

BIG Springs

36-00022, 23

Expert Witness Report

SRBA Case No 39576

Subcases 36-00022, 37-00023

Big Springs

March 26, 1999

C.E. Brockway P.E. PhD.

Brockway Engineering P.L.L.C.

The property served by Big Springs Water Users lies in Sections 13,14,23, and 24 of T 7 S R 13E and Sec 19 T7S R14E just east and south of the City of Hagerman. It consists of parcels irrigated by shareholders of the Big Springs Water Users. Water supply is from Big Springs on the east side of Billingsley Creek. Water is diverted from the developed spring through a concrete box into a 30 inch diameter steel pipe which supplies a distribution system serving a gross area estimated at over 800 acres. Irrigation water and domestic supplies are transported via a series of pipelines varying from 14 inches to 1 ½ inches in diameter. Examination was made of aerial photos including the 1987 SCS aerial photos, other photos from the FSA, and USDA NRCS soils maps and farm maps. The surface irrigated area prior to installation of sprinklers is estimated to be at least 605.1 acres. Some areas irrigated may not have been discernible from the photos available and additional research is required to verify the actual claimed area of 715 acres.

Historically, water supply from the springs was conveyed by pipeline to homes and earthen ditches to fields on each user's farm. A map showing the piping system as of 1990 was supplied by Mr. George Lemmon. The 1987 map attached shows the field system in place at that time and the various fields irrigated in the service area.

Soil permeability and infiltration rates are high, up to 20 in./hr. USDA NRCS soil classifications include Quincy fine sand (QUB), Kecko fine sandy loam (KOB), Anchustequi loam (KCB), and Fathom-Kudlac-Anchustequi complex (FKE) soils. Historical surface irrigation was assumed to have consisted of furrow application from field ditches throughout the area. Field slopes and run lengths are highly variable.

SCANNED
JUN 11 2009

Based on interviews with and data supplied by Mr. Lemmon, irrigation has historically utilized primarily 12 hour sets. Historically, control of furrow flows was likely accomplished with cutouts from earthen ditches and later from siphon tubes.

The duty of water on these lands is in excess of 0.02 cfs/acre (1 miner's inch/acre). In order to estimate the irrigation requirement for the irrigated areas, an analysis using procedures developed by Hubble Engineering for the Idaho Department of Water Resources was utilized. The procedures were incorporated in a computer program developed by C.W. Robison P.E. which has been reviewed by IDWR and utilized previously in numerous "excess flow analyses". Input data sets and computer output for each analysis are included in Appendix A to this report. NRCS soils data are also included in Appendix A.

Farm delivery requirement(duty of water) was calculated using set times and furrow flows as reported or appropriate for the run lengths (field length) and soil types. Project irrigation diversion requirements were calculated for the analysis period utilizing the Bliss weather data set modified for Hagerman and utilizing an 80% probability level of crop consumptive use. Calculations were also performed for the peak period consumptive use.

Estimated irrigation requirements using the Hubble approach or any other method are sensitive to irrigation management procedures. Irrigation efficiency and water requirements are very sensitive to the length of time water is left on the field (set time) and the discharge that is set in each furrow, either from siphon tubes or cutouts. Furrow infiltration rates are highly variable due to soil property variability, slope inconsistencies, antecedent moisture conditions, and crop litter in the furrow. Irrigator's judgement as to how long to leave water on the field or how 'strong' to set the tubes varies from person to person. Estimates of irrigation requirements are therefore best utilized to provide a guideline as to the range of expected requirements rather than to precisely determine what flows early irrigators should have used.

For the estimated surface irrigated area(605.1 acres) the estimated base peak project diversion requirement is 2.31 inches/acre(27.99 cfs) and the analysis period (maximum monthly with 80% probability) project irrigation requirement is 2.02 inches/acre (24.41 cfs). For purposes of this analysis, the crop distribution was assumed to be

approximately 50% alfalfa, 20% field corn, 15% pasture on steeper slopes, and 15% grain on the 56 fields.

The project irrigation requirement does not include ditch losses from the springs to the property or on-farm ditches since the distribution system was primarily pipelines.

A sensitivity analysis was performed to show the effect on calculated irrigation water requirements if the irrigator chooses different set times or furrow flows. That analysis is shown in Appendix A. The furrow flow rates were varied from 80% to 160% of the base furrow flow and the set time was calculated for 12, 18, and 2 hours. The table in Appendix A shows that the calculated required peak project diversion rate could be as much as 53.7 cfs or 4.44 miner's inches per acre. However, the water supply system would not provide this discharge.

The water supply for Big Springs Water Users is spring flow from the Snake Plain aquifer which issues from the Secor/Durfee tunnel. Flow from this spring is subject to variations in water table elevations in the Eastern Snake Plain Aquifer which have been declining since the 1950's. Estimates from springs issuing from the aquifer which have continuous discharge measurements such as Box Canyon Spring and Blue Lakes Spring, show declines since the early 1950's of up to 0.5% per year. Over a nearly 50 year period, this decline could be as much as 25 percent of the 1950 peak discharge. The attached plot of spring flows from the Snake Plain aquifer from Kimberly to King Hill shows a declining trend since the peak flow in the 1950's. For instance, if the current(1999) discharge from the spring is 20 cfs, the discharge in 1950 may have been as much as 27 cfs. This decline accounts for reported decreases in diversions from most of the springs in the Hagerman Valley.

Based on the irrigation requirements analysis, the estimated historic duty of water for full surface irrigation of 605.1 acres under 37-00022 and 37-00023 is 2.31 in/acre(27.99 cfs); however, depending on irrigation management levels, crop selection, or local weather conditions, the irrigation requirement could be over 4.44 in/acre. The claimed water rights for irrigation under 36-00022 and 36-00023 of 17.9 cfs (12.9 +5.0) are justifiable and well below the estimate based on the Hubble procedure. Additional irrigated acreage may be justified based on additional research.

APPENDIX A

Irrigation Water Requirements Analysis
Version 1.25
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

PROJECT IRRIGATION DIVERSION REQUIREMENTS
SUMMARY

Total Irrigated Area: 605.10 acres

Based on analysis period irrigation requirement

Max Project Diversion: 24.41 cfs(2.017 mi/ac)

Based on analysis period peak consumptive use

Peak Project Diversion: 27.99 cfs(2.313 mi/ac)

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

****SENSITIVITY ANALYSIS****

Run Date: 03-27-1999
Base file: bigspr.dat

PEAK PROJECT DIVERSION IN CFS
Furrow flow in FRACTION OF BASE. Set time in HOURS.

		Set time		
F Flow	12	18	24	
0.80	0.00	0.00	0.00	
1.00	0.00	25.17	33.57	
1.20	20.14	30.21	40.28	
1.40	23.50	35.24	46.99	
1.60	26.85	40.28	53.71	

PEAK PROJECT DIVERSION IN MINER'S INCHES PER ACRE
Furrow flow in FRACTION OF BASE. Set time in HOURS.

		Set time		
F Flow	12	18	24	
0.80	0.00	0.00	0.00	
1.00	0.00	2.08	2.77	
1.20	1.66	2.50	3.33	
1.40	1.94	2.91	3.88	
1.60	2.22	3.33	4.44	

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman

Brockway Engineering and C. W. Robison

No canal/lateral/ditch losses

Crop Water Requirements Datafile: hagerman.cir

Probability Level for Analysis: 80.0

Number of Canal/Lateral Segments: 1

Number of Irrigation Methods: 13

Number of Soil Types: 4

Number of Crops: 4

Number of Analysis Periods: 8

CANAL/LATERAL INFORMATION

#	Name	Segment	Upstream Length miles	Width feet	F-Area sq-ft	Seepage	Method
1	Effective Div.	0	.00	.0	.0	Specified S=	.00 cfs/mi

IRRIGATION SYSTEM INFORMATION

Name	Assumed Efficiency	Set Time	Flow	Run Length	Slope-Furrows Width-Others
FURROW 200-1	48.0	12.	4.0	200.	.027
FURROW 200-2	48.0	12.	4.0	200.	.008
FURROW 400-1	48.0	18.	4.0	400.	.022
FURROW 400-2	48.0	18.	4.0	400.	.007
FURROW 600-1	48.0	18.	6.0	600.	.023
FURROW 600-2	48.0	18.	6.0	600.	.008
FURROW 600-3	48.0	24.	5.0	600.	.003
FURROW 800-1	48.0	12.	6.0	800.	.025
FURROW 800-2	48.0	18.	8.0	800.	.009
FURROW 800-3	48.0	24.	6.0	800.	.004
FURROW 1000	48.0	24.	8.0	1000.	.004
FURROW 1200-1	48.0	24.	8.0	1200.	.008
FURROW 1200-2	48.0	24.	9.0	1200.	.004

SOILS INFORMATION

Name	Intake Family	Water Holding Capacity				
		1ft	2ft	3ft	4ft	5ft
QUB	2.0	.94	1.84	2.74	3.64	4.54
KCB	2.0	1.71	3.39	5.07	6.75	8.43
KOB	2.0	1.56	3.05	4.31	5.73	7.47
FKE	2.0	1.41	2.79	4.17	5.55	6.93

CROP SYSTEM INFORMATION

Name	Allowable Deficit	Furrow Spacing	Roughness
Alfalfa Hay	50.0	2.500	.100
Pasture	50.0	2.500	.100
Spring Grain	50.0	2.500	.100
Field Corn	50.0	2.500	.100

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

CROP DISTRIBUTION FOR QUB				by Irrigation System				
Crop	Total	01	02	03	04	05	06	07
		08	09	10	11	12	13	
Alfalfa Hay	92.2	.5	3.4	9.3	5.9	4.1	6.4	.0
		7.9	10.4	.0	.0	20.9	23.4	
Pasture	36.6	.2	1.3	3.7	2.4	1.6	2.5	.0
		3.1	4.1	.0	.0	8.4	9.3	
Spring Grain	27.6	.1	1.0	2.8	1.8	1.2	1.9	.0
		2.4	3.1	.0	.0	6.3	7.0	
Field Corn	27.6	.1	1.0	2.8	1.8	1.2	1.9	.0
		2.4	3.1	.0	.0	6.3	7.0	

CROP DISTRIBUTION FOR KCB				by Irrigation System				
Crop	Total	01	02	03	04	05	06	07
		08	09	10	11	12	13	
Alfalfa Hay	75.7	1.5	4.5	2.4	9.1	18.3	2.8	9.2
		.0	5.9	7.5	.0	.0	14.5	
Pasture	30.3	.6	1.8	1.0	3.6	7.3	1.1	3.7
		.0	2.4	3.0	.0	.0	5.8	
Spring Grain	22.7	.4	1.3	.7	2.7	5.5	.8	2.8
		.0	1.8	2.3	.0	.0	4.4	
Field Corn	22.7	.4	1.3	.7	2.7	5.5	.8	2.8
		.0	1.8	2.3	.0	.0	4.4	

CROP DISTRIBUTION FOR KOB				by Irrigation System				
Crop	Total	01	02	03	04	05	06	07
		08	09	10	11	12	13	
Alfalfa Hay	80.7	.0	.0	.0	.0	.0	.0	.0
		.0	19.8	.0	.0	.0	60.9	
Pasture	32.2	.0	.0	.0	.0	.0	.0	.0
		.0	7.9	.0	.0	.0	24.3	
Spring Grain	24.2	.0	.0	.0	.0	.0	.0	.0
		.0	5.9	.0	.0	.0	18.3	
Field Corn	24.2	.0	.0	.0	.0	.0	.0	.0
		.0	5.9	.0	.0	.0	18.3	

CROP DISTRIBUTION FOR FKE				by Irrigation System				
Crop	Total	01	02	03	04	05	06	07
		08	09	10	11	12	13	
Alfalfa Hay	54.3	.0	2.0	.0	4.1	.0	6.7	.0
		.0	10.0	.0	9.0	22.5	.0	
Pasture	21.7	.0	.8	.0	1.6	.0	2.7	.0
		.0	4.0	.0	3.6	9.0	.0	
Spring Grain	16.2	.0	.6	.0	1.2	.0	2.0	.0

		.0	3.0	.0	2.7	6.7	.0	
Field Corn	16.2	.0	.6	.0	1.2	.0	2.0	.0
		.0	3.0	.0	2.7	6.7	.0	

Irrigation System Key

01 - FURROW 200-1	02 - FURROW 200-2	03 - FURROW 400-1
04 - FURROW 400-2	05 - FURROW 600-1	06 - FURROW 600-2
07 - FURROW 600-3	08 - FURROW 800-1	09 - FURROW 800-2
10 - FURROW 800-3	11 - FURROW 1000	12 - FURROW 1200-1
13 - FURROW 1200-2		

Project/Farm Irrigation Water Requirement Analysis
Version 1.00

Crop Irrigation Requirements (mm/day)

Datafile: hagerman.cir

Title: Bliss Consumptive Use (Allen and Brockway) Adjusted to Hagerman

INPUT DATA

	Total	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay									
Root Depth	.0	.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Mean CU	1087.0	.00	3.52	6.58	7.62	7.19	5.60	3.84	1.34
Mean IR	1007.0	.00	3.05	5.94	6.99	7.03	5.46	3.60	1.02
Std Dev CU	30.0	.00	.29	.46	.41	.21	.25	.27	.12
Std Dev IR	54.0	.00	.57	.77	.89	.37	.51	.49	.39
Field Corn									
Root Depth	.0	.00	.00	.75	1.50	3.00	3.00	3.00	3.00
Mean CU	805.6	.00	.00	2.13	3.81	7.96	6.87	4.38	1.11
Mean IR	750.5	.00	.00	1.66	3.33	7.80	6.71	4.15	.81
Std Dev CU	20.0	.00	.00	.15	.21	.24	.30	.31	.10
Std Dev IR	36.0	.00	.00	.43	.61	.38	.57	.52	.36
Spring Grain									
Root Depth	.0	.00	.50	1.50	3.00	3.00	3.00	3.00	3.00
Mean CU	751.5	.00	1.76	5.34	8.73	7.30	1.52	.00	.00
Mean IR	700.5	.00	1.40	4.83	8.15	7.17	1.42	.00	.00
Std Dev CU	23.0	.00	.15	.37	.47	.22	.07	.00	.00
Std Dev IR	46.0	.00	.38	.62	.89	.34	.27	.00	.00
Pasture									
Root Depth	.0	.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mean CU	1090.0	.00	3.49	5.47	6.73	6.81	5.73	4.52	3.07
Mean IR	1015.0	.00	3.04	4.89	6.16	6.67	5.58	4.28	2.73
Std Dev CU	29.0	.00	.29	.38	.36	.20	.25	.32	.27
Std Dev IR	51.0	.00	.55	.67	.80	.34	.50	.53	.51

