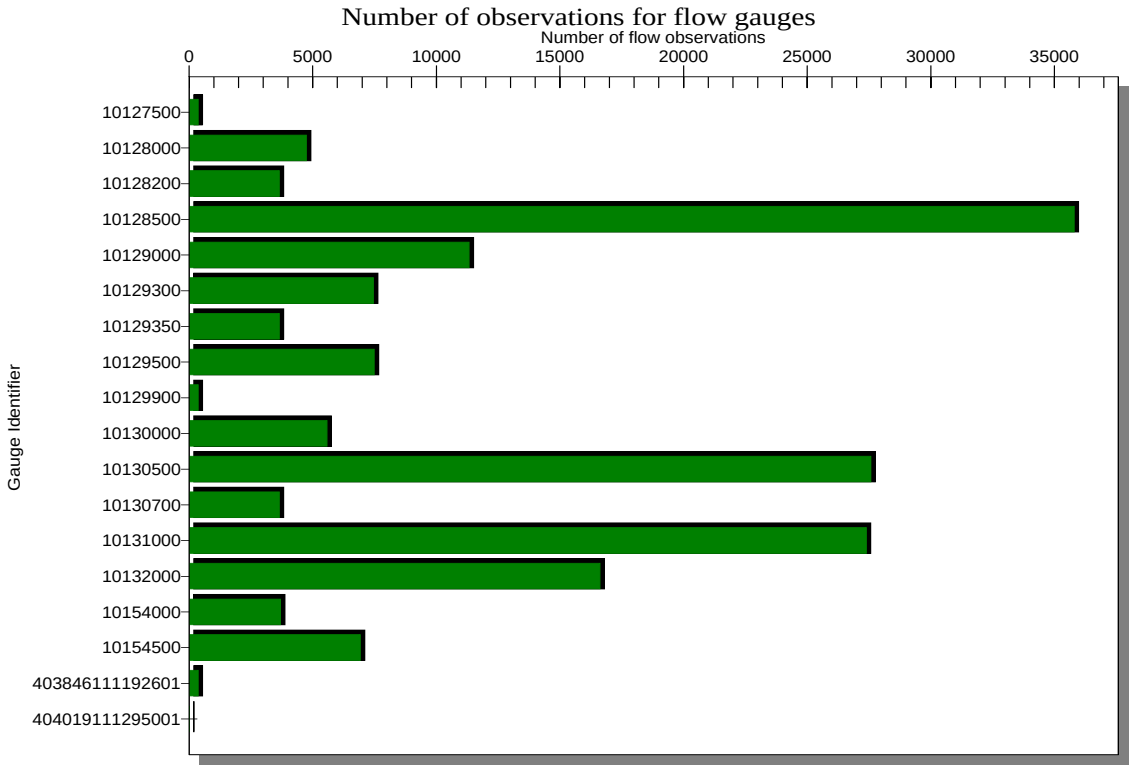


Figure 1. Number of observations collected at each USGS flow monitoring station in the Echo Reservoir TMDL study area.

Table 12. Water quality statistics for streamflow gage stations in the Echo TMDL study area.

Station	No. of Obs.	Range of Dates	Average Flow	Standard Deviation	Variance	Median	Minimum Flow	Maximum Flow
10127500	365	1946 - 1947	107	136.59	18,655.87	42.5	28	612
10128000	4,748	1946 - 1974	61.7	105.89	11,212.59	19	7.1	747
10128200	3,652	1964 - 1974	25.6	33.79	1,141.68	12	6.5	242
10128500	35,794	1904 - 2002	219	346.57	120,108.88	80	20	4,170
10129000	11,323	1938 - 1969	50.6	126.19	15,924.67	0	0	918
10129300	7,458	1957 - 1977	180	242.05	58,587.71	104	23	2,030
10129350	3,653	1963 - 1973	4.66	9.94	98.84	1	0	81
10129500	7,487	1950 - 2002	194	230.74	53,240.50	152	0.1	2,120
10129900	365	2001 - 2002	4.01	5.05	25.54	2.7	1.6	46
10130000	5,574	1941 - 1996	8.59	12.52	156.75	5	0	206
10130500	27,577	1927 - 2002	213	247.94	61,473.84	151	7.0	2,140
10130700	3,652	1964 - 1974	34.6	45.66	2,084.50	13	5.5	367
10131000	27,394	1927 - 2002	68.5	116.72	13,624.56	26	1.0	1,420
10132000	16,619	1927 - 2002	274	326.69	106,723.62	166	0.17	3,010
10154000	3,692	1963 - 1973	15.8	29.12	847.74	3.5	1.60	176
10154500	6,926	1932 - 1998	112	160.88	25,883.32	38	0	870
403846111192601	365	1998 - 1999	0.97	1.75	3.07	0.14	0.04	13.0
404019111295001	11	1988 - 1988	0.20	0.16	0.03	0.145	0.01	0.38

2.0 LOAD CALCULATIONS – DWQ MONITORING DATA

Monthly load calculations in this section were primarily based on total phosphorus measurements collected within the past 10 years. Load calculations for point sources are included in Section 3.0 below. Mean concentrations for datasets with below detection limit values were calculated using the probability plot method of Helsel (1990). Flow data used in monthly load calculations used both instantaneous flow data as well as continuous flow monitoring data obtained from nearby USGS streamflow monitoring sites. The specific data sets used at each monitoring site are identified in the individual tables below.

Table 13. Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Huff Creek Above Confluence with Chalk Creek (492626)								
1	31	1.5	0.101	11	2	0	UDWQ492626 1993-2003	UDWQ492626 1993-2003
2	28	3.8	0.095	24	2	0		
3	31	1.4	0.169	18	2	0		
4	30	4.8	0.367	128	6	0		
5	31	39.8	0.310	936	5	0		
6	30	6.1	0.142	63	5	0		
7	31	1.3	0.118	11	3	0		
8	31	1.8	0.095	13	3	0		
9	30	1.7	0.294	37	2	0		
10	31	1.3	0.087	8	3	0		
11	30	1.0	0.097	7	1	0		
12	31	3.0	0.077	18	3	0		
Total Annual				**1275**				
Chalk Creek at Utah/Wyoming State Line (492628)								
1	31	5.0	0.036	14	2	0	UDWQ492628 1990-1999	UDWQ492628 1990-1999
2	28	1.8	0.005	1	1	1		
3	31	23.6	0.176	316	4	0		
4	30	21.3	0.106	165	10	0		
5	31	47.5	0.127	459	11	0		
6	30	31.6	0.088	204	9	0		
7	31	1.5	0.060	7	4	0		
8	31	3.0	0.028	6	1	0		
9	30	0.6	0.025	1	2	0		
10	31	2.3	0.025	4	2	1		
11	30	2.2	0.018	3	0	0		
12	31	2.0	0.010	2	2	2		
Total Annual				**1181**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Chalk Creek above Confluence with the South Fork (492629)								
1	31	20.0	0.027	40	3	0	UDWQ492629 1990-2003	UDWQ492635 1992-2003
2	28	17.2	0.027	32	3	0		
3	31	24.4	0.109	201	5	0		
4	30	57.6	0.129	545	12	0		
5	31	155.3	0.176	2077	7	0		
6	30	134.0	0.063	618	6	0		
7	31	16.2	0.031	38	4	0		
8	31	16.1	0.016	20	5	2		
9	30	9.7	0.018	13	3	0		
10	31	9.9	0.011	8	7	4		
11	30	12.7	0.010	9	2	2		
12	31	27.0	0.017	35	3	1		
Total Annual				**3636**				
Chalk Creek at US189 Crossing (492635)								
1	31	20.8	0.018	28	10	3	USGS 10131000 1927-2003	UDWQ492635 1992-2003
2	28	23.7	0.059	96	9	2		
3	31	40.5	0.167	513	9	0		
4	30	115.7	0.182	1546	19	0		
5	31	279.4	0.318	6729	13	0		
6	30	176.3	0.099	1277	10	1		
7	31	47.1	0.039	138	7	2		
8	31	23.6	0.047	84	13	2		
9	30	21.5	0.033	52	6	0		
10	31	21.8	0.017	28	9	4		
11	30	23.9	0.019	33	9	1		
12	31	21.1	0.014	22	5	3		
Total Annual				**10544**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
South Fork Chalk Creek 1 Mile Above Chalk Creek (492636)								
1	31	12.0	0.018	16	2	1	UDWQ492636 1993-2003	UDWQ492636 1993-2003
2	28	6.6	0.021	9	3	1		
3	31	14.1	0.133	142	4	0		
4	30	41.5	0.257	782	7	0		
5	31	106.6	0.320	2587	5	0		
6	30	55.2	0.083	338	5	0		
7	31	8.8	0.034	23	3	0		
8	31	10.5	0.042	33	3	0		
9	30	11.0	0.010	8	2	1		
10	31	6.4	0.011	5	3	2		
11	30	4.0	0.010	3	1	1		
12	31	35.0	0.022	58	3	1		
Total Annual				**4006**				
Weber River above Echo Reservoir (492640)								
1	31	136.6	0.079	813	4	0	USGS10130500 1970-2003	UDWQ492640 1992-2003
2	28	134.4	0.069	631	4	0		
3	31	158.5	0.108	1301	5	0		
4	30	201.3	0.078	1150	8	0		
5	31	355.5	0.058	1576	7	0		
6	30	583.3	0.051	2167	14	2		
7	31	273.8	0.115	2384	9	2		
8	31	189.4	0.070	1006	10	0		
9	30	181.5	0.059	791	5	0		
10	31	183.0	0.071	990	6	0		
11	30	165.7	0.041	496	4	0		
12	31	152.1	0.031	353	5	0		
Total Annual				**13657**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Silver Creek above Weber River (492675)								
1	31	9.7	0.668	490	4	0	UDWQ492675 1981-2003	UDWQ492675 1992-2003
2	28	11.2	0.508	390	3	0		
3	31	27.6	0.410	857	4	0		
4	30	25.5	0.192	359	10	0		
5	31	51.6	0.209	818	6	0		
6	30	11.0	0.185	149	6	0		
7	31	7.9	0.279	166	3	0		
8	31	6.5	0.396	196	5	0		
9	30	5.5	0.590	236	3	0		
10	31	9.8	0.413	307	5	0		
11	30	16.6	0.533	649	4	0		
12	31	7.8	0.552	328	3	0		
Total Annual				**4945**				
Silver Creek at City Park above Prospector Square (492695)								
1	31	0.8	0.088	5	1	0	UDWQ492695 1997-2003	UDWQ492695 1997-2003
2	28	0.3	0.137	3	7	0		
3	31	1.3	0.272	27	3	0		
4	30	5.3	0.078	30	4	0		
5	31	6.5	0.075	37	2	0		
6	30	3.6	0.038	10	4	0		
7	31	1.2	0.043	4	2	0		
8	31	0.3	0.048	1	3	0		
9	30	0.6	0.082	4	1	0		
10	31	1.3	0.277	27	4	0		
11	30	1.6	0.213	24	2	0		
12	31	0.5	0.159	6	2	0		
Total Annual				**177**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Weber River Below Wanship Reservoir (Dam Constructed 1954-1957) (492701)								
1	31	76.9	0.021	122	2	1	USGS10129500 1988-2003	UDWQ492701 1992-2003
2	28	81.8	0.030	168	2	0		
3	31	100.7	0.067	508	2	0		
4	30	118.2	0.035	301	6	0		
5	31	241.4	0.051	930	5	0		
6	30	477.4	0.036	1261	5	0		
7	31	282.1	0.044	947	3	0		
8	31	217.8	0.073	1206	3	0		
9	30	179.6	0.082	1081	1	0		
10	31	150.0	0.042	481	4	0		
11	30	133.6	0.016	157	2	1		
12	31	107.0	0.020	162	2	1		
Total Annual				**7162**				
Weber River Above Wanship Reservoir (492725)								
1	31	80.5	0.045	275	10	0	USGS10129300 1957-1977	UDWQ492725 1992-2003
2	28	83.4	0.035	198	7	3		
3	31	119.6	0.062	558	8	0		
4	30	158.5	0.056	654	10	0		
5	31	419.3	0.068	2176	8	0		
6	30	729.0	0.036	1922	13	0		
7	31	211.2	0.041	654	7	0		
8	31	96.2	0.047	340	14	0		
9	30	102.6	0.031	234	9	2		
10	31	114.4	0.026	223	9	1		
11	30	102.7	0.023	171	8	2		
12	31	89.5	0.021	145	4	2		
Total Annual				**7550**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Beaver Creek above Crooked Creek (492830)								
1	31	52.5	0.040	159	2	0	UDWQ492830 1993-1999	UDWQ492830 1993-1999
2	28	10.5	0.035	25	2	0		
3	31	96.3	0.109	796	1	0		
4	30	82.6	0.060	361	6	0		
5	31	222.8	0.081	1369	5	0		
6	30	125.1	0.079	724	5	0		
7	31	76.0	0.081	467	2	0		
8	31	62.3	0.054	253	2	0		
9	30	55.5	0.019	77	1	0		
10	31	32.3	0.038	93	3	0		
11	30	30.0	0.060	132	1	0		
12	31	41.3	0.031	97	1	0		
Total Annual				**4552**				
Beaver Creek above Weber-Provo Canal (492853)								
1	31	3.7	0.044	12	8	0	UDWQ492853 1985-2003	UDWQ492830 1993-1999
2	28	5.3	0.136	49	4	1		
3	31	5.2	0.074	30	8	1		
4	30	23.1	0.051	85	14	0		
5	31	30.9	0.037	86	16	1		
6	30	26.2	0.039	75	10	1		
7	31	4.4	0.032	11	9	0		
8	31	3.4	0.024	6	9	2		
9	30	1.7	0.029	4	6	1		
10	31	3.1	0.021	5	11	4		
11	30	2.2	0.023	4	7	2		
12	31	11.4	0.049	42	5	1		
Total Annual				**409**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Beaver Creek above Kamas Fish Hatchery (492901)								
1	31	5.8	0.010	4	3	2	UDWQ492901 1982-2003	UDWQ492901 1992-2003
2	28	11.4	0.013	10	1	0		
3	31	20.3	0.040	62	3	0		
4	30	46.2	0.040	136	6	0		
5	31	83.2	0.025	155	5	0		
6	30	56.1	0.032	131	4	2		
7	31	11.8	0.018	16	3	2		
8	31	9.7	0.011	8	3	1		
9	30	11.0	0.013	10	2	1		
10	31	5.4	0.015	6	3	1		
11	30	5.8	0.012	5	3	2		
12	31	5.6	0.010	4	1	1		
Total Annual				**549**				
Weber River Above Weber-Provo Diversion (492920)								
1	31	56.3	0.016	66	2	0	USGS10128500 1904-2003	UDWQ492920 1993-1999
2	28	56.5	0.019	74	2	1		
3	31	67.3	0.011	56	1	0		
4	30	177.7	0.040	522	6	2		
5	31	683.4	0.037	1939	5	0		
6	30	901.4	0.019	1229	5	1		
7	31	264.0	0.010	200	2	2		
8	31	114.0	0.010	86	2	2		
9	30	85.1	0.013	81	1	0		
10	31	79.8	0.027	163	3	2		
11	30	69.7	0.010	51	1	1		
12	31	60.6	0.010	46	1	1		
Total Annual				**4513**				

Table 13. (cont'd) Monthly total phosphorus (TP) load calculations for selected DWQ monitoring sites in the Echo Reservoir TMDL study area.

							Data Source	
Month	**Days**	**Mean Flow (cfs)**	**Mean TP Conc. (mg/L)**	**TP Load (kg)**	**Samples**	**Censored Observations**	**Flow**	**Concentration**
Smith and Morehouse Creek above Confluence with the Weber River (492949)								
1	31	18.7	0.010	14	2	2	UDWQ492949 1993-1999	UDWQ492949 1993-1999
2	28	15.0	0.010	10	1	1		
3	31	10.0	0.010	8	1	1		
4	30	21.3	0.013	20	6	3		
5	31	53.5	0.022	90	5	1		
6	30	110.7	0.020	163	5	4		
7	31	39.0	0.025	74	2	1		
8	31	39.6	0.010	30	2	2		
9	30	40.0	0.010	29	1	1		
10	31	36.0	0.025	68	3	2		
11	30	8.0	0.010	6	1	1		
12	31	12.8	0.010	10	1	1		
Total Annual				**522**				
Smith and Morehouse Creek above Smith and Morehouse Reservoir (592400)								
1	31			0	0	0	UDWQ592400 1981-2001	UDWQ592400 1981-2001
2	28			0	0	0		
3	31			0	0	0		
4	30			0	0	0		
5	31	60.0	0.024	109	2	1		
6	30	49.4	0.010	36	11	7		
7	31	17.0	0.010	13	3	3		
8	31	7.6	0.020	12	6	5		
9	30	1.5	0.031	3	4	3		
10	31	6.2	0.010	5	3	3		
11	30	2.0	0.010	1	1	1		
12	31	10.0	0.024	18	2	1		
Total Annual				**198**				

3.0 LOAD CALCULATIONS – POINT SOURCES

Total phosphorus loads for point sources were calculated from flow and water quality monitoring data collected by DWQ at the point of discharge from each facility. Projected future loads were based on the assumption that concentrations of total phosphorus in effluent would be identical to the existing monthly distribution. Future flows were calculated from population projections for the city associated with each point source (Table 5) and the assumption that per capita discharge for each facility would be identical to existing conditions.

Table 14. Population Projections used for calculating future loads from point source discharge in the TMDL study area. Note that only population numbers for year 2025 were used in calculating future loads. All other population data is provided for information purposes only.

	2000	2003	2005	2020	2025	Average annual increase	20 year % increase (2005 - 2025)	Flow Multiplier
Summit County Total	29,736	33,020	36,417	52,806	75,450	10.36	107.18	2.07
Coalville	1,382	1,426	1,573	3,306	4,724	15.02	200.35	3.00
Henefer	684	723	797	1,604	2,292	14.37	187.42	2.87
Kamas	1,274	1,429	1,576	2,984	4,264	13.53	170.53	2.71
Oakley	948	1,125	1,241	2,981	4,259	17.16	243.29	3.43
Park City	7,371	7,854	8,662	17,634	25,196	14.54	190.88	2.91
Balance of County	18,077	20,463	22,568	24,297	34,716	7.69	53.83	1.54

Data source:
Year 2000 population numbers taken from U.S. Census Bureau, Census 2000.
Year 2003 population numbers taken from Economic Report to the Governor 2005 p.45.
Year 2005 County population taken from Utah GOPB population estimates 2000-2050, city estimates adjusted from 2003 data based on increase to county total.
Year 2020 population numbers taken from 2002 Baseline City Population Projections (Salt Lake City April 2003).
Year 2025 County population taken from Utah GOPB population estimates 2000-2050, city estimates adjusted from 2020 data based on increase to county total.

Table 15. Total phosphorus (TP) loading for Coalville WWTP (492632)

Month	Days	Existing Mean Flow (cfs)	Future Mean Flow (cfs)	Mean TP Conc. (mg/L)	Existing Load (kg)	Future Load (kg)
1	31	0.31	0.94	0.78	19	56
2	28	0.29	0.88	0.59	12	36
3	31	0.29	0.87	0.52	11	34
4	30	0.25	0.76	0.58	11	32
5	31	0.28	0.85	0.27	6	17
6	30	0.35	1.04	0.58	15	44
7	31	0.33	0.98	0.51	13	38
8	31	0.31	0.94	0.66	16	47
9	30	0.36	1.07	0.47	12	37
10	31	0.32	0.95	0.04	1	3
11	30	0.31	0.93	0.84	19	58
12	31	0.28	0.85	0.68	15	44
Total Annual					**149**	**446**

Data Source:
Current Mean Flows: Coalville WWTP Flow Data.xls 2002-2003 (upgrades to collection system have changed flow pattern).
Future Mean Flows: 3.0 times the current mean flows.
Future Mean Concentration: UDWQ492632 Because of recent changes in operations, data from 1992-2000 multiplied by 0.36 to match difference between mean of 1992-2000 data and mean of 2001-2003 data. Monthly means estimated from modified data (1992-2003).

Table 16. Total phosphorus (TP) loading for Silver Creek WRF (492679)

Month	Days	Existing Mean Flow (cfs)	Future Mean Flow (cfs)	Mean TP Conc. (mg/L)	Existing Load (kg)	Future Load (kg)
1	31	1.91	6.50	1.951	283	962
2	28	1.96	6.52	2.52	338	1,126
3	31	2.27	6.65	2.352	405	1,186
4	30	1.67	6.40	2.185	268	1,026
5	31	1.51	6.33	2.317	266	1,113
6	30	1.58	6.36	2.76	320	1,289
7	31	1.76	6.44	3.497	468	1,708
8	31	1.83	6.46	2.463	341	1,207
9	30	1.60	6.37	3.17	372	1,482
10	31	1.38	6.28	2.777	291	1,323
11	30	1.40	6.29	3.11	320	1,435
12	31	1.76	6.44	2.967	397	1,449
Total Annual					**4,070**	**15,305**

Data Source:
Current Mean Flows: Silver Creek WRF Flows.xls 1987-2004.
Future Mean Flows (Snyderville WRD data): existing flows adjusted to range from 4.0 MGD (6.19 cfs) to 4.3 MGD (6.65 cfs) in 2025 as per information obtained from Snyderville Water Reclamation District.
Future Mean Concentrations: UDWQ492679 1992-2003 - same values as those used for current conditions.

Table 17. Total phosphorus (TP) loading for Oakley WWTP (492802).

Month	Days	Existing Mean Flow (cfs)	Future Mean Flow (cfs)	Mean TP Conc. (mg/L)	Existing Load (kg)	Future Load (kg)
1	31	0.31	1.06	2.855	67	230
2	28	0.15	0.53	2.865	30	104
3	31	0.31	1.06	2.960	69	238
4	30	0.17	0.59	1.939	24	84
5	31	0.19	0.66	1.850	27	93
6	30	0.33	1.14	1.973	48	165
7	31	0.25	0.85	1.740	33	112
8	31	0.63	2.15	1.273	61	208
9	30	0.21	0.74	1.641	26	89
10	31	0.25	0.85	1.296	24	83
11	30	0.14	0.48	1.278	13	45
12	31	0.16	0.55	4.287	52	179
Total Annual				**2.16**	**475**	**1,631**

Data Source:
Current Mean Flows: UDWQ492802 1975-2003.
Future Mean Flows: 3.43 times the current mean flows.
Future Mean Concentrations: UDWQ492802 and UDWQ492801 1975-2004 (too few data points to do 1992-2003).

Table 18. Total phosphorus (TP) loading for Kamas WWTP (492850)

Month	Days	Existing Mean Flow (cfs)	Future Mean Flow (cfs)	Mean TP Conc. (mg/L)	Existing Load (kg)	Future Load (kg)
1	31	0.38	1.03	3.500	101	273
2	28	0.49	1.33	3.573	120	326
3	31	0.46	1.25	3.697	129	350
4	30	0.54	1.46	2.642	105	283
5	31	1.17	3.17	2.020	179	485
6	30	1.82	4.94	2.519	337	913
7	31	1.08	2.94	1.282	105	285
8	31	0.79	2.13	1.336	80	216
9	30	0.49	1.33	1.678	60	163
10	31	0.39	1.05	1.463	43	116
11	30	0.32	0.88	1.091	26	71
12	31	0.28	0.75	1.773	37	100
Total Annual					**1322**	**3,583**

Data Source:
Current Mean Flows: Kamas Lagoons Flows 98-03.xls 1998-2003.
Future Mean Flows: 2.71 times the current mean flows.
Future Mean Concentrations: UDWQ492850 1975-2003 (too few data points to do 1992-2003).

Table 19. Total phosphorus (TP) loading for Kamas Fish Hatchery (492900)

Month	Days	Existing Mean Flow (cfs)	Future Mean Flow (cfs)	Mean TP Conc. (mg/L)	Existing Load (kg)	Future Load (kg)
1	31	5.56	8.64	0.122	52	80
2	28	5.29	8.22	0.091	33	52
3	31	5.81	9.04	0.095	42	65
4	30	6.45	10.03	0.067	31	49
5	31	6.18	9.62	0.242	114	177
6	30	5.29	8.22	0.127	49	76
7	31	3.83	5.96	0.075	22	34
8	31	3.64	5.66	0.078	21	33
9	30	3.63	5.64	0.052	14	21
10	31	4.04	6.28	0.056	17	27
11	30	4.18	6.50	0.082	25	39
12	31	4.15	6.45	0.044	14	22
Total Annual				0.094	**434**	**675**

Data Source:
Current Mean Flow: Kamas Fish Hatchery Flows 1997-2003.xls 1997-2003.
Future Mean Flows: Estimated from current mean flows given that the hatchery has a water right for 10 cfs - this is assumed to be the peak flow and is assumed to occur at the same time as the current peak flow.
Future Mean Concentrations: UDWQ492900 1992-2003 Same as those used for current conditions.

4.0 RESERVOIR PROFILE DATA

This section contains a detailed review of reservoir monitoring data collected from Echo, Wanship, and Smith and Morehouse Reservoirs. Reservoirs were typically monitored every two years although additional monitoring was completed on Echo Reservoir during 2002 and 2003.

Table 20. Reservoir profile monitoring data for Echo Reservoir.

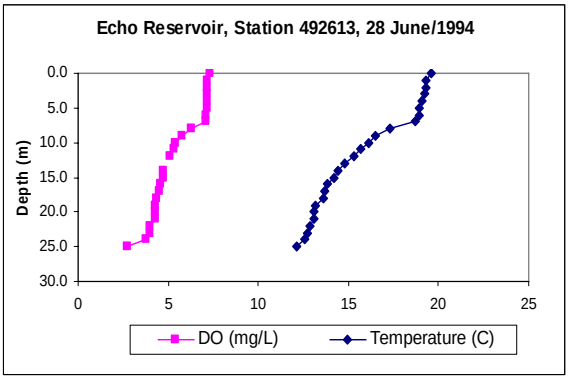
			Temperature			pH			DO		
Date	**Depth (m)**	**Samples**	**Mean**	**% > 20 C**	**Status**	**Mean**	**6.5>%>9.0**	**Status**	**Mean**	**% > 4.0 mg/l**	**Status**
Reservoir Station 492613 - ECHO RES AB DAM 01											
02-Aug-94	19.0	20	19.62	30	NS	8.18	0	S	4.84	70	S
18-Jun-96	28.5	22	13.76	0	FS	8.33	0	S	7.35	100	S
06-Aug-96	24.4	26	18.19	19	PS	7.98	0	S	4.70	46	PS
02-June-98	29.0	30	13.53	3	S	8.22	0	S	6.90	100	S
01-Sep-98	23.7	26	18.35	4	S	7.96	0	S	4.03	42	PS
07-Jun-00	25.6	25	13.69	8	S	8.13	0	S	6.86	96	S
01-Aug-00	18.6	20	20.20	45	NS	7.88	0	S	5.05	60	S
12-Jun-02	25.9	27	12.29	0	S	8.25	0	S	6.38	100	S
16-Jul-02	21.4	23	18.73	35	FS	7.90	0	S	4.26	39	PS
21-Aug-02	17.6	19	18.96	0	S	8.26	0	S	5.08	53	S
02-Oct-02	15.0	16	14.47	0	S	8.26	0	S	6.84	100	S
12-Jun-03	24.4	25	13.16	0	S	8.12	0	S	6.46	88	S
23-Jul-03	20.0	22	18.54	32	NS	7.88	0	S	10.51	95	S
04-Sep-03	12.7	14	19.47	29	NS	8.17	0	S	5.92	64	S
01-Oct-03	6.5	8	14.42	0	S	8.19	0	S	7.99	100	S
Reservoir Station 492614 - ECHO RES 2/3 WAY UP LAKE 02											
18-Jun-96	20.6	21	14.47	9.52	S	8.34	0.00	S	6.92	100.00	S
06-Aug-96	15.5	17	18.92	47.06	NS	8.21	0.00	S	6.10	100.00	S
01-Sep-98	6.7	8	19.09	50.00	NS	8.29	0.00	S	6.37	100.00	S
07-Jun-00	8.5	10	16.41	0.00	S	8.22	0.00	S	7.63	100.00	S
01-Aug-00	6.0	7	22.18	100.00	NS	8.27	0.00	S	7.08	100.00	S
12-Jun-02	7.2	9	16.22	0.00	S	8.16	0.00	S	7.81	100.00	S
16-Jul-02	2.1	4	22.71	75.00	NS	8.43	0.00	S	8.78	100.00	S
21-Aug-02	4.0	5	18.98	0.00	S	8.49	0.00	S	8.52	100.00	S
12-Jun-03	6.1	7	17.05	0.00	S	8.47	0.00	S	8.52	100.00	S
23-Jul-03	2.5	4	23.63	100.00	NS	8.41	0.00	S	8.37	100.00	S

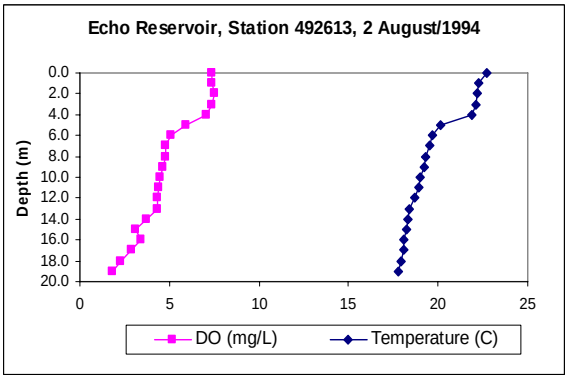
Table 21. Reservoir profile monitoring data for Wanship Reservoir.

