ARC-85-7

IRRIGATED LAND ASSESSMENT OF THE UPPER CLARK FORK DRAINAGE

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Submitted to:
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I. INTRODUCTION

The Montana Department of Fish, Wildlife and Parks (DFWP) is preparing a water reservation request for the upper Clark Fork drainage to be submitted to the Montana Department of Natural Resources and Conservation (DNRC) for review and analysis. One aspect of the water reservation request concerns the status of irrigated land and potentially irrigable land within the upper Clark Fork Valley.

This report discusses the methods used to identify potentially irrigable land and presents acreage figures for irrigated and irrigable land in the upper Clark Fork Valley. Constraints to irrigation imposed by economics and heavy metals are discussed and reflected in the data presented. No attempt was made to project how future costs may alter economic feasibility or how future reclamation activities may ameliorate heavy metal toxicity problems. In addition, the critical question of if and where water may be available for expanding irrigation in the upper Clark Fork drainage was not addressed.

II. MAPPING OF LANDS

A. Arable Lands

Arable lands are those lands which have suitable soil, climatic, and topographic features for supporting sustained crop production. Arable lands only become "irrigable" when water is available and can be supplied and applied cost effectively.

Arable lands that are not currently being irrigated were mapped utilizing aerial photographs upon which soil mapping units had been delineated by the Soil Conservation Service (SCS). Photocopies were made of the aerial photographs while visiting SCS offices in Deer Lodge and Philipsburg. Composite working maps were constructed by taping the photocopies together along the match lines as delineated on the aerial photographs.

Based on capability classes and soil correlations provided by the SCS, all lands that were Class I, II, III, or IV were identified and shaded in on the composite working maps. These lands can sustain irrigated agriculture, but have certain limitations that must be considered by agriculturists.

B. Irrigated Lands

The status of irrigated lands in the upper Clark Fork Valley was determined by relying upon existing data, photointerpretation, field reconnaissance, aerial observation, and limited aerial imagery recorded on a video cassette. The State Engineer's Office has assembled existing data on irrigated lands in the form of a "Water Resources Survey" for each Montana county. Each survey includes maps showing irrigated lands, irrigation ditches, and other pertinent features. Because, however, the Water Resources Surveys were compiled in the 1950s and 1960s, the mapping of irrigated lands is not current.

Updating the mapping of irrigated land acreages was accomplished by comparing SCS aerial photographs with the Water Resources Survey data base. Lands which appeared to be irrigated on aerial photographs, but which were not mapped on Water Resources Surveys, were added to the irrigated land base map. A constraint to updating irrigated land acreages by aerial photointerpretation was that the aerial photographs for Granite County were taken in 1965, whereas the aerial photographs for Deer Lodge and Powell counties were taken in 1976. Because the photographs were not taken at the same time, consistent updating was not possible using aerial photographs.

Additional irrigated lands were identified and mapped through direct aerial observation. A helicopter flight over the study area was made on August 3, 1984. The flight was made during the peak of the irrigation season; therefore, irrigated lands contrasted with the dessicated adjacent rangeland.

On July 18, 1985, aerial imagery was acquired on a video cassette recorder (LMS system) for irrigated lands northwest of Deer Lodge. Because it was apparent that new pivot systems had been added during the course of this study, the imagery was used with the LMS system at the DNRC to update the mapping of irrigable lands.

C. <u>Irrigable Lands</u>

Irrigable lands were identified and delineated on base maps after economic and heavy metal toxicity constraints were considered. Economic constraints were developed based on the assumption that water would either have to be pumped from an existing river or large stream or supplied from reservoirs not yet constructed. Heavy metal constraints were based on data which identified areas where waterborne mine tailings have been deposited on the floodplain of the Clark Fork River.

1. Pumping From Rivers

The economics of pumping irrigation water from the Clark Fork and major tributaries (i.e., Little Blackfoot and Flint Creek)[1] were considered based on a computer analysis using the Soil Conservation Service IRRSYS model. After updating costs of commodities such as electricity, pipes, and pumps (see Appendix A for the parameters included in the analysis), costs for supplying water, as a function of pumping lift elevation, distance, and acreage, were calculated. By varying pump lift elevation, distance, acreage, and irrigation system size, matrices were constructed (Figures 1 through 10) which show the relationships among these variables.

Based on the data generated from the IRRSYS model, costs associated with construction and operation of irrigation systems have been determined. These costs, however, do not include the cost of planting, managing, and harvesting the crop. In order for irrigation to be economically feasible, the value of the crop must offset the cost of supplying water (i.e., IRRSYS model values). Figure 11 is a flow diagram showing how the IRRSYS model used in conjunction with other information was used to identify potentially irrigable lands.

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[1]Only the Clark Fork and major tributaries were considered in the analysis because, based on field observations, tributary streams appear to be maximally utilized as irrigation sources at the present time. Also, it was believed that for the cost of installing a sprinkler irrigation system to be justified, a reliable source of water would be necessary throughout the growing season. The smaller tributary streams probably would not consistently provide water during dry years.

FIGURE 1

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 40-ACRE WHEEL LINE IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	89	100	111	125	137	153	167	180	194	207		
.3	96	108	119	135	147	163	177	189	202			
.5	103	115	126	145	160	179	194	208				
.7	113	127	142	153	175	189	205					
.9	120	137	154	166	186	200						
1.1	130	144	162	173	196							
1.3	140	152	172	193	211							
1.5	148	159	182	205								
2.0	171	192	214									
2.5	204											
3.0												
3.5												
4.0												
4.5												
5.0												
5.5												

FIGURE 2

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND
DISTANCE FROM WATER SOURCE FOR A 80-ACRE WHEEL LINE IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	83	98	111	125	137	151	162	179	192	205		
.3	87	103	117	133	146	161	172	193	206			
.5	94	109	125	139	153	168	180	204				
.7	101	118	131	147	160	177	190	214				
.9	106	125	139	154	172	185	215					
1.1	115	131	144	163	180	192	227					
1.3	120	137	151	170	187	200						
1.5	125	144	157	176	195	207						
2.0	141	159	180	194	215							
2.5	154	174	199	213								
3.0	178	191	217									
3.5	194	208										
4.0												
4.5												
5.0												
5.5												

FIGURE 3

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND
DISTANCE FROM WATER SOURCE FOR A 100-ACRE WHEEL LINE IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	85	98	112	124	136	150	163	179	193	206		
.3	88	103	116	133	146	159	172	192	204			
.5	95	110	124	138	151	166	179	202				
.7	101	116	129	145	162	174	200					
.9	107	123	137	152	169	182	211					
1.1	113	129	146	158	176	189	221					
1.3	117	134	153	165	183	196						
1.5	123	141	159	171	190	203						
2.0	141	155	175	196								
2.5	156	179	192	215								
3.0	172	197	222									
3.5	187	212										
4.0	215											
4.5												
5.0												
5.5												

FIGURE 4

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 100-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	76	88	101	113	126	137	150	161	176	188	201	
.3	79	92	105	117	133	145	158	171	190	202	210	
.5	84	98	112	125	138	150	165	177	200	212	216	
.7	89	102	117	131	145	156	172	185	208	221	223	
.9	94	109	125	137	152	168	179	206	219	232	232	
1.1	97	115	130	143	159	174	187	217	229	228	239	
1.3	102	119	135	148	165	182	193	230	242	235	248	
1.5	108	124	141	159	171	188	201	240	252	242		
2.0	121	138	155	175	186	204	252	239	250			
2.5	138	157	169	191	212	224	248					
3.0	150	171	195	207	231							
3.5	164	186	210	237								
4.0	188	201	227									
4.5	201	232										
5.0												
5.5												

FIGURE 5

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 135-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	76	88	100	112	124	136	150	162	176	188	201	
.3	80	92	105	117	133	146	158	169	188	201		
.5	85	99	112	124	138	152	165	176	199			
.7	90	104	118	130	144	159	171	182	210			
.9	95	109	124	139	151	166	178	210				
1.1	100	115	130	146	159	171	183	221				
1.3	104	120	135	153	165	178	190	231				
1.5	113	130	141	158	173	186	198					
2.0	126	143	162	175	189	202						
2.5	145	166	178	194	206							
3.0	159	183	184	210								
3.5	185	198										
4.0	202											
4.5												
5.0												
5.5												