Project/Farm Irrigation Water Requirement Analysis
Version 1.00

Crop Requirements (in/day)
Crop Rooting Depths (ft)

BASED ON NORMAL DISTRIBUTION

Adjusted Crop Water Requirements for 80.0% probability level									
	Total	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay									
---CU---	43.8	.000	.148	.274	.314	.290	.229	.160	.057
---IR---	41.4	.000	.139	.259	.305	.289	.232	.158	.053
Root Depth		.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Pasture									
---CU---	43.9	.000	.147	.228	.277	.275	.234	.189	.130
---IR---	41.7	.000	.138	.215	.269	.274	.236	.186	.124
Root Depth		.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Grain									
---CU---	30.3	.000	.074	.222	.359	.295	.062	.000	.000
---IR---	29.1	.000	.068	.211	.350	.294	.065	.000	.000
Root Depth		.0	.5	1.5	3.0	3.0	3.0	3.0	3.0
Field Corn									
---CU---	32.4	.000	.000	.089	.157	.321	.280	.183	.047
---IR---	30.7	.000	.000	.080	.151	.320	.283	.181	.044
Root Depth		.0	.0	.8	1.5	3.0	3.0	3.0	3.0

CU Peak to Ave Ratio vs Application Depth Curve (11 pts)

App.Depth(in)	.61	1.06	1.51	2.12	2.73	3.63	4.54	5.60	6.36
	6.96	7.57							
Peak:Average	1.154	1.138	1.123	1.108	1.092	1.077	1.061	1.046	1.038
	1.031	1.023							

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Allowable Soil Water Deficit -- inches
80.0 Percent Probability Level of IR

	SOIL CATAGORY: QUB							
Crop	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.00	2.27	2.27	2.27	2.27	2.27	2.27	2.27
Pasture	.00	.92	.92	.92	.92	.92	.92	.92
Spring Grain	.00	.23	.70	1.37	1.37	1.37	1.37	1.37
Field Corn	.00	.00	.35	.70	1.37	1.37	1.37	1.37

	SOIL CATAGORY: KCB							
Crop	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.00	4.22	4.22	4.22	4.22	4.22	4.22	4.22
Pasture	.00	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Spring Grain	.00	.43	1.28	2.54	2.54	2.54	2.54	2.54
Field Corn	.00	.00	.64	1.28	2.54	2.54	2.54	2.54

	SOIL CATAGORY: KOB							
Crop	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.00	3.73	3.73	3.73	3.73	3.73	3.73	3.73
Pasture	.00	1.52	1.52	1.52	1.52	1.52	1.52	1.52
Spring Grain	.00	.39	1.17	2.15	2.15	2.15	2.15	2.15
Field Corn	.00	.00	.58	1.17	2.15	2.15	2.15	2.15

	SOIL CATAGORY: FKE							
Crop	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.00	3.46	3.46	3.46	3.46	3.46	3.46	3.46
Pasture	.00	1.39	1.39	1.39	1.39	1.39	1.39	1.39
Spring Grain	.00	.35	1.06	2.09	2.09	2.09	2.09	2.09
Field Corn	.00	.00	.53	1.06	2.09	2.09	2.09	2.09

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Peak Consumptive Use based on Peak:Mean(ASWD)
80.0 Percent Probability Level of CU

SOIL CATAGORY: QUB		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Crop									
Alfalfa Hay		--	.164	.303	.346	.320	.253	.177	.063
Pasture		--	.168	.261	.316	.314	.267	.216	.148
Spring Grain		--	.087	.256	.405	.332	.070	--	--
Field Corn		--	--	.103	.181	.362	.316	.206	.053

SOIL CATAGORY: KCB		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Crop									
Alfalfa Hay		--	.158	.293	.335	.309	.244	.171	.061
Pasture		--	.164	.255	.310	.307	.262	.211	.145
Spring Grain		--	.086	.251	.394	.323	.068	--	--
Field Corn		--	--	.102	.177	.352	.308	.200	.052

SOIL CATAGORY: KOB		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Crop									
Alfalfa Hay		--	.159	.295	.337	.312	.246	.172	.061
Pasture		--	.165	.256	.311	.308	.263	.212	.146
Spring Grain		--	.086	.252	.398	.326	.069	--	--
Field Corn		--	--	.103	.178	.356	.310	.202	.052

SOIL CATAGORY: FKE		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Crop									
Alfalfa Hay		--	.160	.296	.339	.313	.247	.173	.061
Pasture		--	.166	.257	.312	.310	.263	.212	.146
Spring Grain		--	.086	.253	.398	.327	.069	--	--
Field Corn		--	--	.103	.179	.356	.311	.203	.052

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 200-1
Furrow Irrigation-> 12.Hours @ 4.0gpm on 200.ft @ .027ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	24.6	24.6	24.6	24.6	24.6	24.6	24.6
Pasture	---	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Spring Grain	---	2.5	7.6	14.8	14.8	14.8	14.8	14.8
Field Corn	---	---	3.8	7.6	14.8	14.8	14.8	14.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.188	2.217	2.604	2.471	1.982	1.350	.454
Pasture	.000	2.909	4.529	5.674	5.776	4.983	3.924	2.623
Spring Grain	.000	5.591	5.799	4.962	4.158	.919	.000	.000
Field Corn	.000	.000	4.382	4.165	4.528	4.009	2.558	.621

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.398	2.589	2.959	2.737	2.159	1.511	.535
Pasture	.000	3.544	5.495	6.674	6.622	5.638	4.545	3.129
Spring Grain	.000	7.156	7.045	5.737	4.705	.993	.000	.000
Field Corn	.000	.000	5.686	4.970	5.131	4.477	2.917	.751

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman

Brockway Engineering and C. W. Robison

No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 200-2

Furrow Irrigation-> 12.Hours @ 4.0gpm on 200.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	24.6	24.6	24.6	24.6	24.6	24.6	24.6
Pasture	---	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Spring Grain	---	2.5	7.6	14.8	14.8	14.8	14.8	14.8
Field Corn	---	---	3.8	7.6	14.8	14.8	14.8	14.8

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac

With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.188	2.217	2.604	2.471	1.982	1.350	.454
Pasture	.000	2.909	4.529	5.674	5.776	4.983	3.924	2.623
Spring Grain	.000	5.591	5.799	4.962	4.158	.919	.000	.000
Field Corn	.000	.000	4.382	4.165	4.528	4.009	2.558	.621

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.398	2.589	2.959	2.737	2.159	1.511	.535
Pasture	.000	3.544	5.495	6.674	6.622	5.638	4.545	3.129
Spring Grain	.000	7.156	7.045	5.737	4.705	.993	.000	.000
Field Corn	.000	.000	5.686	4.970	5.131	4.477	2.917	.751

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 400-1
Furrow Irrigation-> 18.Hours @ 4.0gpm on 400.ft @ .022ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 400-2
Furrow Irrigation-> 18.Hours @ 4.0gpm on 400.ft @ .007ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 600-1
Furrow Irrigation-> 18.Hours @ 6.0gpm on 600.ft @ .023ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 600-2
Furrow Irrigation-> 18.Hours @ 6.0gpm on 600.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 800-1
Furrow Irrigation-> 12.Hours @ 6.0gpm on 800.ft @ .025ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	65.5	65.5	65.5	65.5	65.5	65.5	65.5
Pasture	---	26.6	26.6	26.6	26.6	26.6	26.6	26.6
Spring Grain	---	6.8	20.3	39.5	39.5	39.5	39.5	39.5
Field Corn	---	---	10.2	20.3	39.5	39.5	39.5	39.5

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.445	.831	.977	.926	.743	.506	.170
Pasture	.000	1.091	1.698	2.128	2.166	1.869	1.472	.984
Spring Grain	.000	2.097	2.175	1.861	1.559	.344	.000	.000
Field Corn	.000	.000	1.643	1.562	1.698	1.503	.959	.233

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.524	.971	1.110	1.026	.810	.567	.201
Pasture	.000	1.329	2.060	2.503	2.483	2.114	1.704	1.173
Spring Grain	.000	2.683	2.642	2.151	1.765	.372	.000	.000
Field Corn	.000	.000	2.132	1.864	1.924	1.679	1.094	.282

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 800-2
Furrow Irrigation-> 18.Hours @ 8.0gpm on 800.ft @ .009ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman

Brockway Engineering and C. W. Robison

No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 1200-1

Furrow Irrigation-> 24.Hours @ 8.0gpm on 1200.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	36.9	36.9	36.9	36.9	36.9	36.9	36.9
Pasture	---	14.9	14.9	14.9	14.9	14.9	14.9	14.9
Spring Grain	---	3.8	11.4	22.2	22.2	22.2	22.2	22.2
Field Corn	---	---	5.7	11.4	22.2	22.2	22.2	22.2

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac

With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.792	1.478	1.736	1.647	1.321	.900	.302
Pasture	.000	1.939	3.019	3.783	3.851	3.322	2.616	1.749
Spring Grain	.000	3.727	3.866	3.308	2.772	.612	.000	.000
Field Corn	.000	.000	2.921	2.776	3.018	2.673	1.705	.414

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.932	1.726	1.973	1.825	1.439	1.007	.357
Pasture	.000	2.362	3.663	4.450	4.415	3.758	3.030	2.086
Spring Grain	.000	4.771	4.697	3.824	3.137	.662	.000	.000
Field Corn	.000	.000	3.791	3.313	3.421	2.985	1.945	.500

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL QUB

Irrigation System Efficiency Analysis: FURROW 1200-2
Furrow Irrigation-> 24.Hours @ 9.0gpm on 1200.ft @ .004ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Pasture	---	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Spring Grain	---	3.4	10.2	19.8	19.8	19.8	19.8	19.8
Field Corn	---	---	5.1	10.2	19.8	19.8	19.8	19.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.891	1.663	1.953	1.853	1.486	1.013	.340
Pasture	.000	2.181	3.396	4.256	4.332	3.737	2.943	1.967
Spring Grain	.000	4.193	4.349	3.722	3.118	.689	.000	.000
Field Corn	.000	.000	3.286	3.123	3.396	3.007	1.919	.465

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	1.049	1.941	2.219	2.053	1.619	1.133	.402
Pasture	.000	2.658	4.121	5.006	4.967	4.228	3.409	2.347
Spring Grain	.000	5.367	5.284	4.303	3.529	.744	.000	.000
Field Corn	.000	.000	4.265	3.728	3.848	3.358	2.188	.563

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman

Brockway Engineering and C. W. Robison

No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 200-1

Furrow Irrigation-> 12.Hours @ 4.0gpm on 200.ft @ .027ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	45.6*	45.6*	45.6*	45.6*	45.6*	45.6*	45.6*
Pasture	---	18.3	18.3	18.3	18.3	18.3	18.3	18.3
Spring Grain	---	4.6	13.9	27.4	27.4	27.4	27.4	27.4
Field Corn	---	---	6.9	13.9	27.4	27.4	27.4	27.4

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac

With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.640	1.194	1.403	1.331	1.067	.727	.244
Pasture	.000	1.579	2.458	3.080	3.135	2.704	2.130	1.424
Spring Grain	.000	3.073	3.188	2.682	2.247	.496	.000	.000
Field Corn	.000	.000	2.409	2.289	2.447	2.167	1.382	.335

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.728	1.347	1.540	1.424	1.123	.786	.279
Pasture	.000	1.882	2.918	3.544	3.517	2.994	2.414	1.662
Spring Grain	.000	3.911	3.805	3.016	2.474	.522	.000	.000
Field Corn	.000	.000	3.098	2.684	2.698	2.354	1.534	.395

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 200-2
Furrow Irrigation-> 12.Hours @ 4.0gpm on 200.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	45.6*	45.6*	45.6*	45.6*	45.6*	45.6*	45.6*
Pasture	---	18.3	18.3	18.3	18.3	18.3	18.3	18.3
Spring Grain	---	4.6	13.9	27.4	27.4	27.4	27.4	27.4
Field Corn	---	---	6.9	13.9	27.4	27.4	27.4	27.4

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.640	1.194	1.403	1.331	1.067	.727	.244
Pasture	.000	1.579	2.458	3.080	3.135	2.704	2.130	1.424
Spring Grain	.000	3.073	3.188	2.682	2.247	.496	.000	.000
Field Corn	.000	.000	2.409	2.289	2.447	2.167	1.382	.335

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.728	1.347	1.540	1.424	1.123	.786	.279
Pasture	.000	1.882	2.918	3.544	3.517	2.994	2.414	1.662
Spring Grain	.000	3.911	3.805	3.016	2.474	.522	.000	.000
Field Corn	.000	.000	3.098	2.684	2.698	2.354	1.534	.395

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 400-1
Furrow Irrigation-> 18.Hours @ 4.0gpm on 400.ft @ .022ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 400-2
Furrow Irrigation-> 18.Hours @ 4.0gpm on 400.ft @ .007ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 600-1
Furrow Irrigation-> 18.Hours @ 6.0gpm on 600.ft @ .023ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 600-2
Furrow Irrigation-> 18.Hours @ 6.0gpm on 600.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 600-3
Furrow Irrigation-> 24.Hours @ 5.0gpm on 600.ft @ .003ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	54.7	54.7	54.7	54.7	54.7	54.7	54.7
Pasture	---	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Spring Grain	---	5.6	16.7	32.9	32.9	32.9	32.9	32.9
Field Corn	---	---	8.3	16.7	32.9	32.9	32.9	32.9