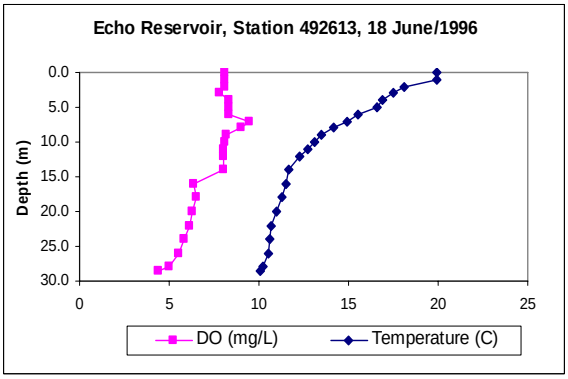
			Temperature			pH			DO		
Date	**Depth (m)**	**Samples**	**Mean**	**% > 20 C**	**Status**	**Mean**	**6.5>%>9.0**	**Status**	**Mean**	**% > 4.0 mg/l**	**Status**
Reservoir Station 592331 - Wanship Res AB Dam											
07-Jun-90	32	33	11.59	0.00	S	7.97	0.00	S	6.51	93.94	S
8-Aug-90	29.5	31	17.51	22.58	PS	7.99	0.00	S	3.49	33.33	NS
03-Jun-92	31	32	11.61	0.00	S	7.79	0.00	S	6.36	90.32	S
02-Sep-92	19	20	16.95	0.00	S	8.34	0.00	S	6.20	80.00	S
13-Jun-94	36	32	13.68	0.00	S	8.13	0.00	S	5.14	80.65	S
02-Aug-94	30	31	16.58	22.58	PS	8.04	0.00	S	3.32	29.03	NS
18-Jun-96	36	27	12.18	0.00	S	8.00	0.00	S	7.07	100.00	S
06-Aug-96	32.2	34	14.58	0.00	S	8.01	0.00	S	5.41	97.06	S
02-Jul-98	31.7	33	12.06	0.00	S	8.02	0.00	S	7.88	100.00	S
07-Jun-00	33.5	29	13.33	0.00	S	8.22	0.00	S	6.88	96.55	S
01-Aug-00	28	29	16.94	24.14	PS	7.84	0.00	S	5.15	62.07	S
13-Jun-02	28.3	30	11.70	0.00	S	8.16	0.00	S	6.83	93.33	S
23-Aug-02	24.1	24	17.02	0.00	S	8.40	0.00	S	6.94	70.83	S
Reservoir Station 592332 -Wanship Res Midlake 02											
18-Jun-96	22.5	19	13.08	0.00	S	8.15	5.26	S	7.25	100.00	S
06-Aug-96	19.4	21	16.43	0.00	S	8.08	0.00	S	6.00	100.00	S
07-Jun-00	14.5	16	14.21	0.00	S	8.30	0.00	S	7.05	100.00	S
01-Aug-00	16	19	19.27	42.11	NS	8.08	0.00	S	5.56	78.95	S
13-Jun-02	5	6	15.22	0.00	S	8.29	0.00	S	7.42	100.00	S
23-Aug-02	1.4	2	18.75	0.00	S	8.62	0.00	S	9.64	100.00	S

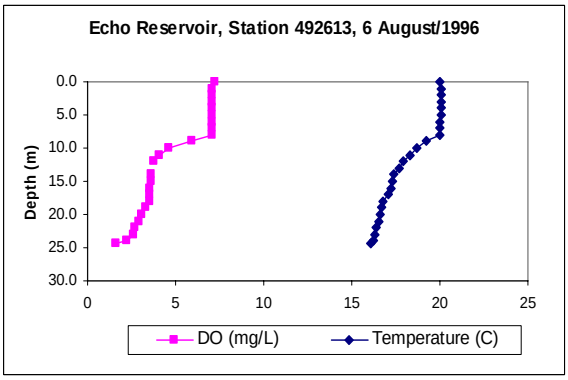
Table 22. Reservoir profile monitoring data for Smith and Morehouse Reservoir.

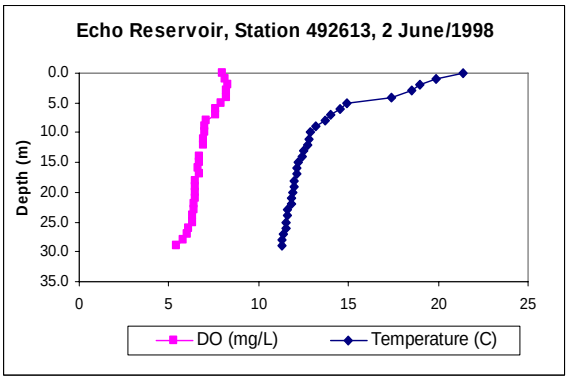
			Temperature			pH			DO		
Date	**Depth (m)**	**Samples**	**Mean**	**% > 20 C**	**Status**	**Mean**	**6.5>%>9.0**	**Status**	**Mean**	**% > 4.0 mg/l**	**Status**
Reservoir Station 592396- Smith and Morehouse Res AB Dam											
9/7/1989	13.9	15	13.58	0.00	S	8.03	0.00	S	6.61	86.67	S
6/11/1991	17	18	6.51	0.00	S	6.36	77.78	NS	8.68	100.00	S
8/27/1991	11	12	14.34	0.00	S	7.62	0.00	S	6.13	100.00	S
8/26/1993	20.4	21	10.60	0.00	S	7.53	0.00	S	6.70	100.00	S
7/13/1995	18.5	20	8.30	0.00	S	7.75	0.00	S	9.25	100.00	S
9/8/1995	14.4	16	13.48	0.00	S	9.04	43.75	NS	5.52	100.00	S
6/4/1997	18.9	20	6.01	0.00	S	6.83	0.00	S	8.99	100.00	S
8/6/1997	16.6	18	12.14	0.00	S	7.35	0.00	S	6.92	100.00	S
5/26/1999	18.4	20	3.84	0.00	S	7.27	0.00	S	7.73	80.00	S
14-Jun-01	17.9	19	8.00	0.00	S	8.16	0.00	S	7.65	100.00	S
05-Sep-01	12.2	14	14.63	0.00	S	6.60	28.57	NS	6.29	92.86	S

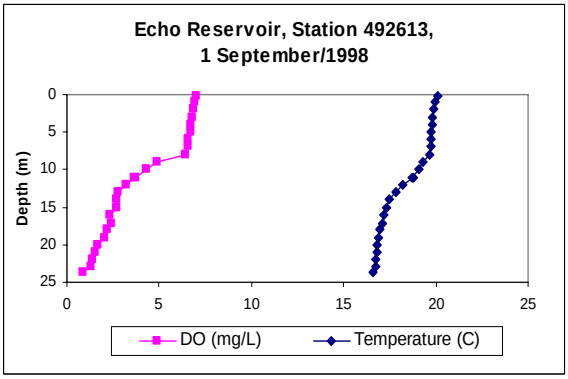


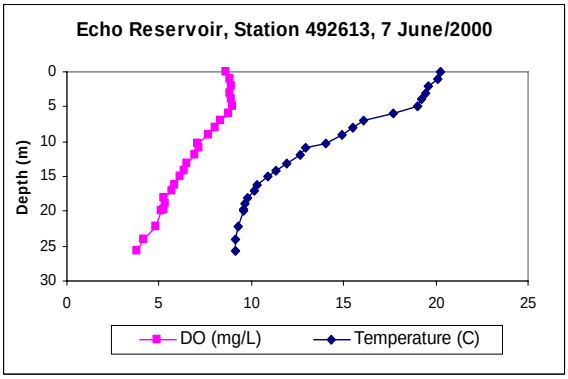












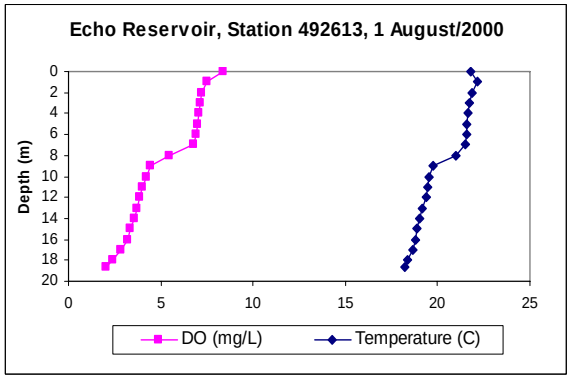
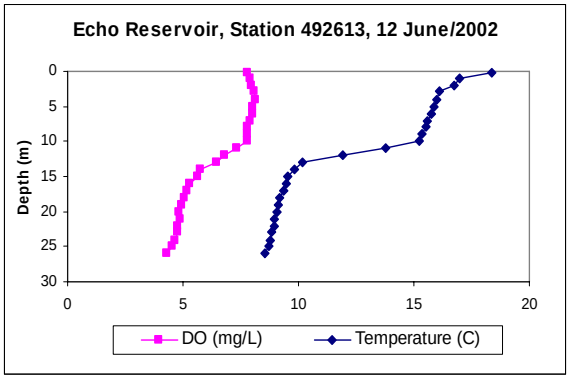
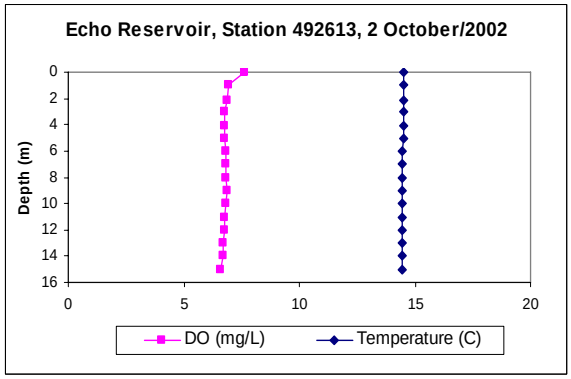
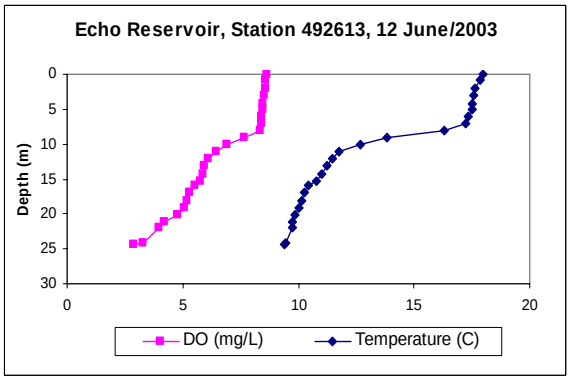


Figure 2. Reservoir profiles at Station 492613 – Echo Reservoir Above Dam 01.







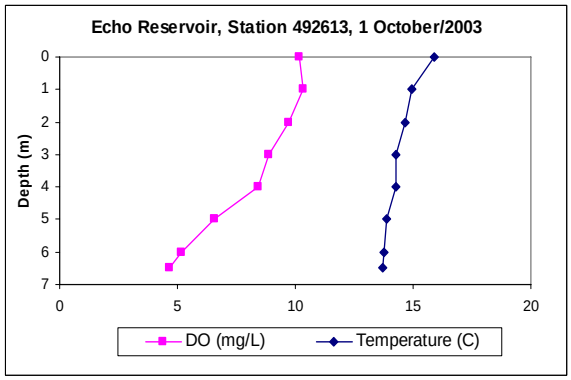
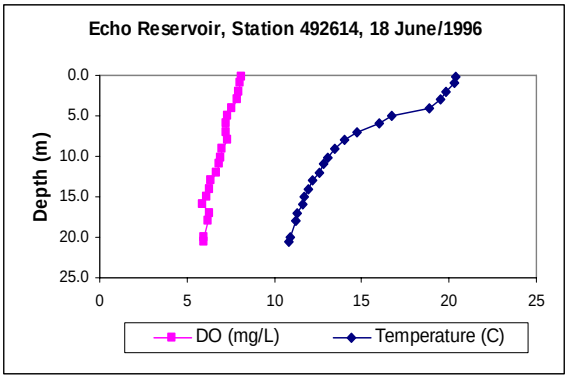
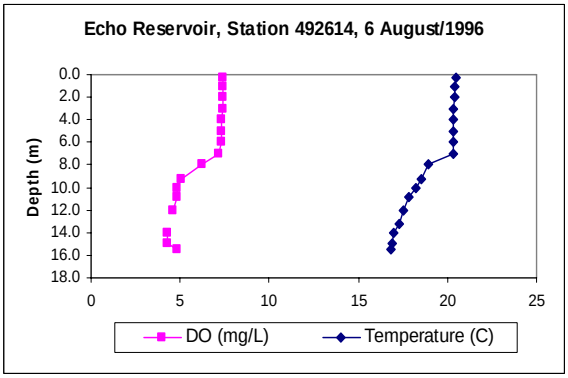
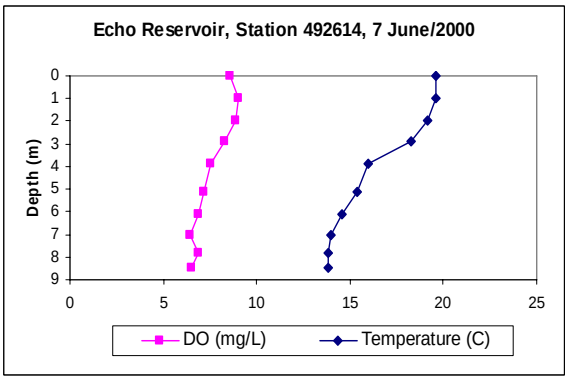
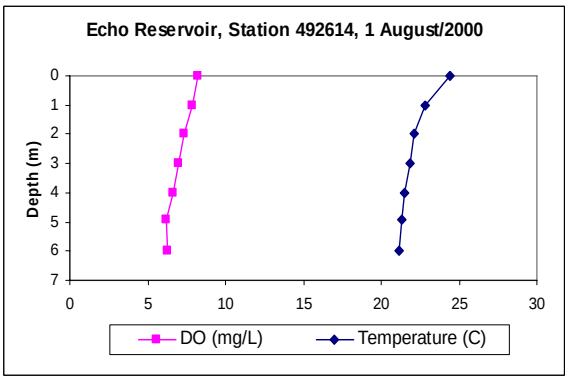


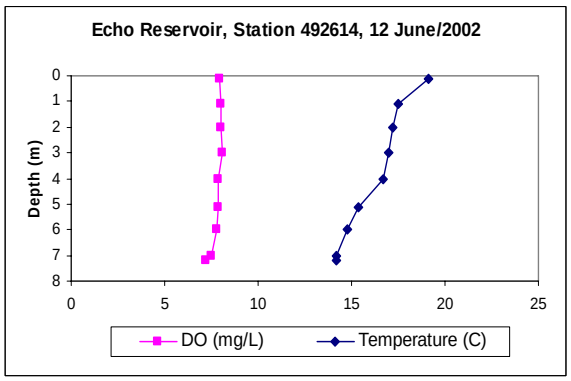
Figure 2. (cont'd.). Reservoir profiles at Station 492613 – Echo Reservoir Above Dam 01.

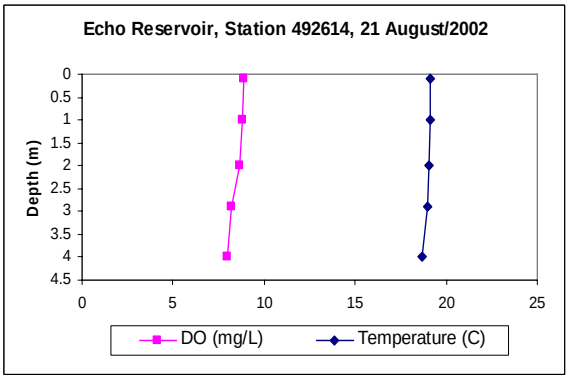


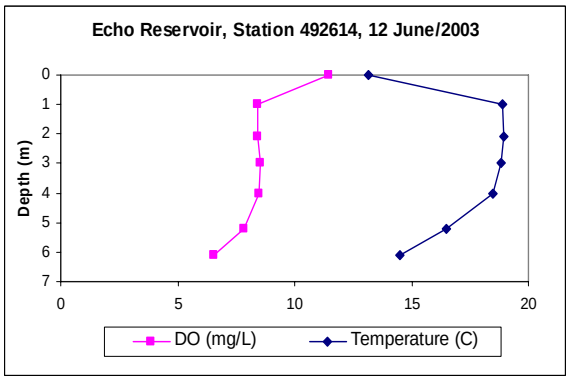


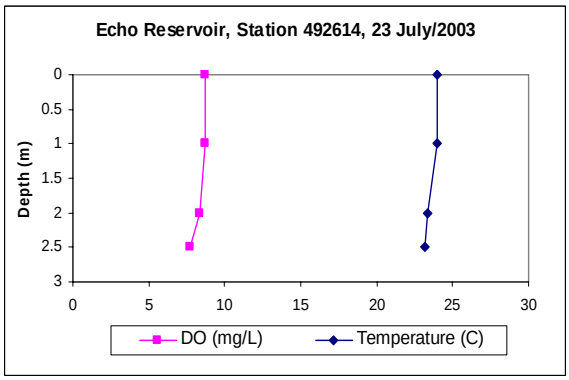












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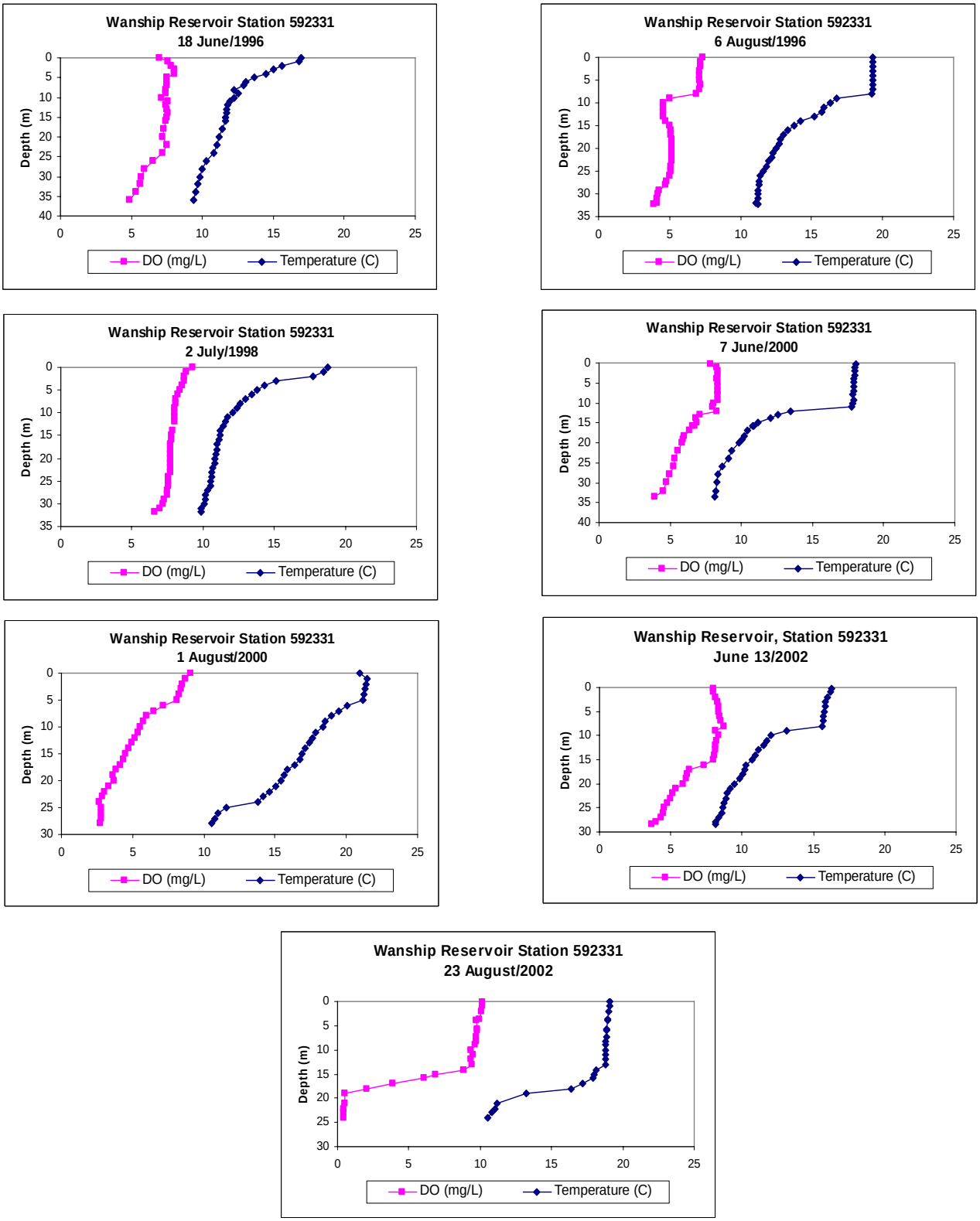

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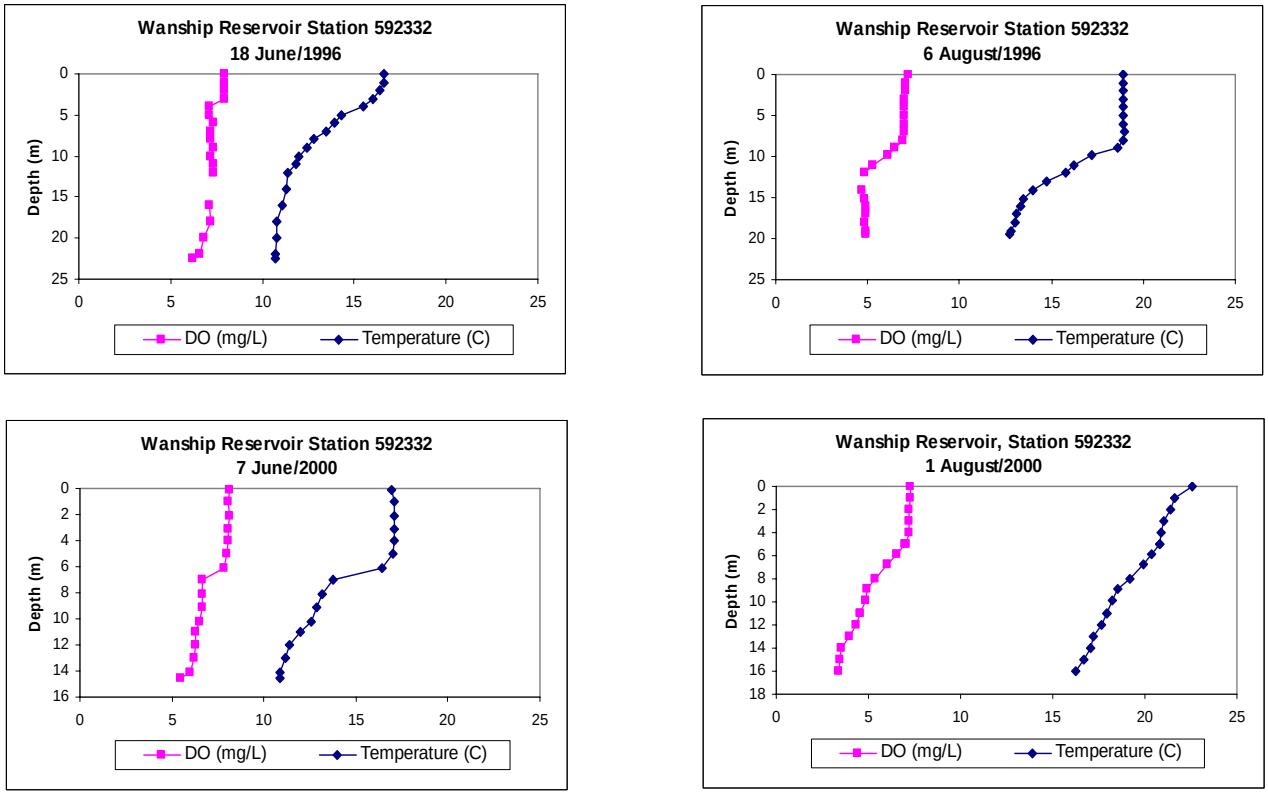

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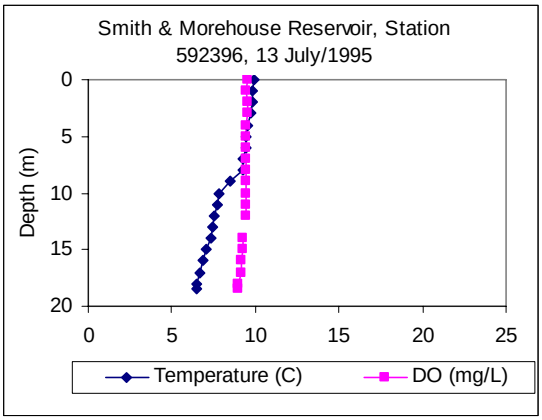

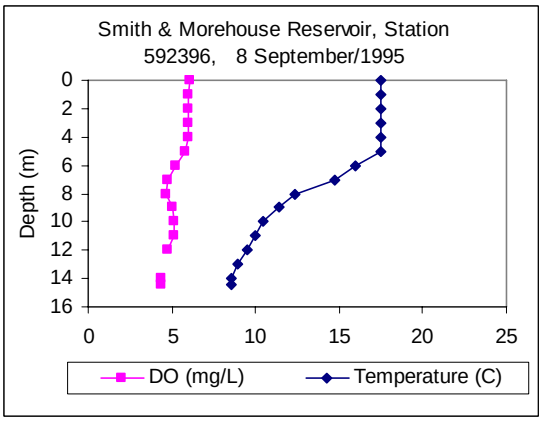

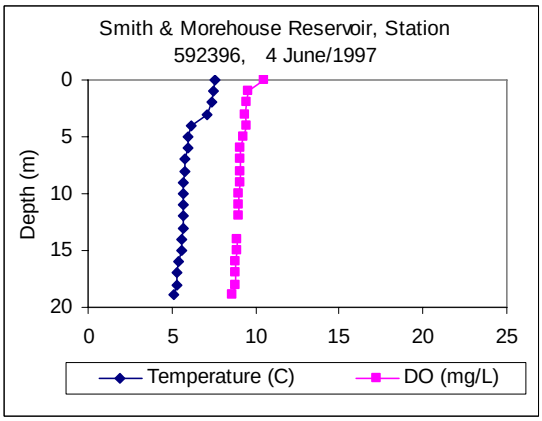

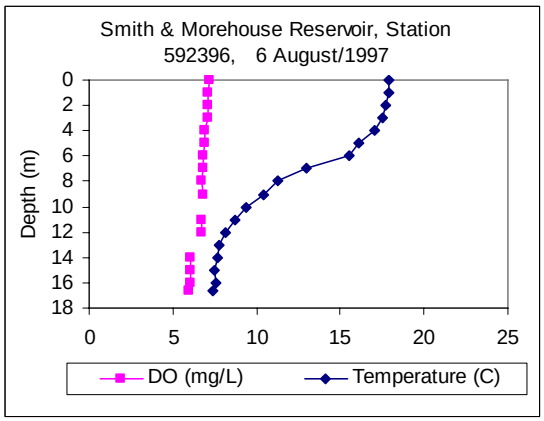

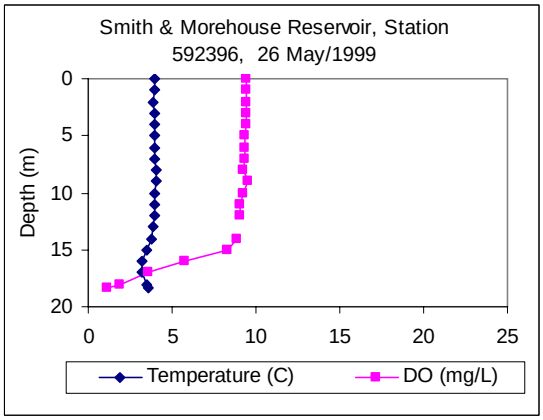

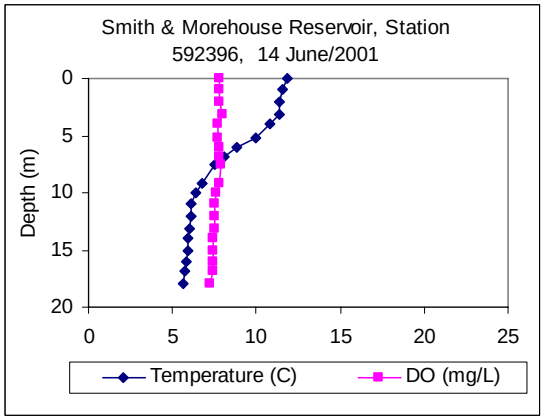

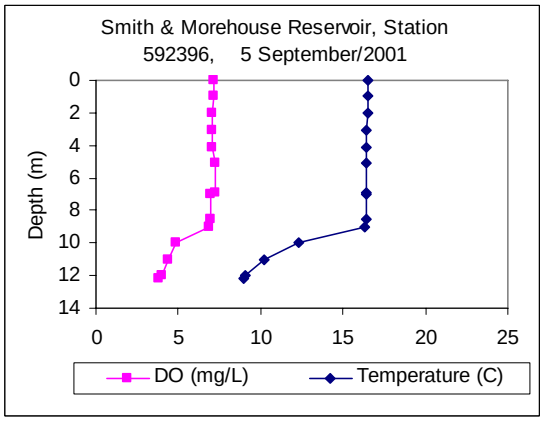

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Appendix – Modeling

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1.0 METHODOLOGY FOR CREATING AN EXISTING CONDITIONS LAND USE/LAND COVER DATASET FOR THE ECHO RESERVOIR WATERSHED

An accurate representation of the land use/land cover in the Echo Reservoir Watershed is needed for modeling purposes. The following steps were taken to produce an existing conditions land use/land cover dataset (i.e., it best reflects the current conditions on the ground in the watershed) for use in modeling and characterization efforts within the Echo Reservoir Watershed.

1. Start with the USGS National Land Cover Dataset (NLCD)

   This dataset represents conditions in the early 1990s and is based on satellite imagery. It is a grid dataset with a cell size of 30 meters. The data and details can be found at: http://landcover.usgs.gov/nationallandcover.html

2. Update the NLCD using the State of Utah Department of Water Resources Water Related Land Use GIS coverage (WRLU).

   The WRLU coverage represents a 1:24,000 scale mapping of the irrigated and non-irrigated agricultural land in the state of Utah (as well as other water related land uses) and is believed to be a better representation of current conditions, especially in the agricultural and urban areas. For more details see: http://www.water.utah.gov/planning/landuse/index.htm

   The following steps were done to update NLCD with WRLU:

   a. Assign NLCD land cover classes to WRLU land use codes. Table 1 shows the WRLU codes and the NLCD codes that they were assigned to.

   b. Convert the WRLU coverage to a 30-meter grid and update the NLCD grid with the areas from the WRLU coverage (replace NLCD values with WRLU where they overlap).

Table 1. WRLU codes and corresponding NLCD land cover classes.

WRLU Code	WRLU Description	NLCD Code	NLCD Description
Irrigated Crop Land			
IA1a	Fruit	61	Orchards/Vineyards/Other
IA2a	Grain	83	Small Grains
IA2a1	Corn	82	Row Crops
IA2b3	Beans	82	Row Crops
IA3a	Alfalfa	81	Pasture/Hay
IA3b	Grass Hay	81	Pasture/Hay
IA3d	Pasture	81	Pasture/Hay
IA4a	Fallow – Plowed or disked	84	Fallow
IA4b	Idle – Overgrown more than one season	86[1]	Idle[1]
Non-Irrigated Crop Land			
IB1a	Grains/Beans/Seeds	183[1]	Small Grains
IB2a	Alfalfa	181[1]	Pasture/Hay
IB2b	Pasture	181[1]	Pasture/Hay
IB3a	Fallow – Plowed or disked	184[1]	Fallow
IB3b	Idle – Overgrown more than one season	186[1]	Idle[1]
Grassy/Phreatophytic/Open Water Areas			
IIA1a	Pasture	181[1]	Pasture/Hay
IIA1b	Hayland	181[1]	Pasture/Hay
IIA2a	Pasture	181[1]	Pasture/Hay
Barren Lands			
IVC	Excavated lands	32	Quarries/Strip Mines/Gravel Pits
Built Up Lands			
VA1	Buildings/Homes	21	Low Intensity Residential
VB1	Buildings/Homes (High Density)	22	High Intensity Residential
VB2	Buildings/Homes (Low Density)	21	Low Intensity Residential
VB3	Open Spaces (Parks, Golf Courses)	85	Urban/Recreational Grasses
VC	Commercial/Industrial	23	Commercial/Industrial/Transportation
VC1	Commercial	23	Commercial/Industrial/Transportation
VC2	Industrial	23	Commercial/Industrial/Transportation
VD	Transportation, Communications, Util.	23	Commercial/Industrial/Transportation

[1]This is not an NLCD class, but was added to the dataset for modeling purposes.