FIGURE 6

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 170-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	76	88	100	107	119	138	151	163	177	190	201	
.3	81	93	106	119	133	144	158	169	188	200		
.5	85	97	110	123	138	149	164	177	198			
.7	88	100	114	128	142	154	169	196				
.9	92	106	120	132	147	164	176	207				
1.1	96	110	125	138	153	169	181	217				
1.3	99	115	129	142	158	175	188	227				
1.5	103	118	135	152	164	183	225					
2.0	112	128	147	166	177	197						
2.5	121	140	158	179	201							
3.0	138	157	171	192	216							
3.5	148	170	194	205								
4.0	158	182	207									
4.5	182	194	214									
5.0	194	221										
5.5	206											

FIGURE 7

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 205-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet) 40	80	120	160	200	240	280	320	360	400	440	480
.1	78	89	102	115	127	140	152	165	180	192	204	
.3	82	93	107	120	133	146	158	171	189	202		
.5	84	96	109	122	136	148	161	174	195	207		
.7	86	98	111	125	138	150	164	176	200			
.9	87	101	115	126	141	153	167	179	205			
1.1	91	105	120	132	146	161	173	203				
1.3	95	109	124	136	151	166	179	214				
1.5	98	111	126	141	154	169	182	220				
2.0	118	136	148	166	184	197						
2.5	129	149	167	180	199							
3.0	140	159	181	202								
3.5	159	171	194	216								
4.0	171	195	207									
4.5	183	208										
5.0	209											
5.5												

FIGURE 8

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE FOR A 240-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	79	91	104	117	129	141	154	166	181	193	205	
.3	83	95	109	121	134	147	160	172	191	202		
.5	86	98	112	124	138	151	165	177	201			
.7	90	102	115	129	144	155	171	200				
.9	92	104	119	134	149	161	177	209				
1.1	96	110	125	137	154	170	182	220				
1.3	99	114	130	142	159	175	217					
1.5	102	117	134	146	163	180	227					
2.0	111	128	144	163	175	195	252					
2.5	119	137	155	175	188	209						
3.0	127	146	166	188	212							
3.5	143	165	177	200								
4.0	153	174	199									
4.5	162	186	229									
5.0	172	196										
5.5	195	245										

FIGURE 9

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE AND A 275-ACRE CENTER PIVOT IRRIGATION SYSTEM

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	81	93	105	118	131	143	156	168	182	195	207	
.3	84	97	109	123	136	148	161	174	193	205		
.5	88	100	113	126	140	153	166	179	203	215		
.7	91	104	117	131	145	157	172	201	214			
.9	94	109	122	136	150	166	178	211				
1.1	97	112	127	139	154	170	183	221				
1.3	101	116	131	143	160	176	189	232				
1.5	104	119	135	152	164	182	194	242				
2.0	113	129	146	164	176	194	211					
2.5	121	144	156	176	196	269						
3.0	135	154	176	188	211							
3.5	144	165	187	212								
4.0	154	176	199									
4.5	174	199										
5.0	184	211										
5.5	195											

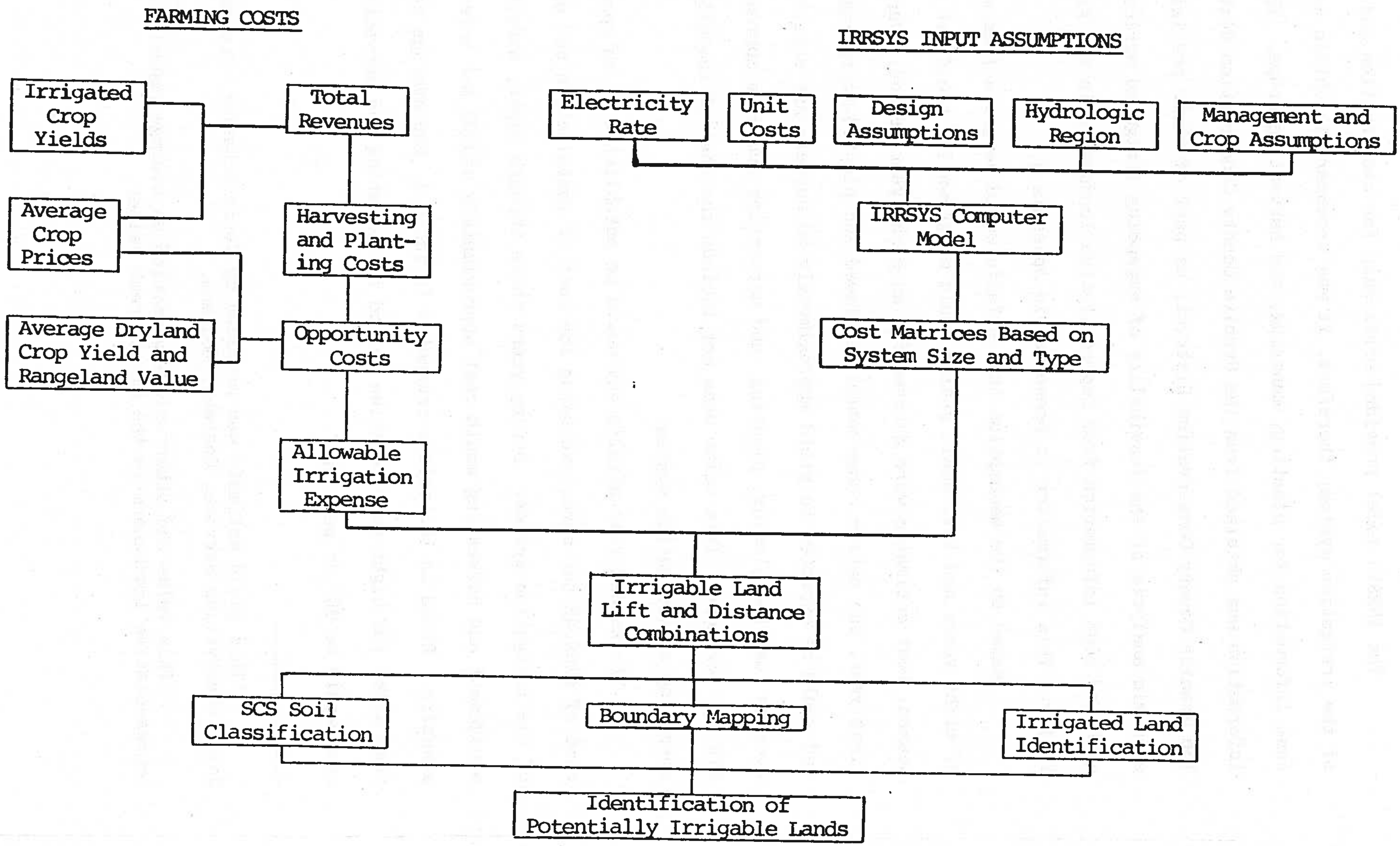
FIGURE 10

COST RELATIONSHIPS BETWEEN PUMPING LIFT ELEVATION AND DISTANCE FROM WATER SOURCE AND COMPOSITE FOR ALL IRRIGATION SYSTEMS

Distance (Miles)	Pumping Lift Elevation (Feet)											
	40	80	120	160	200	240	280	320	360	400	440	480
.1	76	83	100	112	124	136	150	161	176	188	201	210
.3	79	92	105	117	133	144	158	169	188	200		
.5	85	97	110	123	138	149	164	176	198	210		
.7	88	100	114	128	143	154	169	182	208			
.9	92	104	119	132	147	161	176	206				
1.1	95	110	125	137	153	169	181	217				
1.3	99	114	129	142	158	175	188	227				
1.5	102	117	134	146	163	180	194	235				
2.0	111	128	144	163	175	195	211					
2.5	119	137	155	175	188	209						
3.0	127	146	166	188	205							
3.5	143	164	177	200								
4.0	153	174	199									
4.5	162	186	212									
5.0	172	196										
5.5	195											

FIGURE 11

FLOW DIAGRAM FOR IDENTIFYING IRRIGABLE LANDS



Source: John Tubbs, Economist, Montana Department of Natural Resources and Conservation.