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.533	.995	1.169	1.109	.889	.606	.204
Pasture	.000	1.316	2.048	2.566	2.613	2.254	1.775	1.187
Spring Grain	.000	2.561	2.656	2.235	1.872	.414	.000	.000
Field Corn	.000	.000	2.007	1.908	2.039	1.806	1.152	.280

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.607	1.123	1.283	1.187	.936	.655	.232
Pasture	.000	1.568	2.432	2.954	2.931	2.495	2.011	1.385
Spring Grain	.000	3.259	3.171	2.513	2.062	.435	.000	.000
Field Corn	.000	.000	2.582	2.237	2.248	1.962	1.278	.329

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 800-2
Furrow Irrigation-> 18.Hours @ 8.0gpm on 800.ft @ .009ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 800-3
Furrow Irrigation-> 24.Hours @ 6.0gpm on 800.ft @ .004ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
 With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KCB

Irrigation System Efficiency Analysis: FURROW 1200-2
Furrow Irrigation-> 24.Hours @ 9.0gpm on 1200.ft @ .004ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	60.8	60.8	60.8	60.8	60.8	60.8	60.8
Pasture	---	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Spring Grain	---	6.2	18.5	36.6	36.6	36.6	36.6	36.6
Field Corn	---	---	9.3	18.5	36.6	36.6	36.6	36.6

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.480	.896	1.052	.998	.801	.545	.183
Pasture	.000	1.184	1.844	2.310	2.351	2.028	1.597	1.068
Spring Grain	.000	2.305	2.391	2.011	1.685	.372	.000	.000
Field Corn	.000	.000	1.807	1.717	1.835	1.625	1.037	.252

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.546	1.010	1.155	1.068	.843	.590	.209
Pasture	.000	1.411	2.188	2.658	2.638	2.245	1.810	1.246
Spring Grain	.000	2.933	2.854	2.262	1.855	.391	.000	.000
Field Corn	.000	.000	2.324	2.013	2.023	1.766	1.150	.296

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KOB

Irrigation System Efficiency Analysis: FURROW 800-2
Furrow Irrigation-> 18.Hours @ 8.0gpm on 800.ft @ .009ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	53.9	53.9	53.9	53.9	53.9	53.9	53.9
Pasture	---	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Spring Grain	---	5.6	16.9	31.1	31.1	31.1	31.1	31.1
Field Corn	---	---	8.4	16.9	31.1	31.1	31.1	31.1

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.541	1.011	1.187	1.126	.903	.615	.207
Pasture	.000	1.316	2.049	2.567	2.613	2.254	1.776	1.187
Spring Grain	.000	2.527	2.621	2.366	1.982	.438	.000	.000
Field Corn	.000	.000	1.980	1.882	2.159	1.911	1.220	.296

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.621	1.149	1.314	1.215	.958	.671	.238
Pasture	.000	1.575	2.442	2.966	2.943	2.506	2.020	1.391
Spring Grain	.000	3.219	3.139	2.686	2.203	.465	.000	.000
Field Corn	.000	.000	2.552	2.214	2.402	2.096	1.366	.351

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL KOB

Irrigation System Efficiency Analysis: FURROW 1200-2
Furrow Irrigation-> 24.Hours @ 9.0gpm on 1200.ft @ .004ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	53.9	53.9	53.9	53.9	53.9	53.9	53.9
Pasture	---	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Spring Grain	---	5.6	16.9	31.1	31.1	31.1	31.1	31.1
Field Corn	---	---	8.4	16.9	31.1	31.1	31.1	31.1

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.541	1.011	1.187	1.126	.903	.615	.207
Pasture	.000	1.316	2.049	2.567	2.613	2.254	1.776	1.187
Spring Grain	.000	2.527	2.621	2.366	1.982	.438	.000	.000
Field Corn	.000	.000	1.980	1.882	2.159	1.911	1.220	.296

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.621	1.149	1.314	1.215	.958	.671	.238
Pasture	.000	1.575	2.442	2.966	2.943	2.506	2.020	1.391
Spring Grain	.000	3.219	3.139	2.686	2.203	.465	.000	.000
Field Corn	.000	.000	2.552	2.214	2.402	2.096	1.366	.351

Irrigation Water Requirements Analysis

Version 1.00

1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 200-2
Furrow Irrigation-> 12.Hours @ 4.0gpm on 200.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Pasture	---	15.1	15.1	15.1	15.1	15.1	15.1	15.1
Spring Grain	---	3.8	11.4	22.6	22.6	22.6	22.6	22.6
Field Corn	---	---	5.7	11.4	22.6	22.6	22.6	22.6

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.778	1.452	1.706	1.619	1.298	.885	.297
Pasture	.000	1.918	2.987	3.742	3.809	3.286	2.588	1.730
Spring Grain	.000	3.727	3.866	3.260	2.732	.604	.000	.000
Field Corn	.000	.000	2.921	2.776	2.975	2.634	1.681	.408

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.896	1.658	1.896	1.753	1.383	.968	.343
Pasture	.000	2.304	3.572	4.339	4.305	3.665	2.955	2.034
Spring Grain	.000	4.754	4.646	3.708	3.041	.641	.000	.000
Field Corn	.000	.000	3.771	3.278	3.316	2.894	1.885	.485

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 400-2
Furrow Irrigation-> 18.Hours @ 4.0gpm on 400.ft @ .007ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Pasture	---	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Spring Grain	---	5.1	15.3	30.1	30.1	30.1	30.1	30.1
Field Corn	---	---	7.6	15.3	30.1	30.1	30.1	30.1

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.584	1.089	1.280	1.214	.974	.663	.223
Pasture	.000	1.439	2.240	2.806	2.857	2.465	1.941	1.298
Spring Grain	.000	2.795	2.900	2.445	2.049	.453	.000	.000
Field Corn	.000	.000	2.191	2.082	2.231	1.976	1.261	.306

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.672	1.244	1.422	1.315	1.037	.726	.257
Pasture	.000	1.728	2.679	3.254	3.229	2.749	2.216	1.526
Spring Grain	.000	3.565	3.485	2.781	2.281	.481	.000	.000
Field Corn	.000	.000	2.828	2.458	2.487	2.170	1.414	.364

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 600-2
Furrow Irrigation-> 18.Hours @ 6.0gpm on 600.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Pasture	---	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Spring Grain	---	5.1	15.3	30.1	30.1	30.1	30.1	30.1
Field Corn	---	---	7.6	15.3	30.1	30.1	30.1	30.1

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.584	1.089	1.280	1.214	.974	.663	.223
Pasture	.000	1.439	2.240	2.806	2.857	2.465	1.941	1.298
Spring Grain	.000	2.795	2.900	2.445	2.049	.453	.000	.000
Field Corn	.000	.000	2.191	2.082	2.231	1.976	1.261	.306

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.672	1.244	1.422	1.315	1.037	.726	.257
Pasture	.000	1.728	2.679	3.254	3.229	2.749	2.216	1.526
Spring Grain	.000	3.565	3.485	2.781	2.281	.481	.000	.000
Field Corn	.000	.000	2.828	2.458	2.487	2.170	1.414	.364

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 800-2
Furrow Irrigation-> 18.Hours @ 8.0gpm on 800.ft @ .009ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Pasture	---	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Spring Grain	---	5.1	15.3	30.1	30.1	30.1	30.1	30.1
Field Corn	---	---	7.6	15.3	30.1	30.1	30.1	30.1

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
 With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.584	1.089	1.280	1.214	.974	.663	.223
Pasture	.000	1.439	2.240	2.806	2.857	2.465	1.941	1.298
Spring Grain	.000	2.795	2.900	2.445	2.049	.453	.000	.000
Field Corn	.000	.000	2.191	2.082	2.231	1.976	1.261	.306

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.672	1.244	1.422	1.315	1.037	.726	.257
Pasture	.000	1.728	2.679	3.254	3.229	2.749	2.216	1.526
Spring Grain	.000	3.565	3.485	2.781	2.281	.481	.000	.000
Field Corn	.000	.000	2.828	2.458	2.487	2.170	1.414	.364

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 1000
Furrow Irrigation-> 24.Hours @ 8.0gpm on 1000.ft @ .004ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Pasture	---	18.9	18.9	18.9	18.9	18.9	18.9	18.9
Spring Grain	---	4.8	14.3	28.2	28.2	28.2	28.2	28.2
Field Corn	---	---	7.2	14.3	28.2	28.2	28.2	28.2

Note the following symbol meanings

@@@ = Water did not reach end of furrow

* = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.623	1.162	1.365	1.295	1.039	.708	.238
Pasture	.000	1.535	2.389	2.994	3.047	2.629	2.070	1.384
Spring Grain	.000	2.982	3.093	2.608	2.185	.483	.000	.000
Field Corn	.000	.000	2.337	2.221	2.380	2.107	1.345	.326

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.717	1.327	1.517	1.403	1.106	.774	.274
Pasture	.000	1.843	2.858	3.471	3.444	2.932	2.364	1.627
Spring Grain	.000	3.803	3.717	2.966	2.433	.513	.000	.000
Field Corn	.000	.000	3.016	2.622	2.653	2.315	1.508	.388

Irrigation Water Requirements Analysis
Version 1.00
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Irrigation System Analysis FOR SOIL FKE

Irrigation System Efficiency Analysis: FURROW 1200-1
Furrow Irrigation-> 24.Hours @ 8.0gpm on 1200.ft @ .008ft/ft

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	---	56.3	56.3	56.3	56.3	56.3	56.3	56.3
Pasture	---	22.6	22.6	22.6	22.6	22.6	22.6	22.6
Spring Grain	---	5.7	17.2	33.8	33.8	33.8	33.8	33.8
Field Corn	---	---	8.6	17.2	33.8	33.8	33.8	33.8

Note the following symbol meanings
 @@@ = Water did not reach end of furrow
 * = End-of-Furrow application insufficient

On-Farm Diversion Requirements -- miner inches/ac
With a 80.0 percent probability level

Based on analysis period irrigation requirement

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.519	.968	1.137	1.079	.866	.590	.198
Pasture	.000	1.279	1.991	2.495	2.539	2.191	1.725	1.153
Spring Grain	.000	2.485	2.577	2.174	1.821	.402	.000	.000
Field Corn	.000	.000	1.947	1.851	1.983	1.756	1.121	.272

Based on analysis period peak consumptive use

CROP	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa Hay	.000	.597	1.105	1.264	1.169	.922	.645	.229
Pasture	.000	1.536	2.381	2.893	2.870	2.443	1.970	1.356
Spring Grain	.000	3.169	3.097	2.472	2.027	.428	.000	.000
Field Corn	.000	.000	2.514	2.185	2.211	1.929	1.257	.323

Irrigation Water Requirements Analysis
Version 1.25
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Overall Project On-Farm Diversion Requirement
With a 80.0% Water Requirement Probability Level

Based on analysis period irrigation requirement

CROP	Total	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	ac-ft		----- miners inches per ac. -----						
Alfalfa Hay	2250.	.000	.628	1.172	1.376	1.306	1.047	.714	.240
Pasture	2226.	.000	1.537	2.394	2.999	3.053	2.634	2.074	1.387
Spring Grain	1210.	.000	2.966	3.077	2.651	2.221	.491	.000	.000
Field Corn	1129.	.000	.000	2.325	2.210	2.418	2.141	1.366	.332

*Entire Project	6814.	.000	1.066	1.874	2.016	1.958	1.445	.976	.447

Based on analysis period peak consumptive use

CROP	Total	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	arces		----- miners inches per ac. -----						
Alfalfa Hay	303.	.000	.727	1.346	1.538	1.423	1.122	.786	.278
Pasture	121.	.000	1.853	2.873	3.490	3.463	2.948	2.377	1.636
Spring Grain	91.	.000	3.786	3.706	3.027	2.483	.524	.000	.000
Field Corn	91.	.000	.000	3.004	2.614	2.707	2.362	1.539	.396

*Entire Project	605.	.000	1.301	2.253	2.312	2.181	1.583	1.098	.525

Irrigation Water Requirements Analysis
Version 1.25
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Fraction of Soil Type Area served by Canal/Lateral Segment

Canal\Soil Class	01	02	03	04
Effective Div.	1.000	1.000	1.000	1.000

Table Soil Type Key

01 - QUB	02 - KCB	03 - KOB
04 - FKE		

Irrigation Water Requirements Analysis
Version 1.25
1999-03-27 @ 13:48:48

Big Springs Excess Flow Analysis - Hagerman
Brockway Engineering and C. W. Robison
No canal/lateral/ditch losses

Canal/Lateral Discharge Summary
(cubic feet per second)

Canal/Lateral	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Effective Div.	****	Seepage Rate:	.00 cfs/mi or	.00 cfs	****			

Based on analysis period irrigation requirement

DS Delivery	.0	.0	.0	.0	.0	.0	.0	.0
On-Farm Div.	.0	12.9	22.7	24.4	23.7	17.5	11.8	5.4
Seepage Loss	.0	.0	.0	.0	.0	.0	.0	.0
US Div. Req.	.0	12.9	22.7	24.4	23.7	17.5	11.8	5.4

Based on analysis period peak consumptive use

DS Delivery	.0	.0	.0	.0	.0	.0	.0	.0
On-Farm Div.	.0	15.8	27.3	28.0	26.4	19.2	13.3	6.4
Seepage Loss	.0	.0	.0	.0	.0	.0	.0	.0
US Div. Req.	.0	15.8	27.3	28.0	26.4	19.2	13.3	6.4

Big Springs Service Area - Big Springs (Secor/Durfee tunnel)