The result of these steps is a 30-meter resolution grid representation of the land use/land cover that best represents current conditions in the Echo Reservoir Watershed. For the purposes of modeling and reporting results, the land use/land cover classes in the existing conditions dataset can be grouped into a smaller number of classes. Table 2 lists the existing conditions classes and the likely groups into which they would fall.

Table 2. Land use/land cover classes used for modeling in the Echo Reservoir Watershed.

Model Land Cover Class	Existing Conditions Land Cover Class
Urban/Residential	Low Intensity Residential
	High Intensity Residential
	Urban/Recreational Grasses
	Commercial/Industrial/Transportation
Forest Land	Deciduous Forest
	Evergreen Forest
	Mixed Forest
Range Land	Shrubland
	Grassland/Herbaceous
Irrigated Agriculture	Irrigated Pasture/Hay
	Irrigated Row Crops
	Irrigated Small Grains
	Irrigated Fallow
	Irrigated Idle Overgrown More than One Season
	Orchards/Vineyards/Other
Non-Irrigated Agriculture	Non-Irrigated Pasture/Hay
	Non-Irrigated Small Grains
	Non-Irrigated Fallow
	Non-Irrigated Idle Overgrown More than One Season
Wetlands	Woody Wetlands
	Emergent Herbaceous Wetlands
Barren	Bare Rock/Sand/Clay
	Quarries/Strip Mines/Gravel Pits
Water	Open Water
	Perennial Ice/Snow

2.0 CALCULATION OF LOADS FROM ONSITE WASTEWATER TREATMENT SYSTEMS

Information from the Summit County Health Department was used to estimate the number of septic tanks within each of the subwatersheds in the TMDL study area. Health Department records also indicated the number of septic systems associated with full time residences versus the number associated with recreational residences (cabins, summer homes, etc.). Total P loads for each subwatershed were calculated using the following equation:

$$L_i = PN_i qDCEU \tag{2.1}$$

Where:
L_i = Annual TP loading in subwatershed i (kg/yr)
P = Average household size (persons/dwelling)
N_i = Number of dwellings in watershed i
q = Per capita water use (gal/day)
D = Average number of days the dwelling is occupied in a year (days)
C = Average TP concentration in septic discharge (mg/L)
E = Fraction of TP remaining after treatment
U = Units conversion factor

The equation above was evaluated for both recreational dwellings and full time dwellings within each of the subwatersheds in the TMDL study area. Table 3 lists the estimates of onsite wastewater treatment system numbers and the TP loads calculated for each subwatershed using the following assumptions:

1. It is assumed that all septic tanks in the Echo Reservoir watershed service residential dwellings.
2. It is assumed that each residential dwelling has a single septic tank.
3. It is assumed that discharge from septic tanks associated with recreational dwellings is approximately 5 percent of full time septic effluent discharge based on roughly 2.5 weeks residence per year.
4. It is assumed that the average household size in Summit County is 2.87 persons (United States Census Bureau, 2000).
5. It is assumed that full time indoor per capita water use is approximately 70 gallons/person/day (UDWR, 2001).
6. It is assumed that all indoor water use is discharged via the septic systems.
7. It is assumed that the average TP concentration of septic system discharge is 9 mg/L (USEPA, 2002).
8. It is assumed that, on average, 90 percent of the P in the effluent from onsite wastewater treatment systems is retained onsite (a 90 percent treatment rate).

Table 3. Number of onsite wastewater treatment systems and TP (TP) loads by subwatershed.

Housing Area Description	Number of Recreational Dwellings	Number of Full Time Dwellings	Total Number of Dwellings
Upper Weber River Subwatershed			
Alpine Acres	36	0	36
Aspen Acres	39	0	39
Aspen Mountain	0	53	53
Beaver Knolls	0	5	5
Beaver Springs	68	0	68
Weber Canyon	0	22	22
Hidden Lake	32	0	32
Holiday Park	20	0	20
Moffit Basin	0	2	2
Maple Ridge	7	7	13
Pine Mountain	0	218	218
Pine Springs	0	6	6
Weber Area	28	43	71
Wilderness Acres	36	0	36
Total Number of Septic Tanks	266	355	621
TP Load to Water Body (kg/yr)	3.3	88.7	92
Beaver Creek Subwatershed			
Francis	0	25	25
Garth Ranches	0	20	20
Goodworth	0	4	4
Kamas area	14	79	93
Knob Hill	0	5	5
Marion	0	87	87
Marion Meadows	0	4	4
Meadow View	0	13	13
Samak	24	72	96
Spring Hills	0	13	13
Total Number of Septic Tanks	38	322	360
TP Load to Water Body (kg/yr)	0.5	80.5	81
Weber River below Beaver Creek Subwatershed			
Browns Canyon	0	13	13
Oakley area	0	115	115
Wooden Shoe	0	4	4
Total Number of Septic Tanks	0	132	132
TP Load to Water Body (kg/yr)	0	33	33
Wanship Reservoir Subwatershed			
Bridge Hollow	0	18	18
Fox Run	0	9	9
Lake Rockport Estates	18	18	36
Miscellaneous	14	14	27
Total Number of Septic Tanks	32	59	90
TP Load to Water Body (kg/yr)	0.4	14.6	15

Table 3. (cont'd) Number of onsite wastewater treatment systems and TP loads by subwatershed.

Housing Area Description	Number of Recreational Dwellings	Number of Full Time Dwellings	Total Number of Dwellings
Weber River Below Wanship Reservoir Subwatershed			
Cherry Canyon	0	10	10
Pace subdivision	0	3	3
Peoa area	0	50	50
Wanship area	0	71	71
Wanship cottages	0	9	9
Total Number of Septic Tanks	0	143	143
TP Load to Water Body (kg/yr)	0	35.7	35.7
Silver Creek Subwatershed			
Forest Meadows	48	0	48
Highland Estates	0	30	30
Park City area	0	15	15
North Tollgate Canyon	0	211	211
Total Number of Septic Tanks	48	256	304
TP Load to Water Body (kg/yr)	0.6	64.0	64.6
Weber River Below Silver Creek Subwatershed			
Hoytsville	0	133	133
Miscellaneous	0	4	4
Total Number of Septic Tanks	0	137	137
TP Load to Water Body (kg/yr)	0	34.2	34.2
Chalk Creek Subwatershed			
Chalk Creek	0	64	64
Coalville area	0	12	12
Kamp Killcare	0	2	2
Miscellaneous	0	1	1
Thousand Peaks Ranch	0	5	5
Upton	0	13	13
Total Number of Septic Tanks	0	97	97
TP Load to Water Body (kg/yr)	0	24.2	24.2

3.0 LITERATURE VALUES FOR TOTAL PHOSPHORUS EXPORT COEFFICIENTS

Table 4. Literature values for TP export coefficients.

Land Use Activity	Export Coefficient	Units	Methods or Comments	Reference
High density residential	*1.12 **3.4 ***11.6	kg/ha/yr	*Milwaukee.Wis-Urban Land Use **Storm Sewers ***Combined Sewers	USEPA PLOAD Model Input Database
Highway	2.5	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Multi-family residential	1.97	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Residential	[1](1.2) [2](*0.897)	kg/ha/yr	- *Soluable P	[1]Athayde, D.N., P.E. Shelley, E.D. Driscoll, D. Gaboury and G.B. Boyd.1983. Results of the Nationwide Urban Runoff Program: Final Report. USEPA. USEPA Water Planning Division. Washington, DC. [2]Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Urban Land Drainage and Storm Water	[2](1.1 - 5.6) [1](0.27 - 8.5 and a mean of 2.76) [1](0.63 - 1.65 and a mean of 1.11)	kg/ha/yr	Does not represent extreme storm conditions	[1]Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA/600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon. [2]Wells, D. M., T. A. Austin, and B. C. Cook. 1971. Variation of Urban Runoff With Duration and Intensity of Storms. Water Resources Center. Texas Tech Univ., Lubbock, TX. 139 p.
Urban Watersheds	(0.19 - 6.23) Mean: 1.91	kg/ha/yr	Does not represent extreme storm conditions	Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Low and medium-density residential	*1.6 **10.2	kg/ha/yr	*Storm Sewers **Combined Sewers	USEPA PLOAD Model Input Database
Low density residential	*0.47 **0.04	*lb/ac/yr **kg/ha/yr	*Northeast Florida **Milwaukee.Wis-Urban Land Use	USEPA PLOAD Model Input Database
Medium Density Residential	0.58	kg/ha/yr	Milwaukee.Wis-Urban Land Use	USEPA PLOAD Model Input Database

Table 4. (cont'd) Literature values for TP export coefficients.

Land Use Activity	Export Coefficient	Units	Methods or Comments	Reference
Medium-high intensity industrial used	*2.2 **10.9	kg/ha/yr	*Storm Sewers **Combined Sewers	USEPA PLOAD Model Input Database
Business	30	kg/ha/yr		Athayde, D.N., P.E. Shelley, E.D. Driscoll, D. Gaboury and G.B. Boyd.1983. Results of the Nationwide Urban Runoff Program: Final Report. USEPA. USEPA Water Planning Division. Washington, DC.
Commercial	2.05	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Freeways	1.04	kg/ha/yr	Milwaukee.Wis-Urban Land Use	USEPA PLOAD Model Input Database
Industrial	*3.8 **4.77 ***1.49	*kg/ha/yr **lb/ac/yr ***kg/ha/yr	**Northeast Florida ***Milwaukee.Wis-Urban Land Use	*Athayde, D.N., P.E. Shelley, E.D. Driscoll, D. Gaboury and G.B. Boyd.1983. Results of the Nationwide Urban Runoff Program: Final Report. USEPA. USEPA Water Planning Division. Washington, DC. **PLOAD ***PLOAD
Limited-nuisance industrial activities	*1.6 **10.2	kg/ha/yr	*Storm Sewers **Combined Sewers	USEPA PLOAD Model Input Database
Parking Lots	0.78	kg/ha/yr	Milwaukee.Wis-Urban Land Use	USEPA PLOAD Model Input Database
Idle	0.1	kg/ha/yr		Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Bare rock	0.66	lb/ac/yr		USEPA PLOAD Model Input Database
Strip Mines	0.66	lb/ac/yr		USEPA PLOAD Model Input Database
Transitional	0.66	lb/ac/yr		USEPA PLOAD Model Input Database
Shrub	0.66	lb/ac/yr		USEPA PLOAD Model Input Database

Table 4. (cont'd) Literature values for TP export coefficients.

Land Use Activity	Export Coefficient	Units	Methods or Comments	Reference
Forest	[1](0.019 - 0.830) [2](0.03 - 0.9) [3](*0.369)	kg/ha/yr	-Does not represent extreme storm conditions -*Stream Flow, Little cultivated land	[1]Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-01 1. Washington, DC. [2]Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA-600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon. [3]Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Forested	0.34 - 0.9	kg/ha/yr	-Does not represent extreme storm conditions -*Stream Flow, Some logging and road construction	Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Orchards and mixed grain	2.8	g/ha/day	North Carolina	Loehr, R.C. (1974). "Characteristics and comparative magnitude of non-point sources" Journal of Water Pollution Control Federation 46: 1849-1878
250 hog dry lot, row crops, wood, grassland	3.5	g/ha/day	North Carolina	Loehr, R.C. (1974). "Characteristics and comparative magnitude of non-point sources" Journal of Water Pollution Control Federation 46: 1849-1879
Agriculture	0.94	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Land Receiving Manure	0.8 - 2.9	kg/ha/yr	Does not represent extreme storm conditions	Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA/600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon.
Alfalfa and Brome Grass	0.101	kg/ha/yr	'-Does not represent extreme storm conditions	Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Grazed and Pastured Watersheds	(0.14 - 4.90) Mean: 1.50	kg/ha/yr	Does not represent extreme storm conditions	Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.

Table 4. (cont'd) Literature values for TP export coefficients.

Land Use Activity	Export Coefficient	Units	Methods or Comments	Reference
Hay	0.64	kg/ha/yr		Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Pasture	[1](0.1) [2](0.25)	kg/ha/yr	'-Does not represent extreme storm conditions	[1]Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC. [2]Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Pasture	0.5	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Agricultural Crop Land	0.06 - 2.9	kg/ha/yr	Does not represent extreme storm conditions	Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA/600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon.
Corn	2	kg/ha/yr	*Data just represents range, Nebraska	Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC. *[Gilliland, 1987]
Farmland, Corn and Oats	7.85E-02	kg/ha/yr	-Does not represent extreme storm conditions - Surface runoff, 173 acre cultivated site	Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Small Grains	1.5	kg/ha/yr		Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Soy Beans	4.6	kg/ha/yr		Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Parks	0.03	kg/ha/yr	Milwaukee.Wis-Urban Land Use	USEPA PLOAD Model Input Database
Parks	*0.04 **0.34	kg/ha/yr	*Storm Sewers **Combined Sewers	USEPA PLOAD Model Input Database

Table 4. (cont'd) Literature values for TP export coefficients.

Land Use Activity	Export Coefficient	Units	Methods or Comments	Reference
Animal Feedlot and Manure Storage	(2.128 - 795.20) Mean: 300.7	kg/ha/yr	Does not represent extreme storm conditions	Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Continuous Grazing	*4.60 **0.03	kg/ha/yr	-* Total Phosphorus - **Ortho P -*** NH_4^+ - NO_3^- - N	Olness, A., S. J. Smith, E. D. Rhoades, and R. G. Menzel. 1975 Nutrient and Sediment Discharge from Agricultural Watersheds in Oklahoma. J. Environ. Quality 4:331-336 Doran, J. W., J. S. Schepers, and N. P. Swanson. 1981. Chemical and Bacteriological Quality of Pasture Runoff. J. Soil. And Water Cons. 36(3): 166-170
Feedlot Dairy	220	kg/ha/yr		Reckhow, K.H., M. N. Beaulac, and J.T. Simpson. 1980. Modeling phosphorous loading and lake response under uncertainty: a manual and compilation of export coefficients. USEPA. 440/5-80-011. Washington, DC.
Feedlot Runoff	10 - 620	kg/ha/yr	Does not represent extreme storm conditions	Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA/600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon.
Rangeland	[1](0.08) [2](*0.075)	kg/ha/yr	-Does not represent extreme storm conditions - *Primarily grazing, no chemicals added	[1]Porcella, D. B., and D. L. Sorensen. 1980. Characteristics of Nonpoint Source Urban Runoff and its Effects on Stream Ecosystems, EP 1.23: EPA/600/3-80-032. U.S. Environmental Protection Agency Corvallis, Oregon. [2]Dornbush, J. N., J. R. Andersen, and L. L. Harms. 1974. Quantification of Pollutants in Agricultural Runoff, EP 1.23/2: EPA-660/2-74-005. U.S. Environmental Protection Agency Kansas City, Missouri.
Rotational Grazing	0.3 - 1.30	kg/ha/yr	-* Total Phosphorus - **Ortho P -*** NH_4^+ - NO_3^- - N	Doran, J. W., J. S. Schepers, and N. P. Swanson. 1981. Chemical and Bacteriological Quality of Pasture Runoff. J. Soil. And Water Cons. 36(3): 166-170
Wetlands	0.22	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Open Lands	0.16	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database
Woodland	0.13	lb/ac/yr	Northeast Florida	USEPA PLOAD Model Input Database

4.0 RESERVOIR MODEL DESCRIPTION

4.1 MODELING APPROACH AND MODEL SELECTION

Permissible loads to Echo Reservoir were estimated using a water quality model. Due to the level of supporting data available for modeling Echo Reservoir, particularly the general lack of high frequency measurements of water quality in the tributaries to the reservoir and the small number of water quality measurements within the reservoir, it was determined that a relatively simple, steady-state model was appropriate for simulating DO (DO) concentrations within the reservoir. A variety of scenarios were run through the model in order to determine those conditions under which it would be expected that the DO endpoint chosen for this TMDL study would be violated. The scenarios that did not meet the established DO endpoint were re-run repeatedly, reducing the P loading each time, until the endpoint was met. This resulted in an estimate of the reduction in loading required to bring each of the scenarios into compliance with the DO endpoint. The following sections provide a detailed description of the reservoir model that was used and the data and information that were used to set-up, populate, and calibrate the model. Details of the models are provided in Appendices A and B.

4.2 MODEL DESCRIPTION

The model chosen for use in this TMDL study is actually made up of two separate sub-models, which were developed at USU for relatively small, run-of-the-river type reservoirs. The first sub-model, called RTM[1], simulates water temperature within the reservoir. The second sub-model, called RESEN, simulates all of the water quality parameters within the reservoir. The following sections provide a more in depth description of each of these sub-models. The temperature model was run first using scenario-specific flows and storage, and weather data from the Utah Climate Center at Utah State University. The output is the temperature depth profile for the end of each month starting in April, during which it is assumed that the lake turns over as unstratified. These profiles were then overlaid onto the RESEN discretization grid to provide the steady-state temperatures for each month in each model grid cell. The water quality model was then executed using the scenario-based flow, storage, and averages for water quality data for the inflows to Echo Reservoir (the Weber River, Chalk Creek, and the Coalville WWTP). The output from the RESEN model for each scenario is the longitudinal profile for each of the water quality constituents in each layer within the reservoir.

4.2.1 Reservoir Temperature Model (RTM)

RTM, which was developed at Utah State University, represents a steady state solution to the energy balance within the reservoir. The model parameterizes the reservoir basin geometry as longitudinal spatial elements which are further divided into a number of computational elements. The vertical discretization is accomplished by input of depths, area, and volume versus reservoir elevations for each longitudinal spatial element. RTM computes the energy balance within the reservoir through computation of the heat balance, heat transfer, dispersion of heat within the reservoir, and vertical mixing of water by temperature specific density gradients. Input meteorological data consists of shortwave radiation, time of sunrise and sunset, evaporation coefficients, shading, light extinction coefficient, barometric pressure, air temperature, wind speed and relative humidity. RTM uses these inputs to compute the vertical temperature profile at each longitudinal spatial element and therefore provides the expected temperature of the water column throughout the reservoir.

[1] Reservoir Temperature Model

4.2.2 Reservoir Water Quality Model (RESEN)

The RESEN model was developed at Utah State University (Messer *et al.* 1982) for use in simulating phytoplankton growth, nutrient uptake, biochemical oxygen demand (BOD), and DO in small reservoirs. The reservoir water quality model is steady-state, and because of this, inflow and outflow are constant. Fifteen constituents are calculated – six related to algae growth, including two types of algae and related N/P luxury uptake. The other parameters include available P, available N, ultimate BOD, DO, zooplankton, conductivity, total dissolved solids (TDS), organic P (detritus from decay of algae and zooplankton), and organic N (detritus from decay of algae and zooplankton).

Each constituent can be assigned a benthic flux (+/-), and each constituent can be assigned a settling velocity. There is vertical dispersion between the layers represented in the model; with each layer pair assigned a constant dispersion coefficient. The kinetics in the model are adjusted for temperature. The N/P cycles are complex, so the mass balance can be tracked, but both mass balances are good within 0.01 percent when settling and benthic fluxes are switched off. Algae growth produces oxygen, and decay consumes it. Zooplankton decay consumes oxygen. Algae and zooplankton decay produce BOD that in turn consumes oxygen. Decay produces N/P that can be recycled for more algae growth.

The reservoir geometry is assumed to be two dimensional in the direction of flow (x) and depth (z), and that lateral mixing is instantaneous. The fundamental equation for water quality constituents is given by:

$$\frac{\partial c}{\partial t} = \frac{1}{A_x}\frac{\partial}{\partial x}\left(A_z D_z \frac{\partial c}{\partial z}\right) - \frac{1}{A_x}\frac{\partial}{\partial x}\left(A_x \bar{u}_x c\right) - \frac{1}{A_z}\frac{\partial}{\partial z}\left(A_z \bar{u}_z c\right) + r + \frac{s}{V} \quad \text{.....} \qquad (4.1)$$

in which c is the constituent concentration, A_x and A_z are the cross-section area in the direction of x and z, D_z is the vertical dispersion coefficient, u_x is the x-velocity, r is the sum of all reaction rates affecting the constituent, and s/V is the sum of all external sources per unit volume. The terms depend on which water quality constituent is being modeled. At steady state, equation 4.1 is rearranged to equation 4.2 and is integrated over distance from the reservoir inlet to the dam.

$$\frac{\partial c}{\partial x} = \frac{1}{A_x \bar{u}_x}\frac{\partial}{\partial x}\left(A_z D_z \frac{\partial c}{\partial z}\right) - \frac{1}{A_x \bar{u}_x}\frac{\partial}{\partial x}\left(A_x \bar{u}_x c\right) - \frac{1}{\bar{u}_x}\frac{1}{A_z}\frac{\partial}{\partial z}\left(A_z \bar{u}_z c\right) + \frac{1}{\bar{u}_x} r + \frac{1}{\bar{u}_x}\frac{s}{V} \qquad (4.2)$$

Since most of these input parameters are not available from site specific studies within Echo Reservoir, average literature values were used in the model calibration runs. These values represent the best available estimates based on the literature sources and previous water quality efforts on western reservoirs conducted at Utah State University. Adjustments to some kinetic parameters were made during calibration to match with water quality data in Echo Reservoir.

4.3 MODEL SETUP

Available streamflow, water quality, and reservoir physical data were used to setup and populate the model of Echo Reservoir. The following sections describe the datasets and methods that were used.

4.3.1 Bathymetry

The reservoir model is quasi 2-D, which means that it is laterally uniform, explicit longitudinally and vertically layered with up to 8 layers. The model accounts for changing geometry by changing the width and depth along the central axis of the reservoir. The bathymetry inputs to the model consist of a series of

cross sections spaced along the length of the reservoir that are perpendicular to the centerline of the reservoir. The bathymetry of points between the cross sections is linearly interpolated.

Bathymetry for Echo Reservoir was based on data obtained from the Bureau of Reclamation. These data consist of elevation points that were digitized from a scanned contour map of the reservoir. These points were imported to ArcView and used to generate a triangulated irregular network (TIN) surface representation of the reservoir using the 3-D Analyst extension. The bathymetric cross sections were derived from this TIN surface. Figure 1 shows the bathymetry of Echo Reservoir, Figure 2 shows the locations of the cross sections extracted from the TIN and input to the model, and Figure 3 shows a typical cross section. Full details of the model bathymetry are provided in Appendix A.

The model represents up to 8 vertical layers. These layers are as follows:

1. Photic Zone
2. Epilimnion above metalimnion and below photic zone
3. Metalimnion
4. Hypolimnion (5 layers)

The thickness of these vertical layers was calculated from the reservoir storage for each scenario. In general, the Photic zone was assumed to be 1 m deep for all situations, based on the penetration of light available for algae growth. The thermocline depth was determined from the temperature model and the metalimnion was assumed to be 2 meters deep for all scenarios. The epilimnion was assumed to be the layer between the photic zone and the upper boundary on the thermocline. The hypolimnion was the remainder of the depth from the lower boundary on the thermocline to the bottom, divided into five equal-depth layers.

As the cross-section is moved from the headwaters near Coalville to the dam near Echo, the depth and width increase, thereby increasing the cross-sectional area. The thalweg profile is shown in Figure 4, which displays the depth as function of distance from the headwaters to the dam for the 8 m drawdown scenario. Note that at the upstream end of the reservoir, the water level is below the sediment surface and the flow is in the Weber River channel for the first 0.5 mi. For this portion of the model, the depths of each layer are assumed to be a nominal 0.1 m each until the depth exceeds 0.8 m. Then layer depth is added starting with the euphotic zone until 1 m, then to the epilimnion (to the depth of the top of the thermocline from the temperature model), then to the metalimnion (until the bottom of the thermocline), and finally to the hypolimnion equally distributed over the five hypolimnion layers. The layers determined by this method are shown in Figure 4.

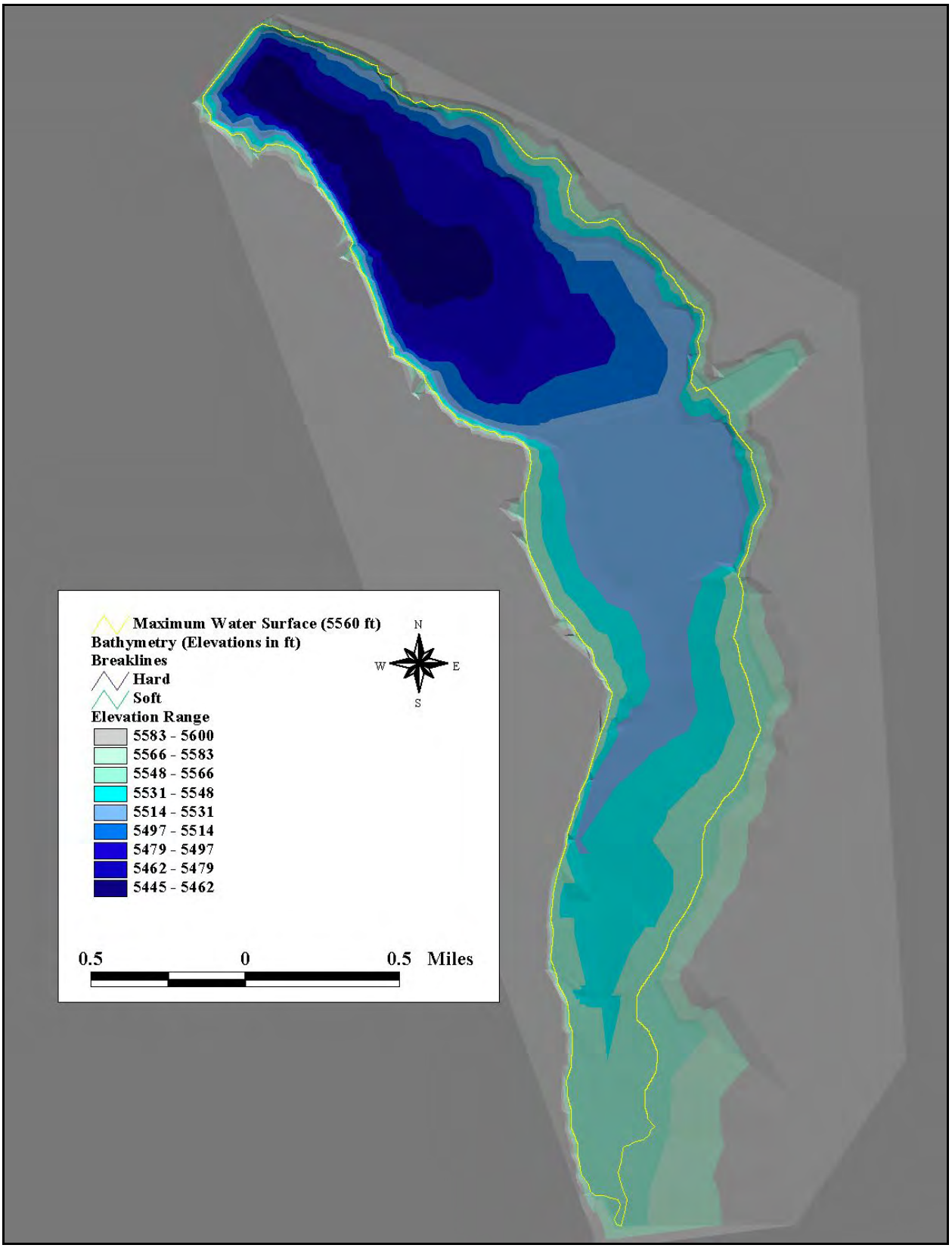

Figure 1. Bathymetry of Echo Reservoir.

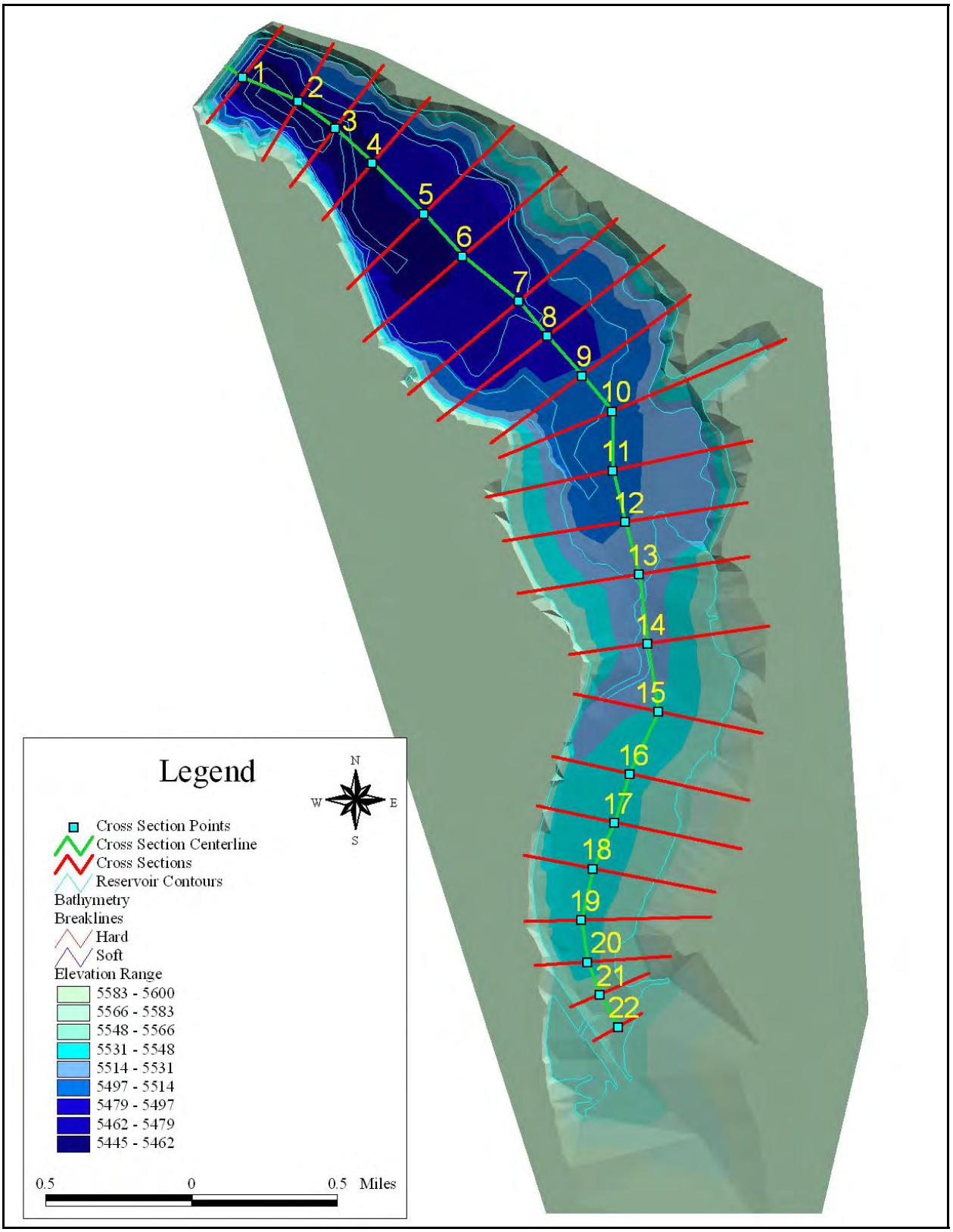

Figure 2. Echo Reservoir Bathymetric Cross Section Locations.