The IRRSYS model provided costs only for construction and operation of the irrigation system; therefore, it was necessary to obtain additional cost information for planting, managing, and harvesting crops. This information was obtained from the Granite County Conservation District. The Granite County Conservation District, as part of their preliminary economic analysis of the feasibility of expanding irrigated agriculture, gathered cost information from representative landowners in the Flint Creek Valley. This information is presented in Appendix B.

Based on the assumption that alfalfa would be grown from seven out of eight years and that small grains would be grown for the first planting season, cost estimates were derived for an eight-year period. During the first year, the native range would be plowed and planted to spring wheat and would be expected to yield approximately 60 bushels per acre.[2] The average cost for plowing, planting, and harvesting would be approximately $78.42[3] per acre. This value does not include the cost of installing and operating an irrigation system.

The second year alfalfa hay would be established at an approximate cost of $109.42 per acre, excluding the cost of installation and operation of the irrigation system. During years three through eight, alfalfa management and harvesting would cost approximately $59.03 per acre annually. Based on the values presented in Table 1, the average cost per year after the eight-year rotation period for planting and harvesting the crop would be $67.75 per acre.

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[2]This yield estimate was provided by Jerry Schaefer, Economist, Soil Conservation Service, Bozeman, Montana.

[3]This value and other values presented an average reported by two representative landowners in the Flint Creek Valley.

TABLE 1

PROJECTED COSTS AND CROP VALUES FOR EIGHT-YEAR ROTATION PERIOD

Year	Cost/Acre	Yield/Acre	Price[1]	Value/Acre[2]
1	$ 78.42	60 bu.[3]	$3.89/bu.	$233.40
2	$109.42	4 tons	$68/ton	$272.00
3	$ 59.03	4 tons	$68/ton	$272.00
4	$ 59.03	4 tons	$68/ton	$272.00
5	$ 59.03	4 tons	$68/ton	$272.00
6	$ 59.03	4 tons	$68/ton	$272.00
7	$ 59.03	4 tons	$68/ton	$272.00
8	$ 59.03	4 tons	$68/ton	$272.00
Average	$ 67.75			$267.18

[1]These prices are based on an 5.5 year average for spring wheat and alfalfa, adjusted to May 1984 dollar values (Kangas 1984).

[2]This value does not consider installation costs for the sprinkler system.

[3]This value was provided by Jerry Schaefer, Economist, Soil Conservation Service, Bozeman, Montana (October 1984).

The average value of the crop over an eight-year period was estimated to be $267.18 per acre. In order for irrigation to become economically feasible, water would have to be delivered at a cost of less than $195.68 per acre ($267.18 - $67.75 - $3.75).[4]

2. Water Development Projects

The Granite County Conservation District is currently studying dam sites for possible water developments in the Flint Creek Valley. One site is on Boulder Creek near Princeton and another site is on the North Fork of Willow Creek above the existing Willow Creek Reservoir. Both sites would provide gravity feed irrigation water to areas that are not currently being irrigated. The Boulder Creek project would allow 5,000 acres to be converted from rangeland to cropland, whereas the Willow Creek project would expand the irrigated land base by 2,000 acres.

Although the final economic analyses of these water development projects have not been completed by the Granite County Conservation District and the SCS, some preliminary economic information is available. Based on the projected benefits of the project, irrigation water would have to be delivered at $38.21 per acre-foot to provide a favorable benefit/cost ratio.

As previously stated, final economic information is not yet available on the projects, particularly in regard to costs of water delivery. In the absence of such information, data on water delivery costs compiled by Finnie (1984) were reviewed. Based on information presented by Finnie, non-subsidized project costs typically run $50.00 per acre-foot for repairing or retrofitting existing water impoundments and between

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[4]The value of the crop is $267.18; $67.75 is the cost of planting, managing, and harvesting; $3.75 is the present value of the grazing land that would be lost.

$150.00 and $300.00 per acre-foot for building new storage capacity. If Finnie's projected cost estimates are anywhere near correct, the cost of delivering water from the proposed Boulder Creek and Willow Creek projects would be prohibitive.

3. Heavy Metal Constraints

Contamination of soils by heavy metals in the upper Clark Fork drainage is a problem which limits the productive potential of some lands and may seriously impair water quality. Airborne heavy metal particulates have been emitted from the Anaconda Smelter since the late 1800s and have settled on land in the Deer Lodge Valley. Additionally, waterborne mine tailings with heavy metal concentrations have contaminated floodplain soils and some agricultural land in close proximity to the Clark Fork River. Heavy metals in soils impose constraints on various land uses including irrigated agriculture. A discussion of studies which have addressed the heavy metal problems in the Deer Lodge Valley and the riverine ecosystem downstream is presented in Appendix C.

Taking into account the constraints that heavy metals impose on irrigated agriculture, no lands were considered potentially irrigable if they occurred on the floodplain between Anaconda and Drummond. Because tailings have been deposited at least as far downstream as Drummond, agricultural activities on the floodplain along this reach of the river could mobilize heavy metals and increase contamination of the Clark Fork River.

Arable lands were considered to be potentially irrigable if they occurred on the floodplain between Drummond and Bonner. Although heavy metals may be present along this reach of the river, there are no "slickens" areas which are readily apparent. Also, there are no reports that heavy metals have affected agricultural activities along this reach of the Clark Fork.

III. RESULTS

Acreages of irrigated and irrigable lands within the upper Clark Fork drainage are presented for various river reaches in Table 2. Only those irrigable acreages capable of being served economically by pumped irrigation water are shown. Economic feasibility has been determined by relying upon the cost values shown in the composite matrix (Figure 10). The composite matrix was used because it reflects the maximum lifts and distances that water could be pumped at the lowest cost for any of the size and type irrigation systems analyzed.

Land acreages that would be irrigable with the construction of water impoundments are not presented. At this time, the benefit/cost ratio of supplying water through new storage facilities does not appear to be favorable. However, data being compiled by the Granite County Conservation District may require additional study to determine the economics of potential water development projects.

In general, the acreages of irrigable lands in the upper Clark Fork Valley occur on the terraces above the floodplain from 3/4 to 1 1/2 miles from the Clark Fork or a major tributary. Because of the distance from the water source and relatively high pumping lift elevation, most of the potentially irrigable land is economically marginal to irrigate. Probably because of the marginal benefit/cost status, very little land is irrigated by pumping directly from the Clark Fork or a major tributary. Most terraces or benches that are now being irrigated are provided with gravity-feed irrigation water supplied from tributary drainages that have been diverted at higher elevations.

TABLE 2

ACREAGE VALUES FOR IRRIGATED AND IRRIGABLE LANDS IN THE UPPER CLARK FORK DRAINAGE

River Reach	Irrigated Acres	Irrigable Acres
Clark Fork (Bonner-Rock Creek)	1,708	480
Clark Fork (Rock Creek-Drummond)	2,236	411
Clark Fork (Drummond-Gold Creek)	2,841	3,863
Perkins Creek	34	--
Clark Fork (Gold Creek-Garrison)	483	1,447
Gold Creek	1,506	--
Warm Springs Creek	52	--
Carten Creek	19	--
Clark Fork (Garrison-Deer Lodge)	2,992	3,456
Mullan Gulch	1,571	--
Willow Creek	553	--
Clark Fork (Deer Lodge-Warm Springs)	6,185	2,042
Warm Springs Creek	1,255	--
Lost Creek	4,572	--
Race Track Creek	8,155	--
Caribou Creek	1,507	--
Peterson Creek	1,046	
Dempsey Creek	1,727	--
Cottonwood Creek	926	--
Fred Burr Creek	4,602	--
Tin Cup Joe Creek	1,109	--
LaMarche Creek	3,196	--
Barker Creek	--	--
Twin Lakes Creek	--	--
Flint Creek (Drummond-Maxville	7,295	1,317
Willow Creek	5,983	--
Flint Creek (Maxville-Georgetown Lake)	9,698	912
North Fork Flint Creek	5	--
Silver Creek	20	--
Boulder Creek	--	--
Little Blackfoot (Garrison-Headwaters)	4,265	1,825
Dog Creek	447	--
Snowshoe Creek	758	--
Trout Creek	604	--
Carpenter Creek	532	--
Six Mile Creek	4,137	--
Total	82,019	15,753

INFORMATION SOURCES

INFORMATION SOURCES

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Kangas, A. 1984. Economic data compiled by Arlen Kangas of the Montana Department of Natural Resources and Conservation, Helena, Montana.