Estimated from 1987 FAS aerial photo with field areas by owner & G. Lemmon data

		Map scale 1"= 660 ft			Prepared by C.E.Brockway 3/23/1999					
Owner	Section	Farm	Field	Area	Est Run	Irrig.	Est. slope	Set	Assumed	Soil
#		Parcel	No.		Length	Type		Time	Efficiency	Type
				acres	ft		ft/ft	hrs	%	
496	NWSE 13	T-590	1	6.4	760	Fur 800-1	0.0250	12	30	QUB
			2	9.3	780	Fur 800-1	0.0250	12	30	QUB
			3	4	400	Fur 400-1	0.0250	12	30	QUB
527	SWSE 13	T-711	1	3.6	650	Fur 600-1	0.0250	12	30	KCB
			2	6.2	650	Fur 600-1	0.0250	12	30	KCB
			3	2.9	230	Fur 200-1	0.0250	12	30	KCB
			4	4.8	400	Fur 400-1	0.0250	12	30	KCB
524	SWSE 13	T-704	1	0.9	80	Fur 200-1	0.0300	6	30	QUB
			2	8.2	630	Fur 600-1	0.0200	12	30	QUB
			3	6.2	470	Fur 400-1	0.0200	12	30	QUB
541	NESW 13	T-726	1	12.9	530	Fur 600-1	0.0250	12	30	KCB
540	SESE 13	T-725	1	2.8	270	Fur 200-2	0.0050	12	30	QUB
			2	11.8	880	Fur 800-2	0.0050	12	30	KCB
			3	6.7	630	Fur 600-2	0.0060	12	30	QUB
525	SWSW 13	T-709	1	13.8	660	Fur 600-1	0.0200	12	30	KCB
464	SWSW 13	T-677	1	2.5	270	Fur 200-2	0.0100	12	30	KCB
			2	5.6	600	Fur 600-2	0.0100	12	30	KCB
			3	1.3	270	Fur 200-2	0.0100	12	30	KCB
526	SESE 14	T-710	1	5.1	240	Fur 200-2	0.0060	12	30	KCB
			2	5.7	430	Fur 400-2	0.0060	12	30	KCB
			3	4.3	450	Fur 400-2	0.0060	12	30	KCB
			4	6.8	410	Fur 400-2	0.0060	12	30	KCB
1401	NENE 24	T-562	1	9.1	1190	Fur 1200-1	0.0100	24	30	QUB
			2	16.3	1190	Fur 1200-1	0.0100	24	30	QUB
			3	11.3	1190	Fur 1200-1	0.0100	24	30	QUB
1401	NWNE 24	T-561	1	5.1	1190	Fur 1200-1	0.0060	24	30	QUB
			2	13.3	810	Fur 800-2	0.0060	12	30	QUB
			3	6	570	Fur 600-2	0.0060	12	30	QUB
			4	3.6	370	Fur 400-2	0.0060	12	30	QUB
			5	4.3	410	Fur 400-2	0.0060	12	30	QUB
			6	1.2	200	Fur 200-2	0.0060	12	30	QUB
1401?	SENE,SWNE 24	?	1	4.3	400	Fur 400-1	0.0200	12	30	QUB
	NESE,NWSE 24		2	4	430	Fur 400-1	0.0200	12	30	QUB
	SWSE,SESE 24		3	7.4	800	Fur 800-2	0.0100	12	30	QUB
			4	2.7	300	Fur 200-2	0.0100	12	30	QUB
			5	1.6	330	Fur 400-2	0.0060	12	30	QUB
			6	2.3	470	Fur 400-2	0.0060	12	30	QUB
			7	19.7	1130	Fur 1200-2	0.0040	24	30	KOB
			8	12.5	760	Fur 800-2	0.0100	12	30	KOB
			9	13.3	530	Fur 600-2	0.0100	12	30	FKE
			10	25.5	1130	Fur 1200-1	0.0060	24	30	FKE
			11	19.4	1130	Fur 1200-1	0.0060	12	30	FKE
			12	4.3	450	Fur 400-2	0.0080	12	30	FKE
			13	3.5	300	Fur 200-2	0.0100	12	30	FKE
			14	3.8	400	Fur 400-2	0.0100	12	30	FKE

Owner #	Section	Farm Parcel	Field No.	Area acres	Est Run Length ft	Irrig. Type	Est. slope ft/ft	Set Time hrs	Assumed Efficiency %	Soil Type	
			15	27	800	Fur 800-2	0.0100	12	30	KOB	
			16	20	800	Fur 800-2	0.0100	12	30	FKE	
1332	NENW,NWNE 24	T-736	1	46.7	1270	Fur 1200-2	0.0015	24	30	QUB	
			2	29	1270	Fur 1200-2	0.0015	24	30	KCB	
497	SWNW,SENE 24	T-591	1	67.6	1190	Fur 1200-2	0.0015	24	30	KOB	
475	NESW 24	T-568	1	34.4	1320	Fur 1200-2	0.0015	24	30	KOB	
467	NENE 23	T-560	1	18.4	660	Fur 600-3	0.0030	12	30	KCB	
507	NENE,NWNE 23	T-684	1	15	730	Fur 800-3	0.0030	12	30	KCB	
			2	0.5	140	Fur 200-2	0.0030	12	30	FKE	
			3	1.4	400	Fur 400-2	0.0030	12	30	KCB	
			4	17.9	990	Fur 1000	0.0030	24	30	FKE	
TOTAL			55	604.2							
Irrigation System Types-all furrow							Crop Types				
Fur 200-1 = Furrow w/ run length 100 to 300, Slope 0.027							50% alfalfa				
Fur 200-2 = Furrow w/ run length 100 to 399, Slope 0.008							15% pasture				
Fur 400-1 = Furrow w/ run length 301 to 500, Slope 0.022							15% grain				
Fur 400-2 = Furrow w/ run length 301 to 500, Slope 0.007							15% corn				
Fur 600-1 = Furrow w/ run length 501 to 700, Slope 0.023											
Fur 600-2 = Furrow w/ run length 501 to 700, Slope 0.008											
Fur 600-3 = Furrow w/ run length 501 to 700, Slope 0.003											
Fur 800-1 = Furrow w/ run length 701 to 900, Slope 0.025											
Fur 800-2 = Furrow w/ run length 701 to 900, Slope 0.009											
Fur 800-3 = Furrow w/ run length 701 to 900, Slope 0.003											
Fur 1000 = Furrow w/ run length 901 to 1100, Slope 0.003											
Fur 1200-1 = Furrow w/ run length 1101 to 1300, Slope 0.008											
Fur 1200-2 = Furrow w/ run length 1101 to 1300, Slope 0.002											

Acreage by irrigation system												
Fur 200-1	Fur 200-2	Fur 400-1	Fur 400-2	Fur 600-1	Fur 600-2	Fur 600-3	Fur 800-1	Fur 800-2	Fur 800-3	Fur 1000	Fur 1200-1	Fur 1200-2
0	0	0	0	0	0	0	6.4	0	0	0	0	0
0	0	0	0	0	0	0	9.3	0	0	0	0	0
0	0	4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	3.6	0	0	0	0	0	0	0	0
0	0	0	0	6.2	0	0	0	0	0	0	0	0
2.9	0	0	0	0	0	0	0	0	0	0	0	0
0	0	4.8	0	0	0	0	0	0	0	0	0	0
0.9	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	8.2	0	0	0	0	0	0	0	0
0	0	6.2	0	0	0	0	0	0	0	0	0	0
0	0	0	0	12.9	0	0	0	0	0	0	0	0
0	2.8	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	11.8	0	0	0	0
0	0	0	0	0	6.7	0	0	0	0	0	0	0
0	0	0	0	13.8	0	0	0	0	0	0	0	0
0	2.5	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	5.6	0	0	0	0	0	0	0
0	1.3	0	0	0	0	0	0	0	0	0	0	0
0	5.1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	5.7	0	0	0	0	0	0	0	0	0
0	0	0	4.3	0	0	0	0	0	0	0	0	0
0	0	0	6.8	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	9.1	0
0	0	0	0	0	0	0	0	0	0	0	16.3	0
0	0	0	0	0	0	0	0	0	0	0	11.3	0
0	0	0	0	0	0	0	0	0	0	0	5.1	0
0	0	0	0	0	0	0	0	13.3	0	0	0	0
0	0	0	0	0	6	0	0	0	0	0	0	0
0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	4.3	0	0	0	0	0	0	0	0	0
0	1.2	0	0	0	0	0	0	0	0	0	0	0
0	0	4.3	0	0	0	0	0	0	0	0	0	0
0	0	4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	7.4	0	0	0	0
0	2.7	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.6	0	0	0	0	0	0	0	0	0
0	0	0	2.3	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	19.7
0	0	0	0	0	0	0	0	12.5	0	0	0	0
0	0	0	0	0	13.3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	25.5	0
0	0	0	0	0	0	0	0	0	0	0	19.4	0
0	0	0	4.3	0	0	0	0	0	0	0	0	0
0	3.5	0	0	0	0	0	0	0	0	0	0	0
0	0	0	3.8	0	0	0	0	0	0	0	0	0

Acreage by irrigation system													
	Fur 200-1	Fur 200-2	Fur 400-1	Fur 400-2	Fur 600-1	Fur 600-2	Fur 600-3	Fur 800-1	Fur 800-2	Fur 800-3	Fur 1000	Fur 1200-1	Fur 1200-2
	0	0	0	0	0	0	0	0	27	0	0	0	0
	0	0	0	0	0	0	0	0	20	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	46.7
	0	0	0	0	0	0	0	0	0	0	0	0	29
	0	0	0	0	0	0	0	0	0	0	0	0	67.6
	0	0	0	0	0	0	0	0	0	0	0	0	34.4
	0	0	0	0	0	0	18.4	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	15	0	0	0
	0	0.5	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1.4	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	17.9	0	0
TOTAL	3.8	19.6	23.3	38.1	44.7	31.6	18.4	15.7	92	15	17.9	86.7	197.4
	604.2												
Irrigation system acres by soil type:													
QUB	0.9	6.7	18.5	11.8	8.2	12.7	0.0	15.7	20.7	0.0	0.0	41.8	46.7
KCB	2.9	8.9	4.8	18.2	36.5	5.6	18.4	0.0	11.8	15.0	0.0	0.0	29.0
KOB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.5	0.0	0.0	0.0	121.7
FKE	0.0	4.0	0.0	8.1	0.0	13.3	0.0	0.0	20.0	0.0	17.9	44.9	0.0
TOTAL	3.8	19.6	23.3	38.1	44.7	31.6	18.4	15.7	92.0	15.0	17.9	86.7	197.4
Total soil type acres													
QUB	183.7												
KCB	151.1												
KOB	161.2												
FKE	108.2												
TOTAL	604.2												

BIG SPRINGS EXCESS FLOW ANALYSIS

Breakdown of irrigation system acres and soil type acreage

Brockway Engineering, PLLC 3/25/99

Irrigation System	Acres	Acreage breakdown by soil type:				Acreage breakdown by crop			
		QUB	KCB	KOB	FKE	Alf (50%)	Past (20%)	SGrain (15%)	FCorn(15%)
Fur 200-1	3.8	0.9	2.9	0.0	0.0	1.9	0.8	0.6	0.6
Fur 200-2	19.6	6.7	8.9	0.0	4.0	9.8	3.9	2.9	2.9
Fur 400-1	23.3	18.5	4.8	0.0	0.0	11.7	4.7	3.5	3.5
Fur 400-2	38.1	11.8	18.2	0.0	8.1	19.1	7.6	5.7	5.7
Fur 600-1	44.7	8.2	36.5	0.0	0.0	22.4	8.9	6.7	6.7
Fur 600-2	31.6	12.7	5.6	0.0	13.3	15.8	6.3	4.7	4.7
Fur 600-3	18.4	0.0	18.4	0.0	0.0	9.2	3.7	2.8	2.8
Fur 800-1	15.7	15.7	0.0	0.0	0.0	7.9	3.1	2.4	2.4
Fur 800-2	92.0	20.7	11.8	39.5	20.0	46.0	18.4	13.8	13.8
Fur 800-3	15.0	0.0	15.0	0.0	0.0	7.5	3.0	2.3	2.3
Fur 1000	17.9	0.0	0.0	0.0	17.9	9.0	3.6	2.7	2.7
Fur 1200-1	86.7	41.8	0.0	0.0	44.9	43.4	17.3	13.0	13.0
Fur 1200-2	197.4	46.7	29.0	121.7	0.0	98.7	39.5	29.6	29.6
TOTAL	604.2	183.7	151.1	161.2	108.2				

BIG SPRINGS EXCESS FLOW

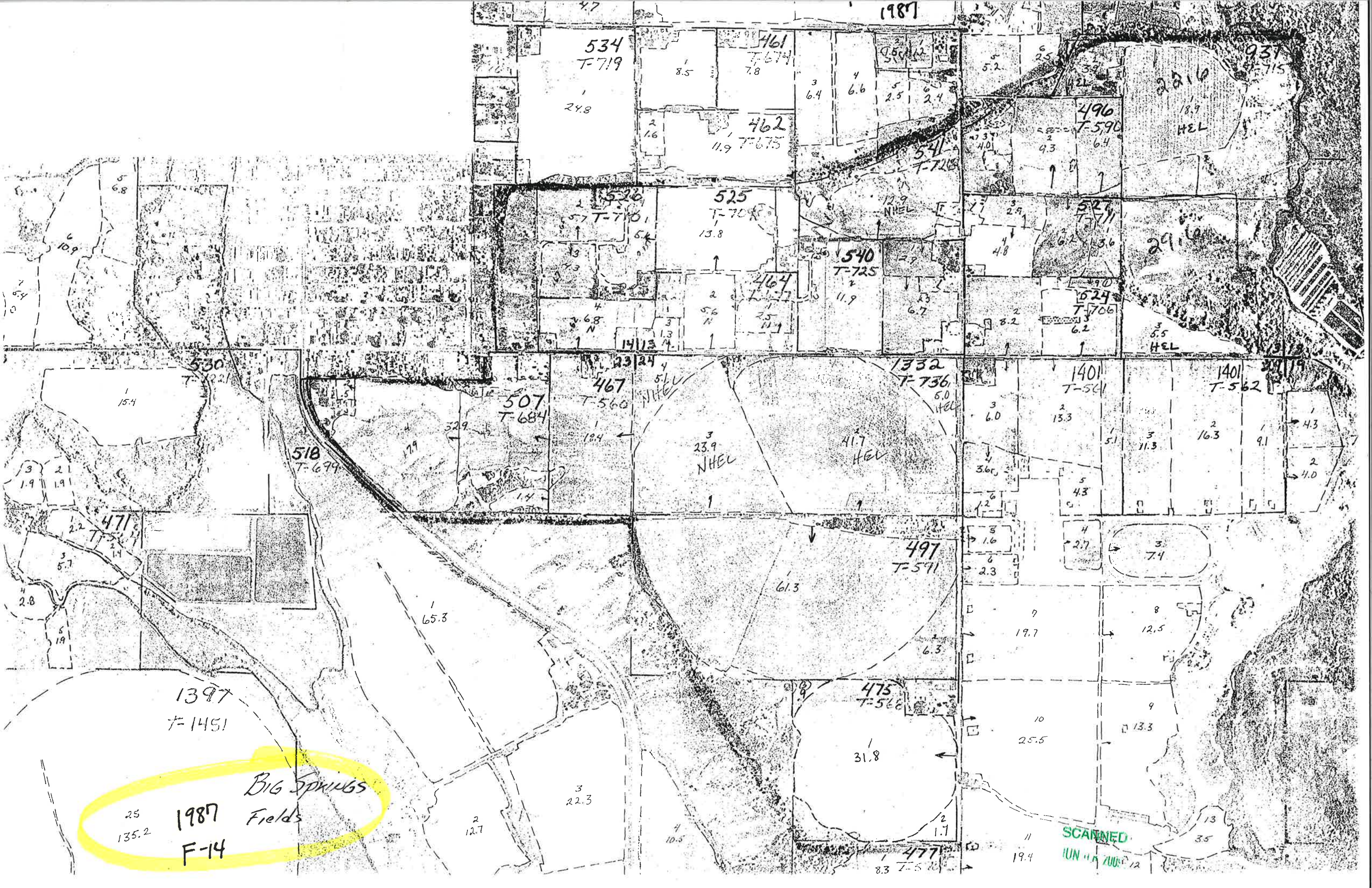
Acreage breakdown by crop applicable to each soil type for each irrigation system