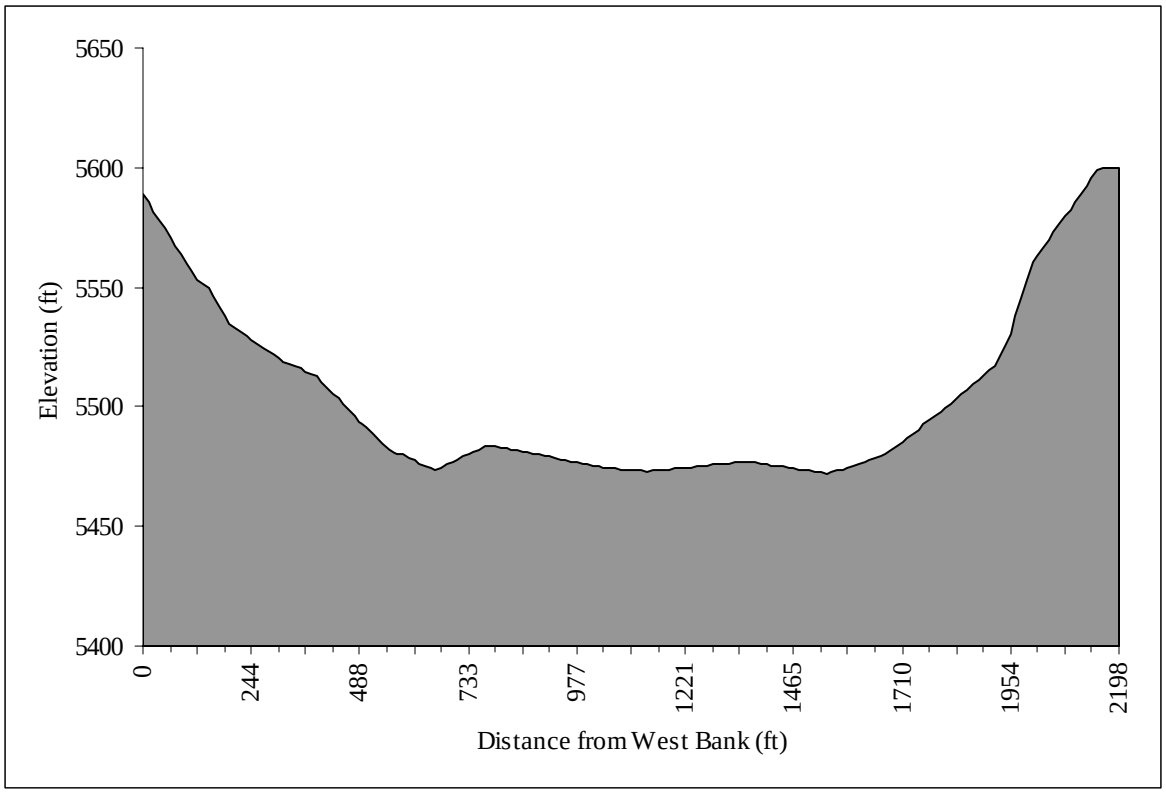

Figure 3. Typical Bathymetric Cross Section (Echo Reservoir cross section 1 upstream of dam).

The actual thickness of the layers was both scenario and location specific. At the upstream end of the reservoir, the water is shallow and the layers are thin. A practical minimum of 0.1 m was applied for each layer. As the water deepened downstream, the photic zone was increased in thickness up to 1 m. As the water deepened further, the epilimnion was deepened up to the depth of the upper boundary of the thermocline. Continuing, the metalimnion was increased until its depth was 2 m. Thereafter, additional depth was applied to the 5 equal hypolimnion layers. An example plot of the layers is shown in Figure 4.

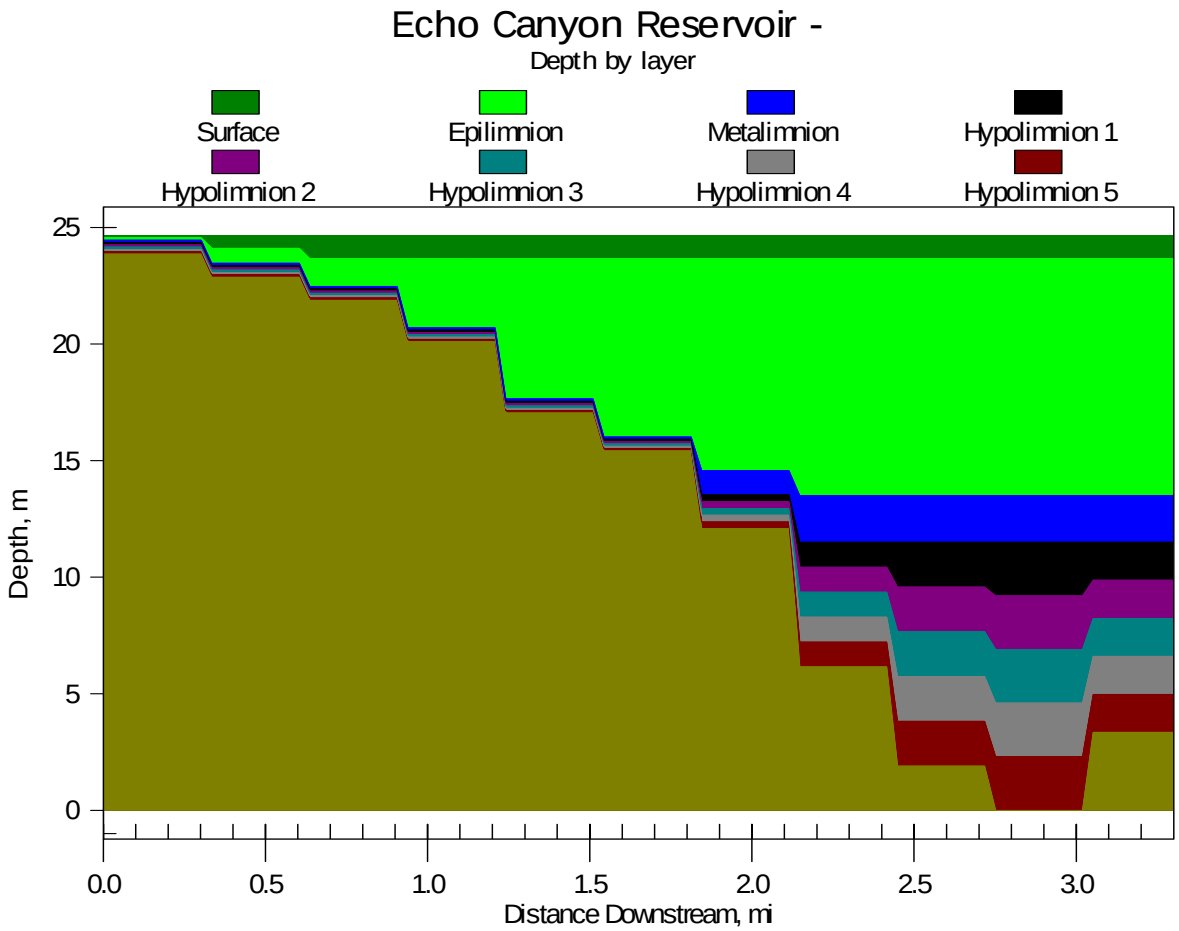

Figure 4. Visualization of layers for the RESEN model for the 8 meter draw-down scenario.

4.3.2 Flow and Storage Conditions

Flow and storage conditions for each of the scenarios run through the model were set using existing streamflow data collected by USGS and reservoir storage data obtained from Utah Division of Water Rights. The reservoir model was used to run individual simulations for the months of June – September under a variety of flow and storage conditions in order to capture the onset of stratified conditions, the subsequent draw down of the reservoir in the late summer and fall, and the differences between wet, average, and dry hydrologic periods. The flow and storage scenarios were initially constructed by identifying representative wet, average, and dry periods from the time series of reservoir storage and streamflow. Table 5 lists these representative periods. Subsequent modeling to further define reservoir conditions was based on a "worst case scenario" using data from 1998 (discussed in section 4.5).

Average monthly storage and flow values were calculated for the scenario periods to provide the model input values. Inflows to the reservoir were estimated by adding the flow measurements from the USGS gages in Chalk Creek (USGS 10131000 – Chalk Creek at Coalville, UT) and the Weber River (USGS 10130500 – Weber River Near Coalville, UT), which are both located just upstream of Echo Reservoir. The average monthly flows listed in Table 5 represent the averages over the representative years listed for each of the scenarios (i.e., the average monthly flow for June of the High Flow/Storage scenario is the average of the June flows over the four year period between 1983 and 1986). Average monthly storage values were estimated similarly using the data from the Division of Water Rights.

Table 5. Echo Reservoir model scenarios.

Scenario	Representative Years	Month	Average Monthly Storage (acre-ft)	Average Monthly Flow (cfs)
High Flow/Storage	1983 – 1986	June	71,639	1,666
		July	69,937	521
		August	57,919	316
		September	44,202	321
Medium Flow/Storage	1996 – 1999	June	71,937	1,073
		July	65,139	339
		August	52,835	252
		September	40,571	247
Low Flow/Storage	1988 – 1992	June	63,297	323
		July	47,249	258
		August	28,225	244
		September	15,115	185

4.4 MODEL CALIBRATION

4.4.1 Reservoir Temperature Model

The Reservoir Temperature Model was used to predict the water temperature profiles and was calibrated using temperature profile data collected by DWQ. As discussed above, reservoir morphometry data were obtained from the U.S. Bureau of Reclamation and flow data were obtained from the U.S. Geological Survey. Meteorological data were found for Ogden, Salt Lake City, and Park City from the Utah Climate Center at Utah State University. Insufficient meteorological data were available for the vicinity of Echo Reservoir, which is at an elevation (about 5500 ft) significantly lower than Park City (about 7000 ft) and higher than Salt Lake City and Ogden (about 4400 ft). As such, meteorological data for all the above listed stations were considered in the model calibration.

Two sets of calibration runs were used. The first was June and August 1994, the months for which temperature profiles were available during the 1990-1995 calibration period. These runs were for the specific dates listed. The second calibration set included averages for conditions during the 1990-1995 period. No calibration was performed for these runs – meaning that no parameters were adjusted.

The results for the 1994 calibration runs are shown in Figure 5. These results show satisfactory prediction of surface water temperatures for both profiles. The hypolimnion temperatures for the June profile are under-predicted by 1 to 7 ^{0}C. The primary reason for this is likely the lack of detailed meteorological data for Echo Reservoir for this period and the fact that spring weather is highly variable, particularly in mountainous areas. The critical portions of the reservoir for purposes of algal growth are the surface waters and the metalimnion, and it was felt that the under-prediction of the hypolimnetic temperatures would not significantly influence the water quality model. The prediction for August 1994 is satisfactory for the entire water column.

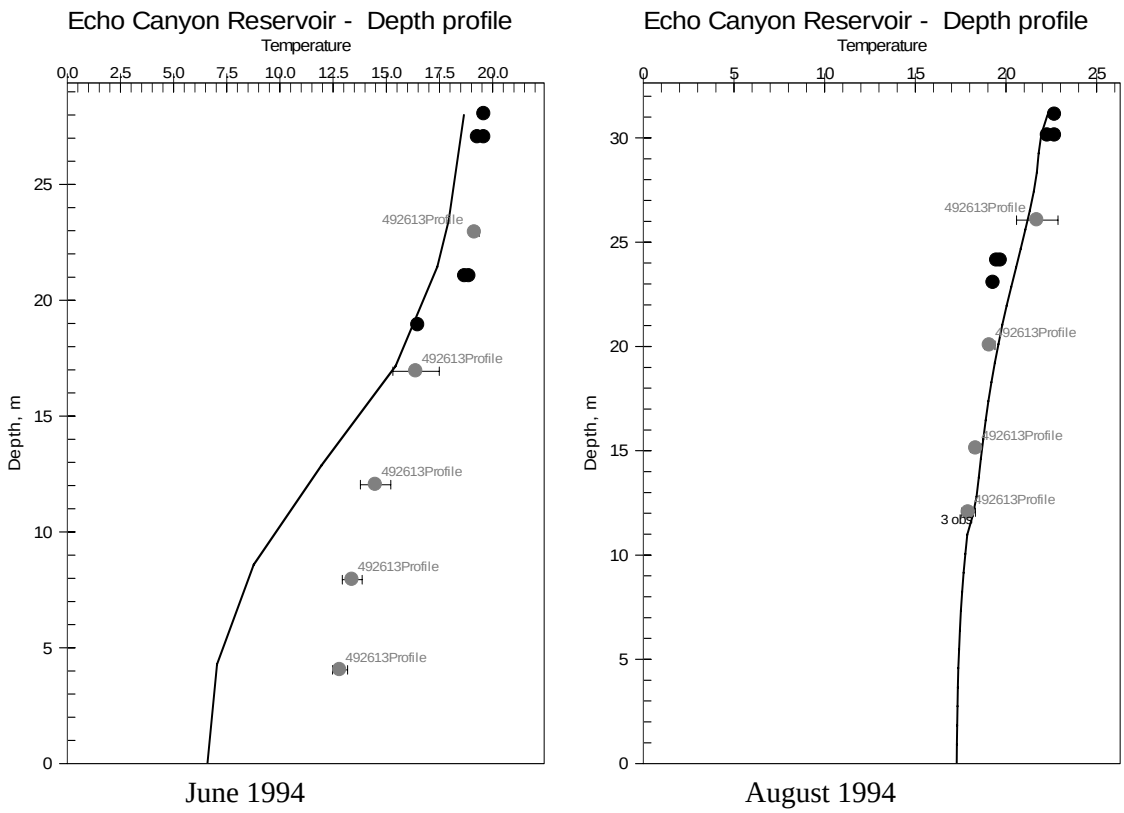

Figure 5. Reservoir temperature results (units of x axis are degrees C) – calibration period June and August, 1994, flow and storage data.

The results for the second case, for which conditions are averaged over the period from 1990-1995, are shown in Figure 6. The results are similar to those described above: 1) satisfactory prediction of the surface water temperatures and under-prediction of the hypolimnetic temperature in June, and 2) improved prediction for the August profile, though the model over-predicts the temperature by 1-2°C for the lower portions of the profile. Though similar, the capability of the model in temperature prediction is less for these averaged conditions. This is because temperature predictions are sensitive to the current climate, and the data available were from single profiles obtained in June and August 1994. Additional data would be required to refine the model and this should be considered in the future.

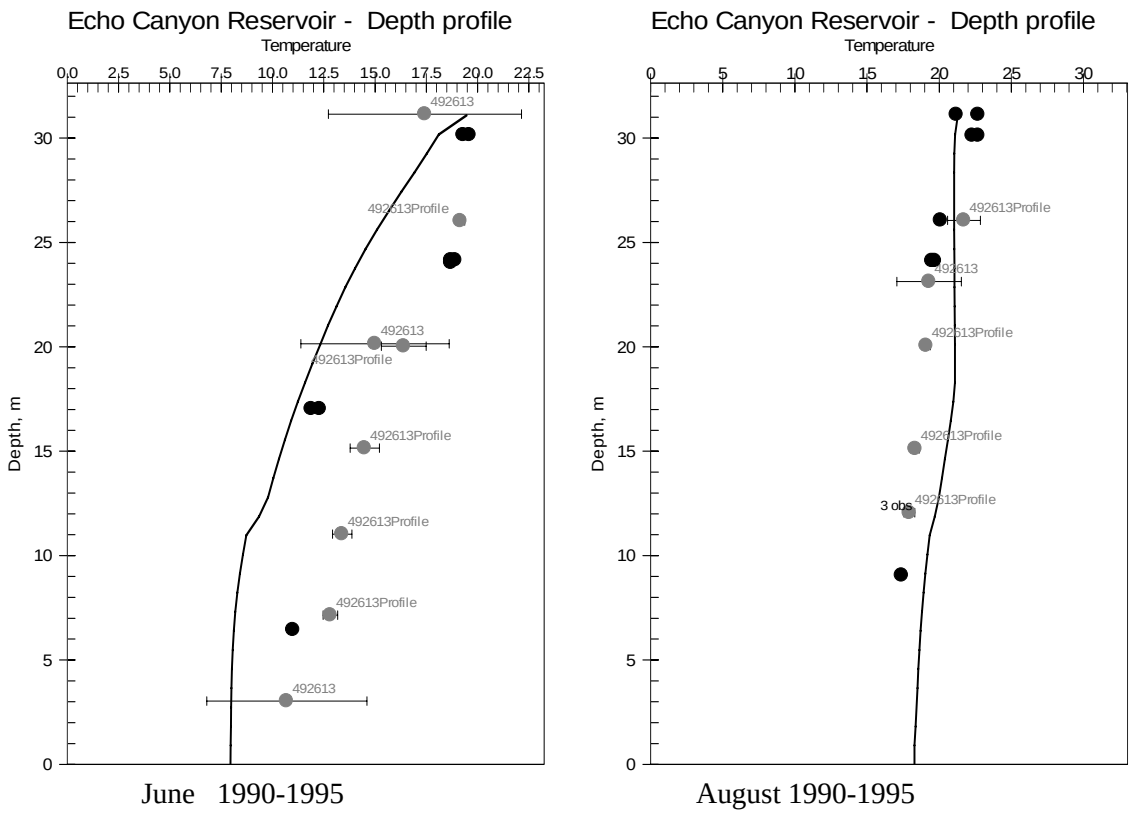

Figure 6. Reservoir temperature results (units of x-axis are degrees C) – calibration period June, August, 1990-1995, averaged flow and storage data.

4.4.2 Reservoir Water Quality Model

The RESEN water quality model of the reservoir was calibrated using existing water quality observations in the reservoir as reported by DWQ. Most parameter values were taken from the literature as far as possible. However, not all were available. The flow, storage, and water quality data for the calibration time period were input to the model and used for calibration purposes.

The model results were compared with the water quality data from sites 492640 + 492632 + 492635 (the sum of the inflows to Echo Reservoir from Chalk Creek, the Coalville WWTP, and the Weber River), 492613 (Echo Reservoir Above the Dam), and 492614 (Echo Reservoir 2/3 Way Up the Lake) for Chlorophyll A. Adjustable parameters were modified (growth and decay rates, half-saturation constants, etc.) within their permissible ranges from the literature to match the Chlorophyll A concentrations reasonably well with the data (both by eye and by minimizing the residual mean square). Figure 7 shows the Chlorophyll A calibration.

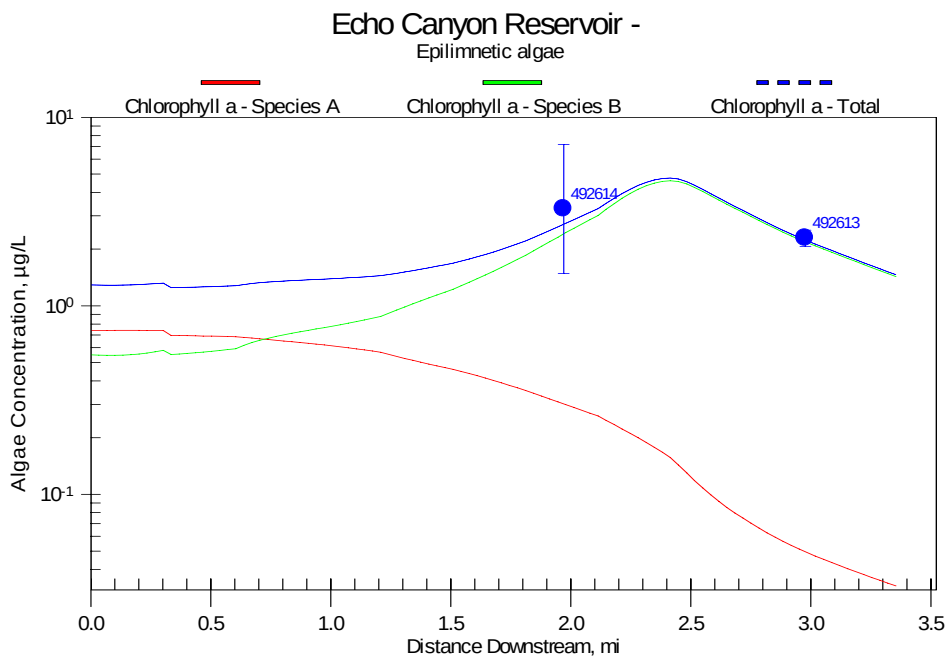

Figure 7. Calibrated longitudinal profiles for Chlorophyll A, Echo Reservoir, June-September, 1990-1995.

Next, DO, both in the epilimnion and the average of the hypolimnion layers, were matched with the water quality data and the benthic sediment oxygen demand (SOD) increment (benthic SOD is the sum of the SOD from carbon deposition and a fixed value of 'historic' unused BOD, or the increment). Figure 8 shows the DO calibration result.

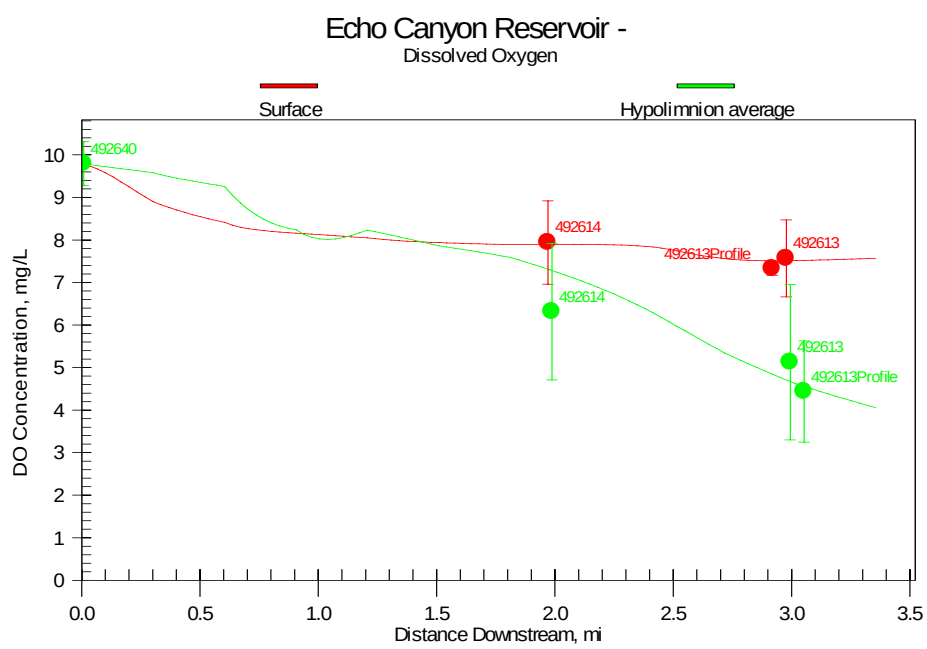

Figure 8. Calibrated longitudinal profiles for DO, Echo Reservoir, June-September, 1990-1995.

Similarly, the total phosphorus (TP) simulation results were matched with the water quality data by adjusting particulate phosphorus (P) settling rates - mainly by eye and direction because it was difficult to

match the TP well with the small amount of data available. For most simulations and data, the algal growth rates were not significantly limited by a shortage of P so an exact match was less critical. Figure 9 shows the results for TP.

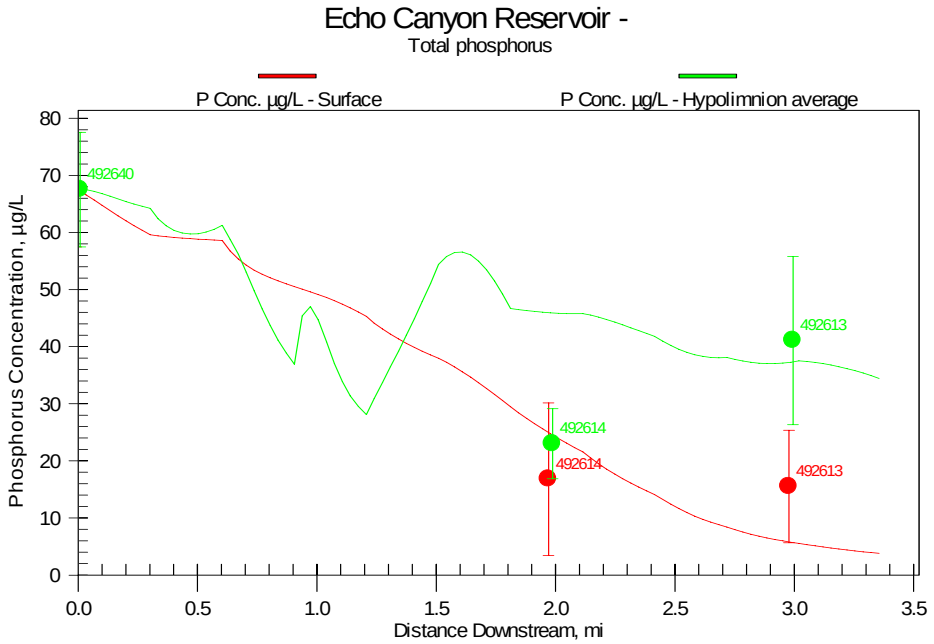

Figure 9. Calibrated longitudinal profiles for TP, Echo Reservoir, June-September, 1990-1995.

Lastly, the profiles for DO and TP were matched, making a few more adjustments in benthic SOD and vertical mixing coefficients, until they were reasonable. Please note that the range of conditions was June through September for a five year period, and there were only two profiles available at station 492613 for this period. As such, finding an exact match was not realistic. The profiles are shown in Figure 10.

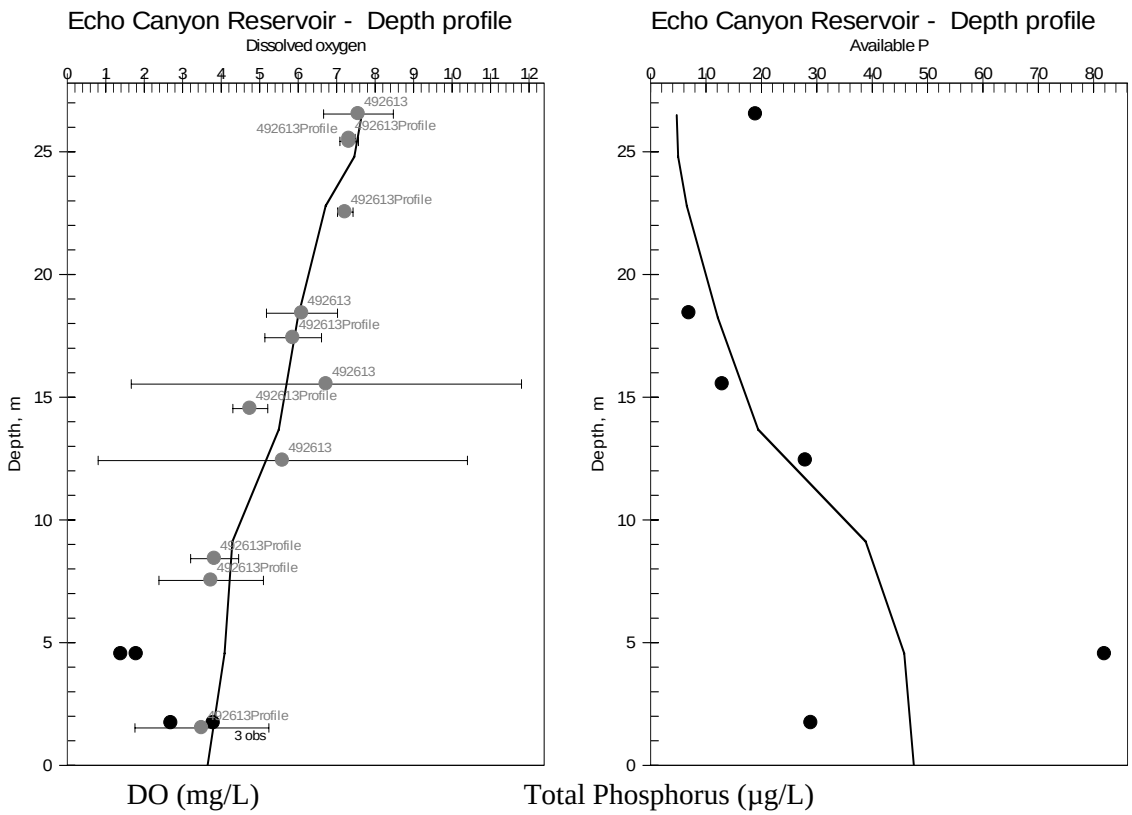

Figure 10. Calibrated profiles for DO and TP, Echo Reservoir, June-September, 1990-1995

4.5 ADDITIONAL MODEL ANALYSIS

4.5.1 Study design

The model study was specifically design to address in-lake conditions that would represent a reasonable 'worst-case' condition. These conditions are described below.

Model assumptions

Flow

The flow year chosen was 1998 (an 'average' water year) during the time of year most likely to display algal blooms and hypolimnetic anoxia (August) due to lower flows, long periods of sunlight, and the maximum temperatures observed prior to the fall turnover.

Flows used in the model were mean annual flows for the Weber River near Coalville (USGS10130500) and Chalk Creek at Coalville (USGS10131000) for the month of August for the years 1980-1999. Both the Weber River and Chalk Creek flow into Echo Reservoir at the upstream boundary of the lake (Figures 11 and 12).

