METHODS OF ANALYSIS

Information on how environmental effects of the alternatives were determined is contained in this section, divided by category.

Water Supply

A hydrologic model was developed to simulate the operations of Clark Canyon Reservoir to meet the water supply needs of irrigators below the reservoir and along the Beaverhead River down to its confluence with the Ruby and Big Hole rivers. Various versions of the model were developed to evaluate proposed alternatives. Development of the model was targeted towards assessing impacts to irrigation water supply, water demands, and stream flows. Reclamation’s HYDROSS (Hydrologic River Operation Study System) computer modeling program was chosen for creation of the model. HYDROSS has a graphical user interface which allows for the relatively easy creation of different modeling networks for each alternative. In general, the model simulates the operations of Clark Canyon Reservoir for the release of water for irrigation and in-stream flow demands based on relative priorities. It also stores and releases water to meet monthly reservoir storage targets. The model tracks natural and project flows in the river network, and simulates return flows from irrigation deliveries.

For NEPA purposes, the model was designed to represent present reservoir operations and reasonable future water supply conditions. The NEPA model is not intended to duplicate historic conditions. A benchmark version of the model was developed first to represent the No-Action alternative. This benchmark version served as the starting point for development of other versions of the model for alternatives evaluation. The different versions of the model were then used to develop incremental impacts from the benchmark (or No-Action) conditions.

Development of the model for reasonable future water supply conditions involved the following generalized assumptions and model operations criteria:

- ❖ The model operates on a monthly time step for 1929-2002. This period was selected to include the drought period of the 1930’s which would be a critical period for evaluating irrigation shortages.
- ❖ Historic inflows to Clark Canyon Reservoir were adjusted to reflect current level of development above the reservoir.
- ❖ Model nodes for calculating inflows, reach gains, points of diversion, points of return flows, etc. were based on existing or discontinued USGS streamflow measurement stations.
- ❖ Missing historic streamflow records at model nodes were filled in with statistically developed data from adjacent sites with measured discharge.
- ❖ Historic streamflow records were adjusted to ‘irrigation-undepleted’ values based on estimated historic diversions and return flows. This allows the model to deplete streamflows based on the net effects of simulated diversions and return flows.
- ❖ Future storage capacity for Clark Canyon Reservoir is anticipated to decline due to sedimentation. Estimated 100-year sedimentation conditions from the East Bench Unit Definite Plan Report were used to define the future reservoir capacities used by the model. The following maximum capacities were used to set monthly maximum modeling targets for the reservoir based on the 100-year sedimentation capacities:

Values in Kaf (thousands acre-feet)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
153.6	151.0	157.1	163.1	169.2	171.8	169.2	166.6	164.0	161.4	158.8	156.2

The minimum reservoir storage capacity for the benchmark model was set to 10 Kaf.

- ❖ Reservoir evaporation is not presently recorded at the reservoir. For modeling purposes, historic reservoir evaporation rates were estimated by measured and statistically derived evaporation rates measured at other sites.
- ❖ Irrigation demands were based on crop irrigation requirements (CIR) generated by the Jensen-Haise method using Reclamation's CONUSE52 computer program. Districts provided information on percent of irrigated crops by type. They also provided information on planting, cover development, and harvest dates. A weighted crop distribution was used calculate the CIR by irrigation district:

Crop	EBID Percent	CCWSC Percent
Wheat	30	5
Alfalfa	37	42
Other Hay	9	19
Barley	20	15
Pasture	4	19

- ❖ Estimated on-farm and conveyance efficiencies were applied to CIR to develop irrigation demands at the head-gate. The efficiencies selected were based on professional experience, input from the districts, and information from the East Bench Unit Definite Plan Report.
- ❖ Return flows from irrigation were distributed to model nodes based on subjective visual interpretation of the relative position of irrigated lands and canals in basin to model nodes. The distribution of return flows over time was based on an estimated pattern derived from a previous Reclamation study.
- ❖ Irrigation demands applied to model were categorized as to whether they belonged to 'non-signers', CCWSC, or EBID. They were further categorized as 1st, 2nd, or 3rd priority demands. Finally, the demands were grouped according to supply canal and assigned to the appropriate model node.
- ❖ Monthly instream flow requirements (IFR) were established for five nodes in the model. In the benchmark model, the IFRs had priority over the irrigation demands. The model determines whether simulated flow discharge at a specific node (inclusive of irrigation requests, return flows, etc.) meet the IFR. If the flows do not meet the IFR, then additional water is released through Clark Canyon Reservoir if natural flow and/or storage are available. Historic monthly reservoir releases were evaluated to develop a table which approximates target IFR release rates based on September reservoir end-of-month (EOM) contents. The following table was developed:

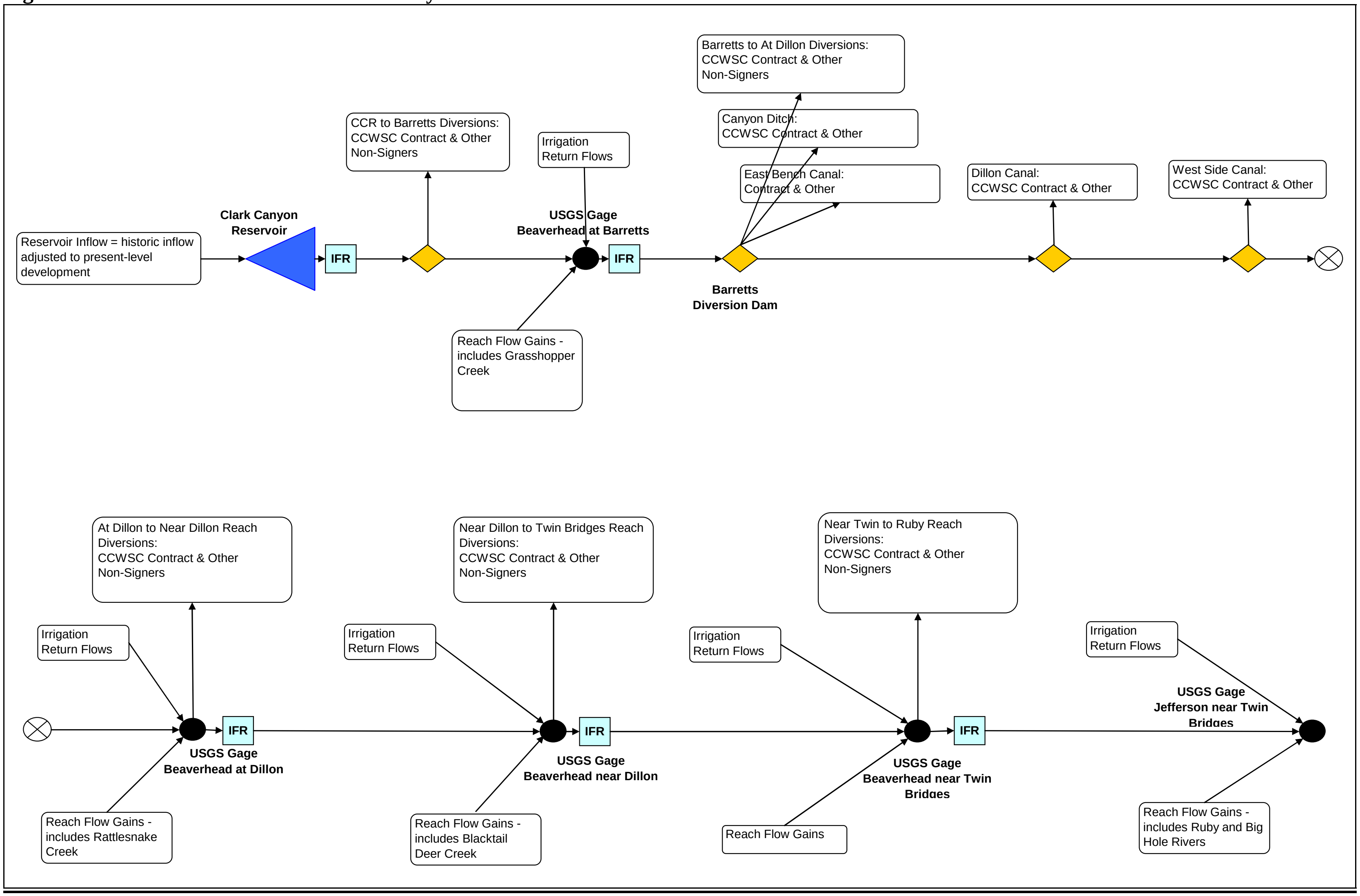
September EOM Content (Kaf)		Oct through March IFR (cfs)
From	to	
0	59.9	25
60	79.9	50
80	119.9	100
120	And greater	200

The IFR for the months of April through September was set to 25 cfs.

Figure 1 illustrates the general configuration of the benchmark version of the Clark Canyon hydrology model.

HYDROSS operates on a monthly time step and cannot perform forecasting and distribution of water supplies on an annual basis. In the real world, the distribution of project water supply to CCWSC and EBID is performed on an annual basis. Historically, project supply is allocated across the irrigation season so that CCWSC will receive its allocation of 4 acre-feet per acre prior to EBID receiving their 3.1 acre-feet per acre. HYDROSS can calculate deliveries based on priorities within a particular month, but cannot look ahead several months at supply and demand, and adjust the current month's deliveries to lower priority demands to protect a higher priority demand at some time in the future. To accommodate this limitation, an iterative modeling procedure was developed which uses interim HYDROSS modeling results and a spreadsheet application to make manual adjustments to monthly demands to more closely simulate how the system is presently operated. This iterative procedure involved running the model and comparing priority-grouped deliveries for each year. Lower priority demands were reduced on a year-by-year case to protect higher priority demands.

Figure 1 - Generalized Network of Clark Canyon Benchmark Model



Water Quality

Reclamation sampled water quality in 2001-2003 at five sites in the reservoir—including both sources of inflows and the tailrace (U.S. Bureau of Reclamation, 2003a). (The sites are listed in Chapter 3, Figure 3.1).

Physical limnology, plankton analysis, nutrients, metals, organics, and hydro-acoustic fisheries data were collected. Water column profiles recorded from surface to bottom for temperature, dissolved oxygen, specific conductance, and pH. Zero to 5 meter (m) samples were collected for chlorophyll analysis. Integrated samples of phytoplankton (0-5 m) and zooplankton (0-15m) were collected at each reservoir site to identify species and density. Nutrient grab samples were collected from the top and bottom of the lake. Samples were analyzed for ortho-phosphate, nitrate, ammonia, and nitrogen also.

Reclamation sampled water quality of EBID (Chapter 3, Figure 3.2) and the Beaverhead River in 2002-2003 (U.S. Bureau of Reclamation, 2003b). Six sites were sampled, three on the river affected by EBID (Barretts Diversion, Anderson Lane Bridge, and Geim Bridge) and three on areas of return flows in EBID (Stone Creek, Spring Creek and the wasteway at the end of the East Bench Canal).

The findings for each of the sites are shown in the following tables.