Schaefer, J., Economist, Soil Conservation Service, Bozeman, Montana. Personal communication (October 2, 1984) to Joe C. Elliott, Ecological Consultant, Helena, Montana.

APPENDIX A

PARAMETERS INCLUDED IN MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION ANALYSIS

IRRSYS INPUT VARIABLES

Name of file: Irrsys.dat(see following pages)

% of Alfalfa: 100%

Peak Use: variable depending on hydrologic region.

Ave. Annual Use: variable depending on hydrologic region.

% Sprinkler Acreage: 100%

Ave. Irrigation Efficiency: 70% (center pivot) or 65% (wheel line)

Max. Net Application: 2 in. (center pivot) or 3 In.(wheel line)

Ave. Pumping Head: variable depending on pivot size.

Peak Management Efficiency: 95%

Seasonal Management Efficiency: 85%

Storage Costs: 0

Additional Costs: 0 for single irrigation system, include turn out costs for multiple irrigation system.

Lateral Electrical Energy: 0

Land Right Costs: 0

Reach: 4

# of Pumps: 1

Ave. Column Diameter: 8 in.(center pivot) or 6 in. (wheel line)

Ave. Column length: 10 ft.

Max. Lift from Water Source: 5 ft.

Min. Outlet Pressure: 0

Powerline Length: 2 mi.

Total Static Head: 0

Inlet Operating Pressure: 0

Additional Flow Required: 0

Reach: variable depending on pipe used- pvc or wsp.

Reach Length: variable.

Acres Served: variable.

Max. Head Loss: 10 ft.

Elevation Change: variable.

Min. Outlet Pressure: 30 psi (center pivot) or 50 psi (wheel line).

Additional Flow: 0

Reach: may be additional reaches if multiple pivots are modeled.

Source: Communication with and review by the U.S. Department of Agriculture: Soil Conservation Service, Bozeman Montana.

Row							
1	B1	B2	Z1	ANO	AN1	V1	AKO
2	T1	T2	Z3	Z4	B3	B4	Z2
3	AN2	V2	AK1	AK2	D3	AK3	AN3
4	AK4	AN4	E8	E9	D5	AK5	AN5
5	V5	T5	AK6	AN6	V6	P6	W6
6	T6	F8	F9				
7	CO	C1	C2	C3	U(1)	U(2)	U(3)
8	U(4)	U(5)	U(6)	U(7)	U(8)	U(9)	U(10)
9	U(11)	U(12)	U(13)	U(14)	E5	E6	C4
10	E7	C5	C6	BO	C7	F4	G4
11	F5	G5	G6	AI1	AI2	YO	Y1
12	Y2	Y3	AI3	AI4	AI5	AI6	Y4
13	Y5						

DESCRIPTION OF VARIABLES USED IN IRRSYS PROGRAM

B1	Earth Canal Minimum Bottom Width (FT)
B2	Earth Canal Maximum Bottom Width (FT)
Z1	Earth Canal Inner Side Slopes Z1:1
ANO	N-Value of Aged Channel
AN1	N-Value of Newly Constructed Channel for TR#25 Stability Check
V1	Maximum Allowable Velocity (FPS) for Stability Check
AKO	Water Surface Evaporation At Peak Delivery (In/Day)
T1	Canal Top Width on Downhill Side (FT)*
T2	Canal Top Width on Uphill Side (FT)*
Z3	Side Slope For Fill Areas Other Than Canal Inner Slopes Z3:1*
Z4	Side Slope For Excavated Areas Other Than Canal Inner Slopes Z4:1*
B3	Concrete Lined Canal Minimum Bottom Width (FT)
B4	Concrete Lined Canal Miximum Bottom Width (FT)
Z2	Concrete Lined Canal Inner Side Slopes Z2:1
AN2	N-Value of Concrete Lined Canal
V2	Concrete Lined Canal Miximum Water Velocity (FPS)
AK1	Ratio of Seepage Cracks to Wetted Area In Lined Canal
AK2	Concrete Canal Lining Thickness (IN)
D3	Siphon Maximum Diameter (IN)
AK3	Siphon Sum of Loss Coefficients
AN3	N-Value for Siphon (Concrete Pipe)
AK4	Pump Sum of Loss Coefficients
AN4	N-Value for Pump Inlet Pipes
E8	Pump Efficiency
E9	Motor Efficiency (Pump Drive)
D5	Welded Steel Pipe Maximum Diameter (IN)
AK5	Welded Steel Pipe Sum of Loss Coefficients
AN5	N-Value Welded Steel Pipe

V5	Welded Steel Pipe Maximum Water Velocity (FPS)
T5	Steel Yield-Point Stress (PSI)
AK6	PVC-IPS & PVC-PIP Sum of Loss Coefficients
AN	PVC-IPS & PVC-PIP Hazen-Williams Design C
V6	PVC-IPS & PVC-PIP Maximum Water Velocity
P6	PVC-IPS & Minimum Pressure Rating (PSI)
W6	Maximum Working Pressure SF (%)
T6	PVC-IPS & PVC-PIP Hydrostatic Design Stress (PSI)
F8	On-Farm Pump Efficiency
F9	On-Farm Motor Efficiency
C0	Unit Cost of Earth Fill ($/CYD)
C1	Unit Cost of Earth Excavation ($/CYD)
C2	Unit Cost of Concrete Lining ($/CYD)
C3	Unit Cost of Structural Concrete ($/CYD
U(1)	Unit Cost 12-Inch RCP Siphon
U(2)	Unit Cost 15-Inch RCP Siphon
U(3)	Unit Cost 18-Inch RCP Siphon
U(4)	Unit Cost 21-Inch RCP Siphon
U(5)	Unit Cost 24-Inch RCP Siphon
U(6)	Unit Cost 27-Inch RCP Siphon
U(7)	Unit Cost 30-Inch RCP Siphon
U(8)	Unit Cost 36-Inch RCP Siphon
U(9)	Unit Cost 42-Inch RCP Siphon
U(10)	Unit Cost 48-Inch RCP Siphon
U(11)	Unit Cost 54-Inch RCP Siphon
U(12)	Unit Cost 60-Inch RCP Siphon
U(13)	Unit Cost 66-Inch RCP Siphon
U(14)	Unit Cost 72-Inch RCP Siphon
E5	Unit Cost of Electricity ($/KW-HR)
E6	Electricity Demand Charge ($/BHP)
C4	Unit Cost of Pumps ($/BHP)
E7	Unit Cost of Power Line Construction ($/Mile)
C5	Unit Cost of Welded Steel Pipe ($/LB)**
C6	Unit Cost of Welded Steel Pipe ($/DIA-IN)**
B0	Unit Cost of Pipe Bedding ($/CYD)
C7	Unit Cost of PVC-IPS & PVC-PIP Pipe ($/LB)***
F4	Sprinkler or Pumping Irrigation System Cost ($/AC)
G4	Flood Irrigation System Cost ($/AC)
F5	Sprinkler Irrigation Labor Requirement (HR/AC/IRR)
G5	Flood Irrigation Labor Requirement (HR/AC/IRR)
G6	Irrigation Labor Cost ($/HR)
A11	Project Interest Rate (%)

AI2	On-Farm Interest Rate (%)
YO	Construction Period (YRS)
Y1	Expected Project Life (YRS)
Y2	Expected Pump Life (YRS)
Y3	Expected On-Farm System Life (YRS)
AI3	O&M (%) - Pipelines, Structures, Etc.
AI4	O&M - Ditches and Concrete Lining
AI5	O&M - Pumps
AI6	O&M - On-Farm Systems
Y4	Contingency Factor for Planning to Design (%)
Y5	Engineering and Project Administration Costs (%)

* These values are used for both earth and concrete lined canals.

** WSP installation cost = (1.6)[(weight of pipe) (C5)+(DIA)(C6)]+Bedding

*** PVC installation cost = (1.6) (weight of pipe)(C7)+Bedding

1.6 * Unit cost of pipe accounts for trench excavation, shaping, backfill, equipment, and labor based on estimates in dodge guide to construction costs - 1977.