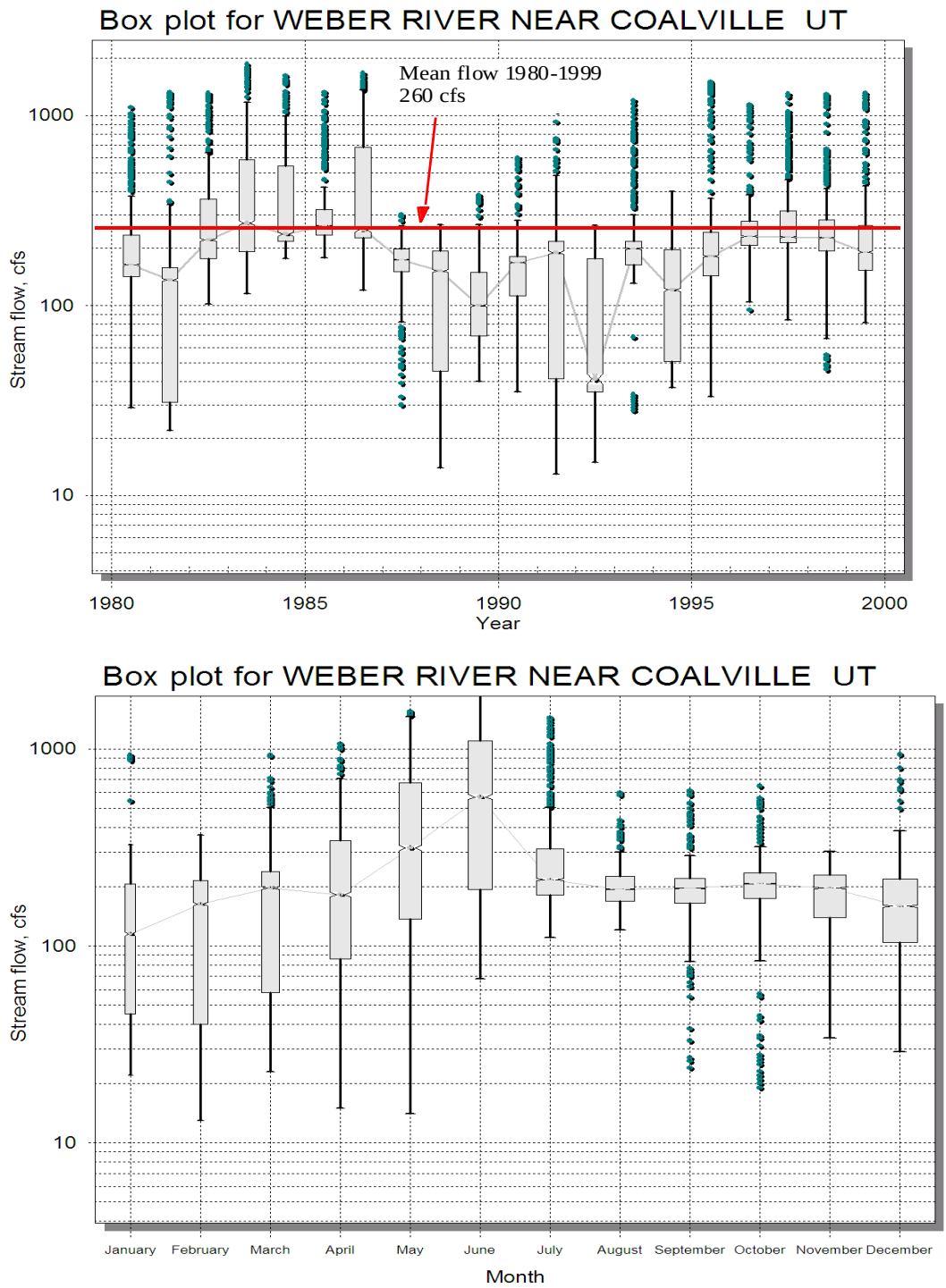

Figure 11. Annual flow, Weber River near Coalville, UT 1980 - 1999 (gage number: USGS10130500)

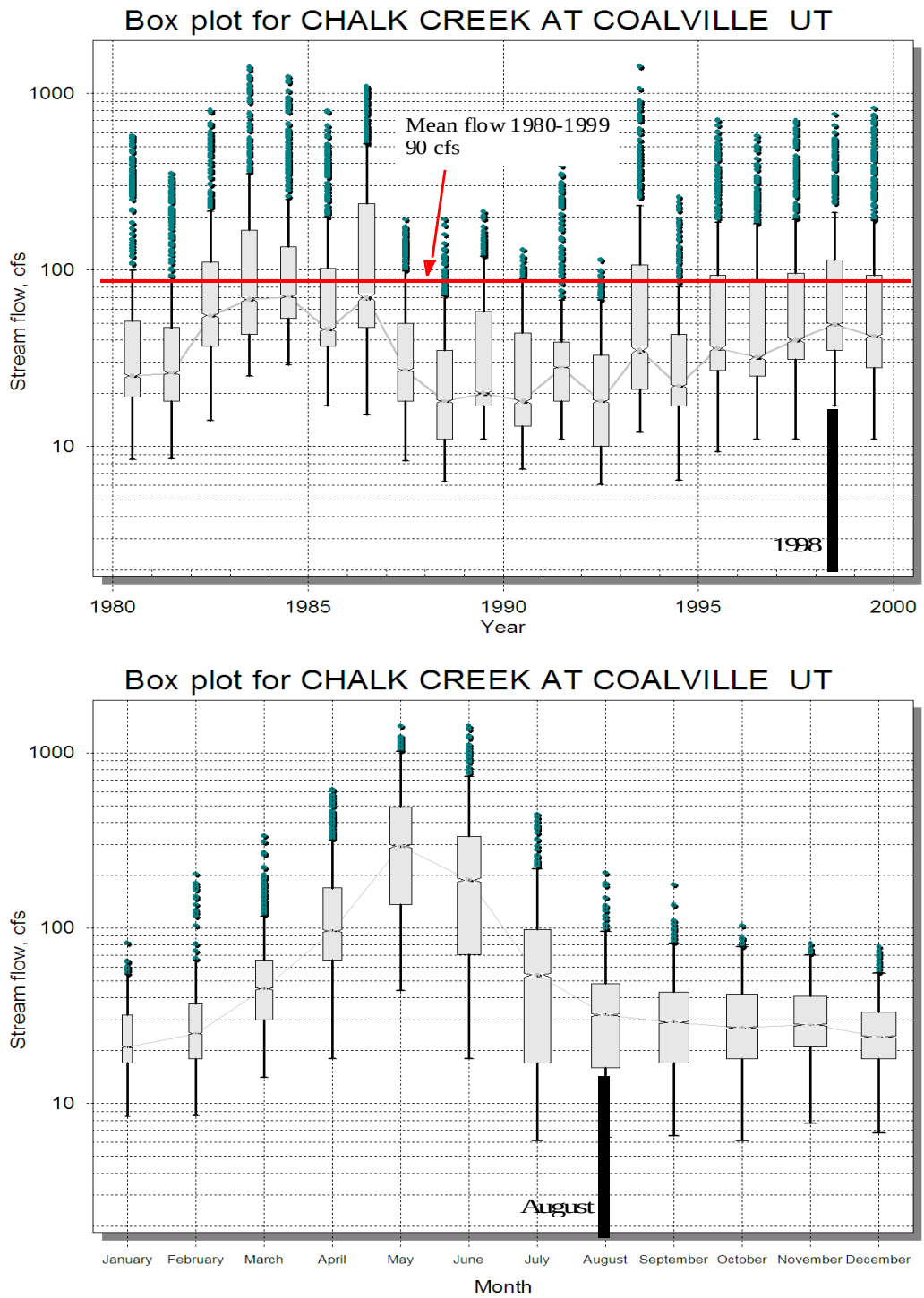

Figure 12. Annual flow, Weber River near Coalville, UT 1980 – 1999 (gage number: USGS10130500).

<u>Storage</u>

In order to evaluate the full range of residence times for August 1998 conditions, the storage in Echo Reservoir was varied from full to conservation pool level, in increments of drawdown of 1, 2, 4, 6, 8, 10, 15, 20, 22, 24 and 33 m. At each drawdown level, the elevation-storage and elevation-surface area relationships were used to modify the vertical layering. The full reservoir

temperature distribution was mapped onto the reduced layering network by removing volume from the hypolimnion while maintaining the depths of the euphotic zone, the epilimnion, and the metalimnion until the total depth at a cross section was too small to sustain this profile. Further volume was removed from first the metalimnion, then the epilimnion to simulate the larger drawdown conditions. Note that as the water level dropped, the upstream portions of the reservoir (near Coalville) were dewatered leaving only the Weber River flowing into a pool nearer the dam.

Influent total phosphorus

Four influent TP concentrations were studied: 0.011, 0.05, 0.07, and 0.10 mg/L. The first of these values represents the lowest observed value in August during 1980-1999. The second value is the State of Utah water quality influent stream concentration guideline determined to be protective of a reservoir. The third value, 0.07 mg/L, represents current typical concentrations for Echo Reservoir influent during August. It is also the median of all TP observations at station 492640 (Weber River near Coalville) for the full period of record, and is the concentration that would result from the target TMDL of 19,800 kg/yr (54.2 kg/d) at the modeled flow rate of 335 cfs . The fourth value 0.10 mg/L is the 80th percentile value of the historical concentrations, and represents an estimate of typical influent concentrations in the absence of P management efforts in the watershed.

Benthic flux

Specification of the benthic flux of oxygen is not as simple as specifying the TP loading into the reservoir. Sediment oxygen demand, the driver of the benthic oxygen flux, is highly dependent on the degree to which organic matter (generally comprising dead algae and invertebrates) has settled to the sediment and is undergoing decay. Accumulation of organic matter is a long-term process and it is reasonable to assume that over the long term, the average sediment oxygen demand will be related to the algal carbon production (primary productivity). Algal carbon production is then related to the algal production potential as embodied in the availability of the limiting nutrients; in the case of Echo Reservoir, the limiting nutrient is P. If the full algal production potential is realized, then the benthic flux is proportional to the TP flux since all of the P in the reservoir influent will be converted to algae and the algae produced during a growing season will eventually die and settle to the sediment to be decayed. In practice, the production of algae approaches, but often doesn’t quite reach the full potential due to other limitations (e.g. light, temperature, residence time) and so the assumption that the sediment oxygen demand is proportional to the TP load may be conservative.

In certain situations, the primary production can exceed the load of the limiting nutrient. To see why this is true, one may regard the limiting nutrient as analogous to the engine that drives the process of fixing carbon from the atmosphere, fueled by sunlight. When P enters the lake, it is taken up by algae to produce more algae, thereby increasing the carbon content of the lake. When the algae decay, generally via aerobic bacteria in the water column, the oxidation of the carbon consumes oxygen. During oxidation some of the nutrient P, namely that in the luxury P pool, is released back to the water column. Once released, that P can be re-used by algae to fix carbon. The carbon is then stored in the form of bacteria, zooplankton, and algal detritus in the sediment. Adding to this water column recycling is the seasonal recycling of P from the benthos during turnover, driving further carbon sequestration and increasing the sediment oxygen demand.

Given the complexity of this process and the dearth of models describing it, the following assumptions were made: 1) the benthic oxygen demand is proportional to the TP loading during a scenario, and 2) the benthic oxygen demand determined during model calibration will be adjusted according to the relative P loads for those situations.

Other Assumptions

Since the temperature model is dynamic, the simulation starts April 1 (when turnover is assumed) and simulates through the season until the end of September. The flows and influent temperatures for each month are set, and the model runs at a 3 hour time step through that time period. The surface elevation varies according to the input and output flows and the temperatures at each depth are calculated.

In order to simulate different storage conditions for August without significant modifications to the model software, the 1998 water temperature simulation for known flows/input temperatures was used, letting the temperature profile develop. Then the upper layer temperatures that corresponded to the depth associated with a particular storage value was distributed over the layers defined for the water quality model. The inlet and outlet flows were set to 335 cfs. Weather and other conditions were set based on August 1998. Few water quality data were available for 1998, so an average was calculated using each August from the 1996-2000 data set and used to represent August 1998. The water quality model was then run for each storage level at stations 492613 and 492614 and used to predict the % of the water column that would be out of compliance with the DO standard.

4.6 Results and Conclusions

4.6.1 Results

The full set of results for these scenarios, comprising longitudinal profile plots and DO compliance assessments for each drawdown/influent TP combination, is shown in Appendix C. The DO assessments are summarized in Figure 13, which plots the percentage of the water column in compliance with the 4 mg/L DO standard at stations 492613 and 492614 in two different ways: a) by drawdown for the four different influent TP concentrations, and b) by influent TP concentration for the 12 different drawdown amounts.

Figure 13 shows the impact of increased TP concentration on compliance with the DO standard at different degrees of drawdown under August 1998 flow conditions. The benthic DO flux is assumed to be proportional to the TP load. At the low concentration of 0.011 mg/L TP, compliance is essentially 100% for all drawdown levels. As the influent TP increases, DO compliance drops for all drawdown levels less than 20 m, with some minor variations that are artifacts of the model's non-linear structure. As the drawdown increases beyond 20 m, the compliance level rises as the oxygen-rich waters of the epilimnion and euphotic zone mix more easily with the shrinking meta- and hypolimnion.

The critical drawdown levels are between 2 and 20 m for all influent [TP] concentrations greater than 0.011 mg/L. For 0.05, 0.07, and 0.1 mg/L, the compliance percentages are approximately 46%, 40% and 20%, respectively at the 3 mile station. It appears from these results that the in-stream water quality criterion of 0.05 mg/L is the upper bound for maintaining at least 50% of the water column above 4 mg/L DO during August under these moderate flow conditions.

The compliance level for temperature in Echo Reservoir is 20°C. As described on page 31 of this appendix (*Other assumptions*), this model assumed that as the reservoir draws down, the temperature profile remains the same, except for the coolest portion of the reservoir which is compressed from the bottom up (Figure 14). This assumption is conservative because the average reservoir temperature increases as the hypolimnion is eliminated. At full draw-down, the temperature is nearly constant with depth and nearly equal to the surface water temperature. For this set of simulations (under August 1998 conditions) no violations of the temperature criterion were calculated; as such, there was no impairment due to temperature during this scenario.

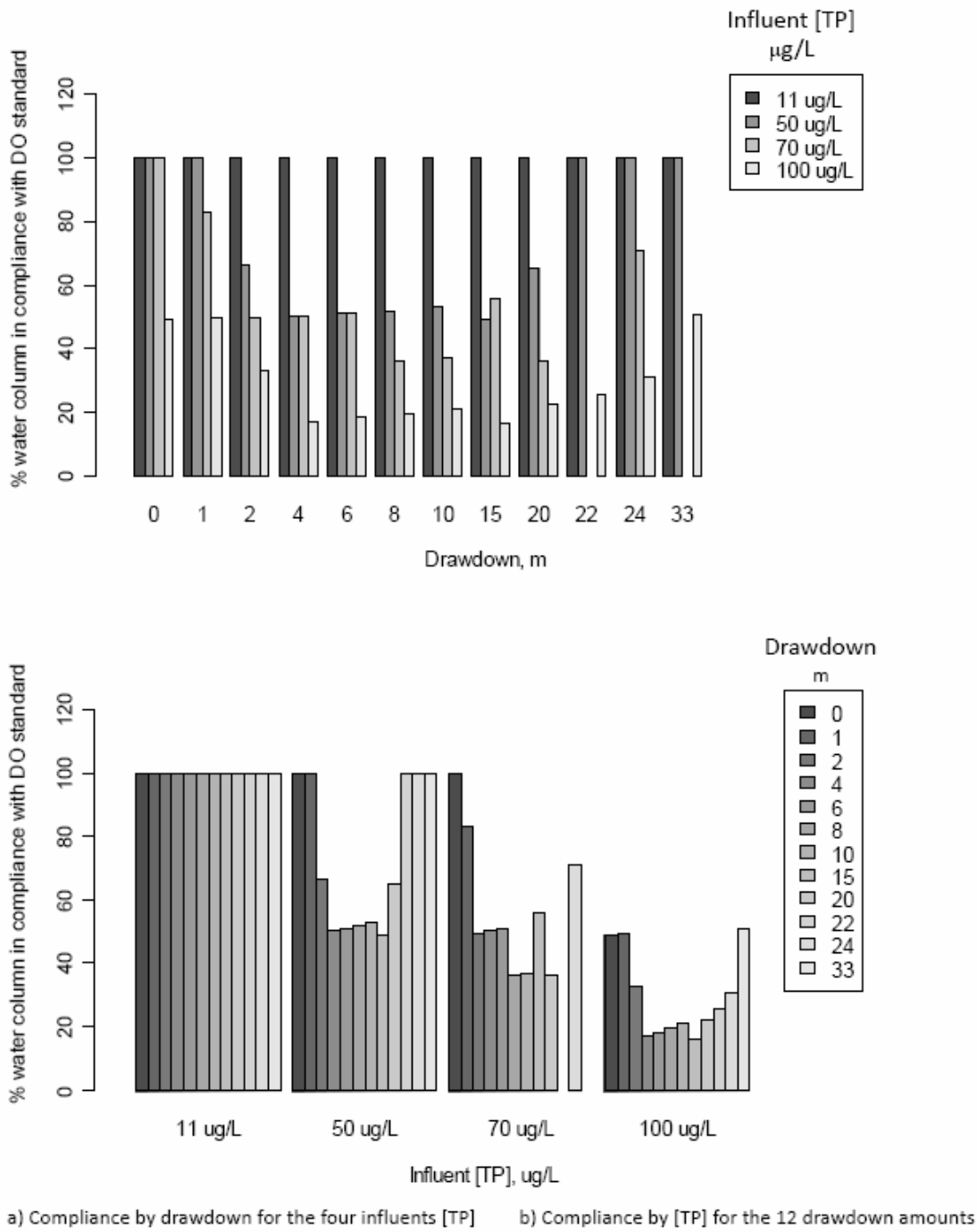

Figure 13. Compliance results for Echo Reservoir Modeling - DO standard compliance as % of the water column with [DO] > 4 mg/L.

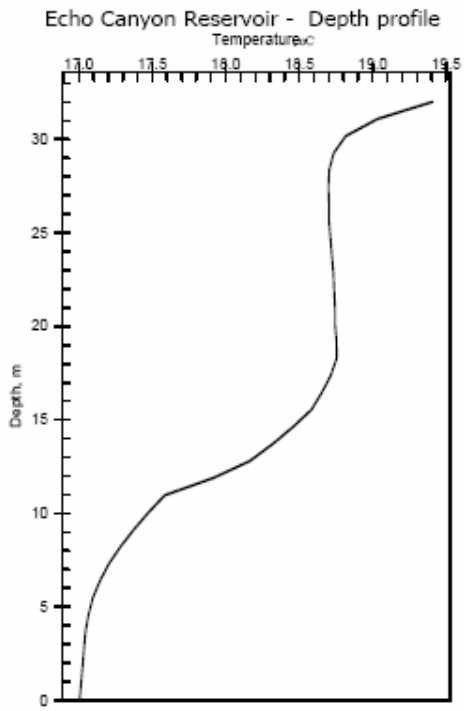

Figure 14. Temperature profile, August 1998 Scenario (note: State of Utah temperature criterion is 20°C).

4.6.2 Conclusions

The model results showed an influence of TP loading on the algae growth and DO concentration in the water column, particularly the hypolimnion. The State of Utah in-stream guideline TP concentration of 0.05 mg/L appears to be protective of the DO in the water column, and small excursions beyond 0.05 mg/L will likely cause impairment in Echo Reservoir with respect to DO, thereby reducing fish habitat. The model predicted that the reservoir would not be impaired due to temperature violations.

5.0 LINKAGE ANALYSIS

Each TMDL requires a linkage analysis that defines the cause-and-effect relationship between pollutant sources and the desired water quality target. Information contained below in Tables 6, 7 and 8 contain calculated watershed loads for each significant source of TP in the TMDL study area. This section describes how calculated watershed loads were linked to measured loads at the watershed outlet.

Calculated pollutant loads were linked to measured watershed outlet loads at three regions including Chalk Creek, the Weber River below Wanship Reservoir (including Silver Creek), and the Weber River above Wanship Reservoir. The linkage was established by assuming that the percent contribution from each pollutant source category to the total watershed load (all sources) was the same percent contribution at the watershed outlet. The percent contribution from each pollutant source and the equivalent watershed outlet loads are shown in Table 6, 7, and 8 near the bottom of each table.

Monthly values for each pollutant source were also determined in order to assess the seasonal distribution of watershed outlet loads. Sufficient monitoring data was available to directly calculate monthly loads for point sources. Due to the limited information characterizing non-point pollutant sources, several assumptions were made including the following:

- Monthly distribution of loads from septic tanks were assumed to be equal throughout the year and calculated by dividing the annual load by 12.

- Monthly loads from land applied manure were determined based on the assumptions and methods previously described in section 4.3.1.2 of the TMDL report, which were based on localized information obtained from NRCS field offices located in the TMDL study area.

- Monthly loads from AFOs, diffuse runoff, and grazing on public and private lands were determined using the HYSEP baseflow separation procedure (Sloto and Crouse 1996) on the 1903-2003 streamflow record for USGS Gage 10128500 (Weber River at Oakley). This method partitions streamflow volume into base-flow and surface-flow components. It is assumed that the flow record at this station (1904 – 2003) is representative of unregulated natural flows in the Weber River and that the percent of flow contributed by surface runoff at this station is representative of surface flows throughout the study area.

Monthly loads for AFOs, diffuse runoff, and grazing on public and private lands were then determined by simply multiplying the fraction of surface flow volume by the annual watershed loads for these pollutants. Total annual loads passing through Wanship Reservoir are decreased by approximately 388 kg or 5.14

percent. Information in Table 7 indicates this reduction to the annual watershed outlet load for each pollutant source.

Table 6. Chalk Creek Existing Conditions Estimated Monthly Total Watershed Loads by Source (these are the total loads not the watershed outlet loads).

Month	Fraction of Surface Flow Volume	AFOs (kg)	Land Applied Manure (kg)	Public Land Grazing (kg)	Private Land Grazing (kg)	Septic Tanks (kg)	Point Source (kg)	Diffuse Runoff (kg)	Total (kg)
January	0.003	0.74	42.83	0.00	10.61	2.00	18.59	19.62	94.38
February	0.003	0.74	23.69	0.00	10.61	2.00	11.91	19.62	68.57
March	0.008	1.98	123.20	0.00	28.28	2.00	11.42	52.31	219.20
April	0.069	17.11	417.54	0.00	243.92	2.00	10.81	451.19	1142.57
May	0.392	97.22	102.79	0.00	1385.72	2.00	5.68	2563.29	4156.69
June	0.429	106.39	0.15	0.00	1516.52	2.00	14.74	2805.23	4445.03
July	0.048	11.90	0.08	0.00	169.68	2.00	12.60	313.87	510.14
August	0.017	4.22	26.49	0.00	60.10	2.00	15.75	111.16	219.71
September	0.012	2.98	49.31	0.00	42.42	2.00	12.36	78.47	187.53
October	0.008	1.98	43.63	0.00	28.28	2.00	0.96	52.31	129.16
November	0.006	1.49	60.69	0.00	21.21	2.00	19.17	39.23	143.79
December	0.005	1.24	71.07	0.00	17.68	2.00	14.54	32.70	139.22
Annual Total Load (kg)		**248**	**961**	**0**	**3,535**	**24**	**149**	**6,539**	**11,456**
Percent of Annual Total Load (Non-point sources only)		2.19	8.50	0.00	31.26	0.21	0.00	57.83	
Annual Watershed Outlet Load (kg) by Pollutant Source (Non-point source contributions based on annual total of 10,544 kg for Station 492635 only)		231	897	0	3,296	22	149	6,098	10,693

Table 7. Weber Above Wanship Existing Conditions Estimated Monthly Total Watershed Loads by Source (these are the total loads not the watershed outlet loads)

Month	Fraction of Surface Flow Volume	AFOs (kg)	Land Applied Manure (kg)	Public Land Grazing (kg)	Private Land Grazing (kg)	Septic Tanks (kg)	Point Source (kg)	Diffuse Runoff (kg)	Total (kg)
January	0.0030	3.54	158.57	0.59	11.15	18.40	219.24	40.55	452.04
February	0.0030	3.54	87.70	0.59	11.15	18.40	183.94	40.55	345.88
March	0.0080	9.45	456.18	1.57	29.74	18.40	240.72	108.14	864.19
April	0.0690	81.49	1546.00	13.52	256.54	18.40	160.43	932.67	3009.06
May	0.3920	462.95	380.62	76.83	1457.46	18.40	319.74	5298.66	8014.67
June	0.4290	506.65	0.56	84.08	1595.02	18.40	434.16	5798.79	8437.67
July	0.0480	56.69	0.31	9.41	178.46	18.40	159.70	648.82	1071.78
August	0.0170	20.08	98.10	3.33	63.21	18.40	161.63	229.79	594.53
September	0.0120	14.17	182.56	2.35	44.62	18.40	99.83	162.20	524.14
October	0.0080	9.45	161.54	1.57	29.74	18.40	84.30	108.14	413.14
November	0.0060	7.09	224.69	1.18	22.31	18.40	64.31	81.10	419.07
December	0.0050	5.91	263.16	0.98	18.59	18.40	103.29	67.59	477.91
Annual Total Load (kg)		**1,181**	**3,560**	**196**	**3,718**	**221**	**2,231**	**13,517**	**24,624**
Percent of Annual Total Load		4.80	14.46	0.80	15.10	0.90	9.06	54.89	100.00
Annual Watershed Outlet Load (kg) by Pollutant Source based on annual total of 7,550 kg for Station 492725		362	1,092	60	1,140	68	684	4,144	7,550
Annual Watershed Outlet Load (kg) below Wanship Reservoir by Pollutant Source based on annual total of 7,162 kg for Station 492701		343	1,035	57	1,081	64	649	3,931	7,162

Table 8. Weber Below Wanship Existing Conditions Estimated Monthly Total Loads by pollutant source. Note that these are total loads and not the watershed outlet loads.

Month	Fraction of Surface Flow Volume	AFOs (kg)	Land Applied Manure (kg)	Public Land Grazing (kg)	Private Land Grazing (kg)	Septic Tanks (kg)	Point Source (kg)	Diffuse Runoff (kg)	Total (kg)
January	0.0030	0.20	41.96	0.00	4.65	11.25	283.15	16.48	357.69
February	0.0030	0.20	23.21	0.00	4.65	11.25	338.35	16.48	394.14
March	0.0080	0.53	120.68	0.00	12.40	11.25	405.29	43.94	594.10
April	0.0690	4.55	408.99	0.00	106.95	11.25	267.77	379.02	1,178.52
May	0.3920	25.87	100.68	0.00	607.60	11.25	265.93	2,153.26	3,164.59
June	0.4290	28.31	0.14	0.00	664.95	11.25	319.71	2,356.50	3,380.86
July	0.0480	3.17	0.08	0.00	74.40	11.25	468.08	263.66	820.64
August	0.0170	1.12	25.95	0.00	26.35	11.25	341.09	93.38	499.14
September	0.0120	0.79	48.30	0.00	18.60	11.25	371.75	65.92	516.61
October	0.0080	0.53	42.74	0.00	12.40	11.25	291.34	43.94	402.20
November	0.0060	0.40	59.44	0.00	9.30	11.25	320.28	32.96	433.62
December	0.0050	0.33	69.62	0.00	7.75	11.25	396.80	27.47	513.21
Annual Total Load (kg)		**66**	**942**	**0**	**1,550**	**135**	**4,070**	**5,493**	**12,255**
Percent of Annual Total Load		0.54	7.68	0.00	12.65	1.10	33.21	44.82	100.00
Annual Watershed Outlet Load (kg) by Pollutant Source based on annual reach gain of 6,495 kg between Station 492701 and Station 492640)		35	499	0	821	72	2,157	2,911	6,495

6.0 FUTURE LOAD CALCULATIONS

Projected future pollutant loads were calculated through the year 2025 for all sources of TP in the TMDL study area. A description of the methods used to calculate future loads from all other sources has been provided in the main text of this TMDL report. A more detailed description of the method used to calculate future loads from diffuse runoff is included below. Summaries of future watershed loads and watershed outlet loads from all pollutant sources are included at the end of this section.

6.1 FUTURE LAND COVER DISTRIBUTION AND CALCULATION OF LOADS FROM DIFFUSE RUNOFF

1. Calculate the new population of each census block within Summit County (using the 2000 census blocks as the base)

Summit County Population in 2000 = 30,048
Projected Summit County Population in 2025 = 75,450

Population in 2025 = (2.51) * (Population in 2000)

2. Calculate the number of new persons in each census block:

New Persons = (Population in 2025) – (Population in 2000)

3. Calculate the density of new persons in each census block:

New Persons Density (people/km^2) = (New Persons)/(Area in $km^{2)}$

4. Intersect the census blocks with the subwatershed boundaries to identify the area of each block in each subwatershed.

5. Recalculate the new persons in each clipped block:

New Persons in Clipped Block = (Area of Clipped Block in km^2) * (New Persons Density)

6. Sum all of the new persons in each subwatershed to get the estimate of new people in each subwatershed in 2025 (Table 9).

Table 9. Year 2025 projected population estimates for subwatersheds in the TMDL study area.

Subwatershed	Total New People
Upper Weber River	1,040
Beaver Creek	3,800
Weber River Below Beaver Creek	1,140
Wanship Reservoir	128
Weber River Below Wanship Reservoir	117
Silver Creek	8,952
Weber River Below Silver Creek	1,935
Chalk Creek	2,073
Echo Reservoir	213
Total of All Subwatersheds	19,398

7. Estimate the distribution of developable land in each subwatershed (Table 10). We assume that new growth will displace other land cover categories according to this distribution.

Developable areas must meet the following criteria:

- The land must be private
- The land must not be urban/residential/transportation already
- The land must be agricultural, rangeland, or forest (no wetlands, open water, etc.)
- The land must have less than 10 degrees slope

Table 10. Developable land for subwatersheds in the TMDL study area.

Subwatershed	Forest (km^2)	Range (km^2)	Agriculture (km^2)	Total (km^2)
Upper Weber River	21	13	12	45
Beaver Creek	11	12	40	63
Weber River Below Beaver Creek	7	8	17	32
Wanship Reservoir	14	21	0	35
Weber River Below Wanship Reservoir	1	1	2	4
Silver Creek	20	21	6	46
Weber River Below Silver Creek	13	17	16	46
Chalk Creek	120	126	14	259
Echo Reservoir	10	12	3	25
Subwatershed	**Forest (%)**	**Range (%)**	**Agriculture (%)**	
Upper Weber River	46.3	28.0	25.6	
Beaver Creek	17.8	18.9	63.3	
Weber River Below Beaver Creek	22.7	25.6	51.7	
Wanship Reservoir	40.1	59.9	0.1	
Weber River Below Wanship Reservoir	28.6	34.1	37.3	
Silver Creek	42.6	45.1	12.4	
Weber River Below Silver Creek	27.9	36.7	35.4	
Chalk Creek	46.1	48.5	5.4	
Echo Reservoir	40.0	49.6	10.4	

8. Estimate the distribution of the new people among existing urban/residential land versus new people associated with new developments. This tells us whether the new people will be associated with land that is already classified as urban/residential (this will increase density) or whether the new people will be creating new urban/residential land. It was estimated that 10 percent of growth would occur in previously developed areas (inbuilding) and 90 percent of growth would occur in previously undeveloped areas.

9. Calculate the area of new urban/residential land using the numbers in step 8, the total new people from step 6, and an assumed 2.5 persons per new housing unit and an assumed average 1 acre per new housing unit (Table 11). It is understood that the area of new housing units outside of the Snyderville Basin will likely be larger than 1 acre, however it is unlikely that any one of these housing units will convert more than one acre to what would be considered urban/residential land (i.e., the house driveway, etc. will likely not take up more than an acre and the rest of the lot will likely remain relatively undisturbed).

Table 11. Calculation of new urban/residential land for subwatersheds in the TMDL study area.