Anderson Lane

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L	213	99	180	188	186	204	93	133	178	**163.8**	**93**	**213**	**180**	**9**
Lab EC	µS/cm	547	481	531	588	591	622	563	507	606	**559.6**	**481**	**622**	**563**	**9**
Lab pH		8.06	7.9	8.27	7.57	7.87	7.59	7.36	8.01	7.8	**7.826**	**7.36**	**8.27**	**7.87**	**9**
TDS	mg/L	390	338	366			380		400	414	**381.3**	**338**	**414**	**385**	**6**
TSS	mg/L	15.2	41.7	35.35	22.2	37.05		70.3	26.9	17.8	**33.31**	**15.2**	**70.3**	**31.13**	**8**
Ammonia –Nitrogen	mg/L		0.03	0.13	0.04	0.07	0.04	0.09	0.09	0.14	**0.079**	**0.03**	**0.14**	**0.08**	**8**
Nitrate + Nitrate - Nitrogen	mg/L	0.72	0.14			0.64		0.32		0.15	**0.394**	**0.14**	**0.72**	**0.32**	**5**
Total Organic Carbon	mg/L	3.3	1.81	5.13	18.25	5.17		3.52	5.17	5.37	**5.965**	**1.81**	**18.3**	**5.15**	**8**
Total Phosphorus	mg/L	0.05	0.01		0.07	0.11	0.27	0.11	0.03	0.08	**0.091**	**0.01**	**0.27**	**0.075**	**8**
Ag	µg / L	4.02	6.2								**5.11**	**4.02**	**6.2**	**5.11**	**2**
Al	µg / L							33.3			**33.3**	**33.3**	**33.3**	**33.3**	**1**
As	µg / L														
B	µg / L	48	53.3		57.9	52	56.5	55.1	48.5	61.3	**54.08**	**48**	**61.3**	**54.2**	**8**
Ba	µg / L	53.6	35.1		51.6	40.8	43.2	30.4	39.5	37.6	**41.48**	**30.4**	**53.6**	**40.15**	**8**
Be	µg / L								0.66		**0.66**	**0.66**	**0.66**	**0.66**	**1**
Ca	mg/L	74	54.3	64.5	66.9	65.2	52.9	55.8	47.8	64.6	**60.67**	**47.8**	**74**	**64.5**	**9**
Cd	µg / L														
Cl	mg/L	14.9	13.4	13.9	13.2	15.8	14.8	13.8	14.4	14	**14.24**	**13.2**	**15.8**	**14**	**9**
Co	µg / L									3.09	**3.09**	**3.09**	**3.09**	**3.09**	**1**
CO3	mg/L														
Cr	µg / L														
Cu	µg / L														
Fe	µg / L	5.64		4.5	4.09					6.9	**5.283**	**4.09**	**6.9**	**5.07**	**4**
HCO3	mg/L	260	121	220	229	227	249	113	162	217	**199.8**	**113**	**260**	**220**	**9**
K	mg/L	3.67	3.58	4.45	4.52	5.67	4.12	4.25	3.97	5.28	**4.39**	**3.58**	**5.67**	**4.25**	**9**
Li	µg / L	19.1	20.2		21.2	24.9	21.6	20.5	22.3	23.9	**21.71**	**19.1**	**24.9**	**21.4**	**8**
Mg	mg/L	24.4	22.2	25.9	25	24.2	21.9	24.3	26.9	26.2	**24.56**	**21.9**	**26.9**	**24.4**	**9**
Mn	µg / L		4.9		38.9			8.51			**17.44**	**4.9**	**38.9**	**8.51**	**3**
Mo	µg / L	13.4									**13.4**	**13.4**	**13.4**	**13.4**	**1**
Ni	µg / L														
Na	mg/L	22.8	20.5	24.5	22.7	23.8	22.6	24.1	25	24.7	**23.41**	**20.5**	**25**	**23.8**	**9**
Pb	µg / L														
Sb	µg / L														
Se	µg / L		49		35.3					49.5	**44.6**	**35.3**	**49.5**	**49**	**3**
Si	mg/L	9.41	9.25		7.89	9.02	7.55	7.72	5.54	10.8	**8.398**	**5.54**	**10.8**	**8.455**	**8**
SiO2	mg/L	20.14	19.8	15.64	16.88	19.3	16.16	16.52	11.86	23.11	**17.71**	**11.9**	**23.1**	**16.88**	**9**
SO4	mg/L	102	105	114	110	113	113	99	116	129	**111.2**	**99**	**129**	**113**	**9**
Sr	µg / L	665	572		677	615	580	532	608	686	**616.9**	**532**	**686**	**611.5**	**8**
V	µg / L				4.26			6.92			**5.59**	**4.26**	**6.92**	**5.59**	**2**
Zn	µg / L														

Barretts

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L	184	112	201	206	185	196	151	179	211	**180.6**	**112**	**211**	**185**	**9**
Lab EC	µS/cm	512	446	578	680	632	617	507	594	665	**581.2**	**446**	**680**	**594**	**9**
Lab pH		8.1	7.67	8	7.67	7.89	7.54	7.49	8.04	7.94	**7.816**	**7.49**	**8.1**	**7.89**	**9**
TDS	mg/L	350	304	410			254		476	474	**378**	**254**	**476**	**380**	**6**
TSS	mg/L	5	45.6	39.59	13.8	17.88	4.6	8	18.7		**19.15**	**4.6**	**45.6**	**15.84**	**8**
Ammonia -Nitrogen	mg/L		0.03	0.16	0.12	0.05		0.07	0.11	0.08	**0.089**	**0.03**	**0.16**	**0.08**	**7**
Nitrate + Nitrate - Nitrogen	mg/L														
Total Organic Carbon	mg/L	2.64	5.75	4.38	4.21	4.95		3.34	5.42	8.44	**4.891**	**2.64**	**8.44**	**4.665**	**8**
Total Phosphorus	mg/L	0.03	0.03		0.01	0.12		0.06	0.04	0.09	**0.054**	**0.01**	**0.12**	**0.04**	**7**
Ag	µg / L		6.39								**6.39**	**6.39**	**6.39**	**6.39**	**1**
Al	µg / L														
As	µg / L														
B	µg / L	46.4	25.7	53.8	57.9	51.2	56.5	41.2	53.8	52.4	**48.77**	**25.7**	**57.9**	**52.4**	**9**
Ba	µg / L	51.2	39.5	53.5	70.9	49.1	54.8	45.2	43.9	51.1	**51.02**	**39.5**	**70.9**	**51.1**	**9**
Be	µg / L		0.65						0.81		**0.73**	**0.65**	**0.81**	**0.73**	**2**
Ca	mg/L	66.9	51.9	77.2	81.4	70.4	60.2	58.3	69.2	79.8	**68.37**	**51.9**	**81.4**	**69.2**	**9**
Cd	µg / L														
Cl	mg/L	10.9	10.8	12.6	13.4	12.9	12.2	9.4	11.9	12.7	**11.87**	**9.4**	**13.4**	**12.2**	**9**
Co	µg / L														
CO3	mg/L														
Cr	µg / L														
Cu	µg / L														
Fe	µg / L	19.8	6.99		11.4	5.28	8.1	22.1			**12.28**	**5.28**	**22.1**	**9.75**	**6**
HCO3	mg/L	225	136	245	251	226	239	185	218	258	**220.3**	**136**	**258**	**226**	**9**
K	mg/L	3.39	2.82	4.08	4.08	4.83	4.93	2.96	4.14	4.41	**3.96**	**2.82**	**4.93**	**4.08**	**9**
Li	µg / L	21.7	19.5	23.6	24	30.7	27.7	19.4	22.4	22.2	**23.47**	**19.4**	**30.7**	**22.4**	**9**
Mg	mg/L	21.7	19.3	26.9	28.3	25.6	23.6	18.1	27.4	27.4	**24.26**	**18.1**	**28.3**	**25.6**	**9**
Mn	µg / L	12.9	5.11		5.28						**7.763**	**5.11**	**12.9**	**5.28**	**3**
Mo	µg / L				11.6						**11.6**	**11.6**	**11.6**	**11.6**	**1**
Ni	µg / L	11.1									**11.1**	**11.1**	**11.1**	**11.1**	**1**
Na	mg/L	22.3	20	25.1	25.6	26.8	26.4	21.4	24.7	24.4	**24.08**	**20**	**26.8**	**24.7**	**9**
Pb	µg / L														
Sb	µg / L														
Se	µg / L	31.8	38.1	39.6	37.9				80		**45.48**	**31.8**	**80**	**38.1**	**5**
Si	mg/L	9.06	8.47	8.77	4.51	8.16	8.85	8.99	9.17	10.9	**8.542**	**4.51**	**10.9**	**8.85**	**9**
SiO2	mg/L	19.39	18.13	18.77	16.07	17.46	18.94	19.24	19.62	23.33	**18.99**	**16.1**	**23.3**	**18.94**	**9**
SO4	mg/L	109	108	129	140	142	134	95	134	139	**125.6**	**95**	**142**	**134**	**9**
Sr	µg / L	647	539	796	862	736	687	548	761	812	**709.8**	**539**	**862**	**736**	**9**
V	µg / L				4.25						**4.25**	**4.25**	**4.25**	**4.25**	**1**
Zn	µg / L														