ANNOTATED DESCRIPTION OF IRRSYS INPUTS[1]

Percent of Alfalfa: 100%

A crop composition of 100 percent alfalfa is assumed since alfalfa is one of the most water intensive crops grown in the state. The system design that will meet the consumptive demands of alfalfa will also be capable of meeting the requirements of other crop mixes. This assumption, however, results in a slight over estimation of annual costs. This over estimation is mainly a result of exaggerated electric costs over the project life. The model forecasts equal annual energy demands needed to meet the consumptive needs of alfalfa. However, annual electric demand will drop, even assuming 100 percent alfalfa, in years when, for agronomic reasons, the ground is fallow or planted with a crop with lower water needs.

Peak Use: (variable) Average Annual Use: (variable)

These variables are dependent upon which climatic region the acreage being analyzed is located. The USDA-SCS has identified five climatic regions in the state.

Percent Sprinkler Acreage: 100%

All irrigated acreage is assumed to be sprinkler irrigated with no flood irrigation.

Average Irrigation Efficiency: 70% (center pivot) or 65% (wheel line)

This efficiency represents the average amount of water applied by an on-farm irrigation system that is consumed by the crop divided by the total amount applied. The unconsumed portion accounts for water losses due to deep percolation,

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[1]Source: John Tubbs, Economist, Montana Department of Natural Resources and Conservation, Helena, Montana.

evaporation, and return flow. These percentages were provided by the USDA-SCS staff in Bozeman.

Maximum Net Application: 2 inch (center pivot), 3 inch (wheel line)

Maximum net application represents the amount of water needed to be placed in the soil by an irrigation system to meet crop water requirements. These application amounts represent the typical Montana farm and were provided by the USDA-SCS staff.

Average Pumping Head: (variable)

Average pumping head refers to the amount of pressure needed to compensate for friction loss in the irrigation system. Friction losses were calculated using the Hazen-Williams equation.

Peak Management Efficiency: 95%
Seasonal Management Efficiency: 85%

These efficiencies were recommended by the USDA-SCS staff as representative of a well managed irrigation system.

Storage Costs: 0

No storage costs were added to system costs, therefore, costs are slightly understated over the project life. A 10 percent contingency factor was included to compensate for this type of under estimation.

Additional Costs: (variable)

No additional costs were added when the system being modeled involved only a single center pivot or wheel line. The cost of turn outs in a multiple pivot system were added, however. For example, $3,000 of additional costs were included for a multiple system composed of two center pivots, $1,500 for each of two turn outs.

Lateral Electrical Costs: 0

No electrical demand was attributed to the laterals. Thus, no costs were included.

Land Rights: 0

Land right costs are assumed to be zero, since the model identifies small acreages and the time involved in identifying land right problems is prohibitive for this study.

Reach: 1

This reach identifies the basic parameters needed to design the pump system. There are nine parameters that are inclusive to this reach.

Number of Pumps: 1

Average Column Diameter: 8 inch (center pivot), 6 inch (wheel line)

Maximum Lift from Water: 5 feet

Minimum Outlet Pressure: 0

This is the minimum pressure needed at the inlet to the on-farm system. Since the pump is attached to the pipeline, zero pressure is assumed. IRRSYS will determine the minimum outlet pressure needed for the pipeline.

Powerline Length

Because the upper Clark Fork basin is in the Montana Power Company service area, no costs were entered into the model for powerline construction. The Montana Power Company constructs powerlines without directly assessing the user for the cost.

Total Static Head: 0

Static head is zero because of the type of system modeled.

Inlet Operating Pressure: 0

Inlet operating pressure is zero due to the type of system modeled.

Additional Flow: 0

Additional flow is zero because of the type of system modeled.

Reach #2

This reach identifies the basic parameters of the water delivery system from the pump to the on-farm system. The first input identifies the type of delivery system (earth canel or pipeline) and the type of material used (PVC or welded steel pipe (WSP)). There are six parameters that are inclusive of this reach.

Reach Length: (variable)

This variable along with elevation change are key to the estimation of irrigable acres. By incrementally increasing reach length and distance the cost matrices are created. The underlying relationship of increasing system costs associated with increasing distances and lifts from the pump allowed the creation of the cost matrices. Reach length was increased by 1/10th of a mile increments up to 6 miles.

Acres Served: (variable)

Acres served specifies system size. For example, a 135 center pivot serves 135 acres.

Maximum Head Loss: 10 Feet

Maximum head loss represents the amount of pressure needed to compensate for friction loss in the pipeline. The USDA-SCS staff in Bozeman provided this figure as representative of typical pipeline system (10 feet/1,000 feet of pipeline).

Elevation Change: (variable)

As discussed previously, elevation change is a key variable in estimating irrigable acres. Elevation was increased by 20 feet intervals up to 1,200 feet of lift.

Minimum Outlet Pressure

Minimum outlet pressure is the pressure required to pump water through the sprinkler heads of the on-farm system. These pressures were provided by the USDA-SCS staff in Bozeman for typical systems.

Additional Flows: 0

Additional flows are only needed with systems that include laterals. The systems we have modeled do not include any laterals.

Reach: 3 to #n #n: Number of Pivots Plus One

Multiple pivot systems are also modeled. Assuming the pivots are located on a level bench and are adjacent to each other, the following inputs are needed for each additional pivot.

Reach Length: (variable)

This reach length is the distance between two adjacent pivot centers. For example, reach length for two adjacent 135 acre center pivots is 2,650 feet.

Acres Served: Pivot Size

See Maximum Head Loss above.

Maximum Head Loss: 10 Feet

See Elevation Change above.

Elevation Change: 0

A level bench is assumed.

Minimum Outlet Pressure; 30 psi

See Additional Flows above.

Additional Flow: 0

See Reach: 3 to #n above.

Electric Rates: $3.04/KwHr

Based on data presented by the Montana Power Company in the Salem Project Application submitted to the Montana Department of Natural Resources and Conservation.

Electric Growth Rate: .58/year

Based on data presented by the Montana Power Company in the Salem Project Application submitted to the Montana Department of Natural Resources and Conservation.

Number of Electrical Growth Years: 15 Years

Based on data presented by the Montana Power Company in the Salem Project Application submitted to the Montana Department of Natural Resources and Conservation.

APPENDIX B

PRELIMINARY ECONOMIC ANALYSIS BY GRANITE COUNTY CONSERVATION DISTRICT

6-22-84

Evaluation on Feasibility of Dam in Granite County

Two landowners in the project area were interviewed to obtain cost and return information for raising irrigated crops. Information was obtained for tearing out hay or sod, establishing hay, and hay. This enterprise information was used to estimate per acre costs and returns. The AGNET system was used to obtain the results. Copies of the output for the six budgets that were run are attached.

The cost and return information for the two landowners was averaged together to obtain an average cost for each enterprise. Yield information and crop mix was also obtained for with and without project situations. This enabled net returns per acre to be calculated for with and without project situations. The change in net farm income as a result of project action would be $76.43 per acre. If you assume two acre feet of water are required for each irrigated acre the net return per acre foot is $38.21.

1) Cost of delivered water? [illegible] [illegible] in [illegible].

2)

6-22-84

Philipsburg Dam Evaluation

Without project

.25 AUM × 15.00/AUM = Typical 8 years infallow rotation w/ small grain $3.75/acre

With Project - 8 year rotation

Tear out

year one produce 80 bu grain

(-2.31) = net return from one year
(12.67) = " " 2-3 rotation
10.36 ÷ 2 = $5.18/ac × .125 (composite acre) $.65/year
average return

Establish hay

divide by 8 (years

-16.24 } year #2
17.07
.83 ÷ 2 = $.42/ac × .125 (composite acre) $.05
3 tons/acre

Hay

averaged over 6 years -

111.05 } net return over 6 years
3-8 100.89
year
211.94 ÷ 2 = 105.97 × .75 (composite acre) $79.48
future with project rotation 80.18
4 tons/acre