Subwatershed	Total New People	Fraction Associated with New Development	Total New Urban/Residential Land (acres)
Upper Weber River	1,040	0.9	374
Beaver Creek	3,800	0.9	1,368
Weber River Below Beaver Creek	1,140	0.9	410
Wanship Reservoir	128	0.9	46
Weber River Below Wanship Reservoir	117	0.9	42
Silver Creek	8,952	0.5	1,790
Weber River Below Silver Creek	1,935	0.9	697
Chalk Creek	2,073	0.9	746
Echo Reservoir	213	0.9	77

10. Update the overall land cover distribution in each subwatershed using the new areas of urban/residential land in the table above and by reducing each of the other land cover categories according to the distribution shown in the table for step 7. This represents the expected land use distribution in the year 2025 (Table 12).

Table 12. Future conditions land use distribution in the Echo Reservoir watershed by subwatershed.

	Area		
Land Use Category	**Acres**	**Square Kilometers**	**Percent**
Upper Weber River Subwatershed			
Urban/Residential/Transportation	1,933	7.8	1.7
Forest Land	7,9016	319.8	70.2
Range Land	26,387	106.8	23.4
Agriculture	2,867	11.6	2.5
Wetlands	30	0.1	0.0
Barren	2,167	8.8	1.9
Water	196	0.8	0.2
Total for Subwatershed	112,596	455.7	100
Beaver Creek Subwatershed			
Urban/Residential/Transportation	2,601	10.5	4.5
Forest Land	34,024	137.7	58.8
Range Land	11,883	48.1	20.5
Agriculture	9,126	36.9	15.8
Wetlands	12	0.0	0.0
Barren	172	0.7	0.3
Water	9	0.0	0.0
Total for Subwatershed	57,826	234.0	100
Weber River Below Beaver Creek Subwatershed			
Urban/Residential/Transportation	815	3.3	4.7
Forest Land	7,034	28.5	40.2
Range Land	5,540	22.4	31.7
Agriculture	4,080	16.5	23.3
Wetlands	0	0.0	0.0
Barren	19	0.1	0.1
Water	0	0.0	0.0
Total for Subwatershed	17,489	70.8	100
Wanship Reservoir Subwatershed			
Urban/Residential/Transportation	206	0.8	0.8
Forest Land	11,897	48.1	46.6
Range Land	12,410	50.2	48.6
Agriculture	35	0.1	0.1
Wetlands	56	0.2	0.2
Barren	36	0.1	0.1
Water	872	3.5	3.4
Total for Subwatershed	25,512	103.2	100
Weber River Below Wanship Reservoir Subwatershed			
Urban/Residential/Transportation	116	0.5	4.0
Forest Land	1,247	5.0	43.6
Range Land	1,110	4.5	38.8
Agriculture	385	1.6	13.5

Table 12. (cont'd) Future conditions land use distribution in the Echo Reservoir watershed by subwatershed.

	Area		
Land Use Category	**Acres**	**Square Kilometers**	**Percent**
Wetlands	1	0.0	0.0
Barren	0	0.0	0.0
Water	0	0.0	0.0
Total for Subwatershed	2,859	11.6	100
Silver Creek Subwatershed			
Urban/Residential/Transportation	4,588	18.6	15.2
Forest Land	15,358	62.2	50.9
Range Land	8,818	35.7	29.2
Agriculture	1,235	5.0	4.1
Wetlands	2	0.0	0.0
Barren	165	0.7	0.5
Water	5	0.0	0.0
Total for Subwatershed	30172	122.1	100
Weber River Below Silver Creek Subwatershed			
Urban/Residential/Transportation	1,350	5.5	4.1
Forest Land	15,123	61.2	45.8
Range Land	12,553	50.8	38.0
Agriculture	3,934	15.9	11.9
Wetlands	12	0.0	0.0
Barren	48	0.2	0.1
Water	0	0.0	0.0
Total for Subwatershed	33,021	133.6	100
Chalk Creek Subwatershed			
Urban/Residential/Transportation	1,412	5.7	0.9
Forest Land	77,472	313.5	48.5
Range Land	76,691	310.4	48.0
Agriculture	3,812	15.4	2.4
Wetlands	22	0.1	0.0
Barren	181	0.7	0.1
Water	39	0.2	0.0
Total for Subwatershed	159,629	646.0	100
Echo Reservoir Subwatershed			
Urban/Residential/Transportation	251	1.0	1.0
Forest Land	9,859	39.9	39.4
Range Land	12,795	51.8	51.1
Agriculture	843	3.4	3.4
Wetlands	401	1.6	1.6
Barren	47	0.2	0.2
Water	837	3.4	3.3
Total for Subwatershed	25,032	101.3	100

Table 12. (cont'd) Future conditions land use distribution in the Echo Reservoir watershed by subwatershed.

	Area		
Land Use Category	**Acres**	**Square Kilometers**	**Percent**
All Subwatersheds Combined			
Urban/Residential/Transportation	13,271	53.7	2.9
Forest Land	251,032	1,015.9	54.1
Range Land	168,186	680.6	36.2
Agriculture	26,317	106.5	5.7
Wetlands	536	2.2	0.1
Barren	2,836	11.5	0.6
Water	1,958	7.9	0.4
Total of all Subwatersheds	464,136	1,878.3	100

11. Recalculate the loads from diffuse runoff using the same export coefficient values but with the 2025 land use distribution (Table 13).

Table 13. Total Phosphorus Loading by Subwatershed and Land Use in year 2025.

Land Use Category	Area (km^2)	Export Coefficient (kg/ha/yr)	Total Phosphorus Loading (kg/yr)
Upper Weber River Subwatershed			
Urban/Residential/Transportation	7.8	1	780
Forest Land	319.8	0.05	1,599
Range Land	106.8	0.1	1,068
Agriculture	11.6	1	1,160
Wetlands	0.1	0.25	3
Barren	8.8	0.2	176
Water	0.8	0	0
Total	455.7		4,786
Beaver Creek Subwatershed			
Urban/Residential/Transportation	10.5	1	1,050
Forest Land	137.7	0.05	689
Range Land	48.1	0.1	481
Agriculture	36.9	1	3,690
Wetlands	0	0.25	0
Barren	0.7	0.2	14
Water	0	0	0
Total	234		5,924
Weber River Below Beaver Creek Subwatershed			
Urban/Residential/Transportation	3.3	1	330
Forest Land	28.5	0.05	143
Range Land	22.4	0.1	224
Agriculture	16.5	1	1,650
Wetlands	0	0.25	0

Table 13. (cont'd) Total Phosphorus Loading by Subwatershed and Land Use.

Land Use Category	Land Use Category	Land Use Category	Land Use Category
Barren	0.1	0.2	2
Water	0	0	0
Total	70.8		2,349
Wanship Reservoir Subwatershed			
Urban/Residential/Transportation	0.8	1	80
Forest Land	48.1	0.05	241
Range Land	50.2	0.1	502
Agriculture	0.1	1	10
Wetlands	0.2	0.25	5
Barren	0.1	0.2	2
Water	3.5	0	0
Total	103.2		840
Weber River Below Wanship Reservoir Subwatershed			
Urban/Residential/Transportation	0.5	1	50
Forest Land	5	0.05	25
Range Land	4.5	0.1	45
Agriculture	1.6	1	160
Wetlands	0	0.25	0
Barren	0	0.2	0
Water	0	0	0
Total	11.6		280
Silver Creek Subwatershed			
Urban/Residential/Transportation	18.6	1	1,860
Forest Land	62.2	0.05	311
Range Land	35.7	0.1	357
Agriculture	5	1	500
Wetlands	0	0.25	0
Barren	0.7	0.2	14
Water	0	0	0
Total	122.1		3,042
Weber River Below Silver Creek Subwatershed			
Urban/Residential/Transportation	5.5	1	550
Forest Land	61.2	0.05	306
Range Land	50.8	0.1	508
Agriculture	15.9	1	1,590
Wetlands	0	0.25	0
Barren	0.2	0.2	4
Water	0	0	0
Total	133.6		2,958
Chalk Creek Subwatershed			
Urban/Residential/Transportation	5.7	1	570
Forest Land	313.5	0.05	1,568
Range Land	310.4	0.1	3,104
Agriculture	15.4	1	1,540

Table 13. (cont'd) Total Phosphorus Loading by Subwatershed and Land Use.

Land Use Category	Land Use Category	Land Use Category	Land Use Category
Wetlands	0.1	0.25	3
Barren	0.7	0.2	14
Water	0.2	0	0
Total	646		6798
Echo Reservoir Subwatershed			
Urban/Residential/Transportation	1	1	100
Forest Land	39.9	0.05	200
Range Land	51.8	0.1	518
Agriculture	3.4	1	340
Wetlands	1.6	0.25	40
Barren	0.2	0.2	4
Water	3.4	0	0
Total	101.3		1,202

12. Total P watershed loads can be summarized by subwatershed (Table 14, Figure 14) or by land use (Table 15, Figure 15) to determine locations or land use types where TP loads are greatest.

Table 14. Future annual TP watershed loads (year 2025) from diffuse loads summarized by subwatershed.

Subwatershed	Total Loading (kg/yr)
Upper Weber River	4,786
Beaver Creek	5,924
Weber River Below Beaver Creek	2,349
Wanship Reservoir	840
Weber River Below Wanship Reservoir	280
Silver Creek	3,042
Weber River Below Silver Creek	2,958
Chalk Creek	6,798
Echo Reservoir	1,202
Watershed Total	28,177

Table 15. Future annual TP watershed loads (year 2025) from diffuse loads summarized by land use.

Land Use Category	Total Loading (kg/yr)
Urban/Residential/Transportation	5,370
Forest Land	5,080
Range Land	6,807
Agriculture	10,640
Wetlands	50
Barren	230
Water	0
Watershed Total	28,177

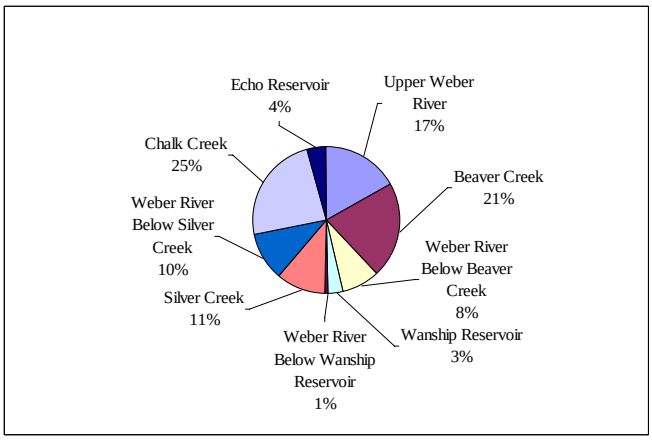

Figure 15. Future TP loads (2025) from diffuse runoff summarized by subwatershed.

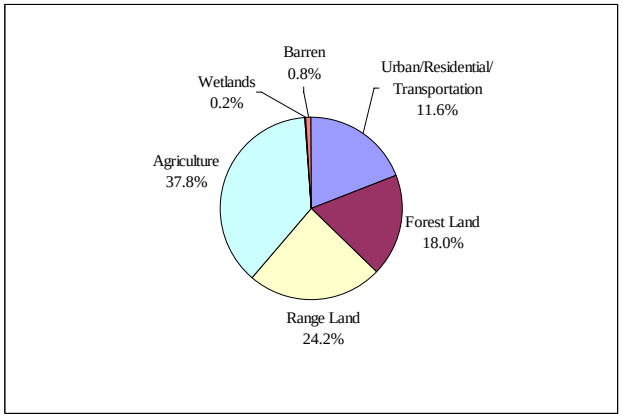

Figure 16. Future TP loads (2025) from diffuse runoff summarized by land use.

6.2 FUTURE WATERSHED OUTLET LOADS

Future watershed outlet loads were calculated for each pollutant source using the calculated future total watershed loads. Methods used to calculate future total watershed loads from all pollutant sources have been previously described in Chapter 5 of this TMDL report. Future watershed outlet loads were based on equation 6.1 below using previously calculated values for existing watershed outlet loads and existing and future total watershed loads. Summaries of future total watershed loads and future watershed outlet loads for three regions in the TMDL study area are provided below in Table 16 through Table 21.

$$\frac{[Future\ Total\ Watershed\ Loads]}{[Existing\ Total\ Watershed\ Loads]} = \frac{[Future\ Watershed\ Outlet\ Loads]}{[Existing\ Watersehd\ Outlet\ Loads]} \qquad (6.1)$$

Table 16. Chalk Creek Future Conditions Estimated Monthly Total Watershed Loads by Source (these are the total loads not the watershed outlet loads)

Month	Fraction of Surface Flow Volume that ccurs	AFOs (kg)	Land Applied Manure (kg)	Public Land Grazing (kg)	Private Land Grazing (kg)	Septic Tanks (kg)	Point Source (kg)	Diffuse Runoff (kg)	Total (kg)
January	0.003	0.73	42.28	0.00	10.56	3.43	55.76	20.39	133.15
February	0.003	0.73	23.39	0.00	10.56	3.43	35.73	20.39	94.24
March	0.008	1.96	121.63	0.00	28.15	3.43	34.26	54.38	243.81
April	0.069	16.89	412.19	0.00	242.78	3.43	32.42	469.06	1,176.77
May	0.392	95.97	101.47	0.00	1,379.25	3.43	17.03	2,664.82	4,261.97
June	0.429	105.03	0.15	0.00	1,509.43	3.43	44.23	2,916.34	4,578.61
July	0.048	11.75	0.08	0.00	168.89	3.43	37.80	326.30	548.25
August	0.017	4.16	26.15	0.00	59.81	3.43	47.24	115.57	256.37
September	0.012	2.94	48.68	0.00	42.22	3.43	37.07	81.58	215.91
October	0.008	1.96	43.07	0.00	28.15	3.43	2.87	54.38	133.86
November	0.006	1.47	59.91	0.00	21.11	3.43	57.51	40.79	184.22
December	0.005	1.22	70.16	0.00	17.59	3.43	43.61	33.99	170.01
Annual Total		**245**	**949**	**0**	**3,518**	**41**	**446**	**6,798**	**11,997**

Table 17. Chalk Creek Future Conditions Watershed Outlet Loads.

Source	Existing Conditions Annual Watershed Load (kg)	Future Conditions Annual Watershed Load (kg)	Percent Change In Annual Watershed Loading (%)	Existing Conditions Annual Watershed Outlet Load (kg)	Future Conditions Annual Watershed Outlet Load (kg)
Direct Stream Loads from AFOs	248.00	244.82	-1.28	231.26	228.30
Land Applied Manure	961.48	949.16	-1.28	896.60	885.11
Public Land Grazing	0.00	0.00	0.00	0.00	0.00
Private Land Grazing	3,535.00	3,518.49	-0.47	3,296.46	3,281.06
Septic Systems	24.00	41.16	71.50	22.38	38.38
Point Sources	149.00	445.53	199.02	149.00	445.53
Diffuse Runoff	6,539.00	6,798.00	3.96	6,097.75	6,339.27
Total Without WWTP:	11,307	11,552		10,544	10,772
Total With WWTP:	11,456	11,997		10,693	11,218

Table 18. Weber Above Wanship Future Conditions Estimated Monthly Total Watershed Loads by Source (these are the total loads not the watershed outlet loads)

Month	Fraction of Surface Flow Volume that occurs	AFOs (kg)	Land Applied Manure (kg)	Public Land Grazing (kg)	Private Land Grazing (kg)	Septic Tanks (kg)	Point Source (kg)	Diffuse Runoff (kg)	Total (kg)
January	0.003	3.30	147.79	0.59	10.93	56.70	582.79	41.70	843.80
February	0.003	3.30	81.74	0.59	10.93	56.70	482.07	41.70	677.03
March	0.008	8.81	425.19	1.57	29.14	56.70	653.91	111.19	1,286.51
April	0.069	75.95	1,440.98	13.52	251.34	56.70	416.02	959.03	3,213.55
May	0.392	431.50	354.76	76.83	1,427.93	56.70	754.77	5,448.41	8,550.90
June	0.429	472.23	0.53	84.08	1,562.71	56.70	1,154.43	5,962.67	9,293.35
July	0.048	52.84	0.28	9.41	174.85	56.70	431.23	667.15	1,392.46
August	0.017	18.71	91.43	3.33	61.93	56.70	456.77	236.28	925.16
September	0.012	13.21	170.16	2.35	43.71	56.70	273.33	166.79	726.25
October	0.008	8.81	150.56	1.57	29.14	56.70	226.30	111.19	584.27
November	0.006	6.60	209.42	1.18	21.86	56.70	154.87	83.39	534.02
December	0.005	5.50	245.28	0.98	18.21	56.70	301.50	69.50	697.67
Annual Total		1,101	3,318	196	3,643	680	5,888	13,899	28,725

Table 19. Weber Above Wanship Future Conditions Watershed Outlet Loads.

	Annual Watershed Load			Annual Watershed Outlet Load			
Source	**Existing Conditions (kg)**	**Future Conditions (kg)**	**Percent Change (%)**	**Existing Conditions Above Wanship (kg)**	**Existing Conditions Below Wanship (kg)**	**Future Conditions Above Wanship (kg)**	**Future Conditions Below Wanship (kg)**
Direct Stream Loads from AFOs	1,181.00	1,100.77	-6.79	362.11	343.50	337.51	320.16
Land Applied Manure	3,559.98	3,318.14	-6.79	1,091.53	1,035.43	1,017.38	965.09
Public Land Grazing	196.00	196.00	0.00	60.10	57.01	60.10	57.01
Private Land Grazing	3,718.00	3,642.67	-2.03	1,139.98	1,081.39	1,116.88	1,059.48
Septic Systems	220.80	680.40	208.15	67.70	64.22	208.62	197.90
Point Sources	2,231.28	5,887.99	163.88	684.13	648.98	1,805.32	1,712.55
Diffuse Runoff	13,517.00	13,899.00	2.83	4,144.46	3,931.47	4,261.58	4,042.58
Total:	**24,624**	**28,725**		**7,550**	**7,162**	**8,807**	**8,355**

Table 20. Weber Below Wanship Future Conditions Estimated Monthly Total Watershed Loads by Source (total loads not watershed outlet loads).

Month	**Fraction of Surface Flow Volume that occurs**	**AFOs (kg)**	**Land Applied Manure (kg)**	**Public Land Grazing (kg)**	**Private Land Grazing (kg)**	**Septic Tanks (kg)**	**Point Source (kg)**	**Diffuse Runoff (kg)**	**Total (kg)**
January	0.003	0.18	38.59	0.00	4.46	30.90	961.89	18.84	1,054.87
February	0.003	0.18	21.34	0.00	4.46	30.90	1,125.53	18.84	1,201.25
March	0.008	0.49	111.00	0.00	11.90	30.90	1,186.24	50.24	1,390.76
April	0.069	4.19	376.19	0.00	102.60	30.90	1,026.21	433.32	1,973.41
May	0.392	23.80	92.60	0.00	582.91	30.90	1,113.03	2,461.76	4,305.00
June	0.429	26.04	0.13	0.00	637.93	30.90	1,288.55	2,694.12	4,677.68
July	0.048	2.91	0.07	0.00	71.38	30.90	1,707.67	301.44	2,114.37
August	0.017	1.03	23.86	0.00	25.28	30.90	1,207.50	106.76	1,395.33
September	0.012	0.73	44.43	0.00	17.84	30.90	1,481.86	75.36	1,651.12
October	0.008	0.49	39.31	0.00	11.90	30.90	1,322.59	50.24	1,455.43
November	0.006	0.36	54.67	0.00	8.92	30.90	1,435.29	37.68	1,567.83
December	0.005	0.30	64.03	0.00	7.44	30.90	1,448.72	31.40	1,582.79
Annual Total		**61**	**866**	**0**	**1,487**	**371**	**15,305**	**6,280**	**24,370**

Table 21. Weber Below Wanship Future Conditions Watershed Outlet Loads.

Source	Pre BMP Existing Conditions Annual Watershed Load (kg)	Post BMP Future Conditions Annual Watershed Load (kg)	Percent Change In Annual Watershed Loading (%)	Pre BMP Existing Conditions Annual Watershed Outlet Load (kg)	POST BMP Future Conditions Annual Watershed Outlet Load (kg)
Direct Stream Loads from AFOs	66.00	60.71	-8.02	34.98	32.17
Land Applied Manure	941.78	866.25	-8.02	499.10	459.07
Public Land Grazing	0.00	0.00	0.00	0.00	0.00
Private Land Grazing	1,550.00	1,487.03	-4.06	821.43	788.06
Septic Systems	135.00	370.80	174.67	71.54	196.51
Point Sources	4,069.53	15,305.05	276.09	2,156.91	8,111.91
Diffuse Runoff	5,493.00	6,280.00	14.33	2,911.04	3,328.11
Total:	**12,255**	**24,370**		**6,495**	**12,916**

Appendix – Project Implementation Plan (PIP)

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1.0 INTRODUCTION

The overall success of any watershed initiative to address water quality concerns is a result of a strong locally led watershed committee. The Upper Weber River Watershed is a prime example of an area with the need for an active and well supported watershed committee to effectively and fairly determine the best course of action to achieve water quality goals. The Division of Water Quality has direct regulatory authority over point sources in the watershed, but does not exercise a similar authority in regards to non-point sources of pollution. As a result, the potential exists for point sources to bear an undue share of the reductions needed to meet TMDL requirements.

Accordingly it is recommended that the following stakeholders take an active role participating in and supporting the Upper Weber River Watershed Committee in order to assure a fair and reasonable approach is taken to achieve the goals of this TMDL:

- Summit County Commission
- Summit County Soil Conservation District
- Kamas Valley Soil Conservation District
- Weber River Water Users
- Weber River Water Conservancy District
- Coalville City
- Oakley City
- Kamas City
- Snyderville Basin Water Reclamation District

The allocations proposed in this TMDL can be achieved through a variety of point and non-point source reductions. This TMDL report has proposed one possible allocation to achieve needed reductions but there are other solutions and allocation scenarios that may work as well or better if orchestrated through an active watershed committee. The Upper Weber River Watershed Committee must take a lead role in overseeing the implementation of this TMDL and determining fair, economically feasible solutions to achieve the goals of this TMDL. This should include an aggressive pursuit of funding for non-point source projects as well as a major role in facilitating any pollutant trading between point sources and/or non-point sources.

In order to achieve water quality targets and TMDL endpoints, it will be necessary to implement practices that are commonly described as Best Available Technologies (BATs) or Best Management Practices (BMPs). BATs are used to treat effluent discharged by any type of facility through a distinct location such as a culvert or ditch. Effluent limits associated with BATs are typically based on the average performance of the best technology that can be used to treat parameters of concern. BMPs are practices used to protect the physical and biological integrity of surface and groundwater, primarily with regard to non-point sources of pollution. BMPs are most effective when combined to create a BMP system that will comprehensively reduce or eliminate pollution from a source. It should be noted that no single BMP system is considered to be the most effective way of controlling a particular pollutant in all situations. Rather, the design of a BMP system should consider local conditions that are known to influence the production and delivery of non-point source pollutants. The design of a BMP system should not only account for the type and source of pollutant, but should also consider background factors such as the physical, climatic, biological, social, and economic setting. Since a significant proportion of the load reductions required to meet this TMDL originate from non-point sources a rigorous monitoring program will be required through the period of implementation to provide reasonable assurance that the BMPs are

effective. The Utah Division of Water Quality has and will continue to monitor the chemical, physical and biological parameters of water quality within the Echo Reservoir Watershed.

Echo Reservoir is currently impaired for low levels of DO (Figure 1). This TMDL has determined that the existing annual total phosphorus loads of 24,350 kg/yr to Echo Reservoir be reduced by approximately 19 percent in order to meet the TMDL Target Load of 19,800 kg/yr. It is anticipated that if the target load is met, DO concentrations will fully support the beneficial use for cold water aquatic species associated with Echo Reservoir.

Figure 1. Echo Reservoir.

As pollutant loads are transferred through the TMDL study area, they are influenced by a number of different processes that reduce the mass of total phosphorus delivered to a subwatershed or watershed outlet and ultimately to Echo Reservoir. Some of these processes can include adsorption, algal uptake, settling, and flow diversion for irrigation purposes. A linkage assessment defining the relationship between watershed loads and watershed outlet loads has been previously defined in Chapter 4. The BATs and BMPs recommended in this report will address watershed loads of total phosphorus before they enter a receiving water body (total watershed loads). If BATs and BMPs are applied as recommended in this document, it is anticipated that watershed outlet loads will meet the TMDL Target load of 19,800 kg/yr. Existing and future watershed outlet loads are shown in Table 1. The recommended pollutant load allocation for total watershed loads is provided below in Table 2.

A total of seven pollutant sources have been identified during the assessment of water quality conditions in the TMDL study area including the following:

- Point Sources
- Animal feeding operations (AFOs)
- Land areas receiving manure applications
- Private land grazing
- Public land grazing
- Septic tanks
- Diffuse runoff

The TMDL has allocated total phosphorus loads to each pollutant source. The target load associated with the TMDL does not require load reductions from all pollutant sources. However, all sources listed above are considered significant in terms of their influence on water quality conditions in Echo Reservoir. As such, reasonable effort should continue to be made to minimize the influence of each source as development and growth occurs in the watershed areas above Echo Reservoir.

The remainder of this appendix will include recommendations for achieving the necessary reductions from each source and the cost associated with these activities.

Table 1. Existing and future watershed outlet loads by source.

	Existing Outlet Load (kg/yr)	Future Outlet Load (kg/yr)
Point Sources		
Coalville WWTP	149	446
Silver Creek WRF	2,157	8,111
Oakley WWTP	138	475
Kamas WWTP	385	1,043
Kamas FH	126	195
Total Point Source Load	**2,955**	**10,270**
Non-point Sources		
Chalk Creek		
AFOs	231	228
Land applied manure	897	885
Public land grazing	0	0
Private land grazing	3,296	3,281
Septic Systems	22	38
Diffuse Runoff	6,098	6,339
Weber River below Wanship		
AFOs	35	32
Land applied manure	499	459
Public land grazing	0	0
Private land grazing	821	788
Septic Systems	72	197
Diffuse Runoff	2,911	3,328
Weber River above Wanship		
AFOs	343	320
Land applied manure	1,035	965
Public land grazing	57	57
Private land grazing	1,081	1,059
Septic Systems	64	198
Diffuse Runoff	3,931	4,043
Total Non-point Source Load	**21,393**	**22,217**
Grand Total	**24,348**	**32,488**

Table 2. Allocation of total watershed loads by pollutant source[a].

	Existing Watershed Load (kg/yr)	Future Watershed Load (kg/yr)	Load Allocation (kg/yr)
Point Sources			
Coalville WWTP	149	446	823
Silver Creek WRF	4,070	15,305	5,733
Oakley WWTP	475	1,631	798
Kamas WWTP	1,322	3,583	1,656
Kamas FH	434	675	805
Total Point Source Load	**6,450**	**21,640**	**9,815**
Non-point sources			
Chalk Creek			
AFOs	248	245	24
Land applied manure	961	949	190
Public land grazing	0	0	0
Private land grazing	3,535	3,518	2,463
Septic Systems	24	41	41
Diffuse Runoff	6,539	6,798	5,215
Weber River below Wanship			
AFOs	66	61	6
Land applied manure	942	866	173
Public land grazing	0	0	0
Private land grazing	1,550	1,487	1,041
Septic Systems	135	371	371
Diffuse Runoff	5,493	6,280	4,710
Weber River above Wanship			
AFOs	1,181	1,101	110
Land applied manure	3,560	3,318	664
Public land grazing	196	196	196
Private land grazing	3,718	3,643	2,550
Septic Systems	221	680	680
Diffuse Runoff	13,517	13,899	10,424
Total Non-point Source Load	**41,886**	**43,453**	**28,858**
Grand Total	**48,336**	**65,093**	**38,673**

[a] Allocation of total Watershed Loads shown here will meet the TMDL Target Load of 19,800 kg/yr to Echo Reservoir. Conversion of total watershed loads to watershed outlet loads is described in greater detail in Chapter 4.

2.0 POINT SOURCES

Total phosphorus loading from point sources is generated by 5 different facilities in the study area. Four of these operations treat wastewater generated from small towns and nearby residential areas. One facility discharges water from a fish hatchery operated by the Utah Division of Wildlife Resources (UDWR). Source water for the fish hatchery is obtained from two springs located near the facility. A listing of all point sources in the study area is provided below in Table 3 and includes the existing and projected future total phosphorus loads.

Table 3. Annual total phosphorus loads from point sources in the Echo Reservoir watershed.

Point Source Name	Receiving Water	Existing total phosphorus Loads (kg/yr)	Future total phosphorus Loads (kg/yr)	Percent Increase (%)
Coalville Wastewater Treatment Plant	Chalk Creek	149	446	200
Snyderville Basin Silver Creek Water Reclamation Facility	Silver Creek	4,070	15,305	276
Oakley Wastewater Treatment Plant	Weber River	475	1,631	243
Kamas Lagoons	Beaver Creek	1,322	3,583	171
UDWR Kamas Fish Hatchery	Beaver Creek	434	675	56
Total of all Point Sources		**6,450**	**21,640**	**236**

Increased population growth within existing municipal boundaries and other sewered areas will result in increased discharge and loading from the four water treatment facilities. Future loads from each of these facilities were based on the assumption that existing per capita water use will not change. As a result, the assumption was made that increased discharge could be directly correlated with population growth. Future discharge from the Silver Creek Water Reclamation Facility (WRF) was determined from information contained in the Snyderville Growth Management Report and estimates provided by the Snyderville Basin Water Reclamation District (Boyle 2005). Future discharge from the Kamas FH is anticipated to increase by roughly 3 cfs following development of the two springs that provide inflow to the facility (Dewey 2004). Future total phosphorus concentration was held constant for all 5 facilities under the assumption that existing methods to treat discharge would not change. Therefore, flow rates were the only variable that was adjusted in order to calculate future loads from point sources.

The TMDL requires that loading from point sources be reduced by roughly 55 percent in order to meet the Target Load. Recommendations to meet this level of reduction are discussed below.

2.1 RECOMMENDED BATs

At the present time, no phosphorus limits are associated with any point source in the study area. The wasteload allocations recommended by this TMDL are shown in Table 2 above. The allocations shown in Table 2 have considered the existing and future operating conditions of each facility, as well as future expansion and development that is anticipated to occur. As each water treatment facility is expanded or modified to treat increased future flows, the ability to remove total phosphorus should be evaluated as a component of the treatment process.

The treatment method selected to achieve the recommended wasteload allocation will vary depending upon several factors such as the existing concentration, rate of flow, and the presence of constituents in the effluent that can promote or hinder treatment. Phosphorus removal systems can use either biological or chemical treatment or in some cases, a combination of both methods. Land application through a secondary irrigation system is another option depending on volume of effluent and available crop land.

It is not the intent of this assessment to provide a design for wastewater treatment that should be applied at each facility. The method used by each point source to remove total phosphorus from effluent discharge should be based on a detailed site-specific engineering assessment. However, the PIP associated with a TMDL should provide sufficient evidence that indicates wasteload allocations can be met, using proven wastewater treatment methods and available technology.

Figure 2. Silver Creek Water Reclamation Facility.