Giem Bridge

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L	227	166	238	203	245	222	126	253	204	**209.3**	**126**	**253**	**222**	**9**
Lab EC	µS/cm	645	761	709	686	818	740	761	793	735	**738.7**	**645**	**818**	**740**	**9**
Lab pH		8.19	7.79	8.02	7.7	7.95	7.57	7.33	8.15	7.53	**7.803**	**7.33**	**8.19**	**7.79**	**9**
TDS	mg/L	484	582	500			470		600	503	**523.2**	**470**	**600**	**501.5**	**6**
TSS	mg/L	20	27.4	22.5	33.6	28.19	15.7	52		18.1	**27.19**	**15.7**	**52**	**24.95**	**8**
Ammonia -Nitrogen	mg/L		0.03	0.46	0.21	0.06	0.08	0.04	0.14	0.11	**0.141**	**0.03**	**0.46**	**0.095**	**8**
Nitrate + Nitrate - Nitrogen	mg/L	0.67	0.12	0.27	0.3	0.57		0.43	0.42	0.43	**0.401**	**0.12**	**0.67**	**0.425**	**8**
Total Organic Carbon	mg/L	2.86	5.44	6.5	4.43	6		7.08	6.76	5.41	**5.56**	**2.86**	**7.08**	**5.72**	**8**
Total Phosphorus	mg/L	0.01	0.06	0.07	0.01	0.17	0.24	0.02	0.02	0.04	**0.071**	**0.01**	**0.24**	**0.04**	**9**
Ag	µg / L		4.93								**4.93**	**4.93**	**4.93**	**4.93**	**1**
Al	µg / L														
As	µg / L														
B	µg / L	69.6	88		82.2	86.1	82.7	84.7	99.7	81.3	**84.29**	**69.6**	**99.7**	**83.7**	**8**
Ba	µg / L	42.8	49.7		40.7	49.1	46.2	41.9	57.1	47	**46.81**	**40.7**	**57.1**	**46.6**	**8**
Be	µg / L		0.56						0.79		**0.675**	**0.56**	**0.79**	**0.675**	**2**
Ca	mg/L	70.1	88	83.3	69.7	84	65.6	77.4	83.3	74.4	**77.31**	**65.6**	**88**	**77.4**	**9**
Cd	µg / L														
Cl	mg/L	30.7	27.2	31.2	27.1	35	28	24.7	35.4	26.4	**29.52**	**24.7**	**35.4**	**28**	**9**
Co	µg / L				3.14						**3.14**	**3.14**	**3.14**	**3.14**	**1**
CO3	mg/L														
Cr	µg / L														
Cu	µg / L														
Fe	µg / L				6.47	6.9	6.62			7.26	**6.813**	**6.47**	**7.26**	**6.76**	**4**
HCO3	mg/L	277	202	291	248	299	271	154	309	249	**255.6**	**154**	**309**	**271**	**9**
K	mg/L	5.4	8.39	7.79	7.39	10.2	7.8	6.62	8.98	8.12	**7.854**	**5.4**	**10.2**	**7.8**	**9**
Li	µg / L	20.1	27.9		24.4	29.5	24.7	23.2	27.8	26.4	**25.5**	**20.1**	**29.5**	**25.55**	**8**
Mg	mg/L	32.2	36.8	34.8	30.5	36.7	30.4	32.2	38.5	32.4	**33.83**	**30.4**	**38.5**	**32.4**	**9**
Mn	µg / L	7.9	4.26		23.5	8.07	7.27			12.9	**10.65**	**4.26**	**23.5**	**7.985**	**6**
Mo	µg / L														
Ni	µg / L														
Na	mg/L	31.7	34.5	35.2	30.7	36.6	32.2	34.8	38.6	32	**34.03**	**30.7**	**38.6**	**34.5**	**9**
Pb	µg / L														
Sb	µg / L														
Se	µg / L								50.5		**50.5**	**50.5**	**50.5**	**50.5**	**1**
Si	mg/L	12.6	13.1		11.6	14.4	11.7	11.8	12	12.6	**12.48**	**11.6**	**14.4**	**12.3**	**8**
SiO2	mg/L	26.96	28.03	26.54	24.82	30.82	25.04	25.25	25.68	26.96	**26.68**	**24.8**	**30.8**	**26.54**	**9**
SO4	mg/L	134	136	150	129	158	139	118	159	152	**141.7**	**118**	**159**	**139**	**9**
Sr	µg / L	679	828		668	771	694	698	798	751	**735.9**	**668**	**828**	**724.5**	**8**
V	µg / L		5.73		6.73		5.63	7.61	4.79	5.34	**5.972**	**4.79**	**7.61**	**5.68**	**6**
Zn	µg / L														