Irrigation System	For soil QUB:			
	Alfalfa	Pasture	SGrain	FCorn
Fur 200-1	0.5	0.2	0.1	0.1
Fur 200-2	3.4	1.3	1.0	1.0
Fur 400-1	9.3	3.7	2.8	2.8
Fur 400-2	5.9	2.4	1.8	1.8
Fur 600-1	4.1	1.6	1.2	1.2
Fur 600-2	6.4	2.5	1.9	1.9
Fur 600-3	0.0	0.0	0.0	0.0
Fur 800-1	7.9	3.1	2.4	2.4
Fur 800-2	10.4	4.1	3.1	3.1
Fur 800-3	0.0	0.0	0.0	0.0
Fur 1000	0.0	0.0	0.0	0.0
Fur 1200-1	20.9	8.4	6.3	6.3
Fur 1200-2	23.4	9.3	7.0	7.0

For soil KCB:			
Alfalfa	Pasture	SGrain	FCorn
1.5	0.6	0.4	0.4
4.5	1.8	1.3	1.3
2.4	1.0	0.7	0.7
9.1	3.6	2.7	2.7
18.3	7.3	5.5	5.5
2.8	1.1	0.8	0.8
9.2	3.7	2.8	2.8
0.0	0.0	0.0	0.0
5.9	2.4	1.8	1.8
7.5	3.0	2.3	2.3
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
14.5	5.8	4.4	4.4

Irrigation System	For soil KOB			
	Alfalfa	Pasture	SGrain	FCorn
Fur 200-1	0.0	0.0	0.0	0.0
Fur 200-2	0.0	0.0	0.0	0.0
Fur 400-1	0.0	0.0	0.0	0.0
Fur 400-2	0.0	0.0	0.0	0.0
Fur 600-1	0.0	0.0	0.0	0.0
Fur 600-2	0.0	0.0	0.0	0.0
Fur 600-3	0.0	0.0	0.0	0.0
Fur 800-1	0.0	0.0	0.0	0.0
Fur 800-2	19.8	7.9	5.9	5.9
Fur 800-3	0.0	0.0	0.0	0.0
Fur 1000	0.0	0.0	0.0	0.0
Fur 1200-1	0.0	0.0	0.0	0.0
Fur 1200-2	60.9	24.3	18.3	18.3

For soil FKE			
Alfalfa	Pasture	SGrain	FCorn
0.0	0.0	0.0	0.0
2.0	0.8	0.6	0.6
0.0	0.0	0.0	0.0
4.1	1.6	1.2	1.2
0.0	0.0	0.0	0.0
6.7	2.7	2.0	2.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
10.0	4.0	3.0	3.0
0.0	0.0	0.0	0.0
9.0	3.6	2.7	2.7
22.5	9.0	6.7	6.7
0.0	0.0	0.0	0.0



1987

534
T-719

461
T-674

937
T-715

496
T-590

462
T-675

541
T-728

525
T-705

526
T-711

540
T-725

624
T-706

467
T-560

1332
T-736

1401
T-541

1401
T-562

507
T-684

497
T-571

475
T-568

1397
T-1451

BIG SPRINGS
Fields

1987
F-14

SCANNED
JUN 11 2008

R. H. H.





PHYSICAL PROPERTIES OF SOILS
Brockway

(Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Wind erodability index" apply only to the surface layer)

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Shrink- swell potential	Organic matter	Erosion factors			Wind erodi- bility group	Wind erodi- bility index
								K	Kf	T		
	In	Pct	g/cc	In/hr	In/in		Pct					
14: Bahem-----	0-11	8-18	1.40-1.50	0.60-2.00	0.13-0.17	Low	1.0-2.0	0.43	0.43	5	3	86
	11-41	10-18	1.30-1.45	0.60-2.00	0.14-0.19	Low	0.0-0.5	0.49	0.49			
	41-60	0-8	1.45-1.55	2.00-6.00	0.09-0.12	Low	0.0-0.5	0.37	0.37			
31: Chijer-----	0-17	5-8	1.40-1.60	>20.00	0.07-0.09	Low	0.6-1.0	0.17	0.17	3	2	134
	17-43	8-18	1.35-1.55	0.60-2.00	0.10-0.18	Low	0.0-0.5	0.49	0.49			
	43-60	---	---	---	---		---	---	---			
32: Chijer-----	0-10	8-18	1.30-1.50	0.60-2.00	0.10-0.12	Low	0.6-1.0	0.24	0.24	3	3	86
	10-51	8-18	1.35-1.55	0.60-2.00	0.10-0.18	Low	0.0-0.5	0.49	0.49			
	51-55	8-13	1.35-1.55	0.60-2.00	0.10-0.12	Low	0.0-0.5	0.24	0.28			
	55-61	---	---	---	---		---	---	---			
53: Ephrata-----	0-5	10-17	1.30-1.50	2.00-6.00	0.10-0.14	Low	0.5-1.0	0.32	0.37	J	3	86
	5-26	10-17	1.25-1.50	2.00-6.00	0.10-0.15	Low	0.0-0.5	0.37	0.43			
	26-61	0-8	1.55-1.75	>20.00	0.03-0.06	Low	0.0-0.5	0.15	0.20			
55: Fathom-----	0-7	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.6-0.9	0.20	0.20	5	2	134
	7-61	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.0-0.5	0.20	0.20			
56: Fathom-----	0-7	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.6-0.9	0.20	0.20	5	2	134
	7-61	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.0-0.5	0.20	0.20			
59: Fathom-----	0-7	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.6-0.9	0.20	0.20	5	2	134
	7-61	0-5	1.40-1.60	6.00-20.00	0.09-0.10	Low	0.0-0.5	0.20	0.20			
Kudlac-----	0-3	20-25	1.15-1.25	0.20-0.60	0.14-0.16	Low	0.5-1.0	0.43	0.43	5	4L	86
	3-60	25-35	1.50-1.65	0.00-0.06	0.12-0.16	Moderate	0.0-0.5	0.43	0.43			
Anchustequi-----	0-7	20-27	1.30-1.40	0.60-2.00	0.13-0.15	Low	1.0-2.0	0.43	0.43	5	6	48
	7-60	5-35	1.25-1.45	0.20-20.00	0.07-0.19	Moderate	0.0-1.0	0.37	0.37			

PHYSICAL PROPERTIES OF SOILS--Continued
Brockway

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Shrink- swell potential	Organic matter	Erosion factors			Wind erodi- bility group	Wind erodi- bility index
								K	Kf	T		
	In	Pct	g/cc	In/hr	In/in		Pct					
60: Fathom-----	0-9	0-5	1.45-1.65	6.00-20.00	0.06-0.08	Low	0.5-1.0	0.10	0.10	3	1	220
	9-22	0-5	1.40-1.60	6.00-20.00	0.07-0.10	Low	0.0-0.5	0.10	0.10			
	22-42	0-5	1.40-1.60	6.00-20.00	0.07-0.10	Low	0.0-0.5	0.10	0.10			
	42-52	2-10	1.35-1.55	6.00-20.00	0.09-0.12	Low	0.0-0.5	0.20	0.20			
	52-60	---	---	---	---		---	---	---			
Taunton-----	0-16	5-12	1.40-1.60	6.00-20.00	0.09-0.11	Low	0.5-1.0	0.10	0.10	2	2	134
	16-29	10-18	1.25-1.45	0.60-2.00	0.11-0.18	Low	0.0-0.5	0.37	0.43			
	29-59	---	---	---	---		---	---	---			
	59-63	---	---	---	---		---	---	---			
66: Fluvaquents-----	0-7	10-15	1.35-1.50	0.60-2.00	0.14-0.16	Low	1.0-4.0	0.24	0.24	5	8	---
	7-60	10-20	1.30-1.55	0.60-6.00	0.10-0.17	Low	0.5-1.0	0.20	0.20			
Histic Endoaquolls-----	0-11	---	0.65-1.00	0.60-2.00	0.22-0.25	Low	60-85	---	---	---	8	---
	11-60	8-18	1.35-1.55	0.60-6.00	0.12-0.16	Low	10-20	0.20	0.20			
180: Lava Flows.												
Starbuck-----	0-3	10-14	1.25-1.45	0.60-2.00	0.10-0.13	Low	0.7-2.0	0.15	0.49	1	8	---
	3-12	14-18	1.30-1.50	0.60-2.00	0.16-0.18	Low	0.0-0.5	0.37	0.37			
	12-22	---	---	---	---		---	---	---			
206: Rock Outcrop.												
Vining-----	0-6	6-15	1.35-1.55	2.00-6.00	0.10-0.14	Low	0.7-1.0	0.20	0.24	2	3	86
	6-24	7-18	1.40-1.60	2.00-6.00	0.09-0.12	Low	0.0-0.5	0.20	0.32			
	24-28	---	---	---	---		---	---	---			
Kecko-----	0-5	3-8	1.40-1.60	6.00-20.00	0.08-0.10	Low	0.5-1.0	0.10	0.10	5	2	134
	5-40	10-18	1.25-1.50	2.00-6.00	0.13-0.15	Low	0.0-0.5	0.24	0.24			
	40-61	5-10	1.35-1.60	2.00-6.00	0.03-0.12	Low	0.0-0.5	0.10	0.10			

KOB Kecko fine sandy loam, 2 to 4 percent slopes

COMPOSITION

Kecko soil - 85 percent

Inclusions - 15 percent

KECKO SOIL

Positions on landscape: undulating lacustrine terraces

Elevation: 2800 to 3000 feet

Climatic data: (average annual)

precipitation - about 9 inches

air temperature - about 50 degrees F.

frost free period - about 130 days

Typical profile:

0 to 9 inches - brown fine sandy loam

9 to 21 inches - yellowish brown fine sandy loam

21 to 44 inches - light yellowish brown loamy very fine sand and fine sandy loam

44 to 60 inches - very pale brown silt loam

Depth class: very deep (more than 60 inches)

Drainage class: well drained

Permeability: moderately rapid

Available water capacity: moderate; 6 to 9 inches

Potential rooting depth: 60 inches or more

Runoff: very slow

Hazard of erosion:

by water - slight

by wind - moderate

INCLUDED AREAS

Contrasting inclusions:

Ephrata fine sandy loam and Quincy fine sand

SCANNED
JUN 11 2006

Similar inclusions:

Keck fine sandy loam on a 0 to 2 percent slope

INTERPRETATIVE GROUPS

Capability classification:

IIIe irrigated, Vie nonirrigated

Abbreviated version - subject to change.

QUB

QUB Quincy fine sand, 1 to 4 percent slopes

COMPOSITION

Quincy soil - 85 percent

Inclusions - 15 percent

QUINCY SOIL

Positions on landscape: basalt plains

Elevation: 3200 to 3500 feet

Climatic data: (average annual)

precipitation - about 9 inches

air temperature - about 50 degrees F.

frost free period - about 115 days

Typical profile:

0 to 2 inches - brown fine sand

2 to 43 inches - yellowish brown fine sand and loamy fine sand

43 to 61 inches - pale brown loamy fine sand

Depth class: very deep (more than 60 inches)

Drainage class: excessively drained

Permeability: rapid

Available water capacity: low; 3 to 6 inches

Potential rooting depth: 60 or more inches

Runoff: very slow

Hazard of erosion:

by water - none

by wind - very severe

INCLUDED AREAS

Contrasting inclusions:

10 percent Walco fine sand on convex positions

Similar inclusions:

5 percent Fathom fine sand

INTERPRETATIVE GROUPS

Capability classification:

IVe irrigated, VIIe nonirrigated

Abbreviated version - subject to change.