The Silver Creek WRF (Figure 2) will begin construction and expansion activities in 2007 to accommodate future influent flows from Snyderville Basin. Treatment is scheduled to begin in 2007 with a scheduled completion date of 2013 (Boyle 2005). The anticipated design of this facility will remove total phosphorus and nitrogen through biological treatment of wastewater. The opportunity exists for adding equalization capacity to the plant design which would further increase the ability to remove total phosphorus. One of the major limitations to biological treatment of total phosphorus is the amount of volatile fatty acids available to fully trigger the biological phosphorus removal mechanisms (Bowker and Stensel 1987). However, this limitation can be overcome through limited chemical addition or manipulation of the anaerobic/aerobic zones. Discussion with personnel from the Snyderville Basin Water Reclamation District indicated that the design of the upgraded plant would consistently produce effluent with total phosphorus concentrations less than 1.0 mg/l total phosphorus. Under the projected future flow from the Silver Creek WRF, an effluent stream with concentrations less than 1.0 mg/l total phosphorus would meet the recommended load allocation. It is noted that the design of the wastewater collection system in Snyderville Basin allows influent to be sent to the Silver Creek facility or to a similar facility located in nearby East Canyon Creek. During the upgrade to Silver Creek WRF a greater percentage of influent flows will be transferred to East Canyon. As a result, total phosphorus loads from the Silver Creek WRF during 2007 through 2013 will likely be reduced when compared to previous years.

The Oakley WWTP was upgraded in June 2003 from lagoon treatment to a membrane filtration system capable of phosphorus removal. However, they are not currently treating effluent for removal of phosphorus. Chemical addition to influent (most likely alum) at the Oakley WWTP would initiate

phosphorus precipitation and subsequent removal by membrane filtration. It is widely acknowledged that total phosphorus removal through chemical addition can result in total phosphorus concentrations less than 1.0 mg/l (Water Pollution Control Federation 1983). Under the projected future flow from the Oakley WWTP, an effluent stream with concentrations less than 1.0 mg/l total phosphorus would meet the recommended load allocation.

The Coalville WWTP currently operates below design capacity (Table 4). The Coalville WWTP completed improvements to their collection system during 2000 which resulted in significantly reduced flows and total phosphorus concentrations. A recent engineering assessment of the Coalville WWTP has indicated that increased total phosphorus concentration in the effluent stream will likely occur in the near future, due to local development.

Table 4. Existing and projected design characteristics for point sources in the Echo TMDL study area.

Name	Design Capacity (MGD)	Operating Level	Estimated time to design capacity
Coalville WWTP	0.36	65%	15-20 yrs
Silver Creek WRF	2.0	61%	7 yrs
Oakley WWTP	.25	37%	20 yrs
Kamas WWTP	1.7	25%	> 20yrs
Kamas FH	4.52[a]	69%	5-10 yrs

[a] Design capacity for Kamas FH indicates discharge from two source springs providing inflow to the plant. Time to design capacity for Kamas FH indicates the time period when additional development to source springs will increase discharge to a maximum of 10 cfs.

Population projections for Coalville indicate that expansion of the plant will need to occur within the next 20 years. Future plant upgrades or expansion to the Coalville WWTP would need to include the ability to address total phosphorus loading. Small facilities capable of treating 1-2 MGD generally use a combination of biological and chemical treatment to remove phosphorus. Methods such as these can achieve total phosphorus concentrations less than or equal to 1.0 mg/l (Bowker and Stensel 1987) (US-EPA 2000). Total phosphorus concentrations at this level would meet the recommended load allocation for Coalville WWTP under the projected future flows.

The Kamas WWTP uses a lagoon system to treat wastewater and sewage influent from the Kamas area. Although the system is operating well below design capacity, the ability to treat for total phosphorus does not currently exist. Removal of total phosphorus through lagoon systems is typically more difficult in comparison to facilities where wastewater can be treated in a more confined setting such as membrane filtration, oxidation ditch, or ring clarifier systems. Some of the challenges associated with phosphorus removal from lagoon systems include seasonal algal blooms, mixing of surface water and algae (which re-suspends precipitated solids), and management of chemical additions. Typical removal processes can include aeration, slow sand filtration, and chemical addition to lagoon cells or clarifiers that follow the lagoon system. Application of these treatment methods would require additional development to the Kamas lagoon system. Application of the phosphorus removal processes mentioned here is known to result in effluent total phosphorus concentrations of 1 mg/l or less (Pycha and Lopez 2003). Total phosphorus concentrations at this level would meet the recommended load allocations for the Kamas WWTP under the projected future flows.

Existing mean total phosphorus concentrations in the Kamas FH discharge are less than 0.1 mg/l (see Appendix Data). As described in Chapter 5, additional development to the source springs that support this facility are expected to occur within the next 5-10 years, increasing the maximum discharge to 10 cfs or roughly 6.4 MGD. It is not expected that the Kamas FH will change the methods that are currently used to minimize total phosphorus loading. The load allocation shown in Table 2 is based upon the existing monthly distribution of total phosphorus concentration and projected future flows. The intent of this allocation is to accommodate future flows while maintaining or decreasing total phosphorus concentrations. It is recommended that the Kamas FH continue to implement reasonable efforts to minimize total phosphorus concentrations in effluent discharge.

2.2 WATER QUALITY TRADING

Under the traditional paradigm (as detailed above), the point source dischargers within the watershed would in all likelihood eventually need to upgrade their facilities in order to meet future phosphorus load allocations. However, the economics involved with upgrading the smaller WWTP facilities appear to be cost prohibitive, thus making this approach infeasible in addressing phosphorus loading. Given the significantly different costs for each facility to reduce phosphorus, the Echo Reservoir TMDL provides an opportunity to implement a water quality trading approach.

EPA's Water Quality Trading Policy (January 13, 2003) has been developed to "achieve water quality goals more efficiently…Trading programs allow facilities facing higher pollution control costs to meet their regulatory obligations by purchasing environmentally equivalent (or superior) pollution reductions from another source at lower cost, thus achieving the same water quality improvement at lower overall cost." (http//www.epa.gov/owow/watershed/trading.htm)

This approach could lend itself particularly well to the Echo Reservoir watershed because a TMDL has already been developed and the pollutant of concern is total phosphorus. Snyderville Basin Water Reclamation District has completed an assessment of capital costs involved to install chemical phosphorus removal in the Silver Creek WRF. The proposed system could reduce phosphorus to a concentration of 0.4 mg/L or lower. Given the size of the effluent stream processed by the Silver Creek facility, this proposed treatment would be sufficient to address all needed point source reductions for this TMDL. The capital and ongoing operation and maintenance costs for treatment of phosphorus from the Silver Creek facility appear to be many times less than the cost for the smaller municipalities to upgrade their facilities to remove phosphorus. Making use of the economies of scale available at the Silver Creek WRF may be the most cost effective solution to achieve all of the point source allocations proposed in this TMDL.

3.0 ANIMAL FEEDING OPERATIONS/LAND APPLIED MANURE

A total of 18 AFOs are located in the Echo Reservoir TMDL study area (Figure 3) (Loveless 2004). Although scattered throughout the watershed, it is assumed that these operations are generally located in the low-lying agricultural areas within a couple of miles of existing stream courses. Some of the operations in the Echo Reservoir watershed are seasonal in nature, and others have confined animals year round. It is assumed that varying levels of nutrient management practices have been implemented at these operations, although little information is currently available to characterize the AFOs within the watershed.

Loading from AFOs occurs through two different processes. The first process involves direct stream loading caused from runoff generated during storm events or routine cleaning at each operation. Animal wastes are carried by overland flow into adjacent water bodies. The second process involves loading from areas that receive application of animal manures for fertilization during certain times of the year. Animal wastes that are not immediately incorporated into the soil are available to be washed into adjacent streams with runoff generated by precipitation events. A more detailed description of these processes as they occur in the study area is included in Chapter 4 of this report.

Figure 3. Animal feeding operation in the TMDL study area.

The UACD has indicated that 10 of the 18 AFOs have the potential to deliver nutrient loads to the Weber River (Loveless 2004). This TMDL assumes that all 18 operations have the potential to contribute loading to Echo Reservoir through land application of manure to fields that are associated with each operation. In order to meet the TMDL, loading from AFOs must be reduced by 90 percent while loading from land applied manure must be reduced by 80 percent.

3.1 RECOMMENDATIONS

The State of Utah has developed a plan to address loading from AFOs through a combination of voluntary incentive-based programs as well as enforcement of regulatory guidelines on large facilities (Utah AFO\CAFO Committee 2001). It is anticipated this program will play a critical role in implementing nutrient management activities on all 18 operations in order to achieve the desired load allocations recommended by the TMDL.

A variety of activities can be used to minimize or eliminate the potential for nutrient loading from feedlots, barnyards and dairy milk parlors that are associated with AFOs. NRCS agency personnel are currently working with many of the farmers and ranchers in the TMDL study area (Broadbent 2004). Some of the practices used to develop Comprehensive Nutrient Management Plans (CNMPs) are listed below in Table 5 and Table 6. Unit costs associated with each of these practices are also provided.

Table 5. Best management practices recommended for AFOs in the Echo TMDL study area.

NRCS Conservation Practice ID	Description	Per/Unit cost estimate
313	Waste Structure (including concrete retaining wall and manure bunker)	\$270 / yd^3
313	Waste Structure (expand existing manure bunker)	\$300/ yd^3
614	Offsite watering system	\$1.50 / gallon
393	Filter Strip	Site prep = \$70/ac - \$100/ac
390	Riparian Herbaceous Cover	Seed or trees = \$50/ac
386	Field Border	Planting = \$20/ac
382	Fence	\$2 / linear foot
313A	Manure Staging Area	\$1,500

Table 6. Best management practices recommended for land areas receiving land application of animal manures.

NRCS Conservation Practice ID	Description	Estimated cost
590	Nutrient Management	\$10/ac
370	Conservation Cover	Seedbed preparation, planting, seed = \$105/ac
393	Filter Strip (30 ft wide) where necessary at downslope end of field to prevent overland flow.	Site preparation(light), seedbed preparation, planting, seed = \$250/ac
328	Conservation Crop Rotation	\$11.50/ac
329 and 344	**Residue Management**	
	Fertilizer application based on soil test phosphorus (STP) levels.	\$8.50 / $sample_1$
	Band applications of commercial phosphorus near the seed row.	Non-structural – no cost
	No application of manure within 250-750 ft. of stream channel	Non-structural
	Manure only applied to areas not frozen or absent of snow	Non-structural
	Incorporation of all manure within 24 hours	Non-structural
	Delay application within 24 hours of forecasted storm events.	Non-structural

Most of the practices used to eliminate on-site nutrient loading from feedlots involve creating a structure or staging area to store animal manures on a temporary basis (Table 5). When the structure is full, the manure can be transported to nearby fields and used as fertilizer. Other measures such as filter strips and runoff berms minimize the potential for surface runoff during storm events. The ability of BMPs in Table

5 to remove total phosphorus is generally considered to be 90 percent efficient. A critical measure to reducing pollutant loads from AFOs is to eliminate direct access by animals to surface water located adjacent to or within feedlot boundaries. Managing wastewater from dairy parlor areas can reduce or eliminate surface runoff, thus removing over 90 percent of total phosphorus loading from this source alone (Macgregar et al. 1982) (Zimmerman 1998)(Jamieson et al. 2001). Proper use and maintenance of manure storage bunkers and staging areas can further reduce the potential for runoff contribution from AFOs.

It is recommended that nutrient management in areas where manure is applied use structural and non-structural techniques (Table 6). Structural techniques include construction of filter strips that border fields, conservation covers, and use of crop rotation. These measures will minimize surface runoff and promote infiltration. Non-structural techniques are management oriented.

The BMPs recommended by this TMDL continue to support land application of manure for pasture fertilization. This PIP recommends that the amount, timing, and specific areas where manure is applied follow the strategy typically recommended by the NRCS and detailed in conservation practices included in Table 6. The combined efficiency of BMPs to reduce total phosphorus loading from land applied manure is estimated to be 80 percent. Tabbara (2003) indicates that incorporation of manure into the soil immediately following application will reduce total phosphorus availability by 50 percent. A summary of buffer strip efficiencies by Allaway (2003) indicated removal of total phosphorus ranging from 67 percent to 74 percent. Width of buffer strips has been shown to be one of the most significant factors in removing total phosphorus from runoff (Barfield et al. 1998; Schmitt et al. 1999; Lee et al. 2000). Application of manure based on soil test measurements of phosphorus will reduce the potential for over-application of manure. It is not known at this time how much of a reduction will occur if manure application is based on agronomic rates (i.e. application is equivalent to plant uptake). No information is available on existing manure application rates in the TMDL study area. Eliminating manure application on frozen soils or in areas near streams would also reduce the potential for nutrient contributions to surface runoff. Although it is known that these conditions occur in the TMDL study area, no information is available to quantify existing loads from manure applications to these areas.

It is anticipated that if each of the 10 AFOs implement and maintain nutrient management plans according to NRCS guidelines, the TMDL allocation for this source will be met. In order to achieve the TMDL allocation for land areas receiving applied manure, all 18 facilities would be required to comply with the techniques listed in Table 6. This is a conservative assumption as some AFOs may be in watershed areas with little or no potential to contribute loads from land applied manure. Due to the lack of site specific information, this assumption will be used to ensure the allocation is met.

4.0 GRAZING

Grazing livestock are present throughout many of the low-lying, privately owned areas in the watershed (Figure 4). In addition, all or portions of five USFS grazing allotments are present in the watershed, mainly in the upper Weber River and Beaver Creek drainages. The following discussion will address BMPs needed to reduce loading contributed to streams in the TMDL study area from grazing on private lands within the watershed. Although pollutant loads have been calculated for grazing on public lands, no BMPs are recommended at this time as they are already subject to Federal Grazing Standards and Guidelines.

In general, the primary mechanisms by which loading from grazing animals occurs includes direct deposition of manure to existing water bodies and surface runoff from areas where livestock have grazed. During field visits to the TMDL study area, animals were observed grazing throughout the watershed on private lands. Efforts were made to manually count these animals where they were observed, and the locations along with the number and type of animals were recorded. However, field personnel were limited to public transportation routes. As a result, animal counts may not be inclusive of all animals grazing on private lands in the watershed. Conservative assumptions and a margin of safety included in the TMDL account for this uncertainty.

Figure 4. Livestock grazing on privately owned land in TMDL study area.

No information was available to determine the period of time when animals were grazing on private land areas or the frequency with which livestock herds visit certain areas. Large tracts of land are found in the upper portions of the Chalk Creek watershed that extend to the Utah – Wyoming border. It is known that livestock herds pass through these areas during the summer months. In contrast livestock herds observed on valley bottoms consistently graze these pastures in a rest-rotation pattern during the summer. It is likely that some herds winter over in these areas due to access for feeding purposes.

The TMDL recommends that loads from private land grazing be reduced by roughly 10 percent under existing conditions and 30 percent by the year 2025.

4.1 RECOMMENDATIONS

A list of appropriate BMPs for reducing loads from grazing on private lands are included below in Table 7. Many privately owned pastures are located between Echo Reservoir and Wanship Reservoir, Kamas Valley, and the lower Chalk Creek watershed area. Observations made during summer 2004 indicated a high level of direct access to water by livestock in the lower Chalk Creek area and throughout the Kamas valley. A total of 914 Animal Units (AU) with direct access to water were estimated to produce a total watershed load of 4,494 kg/yr. In comparison, a load of 4,308 kg/yr total phosphorus was attributed to 2,187 AUs located within 100 meters of the receiving waters.

Table 7. Recommended BMPs for reducing loads from grazing on private lands.

NRCS ID (where applicable)	Description	Cost
382	Fence	$2 / linear foot
614	Offsite watering system	$1.50 / gallon
393	Filter Strip	$250/acre
	Maintain a minimum herbage stubble height of 4-6 inches within riparian areas. Allow adequate time for re-growth of plants in these areas before reuse.	Non-structural
	Limit springtime grazing of herbaceous vegetation to not exceed 65 percent. Limit livestock use from riparian areas when primary forage plants are still in the vegetative state (early growth stage).	Non-structural
	Rest-Rotation grazing. Allow adequate rest for vegetation recovery in pastures and allotments. Consider limiting grazing in pastures containing riparian areas during hot periods when livestock use of riparian areas typically increases.	Non-structural
	Ensure all livestock are removed from each pasture at the end of the specified use period. Recovery of riparian areas is reduced if some animals remain following use period.	Non-structural
	Implement streambank disturbance standards that require a percentage of stream channels to be in a stable condition before grazing is allowed within pastures adjacent to water.	Non-structural
	Implement structural controls where appropriate such as riparian exclosures, fencing of sensitive areas or offsite watering.	Non-structural
	Manage winter feeding to avoid pastures that contribute direct snowmelt runoff to streams.	Non-structural

The amount of total phosphorus that can be controlled by restricting livestock access to streams has been reported at widely different levels. Sheffield et al. (1997) and Line et al. (2000) indicated measured losses in total phosphorus loading of 98 percent and 75 percent, respectively, when livestock were excluded from streams. In contrast, Gary et al. (1983) and Allaway (2003) indicated total phosphorus loading from direct contribution of animal manure of 5 percent and 2 percent, respectively. Line et al. (2000) indicated that some of the reduction in total phosphorus loading was likely due to reduced erosion from channel banks and upslope areas as well as filtering of surface runoff by vegetation. Similar conclusions were reached by Sheffield et al (1997) and Owens et al. (1996) who observed reductions in sediment loss of 70 percent and 40 percent, respectively, following livestock exclusion from channel corridors. It is recommended that buffer strips be used in combination with control of livestock access in the Echo Reservoir TMDL study area. This combination of practices will maximize the efficiency of total phosphorus removal from surface runoff in a given area. The width of buffer strips to be used at a particular location would be determined by field slope and length, density and height of vegetation, and typical runoff volumes. The combined efficiency of BMPs to reduce total phosphorus loading from grazing on private lands is estimated to be 60 percent.

Removing direct access to water should be a first priority to reduce loads from grazing livestock. If all animal units shown in group 1 of Table 4.14 were shifted to group 2 (i.e. remove direct access to water by livestock), total loading from this source would be roughly 6,100 kg/yr for a reduction of over 2,600 kg/yr

total phosphorus. This would allow the TMDL load allocation to be met. However, it is unlikely that livestock access to water would be removed for all streams. Additional progress toward the TMDL allocation could be made by managing animal herds located within 100 meters of streams. This would lower the intensity with which animal manure is deposited in areas that contribute runoff during snowmelt and storm events. Further reductions could be obtained through the use of filter strips and growth of riparian areas.

5.0 DIFFUSE RUNOFF

Loads from diffuse runoff are related to land use and specific sources within this category include runoff from agricultural lands, urban/residential areas, rangeland, forest land, and other land cover types. Sediment related phosphorus loading from erosion processes accelerated by grazing and other agricultural practices are also included in this category. It is important to note that while these loads may be related to grazing activities, phosphorus loads associated with animal manure deposited by grazing animals are accounted for separately.

The TMDL requires that loads from diffuse runoff be reduced by roughly 10-14 percent under existing conditions and 23-25 percent by the year 2025.

5.1 RECOMMENDATIONS

Total phosphorus loads contributed from diffuse runoff can be reduced as runoff passes through and across surface vegetation. The amount of total phosphorus removed by vegetation is dependent upon the density of vegetation, time of travel, infiltration capacity, and size of soil particles transported by runoff (Allaway 2003). Land cover in the TMDL study area is generally composed of forest and rangeland vegetation in the upper mountain regions while valley bottoms are covered by pastures and cultivated crops interspersed with urban development (Figure 5).

The effectiveness of the type of vegetation to include in buffer strips has been reported with varying results. Lee et al. (2000) reported that buffers consisting of forbs and large woody plants trapped 21 percent more total phosphorus than did buffers comprised of grass species alone. It was assumed that the woody plant species provided a greater infiltration capacity due to their comparatively deep root structure. The larger biomass of woody species in comparison to grass covers was also anticipated to maintain a greater capacity for total uptake of total phosphorus. In contrast, Schmitt et al. (1999) found few differences between grass and woody species buffer strips.

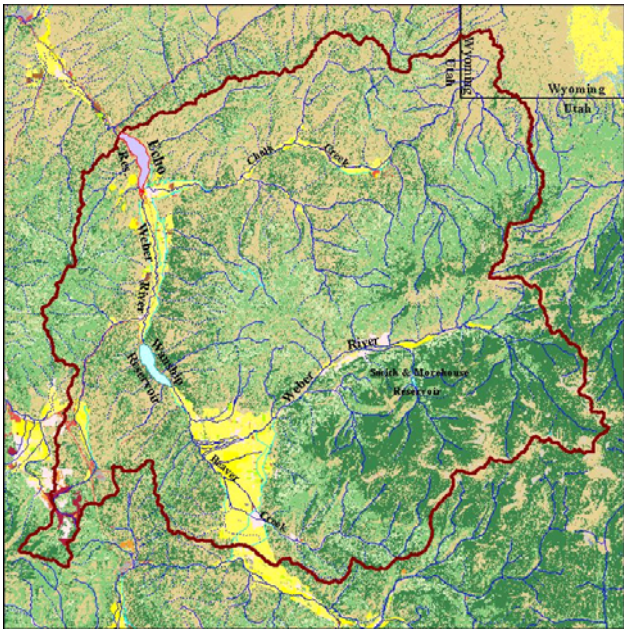

Figure 5. Land use cover used to determine diffuse loads from runoff in the TMDL study.

It is very difficult to make a meaningful comparison between these two types of buffer strips due to the many factors that influence removal efficiency. Allaway (2003) presented a summary of buffer strip efficiency and found that one of the most significant factors is buffer strip width. His review noted that buffer strips between 18 ft. and 30 ft. trap roughly 67 percent of total phosphorus and buffers greater than 33 ft. or more remove 74 percent total phosphorus, on average, from surface runoff volumes. For the purpose of this TMDL, it is anticipated that a 30 ft. buffer strip comprised of grass and forb species will remove 70 percent of total phosphorus loads from diffuse runoff volumes.

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Appendix – Public Comments

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From: Brent Ovard
To: carladams@utah.gov
Date: 3/6/2006 4:39:35 PM
Subject: TMDL Echo Reservoir

I hope these comments arrive in time. I will be brief. Pg 63 2nd paragraph TP loads from Chalk creek unexpected-needs better natural background explanation. Pg 23 2nd paragraph- The management of Echo reservoir during drought years needs to be examined. There has been no discharge from Echo during fall, winter, or early spring the last several years. Pg 54 Is phytoplankton assessment consistent with high phos and low oxygen? Suggests that water quality may be better at Echo . Thanks. Brent

From: "Steve Noyes" <SNOYES@uc.usbr.gov>
To: <CARLADAMS@utah.gov>
Date: 3/6/2006 5:08:02 PM
Subject: Echo Reservoir TMDL

Cark,

I have been so pressed on the Park City Water Supply Study, I have been unable to review and send comments on this TMDL.

I will try to get through the report tomorrow.

I have one comment today, as does Jerry Miller: for this TMDL to be accurate, it has to be combined with a TMDL with Rockport Reservoir, as activities and development above Rockport will affect the releases and water quality released downstream to Echo Reservoir. To protect Echo Reservoir, this has to be factored into it's TMDL.

I don't know how you can handle this, but it should at least mentioned and acknowledged in this Echo TMDL.

Good Luck!!

Steve Noyes

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CC: "Jerry Miller" <JMILLER@uc.usbr.gov>

1.0 ECHO RESERVOIR TMDL RESPONSE TO COMMENTS SUMMARY

1.1 SCOTT PAXMAN, WEBER BASIN WATER CONSERVANCY DISTRICT (WBWCD)

Verbal comment provided in February 2, 2006 public meeting held in Coalville pertaining to Chapter 2, top of p.23, 2nd paragraph with regards to the purpose of Echo Reservoir (paraphrased).

Need to clarify that Echo Reservoir is a single purpose reservoir, for irrigation purposes only. Echo Reservoir has a single year's worth of storage. Water is held in Rockport for power generation… WBWCD only operates Echo Reservoir as a flood control structure (drawdown prior to spring runoff) whereas the Weber River Water Users operate it for all other purposes, i.e. irrigation. In the last 5 or 6 years there have been no releases from Echo Reservoir during the winter months due to the extended drought.

Response:

Comments are addressed by removing statement that Echo Reservoir is used for culinary purposes and adding that the WBWCD only operates Echo Reservoir as a flood control structure (drawdown prior to spring runoff) whereas the Weber River Water Users manage it during irrigation season.

1.2 DUANE SCHMIDT, MAYOR OF COALVILLE CITY

Verbal comment provided in February 2, 2006 public meeting pertaining to the effects of management on the water quality of the reservoir, specifically the effects of drawdown during the late summer in response to irrigation demands downstream.

Response:

The Division concurs that reservoir management does have impact on water quality within Echo Reservoir. This has been characterized in Chapter 2.8 Reservoir Operations and elsewhere throughout the report. In response, the Project Implementation Plan includes a recommendation for a study to investigate the possibility of optimizing dam operations to benefit water quality while meeting downstream water rights.

1.3 MICHAEL LUERS, GENERAL MANAGER SNYDERVILLE BASIN WATER RECLAMATION DISTRICT

Written comment received March 1, 2006 pertaining to two issues, the first regarding management of the reservoir for water quality and the second on the potential for water quality trading amongst point source dischargers within the watershed.

Response:

Regarding the first issue of reservoir management: please refer to the response provided above to Mayor Duane Schmidt's comment, where the PIP includes a recommended study to investigate the possibility of optimizing dam operations to benefit water quality while meeting downstream water rights. In response to the second comment regarding the potential for water quality trading: a section addressing the need for pollutant trading has been included in the PIP.

1.4 MAYOR LEWIS MARCHANT, MAYOR, KAMAS CITY

Written comments received March 3, 2006.

Response: (numbered as received in the letter)

1. The Division concurs that water quality issues identified in Echo Reservoir are indeed a watershed wide issue, and as such, are everybody's responsibility in the Upper Weber River Watershed. The Project Implementation Plan (PIP) has been compiled to reflect this perspective. It is imperative that a locally led and empowered watershed committee orchestrate the implementation of the Echo Reservoir TMDL.

   The current allocation within the TMDL does place a significant burden on the point sources within the watershed but also places a significant reduction on non-point sources in the watershed (See table 5.13; point sources 53% reduction, non-point sources 32% reduction). As noted in the PIP, there are alternatives and approaches that can be taken to achieve the needed total maximum daily load and lessen the burden on the small point sources. The Division encourages pursuit of the best and fairest approach that will achieve the TMDL.

   Reservoir management does affect water quality within Echo Reservoir. This issue is characterized in Chapter 2.8 Reservoir Operations and elsewhere throughout the report. The Project Implementation Plan recommends a study to investigate the possibility of optimizing dam operations to benefit water quality while meeting downstream water rights.

2. As noted in the response to the first comment, much of the success of implementation for the Echo Reservoir TMDL will depend on an effective locally led watershed committee. The Division will continue to monitor water quality in Echo Reservoir as implementation actions are undertaken to assess if the TMDL goals are being met. In 5 to 10 years, an assessment of the success or failure of implementation will be made and the TMDL will have to be re-visited. The specific course of action will be determined at that time using

an open process much like the committee process that has occurred to date in developing the TMDL.

3. The Division concurs that the majority of the phosphorus load for Echo Reservoir is coming from the Chalk Creek and Silver Creek drainages. Water quality has been assessed for Wanship (Rockport) Reservoir and the contributing watershed upstream from Wanship (Rockport). At this time, there are no impaired waterbodies in the upper watershed nor does Wanship (Rockport) fail to meet the standards for its beneficial uses.

1.5 STEVE NOYES, BUREAU OF RECLAMATION

Comment provided via email on March 6, 2006.

Response:

The Division concurs that activities and development above Wanship Reservoir (aka Rockport) have an affect on the quality of water released downstream to Echo Reservoir, which is why those sources have been included in the analysis and allocation scheme. In regards to the need for a separate TMDL analysis on Wanship Reservoir, based on recent assessments of water quality data collected by DWQ, Wanship (Rockport) is currently supporting all of its beneficial uses. Monitoring of both Wanship and Echo Reservoirs will continue on a regular basis so that if water quality deteriorates within Wanship to the point where it is no longer supporting its beneficial uses, a TMDL analysis would be required at that time.

1.6 BRENT OVARD, SUMMIT COUNTY

Comments provided via email sent on March 6, 2006.

Response: (numbered as received in the email)

1. Page 63, second paragraph regarding TP loads from Chalk Creek: Comment addressed by adding statement that Chalk Creek has been observed to carry high sediment loads originating from erosive uplands and unstable streambanks.

2. Page 23, second paragraph regarding management of Echo Reservoir during drought years, specifically no discharge during fall, winter, or early spring the last several years due to drought: Comment addressed by adding statement that there have been no winter releases lately due to drought.

3. Page 54, phytoplankton assessment: Upon closer examination, the phytoplankton assessment depicted in the draft report is not an accurate comparison of the water quality within Echo and Wanship Reservoirs. Specifically, it attempts to draw conclusions from 1 phytoplankton sample on Wanship Reservoir compared to 5 collected on Echo Reservoir. A multitude of other environmental factors aside from water quality, such as morphometry and hydrologic regime, influence the phytoplankton communities found within these reservoirs. Comparison of water quality between reservoirs based solely on these data is misleading and incomplete. Accordingly this section has been removed from the report.

2.0 SCANNED COMMENT LETTERS

06.01197

WATER RECLAMATION DISTRICT

RECEIVED
MAR 0 1 2006
DIVISION OF
WATER QUALITY

February 27, 2006

Mr. John Whitehead
Division of Water Quality
Department of Environmental Quality
288 North 1460 West
P.O. Box 144870
Salt Lake City, UT 84114-4870

Subject: Comments on Draft Echo Reservoir Total Maximum Daily Load (TMDL)

Dear Mr. Whitehead:

Thank you for providing the Snyderville Basin Water Reclamation District (SBWRD) the opportunity to review the draft Echo Reservoir TMDL. Listed below are our comments:

1. As discussed at the point-source stakeholders meeting on February 2nd; we agree with the other point-source stakeholders that Echo Reservoir water quality is unduly influenced by the management of the reservoir. This is not surprising as Echo Reservoir was created as a sole purpose reservoir to provide irrigation water. SBWRD suggests language be included in the final TMDL that encourages the creation of a water quality conservation pool and a dialog be held with water managers to explore options to improve water quality of the reservoir.

2. This TMDL, with several point-sources, provides an opportunity for Water Quality Trading. Attached is EPA's 2003 Water Quality Trading Policy that addresses and promotes this approach to watershed management. Also attached is EPA's January 7, 2003, Memorandum regarding the Watershed-Based NPDES Permitting Policy Statement. SBWRD suggests language be included in the final TMDL that encourages water quality trading among the point sources. We also suggest that the Utah Division of Water Quality take a lead role in facilitating trading agreements.

Again, thank you for the extensive point-source briefings and the opportunity to review the draft document.