Spring Creek

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L	239	242	310	316	281	254	186	293	229	**261.1**	**186**	**316**	**254**	**9**
Lab EC	µS/cm	750	782	951	997	1026	970	829	1058	952	**923.9**	**750**	**1058**	**952**	**9**
Lab pH		8.35	7.74	8.21	7.61	7.84	7.28	7.65	8.21	7.82	**7.857**	**7.28**	**8.35**	**7.82**	**9**
TDS	mg/L	602	642	782			650		420	724	**636.7**	**420**	**782**	**646**	**6**
TSS	mg/L	0	84.7	86.44	106	71.19	68.2	70.3	20.6	38.2	**60.63**	**0**	**106**	**70.3**	**9**
Ammonia -Nitrogen	mg/L		0.05	0.2	0.4	0.13	0.13	0.06	0.17	0.14	**0.16**	**0.05**	**0.4**	**0.135**	**8**
Nitrate + Nitrate - Nitrogen	mg/L	2.91	1.73	2.06	0.5	1.62		0.91	0.77	0.79	**1.411**	**0.5**	**2.91**	**1.265**	**8**
Total Organic Carbon	mg/L	3.44	5.79	7.97	7.02	9.14		3.97	8.23	6.5	**6.508**	**3.44**	**9.14**	**6.76**	**8**
Total Phosphorus	mg/L		0.01	0.03	0.03	0.14	0.17	0.03	0.06	0.03	**0.063**	**0.01**	**0.17**	**0.03**	**8**
Ag	µg / L		5.47								**5.47**	**5.47**	**5.47**	**5.47**	**1**
Al	µg / L														
As	µg / L														
B	µg / L	74.7	106		115	99.2	110	79.1	116	105	**100.6**	**74.7**	**116**	**105.5**	**8**
Ba	µg / L	79	69.4		74.3	71.2	68.2	66.4	103	63	**74.31**	**63**	**103**	**70.3**	**8**
Be	µg / L								0.69		**0.69**	**0.69**	**0.69**	**0.69**	**1**
Ca	mg/L	75.1	67	102	75.7	77.9	65.5	70.9	93.2	66.3	**77.07**	**65.5**	**102**	**75.1**	**9**
Cd	µg / L														
Cl	mg/L	65	70.4	86.3	79.5	59.4	82.9	46.3	92.4	89.1	**74.59**	**46.3**	**92.4**	**79.5**	**9**
Co	µg / L														
CO3	mg/L	3.9									**3.9**	**3.9**	**3.9**	**3.9**	**1**
Cr	µg / L														
Cu	µg / L	4.03									**4.03**	**4.03**	**4.03**	**4.03**	**1**
Fe	µg / L		5.88	5.3	5.71						**5.63**	**5.3**	**5.88**	**5.71**	**3**
HCO3	mg/L	284	295	378	386	343	310	227	358	279	**317.8**	**227**	**386**	**310**	**9**
K	mg/L	8.19	13.7	17	18.5	20.7	18.8	8.63	19.2	22.7	**16.38**	**8.19**	**22.7**	**18.5**	**9**
Li	µg / L	6.81	13.7		15.5	21.5	16.2	9.13	17.5	16.9	**14.66**	**6.81**	**21.5**	**15.85**	**8**
Mg	mg/L	46.5	47.9	59	61.4	59.4	48.7	44.3	64.7	55.7	**54.18**	**44.3**	**64.7**	**55.7**	**9**
Mn	µg / L		8.31								**8.31**	**8.31**	**8.31**	**8.31**	**1**
Mo	µg / L														
Ni	µg / L														
Na	mg/L	33.9	31.5	40.7	41.5	40.1	36.8	32.7	43.9	37.7	**37.64**	**31.5**	**43.9**	**37.7**	**9**
Pb	µg / L														
Sb	µg / L														
Se	µg / L								49.7		**49.7**	**49.7**	**49.7**	**49.7**	**1**
Si	mg/L	18.8	14.8		15.5	20.6	19.3	16.7	22	19.9	**18.45**	**14.8**	**22**	**19.05**	**8**
SiO2	mg/L	40.23	31.67	46.44	33.17	44.08	41.3	35.74	47.08	42.59	**40.26**	**31.7**	**47.1**	**41.3**	**9**
SO4	mg/L	126	131	148	145	156	149	89	162	150	**139.6**	**89**	**162**	**148**	**9**
Sr	µg / L	317	359		403	380	390	295	479	383	**375.8**	**295**	**479**	**381.5**	**8**
V	µg / L	4	11.5		8.84	8.12	11.6	5.18	10.2	15.4	**9.355**	**4**	**15.4**	**9.52**	**8**
Zn	µg / L														