SCANNED
JUN 11 2005

FKE Fathom - Kudlac - Anchustequi complex, 8 to 35 percent slopes

COMPOSITION

Fathom soil - 40 percent
Kudlac soil - 15 percent
Anchustequi - 15 percent

SETTING

Positions on landscape: concave positions and toe slopes of basalt escarpments

Elevation: 2700 to 3000 feet

Climatic data: (average annual)

- * precipitation - about 9 inches
- * air temperature - about 50 degrees F.
- * frost free period - about 130 days

FATHOM SOIL

Typical profile:

0 to 7 inches - brown loamy fine sand
7 to 20 inches - brown loamy fine sand
20 to 61 inches - pale brown loamy fine sand

Depth class: very deep (more than 60 inches)

Drainage class: excessively drained

Permeability: rapid

Available water capacity: low; 3 to 6 inches

Potential rooting depth: 60 or more inches

Runoff: very slow

Hazard of erosion: by water - none
by wind - severe

KUDLAC SOIL

Positions on landscape: convex positions and midslopes on - basalt plains

Typical profile:

0 to 3 inches - pale brown silt loam
3 to 12 inches - pale brown silt loam
12 to 18 inches - light gray silt loam
18 to 23 inches - very pale brown silty clay loam
23 to 29 inches - pale brown silt loam
29 to 60 inches - very pale brown silty clay loam

SCANNED
JUN 11 2005

Depth class: very deep (more than 60 inches)

Drainage class: excessively drained

Permeability: very slow

Available water capacity: low; 3 to 6 inches

Potential rooting depth: 60 or more inches

Runoff: very rapid

Hazard of erosion: by water - very severe
by wind - slight

ANCHUSTEQUI SOIL

Position on landscape: lacustrine terraces

Typical profile:

0 to 7 inches - pale brown loam

7 to 11 inches - very pale brown loam

11 to 60 inches - white to pale brown stratified silty clay
loam to fine sand

Depth class: very deep (60 inches or more)

Drainage class: poorly drained

Permeability: moderately slow

Water table depth: 6 to 60 inches

Available water capacity: high; 9 to 12 inches

Potential rooting depth : 60 inches or more

Restriction to rooting depth: water table at 6 to 60 inches

Runoff: slow

Hazard of erosion: by water - slight; by wind - slight

INCLUDED AREAS

Similar inclusions:

Bahem fine sandy loam in concave positions

Kecko fine sandy loam in concave positions

INTERPRETATIVE GROUPS

Capability classification:

IIIe irrigated, VIe nonirrigated

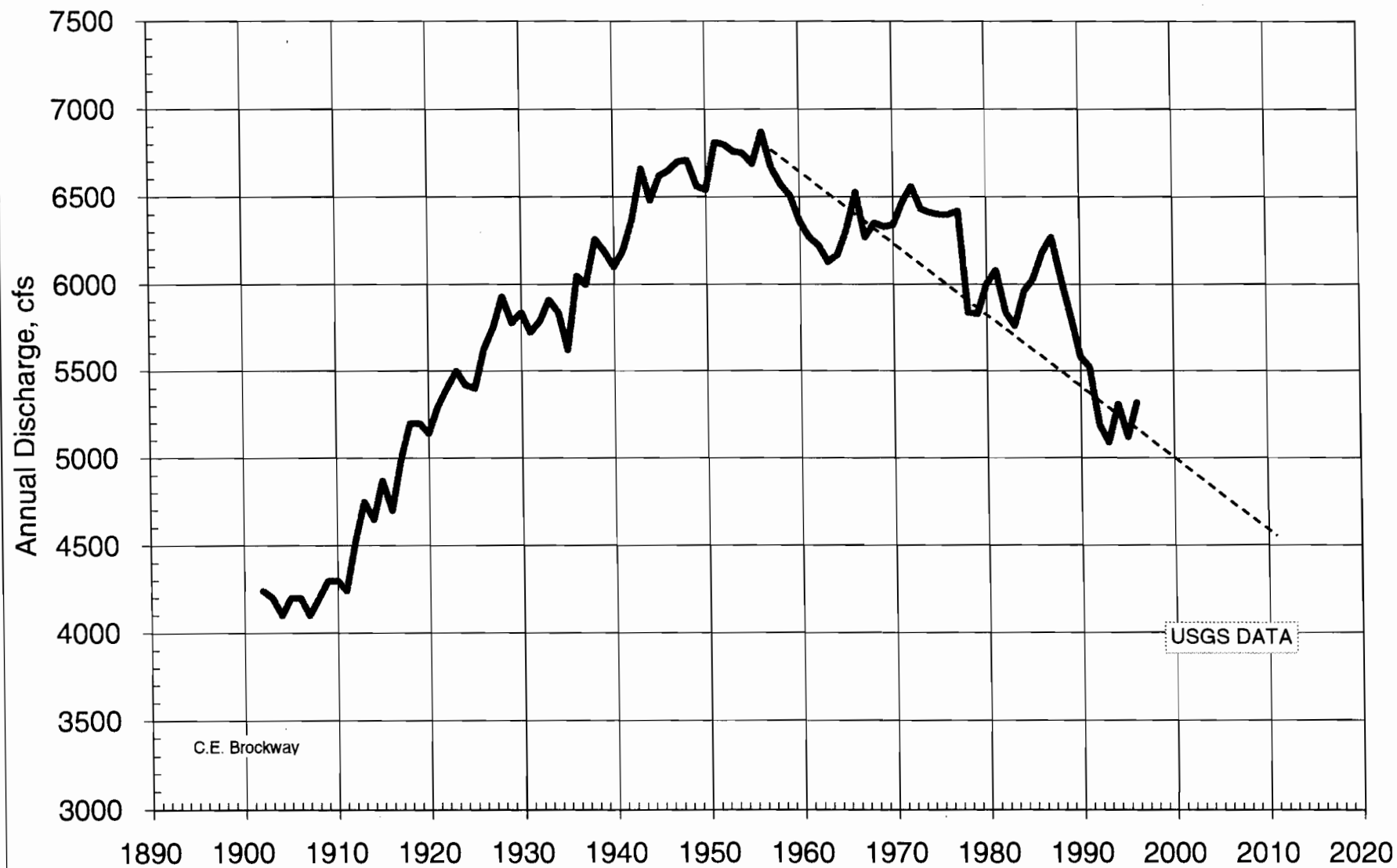
SCANNED
JUN 11 2005

Guidelines for the Evaluation of Irrigation Diversion Rates

**State of Idaho
Department of Water Resources
1301 North Orchard Street
Boise, Idaho 83720**

Prepared by Hubble Engineering, Inc.
and
Associated Earth Sciences
7025 Emerald
Boise, Idaho 83704

SNAKE PLAIN AQUIFER KIMBERLY TO KING HILL SPRING OUTFLOW



IRRIGATION WATER DIVERSION REQUIREMENTS PROGRAM

by
Clarence W. Robison

INTRODUCTION

The rate and volume water requirements for an irrigation diversion are driven by three aspects of crop production: crop consumptive use, leaching of soil salts, and frost protection. The primary aspect is to supply the crop's consumptive use requirements. Losses associated with the inefficiency of irrigation applications systems typically meet the leaching requirements. There have been many studies quantifying the amount of water consumed by individual crops and procedures for estimating the usage from weather or climatic data. These procedures are explained in many irrigation texts and engineering reference materials such as Jensen, et al.¹ The State of Idaho Department of Water Resources commissioned a study with the University of Idaho evaluated the methods of estimating consumptive use and irrigation requirements for the various agricultural crops produced in the state. The study recommended the FAO-Blaney-Criddle method for estimates of crop consumptive use for the state.² Utilization of the crop consumptive use estimates and the associated cropped areas will not yield the required diversion rate to irrigate those crops. The required diversion rates and volumes will depend on the soil characteristics, the irrigation application and delivery system, and system management.

For the purposes of water allocation, some have suggested that the crop with the highest annual consumptive irrigation requirement should determine the diversion rate and volume under a mono cropping assumption. This would yield conservative estimates of the potential diversion requirements; but, are unrealistic. For long term profitability, agriculture requires crop rotations to maintain land productivity and product quality. Secondly, mean consumptive use or irrigation requirement would reflect a diversion rate and volume that would be inadequate fifty percent of the time. Therefore, the program uses crop patterns in conjunction with soil and on farm management practices for project areas.

A computer program was developed to estimate the peak and annual diversion requirements for an irrigated area. The program computes rate and volume requirements for an irrigated area given information describing the area. The procedure requires information describing the irrigation and delivery systems, the soils, and the crops. The program does not estimate or compute crop consumptive use or irrigation requirement. The program uses this data in conjunction with soils and irrigation system information. The procedure used by the program is similar to that described by the Hubble Report, "Guidelines for the Evaluation of Irrigation Diversion Rates."³ The program consists of four major areas: water requirements, application requirements, system efficiencies, and distribution losses.

The following definitions are offered to assist in clarifying the procedures used in the program.

Consumptive Use (*cu*): The amount of water transpired by an activity growing crop plus the amount water evaporated from the soil surface and foliage occupying the area around the growing crop. Typically expressed as a depth per time (mm/day or in/day).

Consumptive Irrigation Requirement (*cir*): The amount of irrigation water required to meet the consumptive use of a crop after accounting for natural precipitation. It typically has the units of depth per time (in/day).

Available Water Holding Capacity (*awhc*): The amount of water held by the soil profile after draining. It typically has the units of depth per unit depth (in/foot).

Allowable Soil Moisture Depletion (*asmd*): The amount of soil moisture which can be depleted from the root zone before the crop suffers stress which would impact crop yield and quality. It typically is a percentage or fraction of the available water holding capacity.

Irrigation Application Depth (*iad*): The amount of water required to replenish the soil moisture in the crop root zone to holding capacity. (in)

Irrigation Return Period (*irp*): The time between irrigations (days).

Irrigation Application Efficiency: The percentage of applied irrigation water stored in the root zone and used by the crop to satisfy crop consumptive use. It is typically a percentage.

METHODS

Irrigation Application Depth

The purpose of irrigation is to supply the crop with its water requirements and any leaching requirements based on the soils and irrigation water. Each irrigation should replenish the soil moisture in the crops root zone. The amount of soil moisture to be replenished by irrigation is the irrigation application depth. The soil moisture capacity, crop rooting depth, and allowable soil moisture depletion for a crop determines the application depth.

$$iad_{crop\ soil} = asmd_{crop} * arzsm_{crop\ soil} \dots\dots\dots [1]$$

where:

$iad_{crop\ soil}$ Irrigation application requirement, depth

$asmd_{crop}$ Allowable soil moisture depletion, fraction.

$arzsm_{crop\ soil}$ Available root zone soil moisture, depth.

The program computes the available root zone soil moisture from the soil moisture profile given by the user and the crop rooting depth using a linear interpolation procedure. For example a soil moisture capacity curve for a Bruneau area soil is shown in Figure 1. The program expects the cumulative soil moisture for 0 to 5 feet by 1 foot intervals. If the soil profile does not extend six feet in depth, the portion beyond the end of the profile should be treated as a soil without any moisture holding capability.

The user supplies the rooting depth over the season and allowable soil moisture deficit for each crop. For perennial crops (alfalfa, pasture grasses, and orchards) the crop rooting depth changes from year to year. The user should select a rooting depth typical of average crop age. Table 1 summarizes typical rooting depths for

Table 1. Rooting depths and allowable soil moisture depletion for various crops.^{3,4,5}

Crop	Rooting Depth	Time to Reach	Allowable Depletion
Alfalfa	4 - 5 ft	-- Perennial --	50-60%
Dry Beans	2 - 2.5 ft	50 days after planting	40-50%
Clover	2 - 3 ft	-- Perennial --	40-50%
Corn	3 - 4 ft	10 days after tasseling	50%
Corn, Sweet	2.5 - 3 ft	10 days after tasseling	40%
Grapes	3 ft	-- Perennial --	65%
Hops	5 ft		50%
Mint	2 - 3 ft		40-50%
Onions	1.5 ft		30%
Orchard	5 - 6 ft	-- Perennial --	50-65%
Potatos	2 - 3 ft	80 days after planting	30-40%
Pasture/Turf	2 - 3 ft	-- Perennial --	50-60%
Peas	2 - 3 ft		50%
Small Grains	3 - 4 ft	heading	50-60%
Sugar Beets	3 - 5 ft	10-60 days after planting	50%

various crops. For example, a mature alfalfa hay crop typically has a rooting depth of 4 feet with an allowable soil moisture depletion of 50 percent which would result in an irrigation application depth of 2.75 inches for the soil shown in Figure 1.

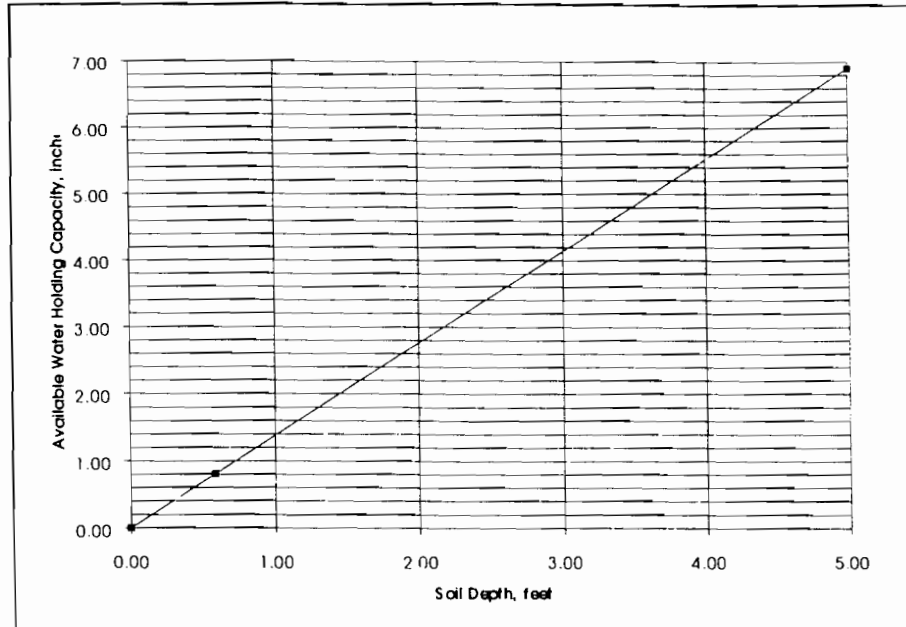


Figure 1. Available soil moisture versus for a Bruneau area soil.

Crop Water Requirements

The program requires crop consumptive use and irrigation requirement data inconjunction with a user specified probability level for meeting the crop needs. Allen and Brockway³ prepared consumptive irrigation requirements for various areas of the State of Idaho based upon the FAO Blaney-Criddle method of estimating crop evapotranspiration. The numbers in their report reflect the mean (average) consumptive irrigation requirements based upon the weather data available for the area. Thus, their published number reflects that fifty percent of the time the actual requirment will be greater than that published. In determination of an irrigation water right or permit, the mean requirement is probably not adquate. Irrigated farm operators would prefer an estimate that is met more than fifty percent of the time. The program combines the consumptive use and and irrigation requirement with the published standard deviations and a risk level specified by the user. The current version of the program assumes that the consumptive uses and irrigation requirements are normally distributed.