Change in net farm income
80.18 - 3.75 = 76.43/acre

Assume 2 acre feet of water needed per acre

Change in net farm income per acre foot =
76.43 ÷ 2 = $38.21/acre foot

494.07

DINSMORE
TEAROUT

6-22-84

TOTAL CROPLAND ACRES 250.0 | EXPECTED YIELD PER ACRE 80.0
ACRES THIS CROP BUDGET 30.0 | ANIMAL UNITS OF GRAZING 0.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
MOLDBOARD PLOW	2.00			1.44	2.66	8.84	12.95
TANDEM DISC	6.50			0.44	0.97	3.61	5.02
TANDEM DISC	6.50			0.44	0.97	3.61	5.02
SPIKE TOOTH HARROW	IN TANDEM			0.0	0.00	0.32	0.32
GRAIN DRILL	4.00			0.79	0.80	3.37	4.97
SEED		1.00	6.00				6.00
SPRINKLER		1.00	70.00				70.00
ROLLER OR PACKER	7.50			0.39	0.57	3.39	4.34
SPRAYER	CUSTOM						6.00
COMBINE, JD55	2.00			1.58	2.00	11.27	14.85
TRUCK				1.20	0.24	0.96	2.40
TOTALS				6.29	8.20	35.38	131.87

CASH COSTS		
PURCHASED MATERIALS	76.00	
FUEL AND LUBE	6.29	
REPAIRS AND MAINTANANCE	8.20	
CUSTOM HIRE AND MACHINE RENTAL	6.00	
INTEREST ON OPERATING EXPENSE	7.72	
(96.49 X 16.00% FOR 6.0 MONTHS)		
TOTAL CASH COSTS		104.21
LABOR		
DIRECT LABOR	8.12	
(1.7 HRS X 4.00/HR X 1.2 (OVERHEAD))		
TOTAL CASH COSTS AND LABOR		112.33
FIXED COSTS		
FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)	35.38	
REAL ESTATE TAXES	3.00	
INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0)	0.0	
TOTAL FIXED COSTS		38.38
TOTAL COST, EXCEPT OVERHEAD AND MGT.		150.70
		8.7
OVERHEAD AND MANAGEMENT		
OVERHEAD (TOTAL CASH COSTS X 5.00%)	5.21	
MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD)	0.0	
TOTAL OVERHEAD AND MANAGEMENT		5.21
TOTAL COST PER ACRE		155.91
TOTAL COST PER UNIT OF PRODUCTION (BASED ON ESTIMATED YIELD)		1.95
		8.41
ESTIMATED RETURNS		
ESTIMATED CROP RETURN PER ACRE	153.60	
ESTIMATED AUM GRAZING RETURNS	0.0	
ESTIMATED TOTAL RETURN PER ACRE		153.60
ESTIMATED NET RETURN PER ACRE	-2.31	

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?

GARY METZER
HAY

TOTAL CROPLAND ACRES	325.0	EXPECTED YIELD PER ACRE	4.0
ACRES THIS CROP BUDGET	245.0	ANIMAL UNITS OF GRAZING	1.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
SELF-PROPELLED WINDROWER	3.00			0.84	0.55	2.10	3.49
SELF-PROPELLED BALER	2.60			0.97	0.37	2.10	3.44
TWINE		1.00	2.40				2.40
SELF-PROP. FORAGE CHOPPER	2.00			1.26	0.78	2.94	4.98
SELF-PROPELLED WINDROWER	3.00			0.84	0.55	2.10	3.49
SELF-PROPELLED BALER	2.60			0.97	0.37	2.10	3.44
TWINE		1.00	0.80				0.80
SPRINKLER		1.00	70.00				70.00
GOPHER CONTROL		1.00	1.00				1.00
SELF-PROP. FORAGE CHOPPER	2.00			1.26	0.78	2.94	4.98
TOTALS				6.16	3.40	14.26	98.0[illegible]

CASH COSTS

PURCHASED MATERIALS	74.20	
FUEL AND LUBE	6.16	
REPAIRS AND MAINTANANCE	3.40	
CUSTOM HIRE AND MACHINE RENTAL	0.0	
INTEREST ON OPERATING EXPENSE	6.70	
(83.76 X 16.00% FOR 6.0 MONTHS)		
TOTAL CASH COSTS		90.47

LABOR

DIRECT LABOR	11.69	
(2.4 HRS X 4.00/HR X 1.2 (OVERHEAD))		
TOTAL CASH COSTS AND LABOR		102.16

FIXED COSTS

FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)	14.26	
REAL ESTATE TAXES	3.00	
INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0)	0.0	
TOTAL FIXED COSTS		17.26
TOTAL COST, EXCEPT OVERHEAD AND MGT.		119.42

OVERHEAD AND MANAGEMENT

OVERHEAD (TOTAL CASH COSTS X 5.00%)	4.52	
MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD)	0.0	
TOTAL OVERHEAD AND MANAGEMENT		4.52
TOTAL COST PER ACRE		123.95
TOTAL COST PER UNIT OF PRODUCTION (BASED ON ESTIMATED YIELD)		30.99
		63.95

ESTIMATED RETURNS

ESTIMATED CROP RETURN PER ACRE	220.00	
ESTIMATED AUM GRAZING RETURNS	15.00	
ESTIMATED TOTAL RETURN PER ACRE		235.00
ESTIMATED NET RETURN PER ACRE	111.05	

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?
.STOP

DINSMORE
HAY

TOTAL CROPLAND ACRES 250.0 EXPECTED YIELD PER ACRE 4.0
ACRES THIS CROP BUDGET 190.0 ANIMAL UNITS OF GRAZING 1.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
SELF-PROPELLED WINDROWER	3.00			0.84	1.10	4.17	6.11
BALER, REGULAR	2.60			1.22	0.68	2.74	4.64
TWINE		1.00	2.40				2.40
SELF-PROP. FORAGE CHOPPER	2.00			1.26	1.01	3.80	6.07
SELF-PROPELLED WINDROWER	3.00			0.84	1.10	4.17	6.11
BALER, REGULAR	2.60			1.22	0.68	2.74	4.64
TWINE		1.00	0.80				0.80
SPRINKLER		1.00	70.00				70.00
GOPHER CONTROL		1.00	1.00				1.00
SELF-PROP. FORAGE CHOPPER	2.00			1.26	1.01	3.80	6.07
TOTALS				6.65	5.58	21.41	107.84

CASH COSTS
- PURCHASED MATERIALS 74.20
- FUEL AND LUBE 6.65
- REPAIRS AND MAINTANANCE 5.58
- CUSTOM HIRE AND MACHINE RENTAL 0.0
- INTEREST ON OPERATING EXPENSE 6.91
  (86.43 X 16.00% FOR 6.0 MONTHS)
  - TOTAL CASH COSTS 93.34

LABOR
- DIRECT LABOR 11.69
  (2.4 HRS X 4.00/HR X 1.2 (OVERHEAD))
  - TOTAL CASH COSTS AND LABOR 105.04

FIXED COSTS
- FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%) 21.41
- REAL ESTATE TAXES 3.00
- INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0) 0.0
  - TOTAL FIXED COSTS 24.41
  - TOTAL COST, EXCEPT OVERHEAD AND MGT. 129.45

OVERHEAD AND MANAGEMENT
- OVERHEAD (TOTAL CASH COSTS X 5.00%) 4.67
- MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD) 0.0
  - TOTAL OVERHEAD AND MANAGEMENT 4.67
  - TOTAL COST PER ACRE 134.11
  - TOTAL COST PER UNIT OF PRODUCTION 33.53
    (BASED ON ESTIMATED YIELD)

134.11 − 70 = 64.11

ESTIMATED RETURNS
- ESTIMATED CROP RETURN PER ACRE 220.00
- ESTIMATED AUM GRAZING RETURNS 15.00
  - ESTIMATED TOTAL RETURN PER ACRE 235.00
- ESTIMATED NET RETURN PER ACRE 100.89

DO YOU WANT TO RUN, LIST, CHANGE, ADD, DELETE OR STOP?