Stone Creek

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L	148	98	193	204	199	159	182	196	194	**174.8**	**98**	**204**	**193**	**9**
Lab EC	µS/cm	788	727	861	988	983	976	916	963	981	**909.2**	**727**	**988**	**963**	**9**
Lab pH		8.26	7.72	7.89	7.68	7.33	7.6	7.63	7.83	7.63	**7.73**	**7.33**	**8.26**	**7.68**	**9**
TDS	mg/L	606	552	686			630		636	682	**632**	**552**	**686**	**633**	**6**
TSS	mg/L	103	43.1	32.58		7.64	15.6		7.9	10.5	**31.47**	**7.64**	**103**	**15.6**	**7**
Ammonia -Nitrogen	mg/L		0.02	0.31	0.19	0.06	0.14	0.03	0.1	0.12	**0.121**	**0.02**	**0.31**	**0.11**	**8**
Nitrate + Nitrate - Nitrogen	mg/L	4.7	4.81	4.51	5.32	7.27		3.69	2.68	5.28	**4.783**	**2.68**	**7.27**	**4.755**	**8**
Total Organic Carbon	mg/L	2.93	2.89	5.67	6.58	5.28		13.31	4.33	4.61	**5.7**	**2.89**	**13.3**	**4.945**	**8**
Total Phosphorus	mg/L	0.06	0.01	0.07	0.02	0.12	0.2	0.03		0.08	**0.074**	**0.01**	**0.2**	**0.065**	**8**
Ag	µg / L		5.11								**5.11**	**5.11**	**5.11**	**5.11**	**1**
Al	µg / L							31		31.8	**31.4**	**31**	**31.8**	**31.4**	**2**
As	µg / L														
B	µg / L	79.1	89.89		108	86.5	106	92.6	107	102	**96.39**	**79.1**	**108**	**97.3**	**8**
Ba	µg / L	43.4	29.6		43.2	34.5	32.3	36.4	39.4	30	**36.1**	**29.6**	**43.4**	**35.45**	**8**
Be	µg / L		0.6						0.93		**0.765**	**0.6**	**0.93**	**0.765**	**2**
Ca	mg/L	96.8	82.9	105	108	99	85	94.7	102	103	**97.38**	**82.9**	**108**	**99**	**9**
Cd	µg / L														
Cl	mg/L	63.6	67.5	69.1	71	64.6	75	55.3	70.05	78.1	**68.25**	**55.3**	**78.1**	**69.1**	**9**
Co	µg / L				5.35			4.07			**4.71**	**4.07**	**5.35**	**4.71**	**2**
CO3	mg/L														
Cr	µg / L				4.39						**4.39**	**4.39**	**4.39**	**4.39**	**1**
Cu	µg / L														
Fe	µg / L	6.73		0		6.91					**4.547**	**0**	**6.91**	**6.73**	**3**
HCO3	mg/L	181	119	236	249	243	194	222	239	236	**213.2**	**119**	**249**	**236**	**9**
K	mg/L	4.82	4.22	6.47	6.63	8.39	6.52	4.99	6.35	7.72	**6.234**	**4.22**	**8.39**	**6.47**	**9**
Li	µg / L	6.48	8.66		12.3	17.8	12.6	9.32	11.4	14.5	**11.63**	**6.48**	**17.8**	**11.85**	**8**
Mg	mg/L	32.8	26.4	32.6	32.9	30.3	32	31.1	33.2	31.6	**31.43**	**26.4**	**33.2**	**32**	**9**
Mn	µg / L	5.51									**5.51**	**5.51**	**5.51**	**5.51**	**1**
Mo	µg / L														
Ni	µg / L														
Na	mg/L	51.8	41.5	56.7	57.2	54.2	57.8	52.6	57.2	58.3	**54.14**	**41.5**	**58.3**	**56.7**	**9**
Pb	µg / L				30.1						**30.1**	**30.1**	**30.1**	**30.1**	**1**
Sb	µg / L														
Se	µg / L	67	62.4		52.6	40.9					**55.73**	**40.9**	**67**	**57.5**	**4**
Si	mg/L	14.2	11.9		15.3	14.4	15.3	12.8	14.1	15.5	**14.19**	**11.9**	**15.5**	**14.3**	**8**
SiO2	mg/L	30.39	25.47	30.39	32.74	30.82	32.74	27.39	30.17	33.17	**30.36**	**25.5**	**33.2**	**30.39**	**9**
SO4	mg/L	188	197	198	198	185	198	175	196	195	**192.2**	**175**	**198**	**196**	**9**
Sr	µg / L	262	229		269	241	249	247	256	239	**249**	**229**	**269**	**248**	**8**
V	µg / L		5.41		6.04		6.31	4.51	5.74	6.35	**5.727**	**4.51**	**6.35**	**5.89**	**6**
Zn	µg / L														

Terminal

	Units	05/01/02	06/11/02	07/10/02	08/13/02	09/17/02	10/07/02	04/22/03	07/01/03	07/29/03	Mean	Min.	Max.	Median	N
Alkalinity as CaCO3	mg/L		114	163	140				183		**150**	**114**	**183**	**151.5**	**4**
Lab EC	µS/cm		536	556	5.87				612		**427.5**	**5.87**	**612**	**546**	**4**
Lab pH			7.54	7.99	7.72				8.17		**7.855**	**7.54**	**8.17**	**7.855**	**4**
TDS	mg/L		374	354					476		**401.3**	**354**	**476**	**374**	**3**
TSS	mg/L		17.4	14.25	5.6						**12.42**	**5.6**	**17.4**	**14.25**	**3**
Ammonia -Nitrogen	mg/L			0.11	0.09				0.11		**0.103**	**0.09**	**0.11**	**0.11**	**3**
Nitrate + Nitrate - Nitrogen	mg/L														
Total Organic Carbon	mg/L		2.57	5.61	4.98				5.98		**4.785**	**2.57**	**5.98**	**5.295**	**4**
Total Phosphorus	mg/L		0.04	0.03	0.03				0.04		**0.035**	**0.03**	**0.04**	**0.035**	**4**
Ag	µg / L		6.39								**6.39**	**6.39**	**6.39**	**6.39**	**1**
Al	µg / L														
As	µg / L														
B	µg / L		55.2		56				52.8		**54.67**	**52.8**	**56**	**55.2**	**3**
Ba	µg / L		39.5		50.8				49.6		**46.63**	**39.5**	**50.8**	**49.6**	**3**
Be	µg / L		0.57						0.74		**0.655**	**0.57**	**0.74**	**0.655**	**2**
Ca	mg/L		63.4	60.4	55.1				67.9		**61.7**	**55.1**	**67.9**	**61.9**	**4**
Cd	µg / L														
Cl	mg/L		12.9	12.8	13.3				11.7		**12.68**	**11.7**	**13.3**	**12.85**	**4**
Co	µg / L		3.64								**3.64**	**3.64**	**3.64**	**3.64**	**1**
CO3	mg/L														
Cr	µg / L														
Cu	µg / L														
Fe	µg / L			0							**0**	**0**	**0**	**0**	**1**
HCO3	mg/L		140	199	170				223		**183**	**140**	**223**	**184.5**	**4**
K	mg/L		3.47	3.64	3.67				4.7		**3.87**	**3.47**	**4.7**	**3.655**	**4**
Li	µg / L		22.1		23.9				22.8		**22.93**	**22.1**	**23.9**	**22.8**	**3**
Mg	mg/L		25	26.8	28.3				27.3		**26.85**	**25**	**28.3**	**27.05**	**4**
Mn	µg / L														
Mo	µg / L														
Ni	µg / L														
Na	mg/L		22.5	25.2	26.1				24.5		**24.58**	**22.5**	**26.1**	**24.85**	**4**
Pb	µg / L														
Sb	µg / L														
Se	µg / L		50.7						46.9		**48.8**	**46.9**	**50.7**	**48.8**	**2**
Si	mg/L		8.71		7.02				9.23		**8.32**	**7.02**	**9.23**	**8.71**	**3**
SiO2	mg/L		18.64	18.45	15.02				19.75		**17.97**	**15**	**19.8**	**18.55**	**4**
SO4	mg/L		132	130	144				131		**134.3**	**130**	**144**	**131.5**	**4**
Sr	µg / L		704		774				748		**742**	**704**	**774**	**748**	**3**
V	µg / L														
Zn	µg / L														

Fisheries

Effects to fisheries were considered adverse if they resulted in a substantial increased incidence of declining years for fishery survival and production. The HYDROSS hydrology model was developed to predict reservoir and river conditions. It is important to remember that the intent of the hydrology model is not to duplicate historic flows, but rather to predict reasonable future conditions as a comparison between the two alternatives.