Peak Consumptive Use

The peak diversion rate for a system is associated with a peak daily consumptive use. The daily consumptive use is also associated with the irrigation return period or irrigation application depth. The higher the soil moisture holding capacity, longer irrigation return intervals, the peak consumptive use approaches the monthly consumptive use. In determining the peak consumptive for a crop, the monthly consumptive reported by Allen and Brockway³ is first adjusted for the level or risk assuming a normal distribution according to the following formula⁶.

$$cu_{crop} = \overline{cu_{crop}} + std_{cu} * z \dots\dots\dots [2]$$

where:

$\overline{cu_{crop}}$ Crop consumptive use associated with a level of risk.

cu_{crop} Published crompt monthly mean consumptive use.

std_{cu} Published standard deviation of the crop consumptive use.

Z Standardized normalized variate associated with a given probability.

The consumptive use is then adjusted for the irrigation return interval period by the irrigation application depth for the crop. The procedure use for adjusting the consumptive use is outlined in Jensen².

$$pcu_{crop\ soil} = cu_{crop} * f(iad_{crop\ soil}) \dots\dots\dots [3]$$

where:

$pcu_{crop\ soil}$ Peak crop consumptive use associated with a level of risk.

$f(iad_{crop\ soil})$ Function relating allowable soil moisture depletion for crop on a soil and monthly
.....consumptive use to peak consumptive use, Figure 6.6, page 223, Jensen².

The function yields values of x.xx, x.xx, and x.xx for allowable depletions of x.xx, x.xx, and x.xx inches respectively.

Irrigation Requirement

The monthly and annual diversion requirement (volume) is based on the crop irrigation requirement. To adjust the published mean daily irrigation requirement for the level of risk the following formula is applied:

$$cir_{crop} = \overline{cir_{crop}} + std_{cr} * z \dots\dots\dots [4]$$

where:

cir_{crop} Consumptive irrigation requirement associated with a level of risk.

$\overline{cir_{crop}}$ Published mean consumptive irrigation requirement.

std_{cr} Published standard deviation of the consumptive irrigation requirement.

z Standardized normalized variate associated with a given probability.

For example, the mean alfalfa hay consumptive irrigation requirement for June is 0.25 inches per day⁷ in the Bruneau area with a standard deviation of 0.04. Thus, the requirement associated with the 80 percent risk level (is not exceeded eighty percent of time) is 0.28 inches per day (12 percent increase).

Soil Infiltration and Intake Families

The analysis of irrigation system efficiency requires an estimate of the infiltration rate for the soil. The methods that will be used to determine system efficiency are based on the USDA - NRCS (SCS) intake family infiltration. The cumulative infiltration function is expressed as:

$$F_n = aT_n^b + c \dots\dots\dots [5]$$

where:

T_n time for infiltration, minutes

F_n cumulative infiltration, inches, for time

a, b, c infiltration coefficients associated with an intake family.

There are two intake families. The first intake family is referred to as the flood intake family and the second is referred as the furrow intake family. The flood intake family is used in border irrigation system analysis and the second is used in furrow and corrugate irrigation systems analysis. The two families are related to each other by the following equation⁸:

$$frw_{family} = 0.28 + 0.14 * fld_{family} \dots\dots\dots [6]$$

where:

fld_{family} flood intake family

frw_{family} furrow intake family

Infiltration coefficients based on the intake family are computed based upon the standard equations published by the USDA-NRCS. The coefficients for the flood intake family are computed with the following equation:

$$a = \left(\frac{fld_{family} + 3.1877}{339.06} \right)^{0.71638} \dots\dots\dots [7]$$

$$b = \left(\frac{fld_{family} + 1.8572}{238.32} \right)^{0.06862} \quad \text{for } fld_{family} < 5.14 \dots\dots\dots [8]$$

$$b = \left(\frac{fld_{family} - 2.5696}{237890} \right)^{0.021171} \quad \text{for } fld_{family} \geq 5.14$$

The infiltration coefficients associated with the furrow intake family are computed with the following equations:

$$a = \left(\frac{frw_{family} + 0.166281}{47.467904} \right)^{0.716378} \dots\dots\dots [9]$$

$$b = \left(\frac{frw_{family} - 0.02}{33.364573} \right)^{0.06862} \quad \text{for } frw_{family} < 1.0 \dots\dots\dots [10]$$

$$b = \left(\frac{frw_{family} - 0.639737}{33304.67292} \right)^{0.021171} \quad \text{for } frw_{family} \geq 1.0$$

Also associated with the furrow intake families are coefficients describing the irrigation water advance through the furrow to the end of the field. These coefficients are usually determined with the following equations:

$$f = 2321 + 5.8653 \cdot fwr_{family} \dots\dots\dots [11]$$

$$g = 4.4685 \cdot 10^{-4} + 0.0015764 \cdot fwr_{family} \dots\dots\dots [12]$$

Irrigation System Application Efficiency

The on farm irrigation diversion requirement has to reflect losses in the application of the irrigation water on the field where the crop is grown. There are many various methods of applying irrigation water: furrow, border, sprinkler, flood, etc. Each of the methods have their advantages and disadvantages and efficiencies. Typically, the largest factor influencing each application method efficiency is the irrigator which is difficult to quantify. The current version of the program has provisions to handle furrow irrigation, level border irrigation, handline - wheel-line sprinkler irrigation, center pivot irrigation, and contour ditch (wild flooding).

Contour Ditch

The program computes irrigation efficiencies for the contour ditch (wild flooding) method of irrigation by a simple mass balance. The user is expected to enter information regarding the length of run, typical flow rate and associated ditch length (field width) irrigated per set, and the time associated with set. The application efficiency is computed with the following equation:

$$AE = \frac{iad \cdot fl \cdot sw}{12 \cdot Q \cdot T_{set}} \cdot 100 \dots\dots\dots [13]$$

where:

AE application efficiency, percent

Q typical flow rate, cfs.

T_{set} set time, hours.

fl field run length, feet

sw set width, feet

No checks are performed to applicability of the method, nor, adequate distribution. The user is advised to refer to local NRCS design guidelines for reasonable efficiencies. For example, on moderately smooth topography conditions and a net irrigation application depth of 3 inches, the USDA NRCS (SCS) has estimated efficiencies for contour ditch irrigation⁸ as shown in Table 2.

Table 2. Efficiency of Contour Ditch Irrigation, Percent

Flood Intake Family	Land Slope (Percent)				
	1 - 2	2 - 4	4 - 8	8 - 16	16 - 32
0.1	8	5	4	3	2
0.3	21	15	11	8	5
0.5	26	18	13	9	6
1.0	54	38	39	20	13
1.5	55	55	39	28	15
2.0	53	55	50	37	25
3.0	52	55	58	52	35

Furrow Irrigation

The program utilizes procedures outlined in Chapter 5, Section 15 Irrigation, of the USDA NRCS (SCS) National Engineering Handbook⁹ to evaluate the furrow irrigation system efficiency. The program does not attempt to determine the optimum furrow inflow; however, it attempts to estimate the efficiency of the system based on the supplied system management. The equations utilized are the equivalent intake depth equation and the time of advance equation.

$$AE = \frac{1.039 * iad * fw * fl}{q * T_{set}} \quad [14]$$

where

AE irrigation application efficiency, percent
 iad gross irrigation application depth, inches
 fw furrow spacing, feet
 fl furrow spacing, feet
 q furrow inflow, gpm
 T_{set} set time, minutes

To evaluate the adequacy of the irrigation, the amount of water infiltrated at the end of the furrow must be determined. This requires computing the infiltration opportunity time at the end of the furrow and then computing the amount infiltrated.

$$T_o = T_{set} - T_{adv} \quad [15]$$

where

T_o infiltration opportunity time at end of furrow, minutes
 T_{adv} advance time for water to reach end of furrow, minutes

$$T_{adv} = \frac{fl}{f} e^{\frac{g * fl}{q * S^{0.5}}} \quad [16]$$

where

f, g soil furrow intake family advance coefficients
 S furrow slope, feet/feet

If the opportunity time, T_o , is less than zero, then the end of field was not irrigated. If the opportunity time is greater than zero, then the amount infiltrated at the furrow end is estimated with the following equation:

$$F_o = \frac{[a * T_o^b + c]}{fw} * \left(0.269 * \left(\frac{q * n}{S^{0.5}} \right)^{0.425} + 0.746 \right) \quad [17]$$

where

F_o infiltrated depth at the furrow end, inches
 a, b, c soil furrow intake family infiltration coefficients
 n Manning's roughness coefficient for furrow or corrugation.

If the end of furrow infiltrated depth, F_o , is less than the desired irrigation application depth (iad), then the furrow end was not adequately irrigated.

Border Irrigation

Border irrigation systems consist of level or gradient borders with or without end stops. The current version of the program does compute efficiency for level and gradient borders without end stops. The equations for estimating border irrigation efficiency are based on inflow rates per unit width. The unit inflow rate is estimated from the following equation and assumes that the entire border is irrigated with the specified flow.

$$q_u = Q / W \quad [18]$$

where

q_u flowrate per unit width, ft²/sec

Q border inflow rate, cfs

W border width, feet

The program assumes that level borders have slopes less than 0.4 percent (0.004 ft/ft) while gradient borders have slopes 0.4 percent or greater. For level borders the recession time (lag time), T_L , is zero. For gradient borders the recession time is estimated from the following equation:

$$T_L = \frac{0.0897 * q_u^{0.2} * n^{1.2}}{S_o^{0.5}} \quad [19]$$

where

S_o border strip slope, ft/ft

n Mannings roughness coefficient

The time, T_n , required to infiltrate the desired application depth, iad , is estimated from the flood intake family infiltration function:

$$T_n = \left(\frac{iad - c}{a} \right)^{1/b} \quad [20]$$

where

T_n infiltration opportunity time, minutes

iad desired infiltration depth, inches

a, b, c flood intake family coefficients

The adequacy of border irrigation is determined by comparing the irrigation set with the time of application. The set time should be greater than or equal to the required application time. The required application time is estimated by:

$$T_s \geq T_a = T_n - T_L \quad [21]$$

where

T_s set (inflow) time, minutes

T_a required application time, minutes

The efficiency is estimated by the following equation:

$$AE = \frac{iad * L}{7.2 * q_u * T_s} \quad [22]$$

where

AE irrigation application efficiency, percent

L border length, feet

Sprinkler Irrigation

Irrigation efficiencies with sprinkler systems are usually between 60 and 90 percent. Table 3 shows typical efficiencies for various sprinkler systems. For center pivot and linear move systems efficiencies are not estimated, these are expected to be specified in the input dataset. For the other systems the program estimates the efficiency from lateral spacings and lengths (area), set time, and lateral flowrates using the following equation:

Table 3. Sprinkler System Irrigation Efficiencies

Sprinkler System Type	Efficiency Range
Hand Move	60 - 85%
Solid Set	60 - 90%
Side Roll	60 - 85%
Linear Move	80 - 90%
Center Pivot	75 - 88%

$$AE = \frac{1.039 * iad * L * W}{Q * T} \dots\dots\dots [23]$$

where

AE irrigation application efficiency, percent
 Q lateral inflow rate, gallons per minute
 T set time, hours
 L lateral line length, feet
 W spacing between lateral risers, feet
 iad irrigation application depth, inches

Irrigation Delivery System Losses

There are losses associated with canals and laterals which delivery the irrigation water from the source to the farm, field, were it is applied. The are several methods for determining the seepage loss from a channel. These include field measurement of the loss or estimation with a seepage formula. Three estimation methods are incorporated into the program: the Mortiz, Etchverry, and Wortstell seepage formulas. These formulas are as follows.

$$S_m = 0.2 * C * \sqrt{Q/V} \dots\dots\dots [24]$$

where

S_m Mortiz seepage loss estimate, cfs/mile
 C factor representing canal (lateral) seepage characteristic, ft/day
 Q canal (lateral) discharge, cfs
 V canal (lateral) velocity, ft/sec

$$S_e = K * i * \sqrt{Q/V} \dots\dots\dots [25]$$

where:

S_e Etchverry seepage loss estimate, cfs/mile
 K canal shape constant
 i canal (lateral) seepage intensity, ft/day
 Q canal (lateral) discharge, cfs
 V canal (lateral) velocity, ft/sec

$$S = 0.0667 * i * W \dots\dots\dots [26]$$

where:

S_w Wortstell seepage loss estimate, cfs/mile
 i canal (lateral) seepage intensity, ft/day
 W canal (lateral) water surface top width, ft

In the methods where a discharge is required for estimating the seepage loss, the downstream flow and any diversions are combined for the discharge. Regardless of how the seepage estimate is determined, the seepage loss for a canal, lateral, segment is computed by:

$$loss = S_l * length_l \dots\dots\dots [27]$$

where:

$loss_l$ conveyance loss for lateral (canal), cfs

S_l lateral (canal) seepage rate, cfs/mile

$length_l$ lateral (canal) segment length, miles

On Farm/Field Delivery Requirements

For each time step associated with the consumptive use data, the on farm, field, irrigation delivery requirement is determined from estimated irrigation system application efficiencies, crop requirements and areas of each crop, soil, and irrigation system combination. The peak delivery requirement is computed by:

$$ofpr_{crop,soil,system} = \frac{cu_{crop}}{AE_{crop,soil,system}} * area_{crop,soil,system} \dots\dots\dots [28]$$

where:

$ofpr$ on farm, field, peak delivery rate for given crop, soil, and irrigation system, ac-in/day

cu peak crop consumptive use for given risk level, inches/day

AE irrigation efficiency for given crop, soil, and irrigation system combination, percent

$area$ area associated with given crop, soil, and irrigation system, acres

The delivery volume for the time period associated with the crop water use data is determined from the following equation:

$$ofdr_{crop,soil,system} = \frac{cir_{crop}}{AE_{crop,soil,system}} * area_{crop,soil,system} \dots\dots\dots [29]$$

where:

$ofdr$ on farm, field, diversion volume for given crop, soil, and irrigation system, ac-in/day

cir crop irrigation requirement for given risk level, inches/day

AE irrigation efficiency for given crop, soil, and irrigation system combination, percent

$area$ area associated with given crop, soil, and irrigation system, acres

Aggregation

The program does not compute requirements on an individual field or farm basis. Instead, the program computes requirements on each combination of crop, soil, and irrigation system for each consumptive use time period. Once the on farm, field, requirement is determined, the program aggregates the peak diversion rate and period diversion volume based on the soil types for each time period.

$$fpr_{soil} = \sum_{crop,system} ofpr_{crop,soil,system} \dots\dots\dots [30]$$

where

$ofpr$ on farm, field, peak delivery rate for given crop, soil, and irrigation system, ac-in/day

fpr on farm, field, peak delivery rate for a soil classification, ac-in/day

$$fdr_{soil} = \sum_{crop,system} ofdr_{crop,soil,system} \dots\dots\dots [31]$$

where

$ofdr$ on farm, field, diversion volume for given crop, soil, and irrigation system, ac-in/day

fdr on farm, field, diversion volume for a soil classification, ac-in/day

To translate aggregated on farm, field, requirements to the point of diversion; the program expects for each defined lateral segment the percentage of each soil type served by it and the lateral segment which supplies it with water. A lateral segment is not required to serve any soil type or any down stream lateral segment. For example in figure x, lateral segments are shown as numbered line segments and soils are shown as lettered areas. Lateral segment number 1 only delivers water to lateral segment number 2. The area defined as soil a is serviced by lateral segments 2 and 3. Lateral segment 3 delivers water to two lateral segments in addition to delivering water to a portion of soil a. Lateral segment 6 delivers water to lateral segment 7 and delivers water to a portion of soils e and c and all of soil d. Starting with the downstream segments, the program applies the following formula to determine the inflow into each lateral segment.