RUN

DINSMORE
ESTAB HAY

TOTAL CROPLAND ACRES 250.0 EXPECTED YIELD PER ACRE 3.0
ACRES THIS CROP BUDGET 30.0 ANIMAL UNITS OF GRAZING 1.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
MOLDBOARD PLOW	2.00			1.44	2.66	8.84	12.95
TANDEM DISC	6.50			0.44	0.97	3.61	5.02
SPIKE TOOTH HARROW	IN TANDEM			0.0	0.00	0.32	0.32
FLOAT	1.50			2.11	1.32	5.73	9.16
FLOAT	1.50			2.11	1.32	5.73	9.16
GRAIN DRILL	4.00			0.79	0.80	3.37	4.97
SEED		1.00	25.00				25.00
SPRINKLER		1.00	70.00				70.00
ROLLER OR PACKER	7.50			0.39	0.57	3.39	4.34
SELF-PROPELLED WINDROWER	3.00			0.84	1.10	4.17	6.11
BALER, REGULAR	2.60			1.22	0.68	2.74	4.64
TWINE		1.00	2.40				2.40
SELF-PROP. FORAGE CHOPPER	2.00			1.26	1.01	3.80	6.07
TOTALS				10.60	10.44	41.70	160.15

CASH COSTS
PURCHASED MATERIALS 97.40
FUEL AND LUBE 10.60
REPAIRS AND MAINTANANCE 10.44
CUSTOM HIRE AND MACHINE RENTAL 0.0
INTEREST ON OPERATING EXPENSE 9.48
(118.44 X 16.00% FOR 6.0 MONTHS)
TOTAL CASH COSTS 127.92

LABOR
DIRECT LABOR 17.22
(3.6 HRS X 4.00/HR X 1.2 (OVERHEAD))
TOTAL CASH COSTS AND LABOR 145.14

FIXED COSTS
FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%) 41.70
REAL ESTATE TAXES 3.00
INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0) 0.0
TOTAL FIXED COSTS 44.70
TOTAL COST, EXCEPT OVERHEAD AND MGT. 189.85

OVERHEAD AND MANAGEMENT
OVERHEAD (TOTAL CASH COSTS X 5.00%) 6.40
MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD) 0.0
TOTAL OVERHEAD AND MANAGEMENT 6.40
TOTAL COST PER ACRE 196.24
TOTAL COST PER UNIT OF PRODUCTION 65.41
(BASED ON ESTIMATED YIELD)
126.24

ESTIMATED RETURNS
ESTIMATED CROP RETURN PER ACRE 165.00
ESTIMATED AUM GRAZING RETURNS 15.00
ESTIMATED TOTAL RETURN PER ACRE 180.00
ESTIMATED NET RETURN PER ACRE -16.24

[redacted]

GARY METZER
ESTAB HAY

TOTAL CROPLAND ACRES	325.0	EXPECTED YIELD PER ACRE	3.0
ACRES THIS CROP BUDGET	40.0	ANIMAL UNITS OF GRAZING	1.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
MOLDBOARD PLOW	2.50			0.69	1.05	2.90	4.65
TANDEM DISC	4.00			0.43	0.31	1.19	1.93
SPIKE TOOTH HARROW	IN TANDEM			0.0	0.00	0.24	0.25
FLOAT	2.00			0.87	0.52	2.36	3.75
FLOAT	2.00			0.87	0.52	2.36	3.75
ROLLER OR PACKER	7.50			0.23	0.08	0.96	1.27
GRAIN DRILL	4.00			0.43	0.46	2.03	2.92
SEED		1.00	25.00				25.00
		0.01	0.01				0.01
SPRINKLER		1.00	70.00				70.00
ROLLER OR PACKER	7.50			0.23	0.08	0.96	1.27
SELF-PROPELLED WINDROWER	3.00			0.84	0.55	2.10	3.49
SELF-PROPELLED BALER	2.60			0.97	0.37	2.10	3.44
TWINE		1.00	2.40				2.40
SELF-PROP. FORAGE CHOPPER	2.00			1.26	0.78	2.94	4.98
TOTALS				6.84	4.71	20.14	129.07

CASH COSTS

PURCHASED MATERIALS	97.40 − 70 = 27.4	
FUEL AND LUBE	6.84	
REPAIRS AND MAINTANANCE	4.71	
CUSTOM HIRE AND MACHINE RENTAL	0.0	
INTEREST ON OPERATING EXPENSE	8.72	
(108.95 X 16.00% FOR 6.0 MONTHS)		
TOTAL CASH COSTS		117.67
		45.67

LABOR

DIRECT LABOR	16.25	
(3.4 HRS X 4.00/HR X 1.2 (OVERHEAD))		
TOTAL CASH COSTS AND LABOR		133.91

FIXED COSTS

FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)	20.14	
REAL ESTATE TAXES	3.00	
INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0)	0.0	
TOTAL FIXED COSTS		23.14
TOTAL COST, EXCEPT OVERHEAD AND MGT.		157.05

OVERHEAD AND MANAGEMENT

OVERHEAD (TOTAL CASH COSTS X 5.00%)	5.88	
MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD)	0.0	
TOTAL OVERHEAD AND MANAGEMENT		5.88
TOTAL COST PER ACRE		162.93
TOTAL COST PER UNIT OF PRODUCTION (BASED ON ESTIMATED YIELD)		54.31
		92.93

ESTIMATED RETURNS

ESTIMATED CROP RETURN PER ACRE	165.00	
ESTIMATED AUM GRAZING RETURNS	15.00	
ESTIMATED TOTAL RETURN PER ACRE		180.00
ESTIMATED NET RETURN PER ACRE	17.07	

TOTAL CROPLAND ACRES	325.0	EXPECTED YIELD PER ACRE	80.0
ACRES THIS CROP BUDGET	40.0	ANIMAL UNITS OF GRAZING	0.0

OPERATION	ACRES /HOUR	PURCHASED MATERIALS AMOUNT /ACRE	PURCHASED MATERIALS COST /UNIT	MACHINERY COSTS FUEL AND LUBE	MACHINERY COSTS REPAIR AND MAINT.	MACHINERY COSTS FIXED	TOTAL COSTS
MOLDBOARD PLOW	2.50			0.69	1.05	2.90	4.65
TANDEM DISC	4.00			0.43	0.31	1.19	1.93
TANDEM DISC	4.00			0.43	0.31	1.19	1.93
SPIKE TOOTH HARROW	10.00			0.17	0.04	0.37	0.58
FLOAT	2.00			0.87	0.52	2.36	3.75
GRAIN DRILL	4.00			0.43	0.46	2.03	2.92
SEED		1.00	6.00				6.00
GOPHER CONTROL		1.00	1.00				1.00
SPRINKLER		1.00	70.00				70.00
ROLLER OR PACKER	7.50			0.23	0.08	0.96	1.27
SPRAYER	CUSTOM						6.00
COMBINE, 55JD	2.00			1.58	1.50	8.45	11.53
TRUCK				1.20	0.24	0.96	2.40
TOTALS				6.04	4.50	20.41	113.9[illegible]

CASH COSTS		
PURCHASED MATERIALS	77.00	
FUEL AND LUBE	6.04	
REPAIRS AND MAINTANANCE	4.50	
CUSTOM HIRE AND MACHINE RENTAL	6.00	
INTEREST ON OPERATING EXPENSE	7.48	
(93.54 X 16.00% FOR 6.0 MONTHS)		
TOTAL CASH COSTS		101.03
LABOR		
DIRECT LABOR	11.44	
(2.4 HRS X 4.00/HR X 1.2 (OVERHEAD))		
TOTAL CASH COSTS AND LABOR		112.47
FIXED COSTS		
FIXED MACHINERY COSTS (INCLUDES INTEREST AT 16.00%)	20.41	
REAL ESTATE TAXES	3.00	
INTEREST ON LAND ($ 0.0 VALUE/A X 0.0 % X 1.0)	0.0	
TOTAL FIXED COSTS		23.41
TOTAL COST, EXCEPT OVERHEAD AND MGT.		135.88
OVERHEAD AND MANAGEMENT		
OVERHEAD (TOTAL CASH COSTS X 5.00%)	5.05	
MANAGEMENT CHARGE ($ 0.0 X ESTIMATED YIELD)	0.0	
TOTAL OVERHEAD AND MANAGEMENT		5.05
TOTAL COST PER ACRE		140.93
TOTAL COST PER UNIT OF PRODUCTION (BASED ON ESTIMATED YIELD)		1.76
ESTIMATED RETURNS		
ESTIMATED CROP RETURN PER ACRE	153.60	
ESTIMATED AUM GRAZING RETURNS	0.0	
ESTIMATED TOTAL RETURN PER ACRE		153.60
ESTIMATED NET RETURN PER ACRE	12.67	

... CHANGE, ADD, DELETE OR STOP?