The model tried to fulfill the full crop irrigation requirement and did not take into consideration any management actions to conserve water during droughts. Also, the model incorporated the entire period of record inflows (1929-2002), which included years before construction of the East Bench Unit. Past reservoir levels were only available from 1965 to present. Many of these were extreme drought years, and—with several drought years in a row—resulted in several "declining" years predicted if conditions in the 1930's were to occur again. For these reasons, the modeled results varied considerably from actual past conditions, with poorer conditions predicted. Thus, the model represented the worst-case scenario but still provided a basis on which to compare the alternatives.

Clark Canyon

In general, rainbow and brown trout populations and condition factors would be expected to trend with reservoir storage and primary production in the reservoir.

Fisheries would be expected to remain healthy in years where storage remained over 60,000 AF at the end of the irrigation season, with optimum fishery conditions expected with pools over 100,000 AF. The threshold of 60,000 AF would result in about 3,000 surface acres of lake available for primary production and is the suggested minimum pool for healthy fisheries by Oswald (1993) and Oswald (2005). Surface acreage drops drastically as lake content decreases below 60,000 AF. Survival and growth of stocked and wild fish would be expected to decline in years where storage drops below this level. In drought years where the reservoir reaches the minimum pool of less than 30,000 AF, it was assumed the Eagle Lake strain rainbow trout egg collection would not take place. This would result in loss of eggs to the hatchery system for that year. It would also result in declining growth and survival of any rainbow trout stocked in the reservoir, and could cause the management decision to not stock fish that particular year.

There is not enough information about other species in the reservoir to determine specific effects, but it was assumed they would generally trend with effects to trout species as all are dependent upon primary production of the food chain.

Hydrology modeling used the period of record 1929-2002 inflows to predict EOM reservoir content for those years if the reservoir and irrigation project had been in place for each alternative. This was used to represent reservoir content in the future under the different scenarios. Conditions for fisheries in the reservoir for each year were analyzed using specific criteria to place them in one of four categories, as described below.

Category 1: Optimum

Optimum fishery conditions are based on numbers of wild brown trout and large rainbow trout in the spawning population, as well as condition factors of individual fish and plant survival (Oswald, 2005). This type of year would be characterized by adequate inflows to keep the reservoir over the set EOM level for the entire year. With optimum forecasts, rainbow trout would be expected to be stocked as young-of-year fish in the reservoir by MDFWP. MDFWP may also collect Eagle Lake strain eggs for the hatchery system if these conditions occurred.

Category 2: Good
Good fishery conditions are based on fish populations and health thriving, although at less than optimum conditions. Rainbow and brown trout populations would probably still be considered healthy though slightly lower in numbers and condition factors. With forecasted reservoir levels in this range, MDFWP would still likely stock young-of-year rainbows with anticipation of good survival and growth. Hatchery egg collection would likely be attempted and be expected to be successful if Red Rock River inflows were sufficient to trigger a spawning run.

Category 3: Fair
Fair fishery conditions are based on general fish populations and conditions sustaining, but lower numbers than under good conditions. MDFWP may decide to stock over-wintered yearling rainbows rather than young-of-year fish due to their survival advantage under stressful conditions (Oswald, 2004). MDFWP would likely decide not to collect hatchery eggs and more restrictive fishing limits might be expected to protect the fishery during these conditions.

Category 4: Declining
Declining fishery conditions are based on declining fish survival and condition factors. Even though fish populations would decline, the entire fishery would not be lost. MDFWP might choose to either suspend stocking efforts entirely or plant over-wintered fish. Fishing restrictions would be expected to protect the fishery. Hatchery egg collection would not be attempted.

Results from the hydrology model were used to analyze each year in the period of record according to the above criteria and each year was designated as one of the four categories.
The number of years falling into each category was then counted for each alternative, and the number was divided by 74 (the total years in the record) to show what percentage of years each of the fishery conditions could be expected for each alternative.

To determine effects of each alternative, the information gathered through the above method was used to compare each alternative to the No Action Alternative (the benchmark). If an alternative resulted in more years in the “optimum” or “good” categories than benchmark, or in fewer years in the “declining” category, it would be considered a positive effect. If an alternative resulted in a substantial ($\geq$ 5 years) increase of years in the “declining” category, it would be considered a negative effect.

Upper Beaverhead River

The upper Beaverhead River typically has ample spring/summer flows, but low flows in the winter can limit fishery production in this reach. As this general statement would be expected to apply to future conditions of the river in any of the alternatives, winter flows were used to predict fisheries effects. The MDFWP (1989) recommended a minimum in-stream flow of 200 cfs released from Clark Canyon Dam to support an optimal fishery. These releases were based on wetted perimeter studies evaluating available habitat.

Flows below the 200 cfs recommendation by MDFWP result in side channels and other habitats become unavailable to fish for spawning and rearing. While 200 cfs releases from the dam would be optimal, winter flows in the range of about 125-200 cfs would appear to maintain the fishery at an acceptable level, while flows less than 65 cfs would result in a poor (declining) fishery (Oswald, 2005). Brown trout spawn in the fall and the eggs over-winter, so consistent flows throughout the non-irrigation season are important to avoid either dewatering or flushing of eggs.

Hydrology modeling used the 1929-2002 period of record to predict Clark Canyon Reservoir releases to the Beaverhead River for those years if the reservoir and irrigation project had been in place for each alternative. This was used to represent reservoir outflows in the future under the different scenarios. Oswald (2003) discussed winter flows using the mean of non-irrigation season (October-March) flows, so the same method was used in this analysis. Each year was evaluated using average of October-December flows of the previous year, along with January-March of the current year to predict fishery conditions for that year. Conditions for upper river fisheries for each year were analyzed using specific criteria to place them in one of four categories, as described below.

Category 1: Optimum

Optimum fishery conditions are based on 18" or larger brown trout numbers per mile (> 500 fish per mile) and quality of fish for the following spring and summer fishing season. Increased biomass of fish in the river, condition factors, and size of fish were all found to be optimal under these conditions by Oswald (2003).

Category 2: Good

Good fishery conditions are based on 18" or larger brown trout numbers per mile (range of 350 to 500 fish per mile) and health thriving, although less than optimum conditions. Oswald (2005) stated that winter flows in this range—though not optimal—would probably be able to sustain a healthy fishery.

Category 3: Fair

Fair fishery conditions are based on 18"or larger brown trout numbers per mile (range of 200 to 350 fish per mile) and health of the fish. Under these conditions, fish numbers and health would decline slightly.