Sincerely,

Michael D. Luers, General Manager

cc: Michael Boyle, Operations Manager
Echo Reservoir TMDL file

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN - 7 2003

OFFICE OF WATER

MEMORANDUM

SUBJECT: Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Policy Statement

FROM: G. Tracy Mehan, III
Assistant Administrator

TO: Water Division Directors, Regions I - X

I am pleased to transmit to you the final Watershed-Based NPDES Permitting Policy Statement. The policy referenced in my December 3, 2002, memorandum on Advancing the Watershed Approach, represents an important aspect of EPA's commitment to watershed management and support for a holistic watershed approach to water quality management.

The policy describes the benefits of watershed-based permitting, and the implementing mechanisms for this component of the watershed approach, and how EPA will be encouraging an increase in the use of watershed-based NPDES permits over the next 12 months. Owing to the importance of NPDES permits and the potential benefits and efficiencies of this approach, I encourage you to work with your states to move watershed-based permitting from the concept stage to implementation stage.

If you have questions regarding this policy, please contact Robin Kime at (202) 564-5047. I greatly appreciate your support and leadership in this effort.

Attachment

cc: Christine Todd Whitman, Administrator
Linda Fisher, Deputy Administrator
Jessica Furey, Associate Administrator, Office of Policy, Economics, and Innovation
Regional Administrators
Office Directors, Office of Water

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WATERSHED-BASED NPDES PERMITTING POLICY STATEMENT

Purpose

As outlined in Assistant Administrator for Water, G. Tracy Mehan's December 3, 2002, memo to EPA Office Directors and EPA Regions, EPA is committed to implement Office of Water programs through watershed management. EPA is issuing this policy statement to demonstrate the Agency's significant level of support for developing and issuing National Pollutant Discharge Elimination System (NPDES) permits on a watershed basis, and to further the objectives of the 1994 NPDES Watershed Strategy. For this Policy, watershed-based permitting is defined as an approach that produces NPDES permits that are issued to point sources on a geographic or watershed basis to meet watershed goals. This policy statement communicates EPA's policy on implementing NPDES permitting activities on a watershed basis, discusses the benefits of watershed-based permitting, presents an explanation of the process and several mechanisms to implement watershed-based permitting, and outlines how EPA will be encouraging watershed-based permitting.

A holistic watershed management approach provides a framework for addressing all stressors within a hydrologically defined drainage basin instead of viewing individual sources in isolation. Within a broader watershed management system, the watershed-based permitting approach is a tool that can assist with implementation activities. The utility of this tool relies heavily on a detailed, integrated and inclusive watershed planning process. Watershed planning includes monitoring and assessment activities that generate the data necessary for clear watershed goals to be established and permits to be designed to specifically address the goals.

Policy

EPA will build on the existing NPDES Watershed Strategy and previous activities to actively support and promote watershed-based NPDES permitting. Further, EPA will work to provide greater incentives and mechanisms necessary to undertake a more holistic and integrated approach to assessing water quality conditions, identifying and quantifying pollutant sources, developing and implementing efficient control practices, and working with stakeholders to the extent authorized by the Clean Water Act and implementing regulations. EPA will educate stakeholders about the benefits of watershed-based permitting, facilitate stakeholder involvement, and move watershed-based permitting from concept to implementation.

Benefits

EPA continues to support a holistic watershed approach to water quality management. The process for developing and issuing NPDES permits on a watershed basis is an important tool in water quality management. EPA believes that developing and issuing NPDES permits on a watershed basis can benefit all watershed stakeholders, from the NPDES permitting authority to local community

members. A watershed-based approach to point source permitting under the NPDES program may serve as one innovative tool for achieving new efficiencies and environmental results. EPA believes that watershed-based permitting can:

- lead to more environmentally effective results;
- emphasize measuring the effectiveness of targeted actions on improvements in water quality;
- provide greater opportunities for trading and other market based approaches;
- reduce the cost of improving the quality of the nation's waters;
- foster more effective implementation of watershed plans, including total maximum daily loads (TMDLs); and
- realize other ancillary benefits beyond those that have been achieved under the Clean Water Act (e.g., facilitate program integration including integration of Clean Water Act and Safe Drinking Water Act programs).

Explanation of the Process and Mechanisms to Implement Watershed-Based Permitting

Watershed-based permitting is a process that ultimately produces NPDES permits that are issued to point sources on a geographic or watershed basis. In establishing point source controls in a watershed-based permit, the permitting authority may focus on watershed goals, and consider multiple pollutant sources and stressors, including the level of nonpoint source control that is practicable. In general, there are numerous permitting mechanisms that may be used to develop and issue permits within a watershed approach. The most common approach currently used in many states is to re-issue NPDES permits according to a five-year rotating basin schedule. Each source receives an individual permit and the permits are issued based on basin or watershed management areas. This process allows permittees to compare their permits with other dischargers in the same area and facilitates sharing data to arrive at the most appropriate limits. Some other permit approaches currently available include:

Watershed-based General Permit - Common Sources. An NPDES permitting authority would develop and issue this type of general permit to a category of point sources within a watershed, such as all publicly owned treatment works (POTWs) or all confined animal feeding operations (CAFOs) or all storm water discharges from municipal separate storm sewer systems. This is similar to current general permits, except that the geographic area covered by the permit would correspond to the watershed boundary. The most significant difference between a traditional general permit and the watershed-based general permit for common sources would be permit requirements that reflect watershed-specific water quality standards.

Watershed-based General Permit - Collective Sources. Unlike the watershed-based general permit described above, this type of permit would address all point sources within the watershed or alternatively, several subcategories of point sources within the watershed. This type of permit would be similar to the multi-sector general permit for storm water discharges associated with industrial activity with requirements being tied to categories and subcategories of discharges. Again, the distinguishing

feature of this type of permit would be geographic coverage based on the watershed-boundaries and the permit requirements reflecting watershed-specific water quality standards.

Watershed-based Individual Permit - Multiple Permittees. Similar to the approach used for Phase I MS4s with multiple permittees, this type of permit would allow several point sources within a watershed to apply for and obtain permit coverage under an individual permit.

Integrated Municipal NPDES Permit. This type of permit would bundle all NPDES permit requirements for a municipality (e.g., storm water, combined sewer overflows, biosolids, pretreatment, etc.) into a single municipal permit. While this type of permit would focus on municipal boundaries rather than watershed boundaries, the analysis in developing permit requirements would reflect watershed-specific water quality standards.

These are not all the possible mechanisms that may be used. EPA and states may consider other possible approaches that are consistent with the NPDES regulations and the Clean Water Act (CWA).

How EPA will Be Encouraging Watershed-Based NPDES Permitting

EPA is developing a framework for watershed-based NPDES permitting. It will be supported by a targeted communications approach focused on informing key stakeholders about the variety of tools developed by EPA to implement a watershed-based permitting approach. Over the next 12 months, EPA anticipates developing and issuing guidance addressing different aspects of the watershed-based permitting approach, including general implementation issues, technical tools and approaches, and procedural considerations. EPA will also be researching and documenting case studies that demonstrate different approaches for watershed-based permitting. EPA will maintain and periodically update the list of case studies.

This policy expresses EPA's support for watershed-based NPDES permitting. Implementation of watershed-based permitting will be governed by existing requirements of the CWA and EPA's NPDES implementing regulations. Those CWA provisions and regulations contain legally binding requirements. This document does not substitute for those provisions or regulations. The recommendations in this memorandum are not binding; the permitting authority may consider other approaches consistent with the CWA and EPA regulations. When EPA makes a permitting decision, it will make each decision on a case-by-case basis and will be guided by the applicable requirements of the CWA and implementing regulations, taking into account comments and information presented at that time by interested persons regarding the appropriateness of applying these recommendations to the particular situation. EPA may change this guidance in the future.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Office of Water
Water Quality Trading Policy
January 13, 2003

I. Background and Purpose of the Policy

The Clean Water Act (CWA)[1] was enacted in 1972 to restore and maintain the chemical, physical, and biological integrity of the nation's waters. It established a national policy that called for the discharge of pollutants to be eliminated and established interim goals for protecting fish, wildlife and recreational uses. The CWA also established a national policy for development and implementation of programs so the goals of the Act could be met through controls of point and nonpoint sources of pollution. Congress recognized and preserved the primary responsibilities and rights of the States to prevent, reduce and eliminate pollution.

The application of technology and water quality based requirements through the National Pollutant Discharge Elimination System (NPDES) permit program has achieved and remains critical to success in controlling point source pollution and restoring the nation's waters. Despite these accomplishments approximately 40% of the rivers, 45% of the streams and 50% of the lakes that have been assessed still do not support their designated uses[2]. Sources of pollution such as urban storm water, agricultural runoff and atmospheric deposition continue to threaten our nation's waters. Nutrient and sediment loading from agriculture and storm water are significant contributors to water quality problems such as hypoxia in the Gulf of Mexico and decreased fish populations in Chesapeake Bay. Population growth and development place increasing demands on the environment making it more difficult to achieve and maintain water quality standards.

Finding solutions to these complex water quality problems requires innovative approaches that are aligned with core water programs. Water quality trading is an approach that offers greater efficiency in achieving water quality goals on a watershed basis. It allows one source to meet its regulatory obligations by using pollutant reductions created by another source that has lower pollution control costs. Trading capitalizes on economies of scale and the control cost differentials among and between sources.

The United States Environmental Protection Agency (EPA) believes that market-based approaches such as water quality trading provide greater flexibility and have potential to achieve water quality and environmental benefits greater than would otherwise be achieved under more traditional regulatory approaches. Market-based programs can

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1 Federal Water Pollution Control Act (Public Law 92-500, as amended), 33 U.S.C. Sec. 1251, et. seq.
2 About 33 percent of the nation's waters have been assessed by States and tribes pursuant to Section 305(b) of the Clean Water Act (National Water Quality Inventory: 2000 Report, EPA). The proportion of non-assessed water that do not meet designated uses is likely lower since assessments tend to be focused in known problem areas.

achieve water quality goals at a substantial economic savings. EPA estimates that in 1997 annual private point source control costs were about $14 billion and public point source costs were about $34 billion[3]. The National Cost to Implement Total Maximum Daily Loads (TMDLs) Draft Report estimates that flexible approaches to improving water quality could save $900 million dollars annually compared to the least flexible approach (EPA, August 2001). Nitrogen trading among publicly owned treatment works in Connecticut that discharge into Long Island Sound is expected to achieve the required reductions under a TMDL while saving over $200 million dollars in control costs. Market-based approaches can also create economic incentives for innovation, emerging technology, voluntary pollution reductions and greater efficiency in improving the quality of the nation's waters.

The purpose of this policy is to encourage states, interstate agencies and tribes to develop and implement water quality trading programs for nutrients, sediments and other pollutants where opportunities exist to achieve water quality improvements at reduced costs. More specifically, the policy is intended to encourage voluntary trading programs that facilitate implementation of TMDLs, reduce the costs of compliance with CWA regulations, establish incentives for voluntary reductions and promote watershed-based initiatives. A number of states are in various stages of developing trading programs. This policy provides guidance for states, interstate agencies and tribes to assist them in developing and implementing such programs.

This policy addresses issues left open by and limitations encountered implementing projects and programs under EPA's January 1996 Effluent Trading In Watersheds Policy and May 1996 Draft Framework for Watershed-Based Trading ("Draft Framework"). This policy should be given precedence over any inconsistencies with the Draft Framework.

This policy draws upon lessons from a number of recent pilot trading projects and state experiences in developing water quality trading programs. These initiatives demonstrate how trading can occur under the CWA and existing federal regulations. They illustrate the importance of voluntary watershed-based partnerships, inter-agency cooperation and public participation in implementation of trading programs. They show that flexible market-based approaches can facilitate states and tribes finding solutions to complex and diverse water quality and socioeconomic issues. These efforts have also highlighted the importance of keeping transaction and administrative costs manageable while retaining accountability. The lessons learned from these efforts have informed the development of this policy.

This policy describes various requirements of the CWA and implementing regulations that are relevant to water quality trading, including: requirements to obtain permits (Sections 402 and 404), antibacksliding provisions (Section 303(d)(4) and Section 402(o)), the development of water quality standards including antidegradation policy (Section 303(c)), federal NPDES permit regulations (40 CFR Parts 122, 123 and 124), TMDLs (Section 303d(1)) and water quality management plans (40 CFR Part 130).

3 A Retrospective Assessment of the Costs of the Clean Water Act: 1972 – 1997 (EPA October, 2000).

These CWA provisions and regulations contain legally binding requirements. This policy does not substitute for those provisions or requirements. In addition, this policy identifies general elements and provisions that EPA believes are important for creating credible water quality trading programs.

When EPA makes a decision with regard to any particular permit, TMDL, water quality standards or water quality management plan that includes provisions for trading to occur, it will make each decision on a case-by-case basis guided by the applicable requirements of the CWA and implementing regulations and the specific facts and circumstances involved.

II. Trading Objectives

EPA supports implementation of water quality trading by states, interstate agencies and tribes where trading:

A. Achieves early reductions and progress towards water quality standards pending development of TMDLs for impaired waters.

B. Reduces the cost of implementing TMDLs through greater efficiency and flexible approaches.

C. Establishes economic incentives for voluntary pollutant reductions from point and nonpoint sources within a watershed.

D. Reduces the cost of compliance with water quality-based requirements.

E. Offsets new or increased discharges resulting from growth in order to maintain levels of water quality that support all designated uses.

F. Achieves greater environmental benefits than those under existing regulatory programs. EPA supports the creation of water quality trading credits in ways that achieve ancillary environmental benefits beyond the required reductions in specific pollutant loads, such as the creation and restoration of wetlands, floodplains and wildlife and/or waterfowl habitat.

G. Secures long-term improvements in water quality through the purchase and retirement of credits by any entity.

H. Combines ecological services to achieve multiple environmental and economic benefits, such as wetland restoration or the implementation of management practices that improve water quality and habitat.

III. Water Quality Trading Policy Statement

A. CWA Requirements. Water quality trading and other market-based programs must be consistent with the CWA.

B. Trading Areas. All water quality trading should occur within a watershed or a defined area for which a TMDL has been approved. Establishing defined trading areas that coincide with a watershed or TMDL boundary results in trades that affect the same water body or stream segment and helps ensure that water quality standards are maintained or achieved throughout the trading area and contiguous waters.

C. Pollutants and Parameters Traded. EPA supports trading that involves nutrients (e.g., total phosphorus and total nitrogen) or sediment loads. In addition, EPA recognizes that trading of pollutants other than nutrients and sediments has the potential to improve water quality and achieve ancillary environmental benefits if trades and trading programs are properly designed. EPA believes that such trades may pose a higher level of risk and should receive a higher level of scrutiny to ensure that they are consistent with water quality standards. EPA may support trades that involve pollutants other than nutrients and sediments on a case-by-case basis where prior approval is provided through an NPDES permit, a TMDL or in the context of a watershed plan or pilot trading project that is supported by a state, tribe or EPA.

EPA also supports cross-pollutant trading for oxygen-related pollutants where adequate information exists to establish and correlate impacts on water quality. Reducing upstream nutrient levels to offset a downstream biochemical oxygen demand or to improve a depressed in-stream dissolved oxygen level are examples of cross-pollutant trading.

EPA does not currently support trading of pollutants considered by EPA to be persistent bioaccumulative toxics (PBTs). EPA would consider a limited number of pilot projects over the next two to three years to obtain more information regarding trading of PBTs. EPA believes pilot projects may be appropriate where the predominant loads do not come from point sources, trading achieves a substantial reduction of the PBT traded and where trading does not cause an exceedance of an aquatic life or human health criterion. Based on the findings of these pilot projects, EPA will consider making revisions to its policy.

Where state or tribal water quality standards allow for mixing zones, EPA does not support any trading activity that would exceed an acute aquatic life criteria within a mixing zone or a chronic aquatic life or human health criteria at the edge of a mixing zone using design flows specified in the water quality standards.

D. Baselines for Water Quality Trading. As explained below, the baselines for generating pollution reduction credits should be derived from and consistent with

water quality standards. The term pollution reduction credits ("credits"), as used in this policy, means pollutant reductions greater than those required by a regulatory requirement or established under a TMDL.

For example, where a TMDL has been approved or established by EPA, the applicable point source waste load allocation or nonpoint source load allocation would establish the baselines for generating credits. For trades that occur where water quality fully supports designated uses, or in impaired waters prior to a TMDL being established, the baseline for point sources should be established by the applicable water quality based effluent limitation, a quantified performance requirement or a management practice derived from water quality standards. In these scenarios the baseline for nonpoint sources should be the level of pollutant load associated with existing land uses and management practices that comply with applicable state, local or tribal regulations.

E. When Trading May Occur.

1. Trading to Maintain Water Quality Standards. Trading may be used to maintain high water quality in waters where water quality standards are attained, such as by compensating for new or increased discharges of pollutants.

2. Pre-TMDL Trading In Impaired Waters. EPA supports pre-TMDL trading in impaired waters to achieve progress towards or the attainment of water quality standards. EPA believes this may be accomplished by individual trades that achieve a net reduction of the pollutant traded or by watershed-scale trading programs that reduce loadings to a specified cap supported by baseline information on pollutant sources and loadings.

EPA also supports pre-TMDL trading that achieves a direct environmental benefit relevant to the conditions or causes of impairment to achieve progress towards restoring designated uses where reducing pollutant loads alone is not sufficient or as cost-effective.

If pre-TMDL trading does not result in the attainment of applicable water quality standards, EPA expects a TMDL to be developed. After a TMDL has been approved or established by EPA, the reductions made to generate credits for pre-TMDL trading may no longer be adequate to generate credits under the TMDL. This will depend on the remaining level of reduction needed to achieve water quality standards and, where applicable, the allocation of point and nonpoint source pollutant loads established by the TMDL.

3. TMDL Trading. Trades and trading programs in impaired waters for which a TMDL has been approved or established by EPA should be consistent with the assumptions and requirements upon which the TMDL is established. EPA encourages the inclusion of specific trading provisions in the TMDL itself, in NPDES permits, in watershed plans and the continuing planning process.

EPA does not support any trading activity that would delay implementation of a TMDL approved or established by EPA or that would cause the combined point source and nonpoint source loadings to exceed the cap established by a TMDL.

4. Technology-Based Trading. EPA does not support trading to comply with existing technology-based effluent limitations except as expressly authorized by federal regulations. Existing technology-based effluent guidelines for the iron and steel industry allow intraplant trading of conventional, nonconventional and toxic pollutants between outfalls under certain circumstances (40 CFR 420.03).

EPA will consider including provisions for trading in the development of new and revised technology-based effluent guidelines and other regulations to achieve technology-based requirements, reduce implementation costs and increase environmental benefits.

5. Pretreatment Trading. EPA supports a municipality or regional sewerage authority developing and implementing trading programs among industrial users that are consistent with the pretreatment regulatory requirements at 40 CFR Part 403 and the municipality's or authority's NPDES permit.

6. Intra-Plant Trading. EPA supports intra-plant trading that involves the generation and use of credits between multiple outfalls that discharge to the same receiving water from a single facility that has been issued an NPDES permit.

F. Alignment With The CWA. Provisions for water quality trading should be aligned with and incorporated into core water quality programs. EPA believes this may be done by including provisions for trading in water quality management plans, the continuing planning process, watershed plans, water quality standards, including antidegradation policy and, by incorporating provisions for trading into TMDLs and NPDES permits.

When developing water quality trades and trading programs, states and tribes should, at a minimum, take into account the following provisions of the CWA and implementing regulations:

1. Requirements to Obtain Permits. Sources and activities that are required to obtain a federal permit pursuant to Sections 402 or 404 of the CWA must do so to participate in a trade or trading program.

2. Incorporating Provisions For Trading Into Permits. In some cases, specific trades may be identified in NPDES permits, including requirements related to the control of nonpoint sources where appropriate. EPA also supports several flexible approaches for incorporating provisions for trading into NPDES permits: i) general conditions in a permit that authorize trading and describe appropriate conditions and restrictions for trading to occur, ii) the use of variable permit limits that may be adjusted up or down based on the quantity of credits generated or

used; and/or, iii) the use of alternate permit limits or conditions that establish restrictions on the amount of a point source's pollution reduction obligation that may be achieved by the use of credits if trading occurs. EPA also encourages the use of watershed general permits, where appropriate, to establish pollutant-specific limitations for a group of sources in the same or similar categories to achieve net pollutant reductions or water quality goals through trading. Watershed permits issued to point sources should include facility specific effluent limitations or other conditions that would apply in the event the pollutant cap established by the watershed permit is exceeded.

3. Public Notice, Comment and Opportunity For Hearing. Notice, comment and opportunity for hearing must be provided for all NPDES permits (40 CFR 124). NPDES permits and fact sheets should describe how baselines and conditions or limits for trading have been established and how they are consistent with water quality standards. EPA does not expect that an NPDES permit would need to be modified to incorporate an individual trade if that permit contains authorization and provisions for trading to occur and the public was given notice and an opportunity to comment and/or attend a public hearing at the time the permit was issued.

4. Consistency With Standard Methods. Where methods and procedures (e.g., sampling protocols, monitoring frequencies) are specified by federal regulations or in NPDES permits, they should continue to be used where applicable for measuring compliance for point sources that engage in trading. EPA believes this is necessary to provide clear and consistent standards for measuring compliance and to ensure that appropriate enforcement action can be taken.

5. Protecting Designated Uses. EPA does not support any use of credits or trading activity that would cause an impairment of existing or designated uses, adversely affect water quality at an intake for drinking water supply or that would exceed a cap established under a TMDL.

6. Antibacksliding. EPA believes that the antibacksliding provisions of Section 303(d)(4) of the CWA will generally be satisfied where a point source increases its discharge through the use of credits in accordance with alternate or variable water quality based effluent limitations contained in an NPDES permit, in a manner consistent with provisions for trading under a TMDL, or consistent with the provisions for pre-TMDL trading included in a watershed plan.

These antibacksliding provisions will also generally be satisfied where a point source generates pollution reduction credits by reducing its discharge below a water quality based effluent limitation (WQBEL) that implements a TMDL or is otherwise established to meet water quality standards and it later decides to discontinue generating credits, provided that the total pollutant load to the

receiving water is not increased, or is otherwise consistent with state or tribal antidegradation policy.

7. Antidegradation. Trading should be consistent with applicable water quality standards, including a state's and tribe's antidegradation policy established to maintain and protect existing instream water uses and the level of water quality necessary to support them, as well as high quality waters and outstanding national resource waters (40 CFR 131.12). EPA recommends that state or tribal antidegradation policies include provisions for trading to occur without requiring antidegradation review for high quality waters. EPA does not believe that trades and trading programs will result in "lower water quality" as that term is used in 40 CFR 131.12(a)(2), or that antidegradation review would be required under EPA's regulations when the trades or trading programs achieve a no net increase of the pollutant traded and do not result in any impairment of designated uses.

G. Common Elements of Credible Trading Programs. EPA believes that, in addition to including provisions to be consistent with the CWA, trading programs should include the following general elements to be credible and successful:

1. Legal Authority and Mechanisms. Clear legal authority and mechanisms are necessary for trading to occur. EPA believes the CWA provides authority for EPA, states and tribes to develop a variety of programs and activities to control pollution, including trading programs. The CWA and federal regulations provide authority to incorporate provisions for trading into NPDES permits issued to point sources and for trading under TMDLs that include provisions for trading to occur.

In addition, states and tribes should use specific legal mechanisms to facilitate trading. Provisions for trading may be established through various mechanisms, including: legislation, rule making, incorporating provisions for trading into NPDES permits and establishing provisions for trading in TMDLs or watershed plans. These provisions may incorporate or be supplemented by private contracts between sources or third-party contracts where the third party provides an indemnification or enforcement function.

2. Units of Trade. Clearly defined units of trade are necessary for trading to occur. Pollutant specific credits are examples of tradable units for water quality trading. These may be expressed in rates or mass per unit time as appropriate to be consistent with the time periods that are used to determine compliance with NPDES permit limitations or other regulatory requirements.

3. Creation and Duration of Credits. Credits should be generated before or during the same period they are used to comply with a monthly, seasonal or annual limitation or requirement specified in an NPDES permit. Credits may be generated as long as the pollution controls or management practices are functioning as expected.

4. Quantifying Credits and Addressing Uncertainty. Standardized protocols are necessary to quantify pollutant loads, load reductions, and credits. States and tribes should develop procedures to account for the generation and use of credits in NPDES permits and discharge monitoring reports in order to track the generation and use of credits between sources and assess compliance.

Where trading involves nonpoint sources, states and tribes should adopt methods to account for the greater uncertainty in estimates of nonpoint source loads and reductions. Greater uncertainty in nonpoint source estimates is due to several factors including but not limited to variability in precipitation, variable performance of land management practices, time lag between implementation of some practices and full performance, and the effect of soils, cover and slope on pollutant load delivery to receiving waters.

EPA supports a number of approaches to compensate for nonpoint source uncertainty. These include monitoring to verify load reductions, the use of greater than 1:1 trading ratios between nonpoint and point sources, using demonstrated performance values or conservative assumptions in estimating the effectiveness of nonpoint source management practices, using site- or trade-specific discount factors, and retiring a percentage of nonpoint source reductions for each transaction or a predetermined number of credits. Where appropriate, states and tribes may elect to establish a reserve pool of credits that would be available to compensate for unanticipated shortfalls in the quantity of credits that are actually generated.

The site-specific procedures and protocols used in water quality trading programs that involve agriculture and forestry operations should be developed by states and tribes in consultation with United States Department of Agriculture (USDA) agencies. Those procedures should estimate nutrient or sediment load delivery to the stream segment, water body or watershed where trading occurs. Numerous methods and procedures to determine nutrient and sediment load reductions associated with conservation practices on agricultural and forest land have been developed or used by the USDA agencies, including the Natural Resources Conservation Service, Forest Service, Agricultural Research Service and the Cooperative State, Research, Education and Extension Service. Some of these methods may be applied to water quality trading.

As an example, the Revised Universal Soil Loss Equation (RUSLE) may be used in some locations to estimate the sediment yield at the end of a slope in agricultural settings. The sediment yield at the end of a slope coupled with an appropriate method to estimate sediment delivery to the receiving waters can provide a reasonable estimate of sediment load and load reductions. Representative soil sampling to determine the phosphorus content of soils can be used with this approach to estimate non-soluble sediment-bound phosphorus loads and load reductions. Different methods are appropriate to estimate soluble phosphorus and nitrogen loads and load reductions.

EPA and the USDA are working with other agencies to evaluate existing methods and to develop improved methods and procedures for estimating loads from agricultural and forestry lands. More precise estimations will be possible as technologies improve and new technologies are developed.

For storm water runoff other than agriculture, EPA recommends monitoring or modeling to estimate pollutant loads and load reductions. EPA believes this may be based on local hydrology and actual data or pollutant loading factors that relate land use patterns, percent imperviousness or percent disturbed land and controls or management practices in a watershed to per acre or per unit pollutant loads, where other methods are not specified in a permit or regulation.

5. Compliance and Enforcement Provisions. Mechanisms for determining and ensuring compliance are essential for all trades and trading programs. These may include a combination of record keeping, monitoring, reporting and inspections. Compliance audits should be conducted frequently enough to ensure that a high level of compliance is maintained across the program. States and tribes should establish clear enforceable mechanisms consistent with NPDES regulations that ensure legal accountability for the generation of credits that are traded. In the event of default by another source generating credits, an NPDES permittee using those credits is responsible for complying with the effluent limitations that would apply if the trade had not occurred. EPA also recommends that states and tribes consider providing periodic accounting and reconciliation periods and establishing appropriate enforcement provisions for failure to generate the quantity of credits that are traded.

EPA recommends that states and tribes consider the role of compliance history in determining source eligibility to participate in trading.

EPA recommends that states and tribes consider including provisions to address situations where nonpoint source controls and management practices that are implemented to generate credits fail due to extreme weather conditions or other circumstances that are beyond the control of the source.

6. Public Participation And Access To Information. EPA supports public participation at the earliest stages and throughout the development of water quality trading programs to strengthen program effectiveness and credibility.

Easy and timely public access to information is necessary for markets to function efficiently and for the public to monitor trading activity. EPA encourages states and tribes to make electronically available to the public information on the sources that trade, the quantity of credits generated and used on a watershed basis, market prices where available, and delineations of watershed and trading boundaries. This information is necessary to identify potential trading

opportunities, allow easy aggregation of credits, reduce transaction costs and establish public credibility.

7. Program Evaluations. Periodic assessments of environmental and economic effectiveness should be conducted and program revisions made as needed. Environmental evaluations should include ambient monitoring to ensure impairments of designated uses (including existing uses) do not occur and to document water quality conditions. Studies should be performed to quantify nonpoint source load reductions, validate nonpoint source pollutant removal efficiencies and determine whether the anticipated water quality objectives have been achieved. Economic evaluations should include the number and type of trades, the price paid for pollutant reduction credits, transaction costs, the costs incurred to administer the program, and where possible any net cost savings resulting from trading.

The results of program evaluations should be made available to the public. An opportunity for comment should also be provided on changes to the program as necessary to ensure that water quality objectives and economic efficiencies are achieved, and that trading does not result in an impairment of designated uses (including existing uses).

H. EPA's Oversight Role. States and tribes are encouraged to consult with EPA throughout development of trading programs to facilitate alignment with the CWA. EPA has various oversight responsibilities under the CWA, including approval or establishment of TMDLs, approval of revisions to state or tribal water quality standards, review of NPDES permits and provisions for reviewing and making recommendations regarding revisions to a state's or tribe's water quality management plans through the continuing planning process. In general, EPA does not believe that the development and implementation by states and tribes of trading programs consistent with the provisions of this policy necessarily warrant a higher level of scrutiny under these oversight authorities than is appropriate for activities not involving trading. However, where questions or concerns arise, EPA will use its oversight authorities to ensure that trades and trading programs are fully consistent with the CWA and its implementing regulations.

From: Brent Ovard
To: carladams@utah.gov
Date: 3/6/2006 4:39:35 PM
Subject: TMDL Echo Reservoir

I hope these comments arrive in time. I will be brief. Pg 63 2nd paragraph TP loads from Chalk creek unexpected-needs better natural background explanation. Pg 23 2nd paragraph- The management of Echo reservoir during drought years needs to be examined. There has been no discharge from Echo during fall, winter, or early spring the last several years. Pg 54 Is phytoplankton assessment consistent with high phos and low oxygen? Suggests that water quality may be better at Echo . Thanks. Brent

From: "Steve Noyes" <SNOYES@uc.usbr.gov>
To: <CARLADAMS@utah.gov>
Date: 3/6/2006 5:08:02 PM
Subject: Echo Reservoir TMDL

Cark,

I have been so pressed on the Park City Water Supply Study, I have been unable to review and send comments on this TMDL.

I will try to get through the report tomorrow.

I have one comment today, as does Jerry Miller: for this TMDL to be accurate, it has to be combined with a TMDL with Rockport Reservoir, as activities and development above Rockport will affect the releases and water quality released downstream to Echo Reservoir. To protect Echo Reservoir, this has to be factored into it's TMDL.

I don't know how you can handle this, but it should at least mentioned and acknowledged in this Echo TMDL.

Good Luck!!

Steve Noyes

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