APPENDIX C

HEAVY METAL PROBLEMS IN THE DEER LODGE VALLEY

APPENDIX C

HEAVY METALS

Contamination of soils by heavy metals in the upper Clark Fork drainage is a problem which limits the production potential of some lands and may seriously impair water quality. Airborne heavy metal particulates have been emitted from the Anaconda Smelter since the late 1800s and have settled on land in the Deer Lodge Valley. Additional waterborne mine tailings with high heavy metal concentrations have contaminated flood-plain soils and some agricultural land in close proximity to the Clark Fork River.

Heavy metals in soils impose constraints on various land uses including irrigated agriculture. The following studies have addressed the heavy metal problems in the Deer Lodge Valley or in the riverine ecosystem downstream.

A. <u>MultiTech</u>

The consulting firms of MultiTech and Stiller and Associates have contracted with the Montana Department of Health and Environmental Sciences (DHES) through the federally funded Superfund Program to prepare the Silver Bow Creek Remedial Investigation Work Plan. This plan describes the many problems in the Anaconda-Butte area associated with past mining and smelting activities and suggests means to reduce or better identify the problems.

MultiTech cites the work of various agencies and consultants and states:

> Just downstream of the Warm Springs Ponds, Warm Springs Creek and Silver Bow Creek converge to form the Clark Fork River. Warm Springs Creek is a high quality stream that is degraded in its lower reaches. The cause of the degradation is possibly a combination of seepage from AMC treatment ponds and irrigation dewatering (Casne and others 1975). Tailings deposits cover much of the floodplain of the Upper Clark Fork and contribute unknown contaminants, via runoff, to the river. MDHES (1983) study found an increase in sulfate and total copper loads for the Clark Fork River from its origin to Deer Lodge. This increase is thought to be the result of impacts from floodplain and in-stream tailing deposits (Green 1984).
>
> Tributaries to the Clark Fork River along this reach are affected by some mining and agricultural activity. These lands may produce some contaminant loads to the Clark Fork River.

MultiTech additionally states,

> Soil contamination along the Upper Clark Fork River is nearly identical to that described for the canyon to Warm Springs Ponds river segments. A much greater extent of irrigated land is found along this portion of the Clark Fork. The downstream extent of significant contamination is presently indeterminate. Barren areas are common aong the river point bars as far as Deer Lodge. It is expected that contamination could occur at least as far downstream as Garrison.
>
> The literature review in Section 9.4.2 documents the need for systematic identification and demarcation of those lands either known or suspected to be affected by "heavy metal" contaminated irrigation waters. Initially, those ditches that received surface waters diverted or pumped from either Silver Bow Creek or Upper Clark Fork River were identified. This effort was accomplished via review of the respective water resource surveys for Silver Bow (Buck _et al_. 1955a), Deer Lodge (Buck _et al_. 1955b), and Powell Counties (Buck _et al_. 1959). Secondly, those owners potentially affected were identified either through inspection of each county's land ownership (plat) books or interviewing knowledgeable Soil Conservation Service personnel in Deer Lodge (Tribelhorn and Dutton, personal communications). Thirdly, a news release was published on February 28, 1984 in the _Montana Standard_ (Kemmick

1984) that included a solicitation for information pertinent to the irrigated lands study. The initial listing of persons that will be contacted are presented by soil conservation district in Appendix Table 9.5-5.

A preliminary estimate of areal extent of affected lands totals to 5380 acres, for the three given counties. The respective county figures are as follows: Silver Bow, 0 acres; Deer Lodge, 1115 acres; and Powell, 4265 acres. Apparently, the combined municipal and industrial effluents discharged by Butte sources into Silver Bow Creek have prevented any attempts at using its water for regular or flood irrigation purposes (Buck et al. 1955a). The inclusion of the entire Deer Lodge Valley Conservation District seems appropriate, as waters from the Clark Fork River are pumped or diverted from it throughout this area. Furthermore, "heavy metal" contamination of riparian vegetation by sediments has been documented in the vicinity of Drummond, Montana (Ray 1983). This town is located approximately 10 river miles west of the Granite County-Powell County border, implying that transport of effluents has traveled (historically) at least this far downstream.

B. University of Montana

The Gordon Environmental Studies Laboratory of the University of Montana has recently completed studies on the Grant-Kohrs Ranch, a National Historic Site administered by the National Park Service, and on the floodplain of the Clark Fork River between Rocker and Drummond. These studies were conducted to measure heavy metal contamination in soils which are barren of vegetation or have plant communities indicative of heavy metal pollution.

Ray (1984) found elevated levels of copper, cadmium, and arsenic at all sites studied along the Clark Fork with some of the highest concentrations being present at Drummond, the site farthest from the source of the waterborne mine tailings. All of Ray's samples were collected on barren or sparsely vegetated areas which showed surficial evidence of waterborne sediment deposition.

Rice and Ray (1984) conducted a floral and faunal survey of the Grant-Kohrs Ranch National Historic Site. They found that the top 25 centimeters of soil on the Clark Fork floodplain had metal concentrations one to two orders of magnitude greater than the concentrations in the control samples. Only a small fraction of this contamination was attributed to deposition of airborne particulates during the period of smelter operation, 1884 through 1980. Deposition on the floodplain of toxic metal enriched sediments was determined by Rice and Ray to be the predominant and continuing mechanism of contamination.

C. Hydrometrics

The consulting firm, Hydrometrics (1983), conducted long-term environmental rehabilitation studies in the Deer Lodge Valley under contract to the Anaconda Minerals Company. Hydrometrics reported that milling and smelting operations at Butte and Anaconda have resulted in extensive but relatively thin tailings deposits on the floodplain. These deposits have killed riparian vegetation in numerous areas and have created barren or sparsely vegetated areas which resulted from past attempts to irrigate with poor quality water diverted from the Clark Fork River. Field reconnaissance and aerial photo-interpretation were used to map approximately one million cubic yards of tailings (covering 1,250 acres) deposited on the floodplain between Warm Springs and Deer Lodge.

Hydrometrics also conducted soil tests in the Deer Lodge Valley. They found that soils with low pHs had sparse vegetation cover and that soil pH was inversely related to soluble metal concentrations. Downward percolation of metals from tailings and redeposition in the underlying alluvial soils has increased concentrations of copper, zinc, manganese, and sulfur to a depth of 24 inches in some sites.

D. Soil Conservation Service

The Soil Conservation Service (SCS) in Deer Lodge has mapped some areas within the Deer Lodge Valley where toxic metals have affected plant growth and soil productivity. The SCS uses the term "slickens" to describe

> An undifferentiated soil type consisting of accumulation of fine-textured materials, such as are separated in placer-mine and ore-mill operations. Slickens from ore mills consist largely of freshly ground rock that commonly have undergone chemical treatment during milling or smelting processes.

SCS personnel are also aware of landowners who have problem soils or suspect that heavy metals have affected their agricultural operations.

E. Graduate Studies

Graduate students at the University of Montana conducted studies on vegetation and soils in the vicinity of Anaconda. Munshower (1972) studied cadmium compartmentation and cycling in grasses and soils of the Deer Lodge Valley and was able to construct isopols which linked areas of similar soil concentrations of cadmium. The isopol concentrations were attributed only to airborne deposition of particulates produced by the smelting of ore.

Other studies were conducted by Taskey (1970) and Hartman (1976). Taskey studied the contamination of soils around Anaconda by airborne heavy metals, whereas Hartman studied the influence of heavy metals on the fungal flora of the soil.

F. Mile High Conservation District

A reclamation project funded by the Montana Department of Natural Resources and Conservation (DNRC) Water Development Bureau has been initiated for the Mile High Conservation District, Deer Lodge Valley Conservation District, and the Headwaters Resource Conservation and Development Area. This research concerns reclamation techniques for heavy metal contaminated agricultural lands in Deer Lodge, Powell, and Silver Bow counties, with the primary focus of the research being on the development of cost-effective practices for reestablishing hay and forage production on soils contaminated by heavy metals. Such reclamation practices, however, must be permanent so future sulfide oxidation does not lower soil pH. In addition, acceptable reclamation practices must not increase the metal content of forage to levels toxic to livestock.

In recognition that irrigated agrculture could affect the vertical and areal distribution of heavy metals in soils and mobilize these metals so as to contaminate surface and shallow ground water, a detailed hydrological investigation will also be part of the reclamation study being conducted by the Mile High Conservation District. Wells, shallow ground water, and surface waters will be monitored to determine how agricultural practices affect the soil/heavy metal/hydrological interactions.