Category 4: Declining

Declining fishery conditions are based on 18" or larger brown trout numbers per mile (< 200 fish per mile) and health of the fish. Under these conditions, fish numbers and health would decline, but the entire fishery would not be lost. Oswald (2003) found sharp declines in brown trout populations and condition factors in years following these drought condition events.

As with reservoir fisheries, results from the hydrology model were used to analyze each year in the period of record according to the above criteria, and each year was designated as one of the four categories. The number of years falling into each category was then counted for each alternative, and the number was divided by 74 to show what percentage of years each of the fishery conditions could be expected for each alternative.

To determine effects, the information gathered through the above method was used to compare the Preferred Alternative to No Action (the benchmark). If an alternative resulted in more years in the "optimum" or "good" categories than benchmark, or in fewer years in the "declining" category, it would be considered a positive effect. If an alternative resulted in a substantial (≥ 5 years) increase in years in the "declining" category, it would be considered a negative effect.

Lower Beaverhead River

The lower Beaverhead River fishery also depends on ample in-stream flows. The 1985 in-stream flow right for fisheries in this section of the river is 200 cfs (Montana Department of Fish, Wildlife and Parks, 1989). Again, modeling was used to predict flows in the Beaverhead.

For the lower Beaverhead, flows near the town of Twin Bridges, Montana, were used. These flows were analyzed to compare the number of years during the period of record in which flows would be expected to drop below the optimal 200 cfs level. A decrease in such years would have a positive fishery effect, while an increase would have a negative effect.

Another issue in this section of the river is the suspected effect of return flows contributing to an inverted hydrograph. The overall hydrograph of the river was graphed to visualize any changes due to the Preferred Alternative as compared to No Action. Two lines were plotted on the graph to represent median water years (the 50th percentile) and the ten driest years on record.

Jefferson River

The Jefferson River at Twin Bridges was also modeled to compare effects of the Preferred Alternative to No Action. The overall hydrograph of this river was graphed to visualize any changes.

Social and Economic Conditions

Reclamation's East Bench Unit consists of the East Bench Irrigation District and the Clark Canyon Water Supply Company. Major irrigated crops produced by the unit are alfalfa and small grains (wheat and barley).

Table MA-1 shows crop census information supplied by the districts for 1999-2001. These are the latest years for which information is available.

Acreage for hay and irrigated pasture, combined in this analysis, is represented by *alfalfa hay* in the table. According to interviews with local farmers within the East Bench Unit, irrigated pasture is no longer a significant part of the total crop mix, an average of only 13.6 percent of district acreage from 1999-2001. Instead, farmers lease land in the mountains to pasture their cattle.

Reclamation developed a multi-crop farm budget in November 2004 to accurately reflect agriculture in the districts. Table MA-2 shows the crop mix used for the representative farm to determine *payment capacity*. Payment capacity determines the ability of the districts to pay for irrigation water, current maintenance costs, project pumping power, debt repayment, a reserve fund, and other expenses.

Table MA-1: Crop Census Data (acres)

	2001	2000	1999	Avg.	Percentage
Alfalfa Hay	17,360	18,245	17,385	17,663	38.78
Other Hay	10,170	10,536	10,276	10,327	22.68
Wheat	5,227	6,671	7,139	6,346	13.93
Barley	1,433	5,614	3,211	3,419	7.51
Irrigated Pasture	4,785	5,664	8,068	6,172	13.55
Seed Potatoes	1,184	1,147	1,232	1,188	2.61
Other	50		803	427	0.94
Total	**40,209**	**47,877**	**48,114**	**45,542**	**100**

Table MA-2: Crop Mix for the Districts

Crops	Establishment Alfalfa	Alfalfa	Wheat	Barley	Total Irrigated Acreage
Acres	60	240	80	60	440
Percentage	13.64	54.55	18.18	13.64	100

Hydrology models for the study predicted changes in the average annual water supply to farms for the different alternatives. The model results, accounting for conveyance system losses and on-farm efficiencies, were used to evaluate the potential impacts to the irrigators. The indicator used in the analysis is the amount of water available for beneficial use by the crop, as measured at the crop root zone.

The two primary methods of applying irrigation water to crops utilized by irrigators in the both the CCWSC and the EBID are flood and sprinkler application techniques. Due to the difference in efficiencies in the two methods, the amount of water diverted at the river headgate to the crop root zone is different for the two irrigation methods.

The water available at the crop root zones for both the CCWSC and the EBID to the No-Action and Preferred Alternatives is displayed in Table MA-3. The information in the table displays the average values and percentile values for all the irrigated acres (composite total) of each entity and is also provided for the two irrigation methodologies (flood and sprinkler application) utilized by the producers for the study period .

Table MA-3: Water Deliveries to the Crop Root Zones

		No Action Alternative			Preferred Alternative		
Entity	Statistical Indicator	Composite Total (AF/ac)	Sprinkler Delivery (AF/ac)	Flood Delivery (AF/ac)	Composite Total (AF/ac)	Sprinkler Delivery (AF/ac)	Flood Delivery (AF/ac)
CCWSC							
	Average	1.45	1.47	1.36	1.36	1.38	1.29
	10th Percentile	1.15	1.24	0.84	0.92	0.96	0.80
	25th Percentile	1.26	1.32	1.12	1.14	1.19	1.08
	50th Percentile	1.45	1.45	1.42	1.40	1.40	1.37
	75th Percentile	1.61	1.61	1.60	1.56	1.57	1.53
	90th Percentile	1.76	1.76	1.75	1.68	1.72	1.65
EBID							
	Average	1.04	1.04	1.01	1.05	1.05	1.01
	10th Percentile	0.32	0.32	0.37	0.62	0.63	0.60
	25th Percentile	1.01	1.01	0.90	0.94	0.94	0.90
	50th Percentile	1.17	1.17	1.14	1.12	1.12	1.09
	75th Percentile	1.30	1.30	1.29	1.29	1.29	1.21
	90th Percentile	1.41	1.41	1.40	1.38	1.38	1.31

Recreation

Effects of the alternatives on recreation were considered adverse if they resulted in a decline in the quality or quantity of recreational facilities or services, or if they involved installation of new facilities that could adversely affect the recreational environment.

Barretts Diversion Dam Flows

Median flows (1929-2002) at Barretts Diversion Dam range from a low of 106 cfs in January to a high of 1139 cfs in July. The Beaverhead River has higher flows during the irrigation season, which is also the prime recreation season for fishermen and floaters.