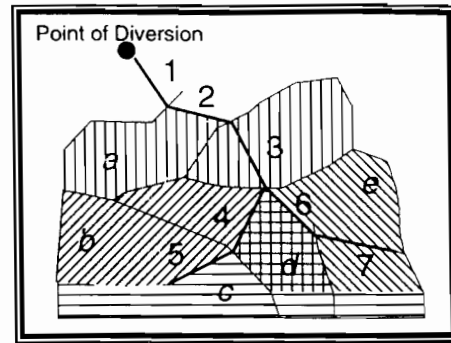


Figure x. Soils and Laterals Representation.

$$Q_i = \sum Q_d + \sum_{soil} psl_{i,soil} * fdr_{soil} h_{loss} \dots \dots \dots [32]$$

where

- Q_i require inflow into lateral segment i,
- Q_d downstream lateral delivery requirements for segment i
- $psl_{i,soil}$ percent of soil classification served by segment i.

PROGRAM IMPLEMENTATION

The methods describe in the preceeding section were implemented in a FORTRAN program. The listing of the program is found in Appendix A. The program uses dynamic allocation of array space and thus requirements for running the program will depend on the amount of detail required to describe the irrigated area. The program was compiled using the Microsoft FORTRAN PowerStation Version 1 compiler.

PROGRAM OPERATION

The program is configured to operate on matrixes describing the various cropping, soil, and irrigation system patterns for each consumptive use period. The program utilizes two input data files. The first data file is unique for the system, area, which irrigation diversion requirements are being determined for. The file contains crop, soil, and irrigation system mixtures and characteristics. Also, the file contains the data describing the delivery system network of canals and laterals. The second data file describes the crop water use data and rooting depth data as a function of time. This file is not unique to a system, it should describe the crop water use and rooting depths for a climatic region and may be used with other system analyses within the same climatic region. The two files are linked via the crop names found within the two files. The second file may contain more crops than the first file; however, each crop specified in the first file must be defined in the second file.

Regional Crop Water Use Data File

The regional crop water use data file is constructed from published information on crop water use such as Allen and Brockway³. The file contains several data areas of which five are repeated for each crop and vary throughout the irrigation season. The first area is simple documentation. The second area describes the relationship between the mean use value in the data set and an estimated peak use due soil moisture holding capacity. The five data areas specific to the crops are found next for each crop. Finally, the end of data is signal by a single record with the contents "END OF FILE" as the last record. The format of the data file is describe in Table x. The first record of the data file is an alphanumeric record for documenting the crop water use data. It suggested that the source of the data be included in the descriptive title. The next record indicates the number of points used to describe the mean to peak usage relationship. Record three contains irrigation application depths and record four contains peak to mean ratios associated with the depths. The fifth record identifies the water use periods that are represented by the data. Records 6 through 11 describe the data for a specific crop which is identified in record 6. An example data file is shown in Figure x.

System Definition File

Table x. Regional Crop Water Use Data File Format

Line	Format	Description
1	A80	Data set descriptive title
2	2I5	Number of mean to peak values followed by number of water use periods for the crops
3	10X,11F6.0	
4	10X,11F6.0	
5	10X,11A6	Water Use Period Descriptors
6	A15	Crop Name for next 5 records
7	15X,11F6.2	Crop rooting depth by period, feet
8	15X,11F6.2	Consumptive Use, in/day/period
9	15X,11F6.2	Irrig. Requirement, in/day/period
10	15X,11F6.2	Consumptive Use standard dev.
11	15X,11F6.2	Irrig. Requirement standard dev
Repeat Line 6 through 11 for remaining crops.		
LAST	A15	END-OF-FILE

Bruneau Consumptive Use from Allen and Brockway 83												
11	8											
App.Depth	15.38	26.92	38.46	53.85	69.23	92.31	115.4	142.3	161.5	176.9	192.3	
Peak to M	1.154	1.138	1.123	1.108	1.092	1.077	1.061	1.046	1.031	1.016	1.001	
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total			
Alfalfa Hay												
Root Depth	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00			
MEAN CU	2.72	6.08	7.23	6.98	5.36	3.43	1.20	1011.				
MEAN IR	2.18	5.62	6.39	6.79	5.16	3.17	0.94	926.0				
STDEV CU	0.26	0.66	0.44	0.28	0.25	0.27	0.10	29.0				
STDEV IR	0.48	0.66	0.98	0.32	0.64	0.44	0.31	57.0				
Alfalfa Seed												
Root Depth	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00			
MEAN CU	3.26	5.90	7.27	6.20	3.23	1.68	0.59	861.0				
MEAN IR	2.69	5.45	6.42	6.01	3.05	1.44	0.34	778.0				
STDEV CU	0.31	0.38	0.44	0.25	0.15	0.13	0.05	25.0				
STDEV IR	0.53	0.65	0.98	0.29	0.51	0.33	0.28	52.0				
Dry Beans												
Root Depth	0.00	0.50	1.00	1.75	2.50	0.00	0.00					
MEAN CU	1.97	4.39	7.93	3.22				541.0				
MEAN IR	1.67	3.79	7.75	3.12				505.0				
STDEV CU	0.13	0.26	0.32	0.15				17.0				
STDEV IR	0.34	0.68	0.34	0.45				35.0				
Field Corn												
Root Depth	0.00	0.75	1.50	3.00	3.00	3.00	3.00					
MEAN CU	1.97	3.61	7.72	6.58	4.05	1.05	767.0					
MEAN IR	1.64	2.96	7.52	6.37	3.79	0.80	709.0					
STDEV CU	0.13	0.22	0.31	0.30	0.31	0.08	23.0					
STDEV IR	0.37	0.68	0.34	0.70	0.46	0.08	42.0					
Silage Corn												
Root Depth	0.00	0.75	1.50	3.00	3.00	3.00	3.00					
MEAN CU	1.97	3.61	7.72	6.58	4.05	1.05	767.0					
MEAN IR	1.64	2.96	7.52	6.37	3.79	0.80	709.0					
STDEV CU	0.13	0.22	0.31	0.30	0.31	0.08	23.0					
STDEV IR	0.37	0.68	0.34	0.70	0.46	0.08	42.0					
Potato												
Root Depth	0.50	1.00	2.00	2.00	2.00	2.00	2.00					
MEAN CU	1.49	2.58	6.49	7.11	5.32	2.66		789.0				
MEAN IR	1.12	2.31	5.87	6.98	5.16	2.46		731.0				
STDEV CU	0.14	0.17	0.35	0.29	0.24	0.21		24.0				
STDEV IR	0.32	0.34	0.74	0.50	0.52	0.31		44.0				
Sugar Beets												
Root Depth	0.50	1.50	3.00	3.00	3.00	3.00	3.00					
MEAN CU	1.49	2.60	4.85	8.92	6.86	4.81	3.23	935.0				
MEAN IR	1.12	1.66	4.12	8.32	6.56	4.24	1.96	857.0				
STDEV CU	0.14	0.16	0.29	0.35	0.31	0.25	0.28	24.0				
STDEV IR	0.33	0.37	0.74	0.57	0.73	0.51	0.36	50.0				
Spring Grain												
Root Depth	0.50	1.50	3.00	3.00	3.00	3.00	3.00					
MEAN CU	1.49	2.60	4.85	8.92	6.86	4.81	3.23	935.0				
MEAN IR	1.12	1.66	4.12	8.32	6.56	4.24	1.96	857.0				
STDEV CU	0.14	0.16	0.29	0.35	0.31	0.25	0.28	24.0				
STDEV IR	0.33	0.37	0.74	0.57	0.73	0.51	0.36	50.0				
Winter Grain												
Root Depth	0.50	1.50	3.00	3.00	3.00	3.00	3.00					
MEAN CU	1.49	2.60	4.85	8.92	6.86	4.81	3.23	935.0				
MEAN IR	1.12	1.66	4.12	8.32	6.56	4.24	1.96	857.0				
STDEV CU	0.14	0.16	0.29	0.35	0.31	0.25	0.28	24.0				
STDEV IR	0.33	0.37	0.74	0.57	0.73	0.51	0.36	50.0				
Pasture												
Root Depth	0.50	1.50	3.00	3.00	3.00	3.00	3.00					
MEAN CU	2.84	5.05	8.20	9.91	9.49	4.16	3.30	1024.				
MEAN IR	2.32	4.64	8.67	9.43	9.29	3.91	2.91	944.0				
STDEV CU	0.37	0.31	0.38	1.29	0.25	1.31	0.23	26.0				
STDEV IR	0.44	0.57	0.66	0.60	0.63	0.46	0.40	53.0				
Orchard												
Root Depth	5.00	5.00	5.00	5.00	5.00	5.00	5.00					
MEAN CU	2.16	4.31	6.85	7.30	6.06	4.41	1.30	1034.				
MEAN IR	1.66	3.92	6.06	6.11	5.86	4.10	2.03	943.0				
STDEV CU	0.21	0.28	0.41	0.30	0.28	0.34	0.19	27.0				
STDEV IR	0.43	0.52	0.92	0.33	0.66	0.51	0.36	54.0				
END OF FILE												

Figure x. Example Regional Crop Water Use Data File

The irrigated area system definition file defines the physical characteristics of the area and the irrigation management features, and the cropping information. The file contains several different data areas. The overall format specification for the individual records in the file are listed in Table xx and an example data file is shown in figure xx. The first data area is simple documentation of the data file. It consists of three alpha-numeric records. The second data area defines the number of irrigation systems, the number of crops, the number of soil types, and the number canal (lateral) segments and the risk level associated with the analysis.

The third data area of the file supplies the physical information concerning the canal -- lateral distribution system. For each later segment information describing the segment is given. The lateral segments must be entered starting at with the furthest downstream segment. The last segment entered should be the canal should be the one associated with the point of diversion. The numbering of the segments corresponds to the order they are entered in the data file. Currently, there are four options for seepage loss computations. The options are identified by numerical values of LMETHD. The first method associated with a value of 0 for LMETHD assumes a measured loss. This measured loss is entered as FAC1. The second method associated with a LMETHD value of 1 is based on the Moritz equation. The program uses the FAC1 value as the Moritz seepage coefficient C and assumes that it has the units of feet per day. The third method associated with a LMETHD value of 2 is based on the Etchverry formula. With this method, FAC1 is assumed to be i (ft/day) and FAC2 equals the Etchverry K value. The last method associated with a LMETHD value of 3 uses the Worstell method where LFAC1 equals the seepage factor i (ft/day). This data area starts with record 5 and ends when all the lateral segments have been defined. Line A shown in Table x.x describes the format associated with each lateral segment record.

The next data area describes the various irrigation systems used in the area of interest. For each irrigation system, a record with the format shown in Table x.x for line B should be found in the data area. The first three characters of the irrigation system name control how the program computes the application efficiency. Currently, the program handles furrow (FUR), gradient border (BOR), contour ditch (___), sprinkler (SPR), and center pivot (PIV) irrigation systems. The estimated efficiency is only used with the center pivot irrigation system. The remaining data elements depend on the type of irrigation system specified. For furrow irrigation systems the estimated

Table xx. System Definition File Format Specifications.

Line	Format	Description
1,2,3	A80	Dataset documentation, title, etc.
4	4I5,F5.0	NSEG,NSYS,NSOIL,NCROP,RISK
A	A15,7F5.2	Canal/Lateral Information Name -- 15 character identifier UPSEG -- Upstream segment number LENGTH -- Length of segment (miles) WIDTH -- Top width of segment (feet) XFAREA -- Cross sections flow area (sq. ft) LMETHD -- Method of seepage loss computation CFAC1 -- Factor associated with seepage comp. CFAC2 -- Facotr associated with seepage comp
B	A15,6F5.2	Irrigation System Information Name -- Irrigation System Name and Code ESTEFF -- Estimated system efficiency, % SETIME -- Set time, hours FLOW -- Inflow, gpm LENGTH -- length associated with system, feet SFAC1 -- System dependent factor SFAC2 -- System dependent factor
C	A15,7F5.2	Soil Information Name -- Soil Classification Identifier INFAM -- NRCS Flood Intake Family AWHC1 -- Water holding capacity 0 -- 1 ft, inches AWHC2 -- Water holding capacity 0 -- 2 ft, inches AWHC3 -- Water holding capacity 0 -- 3 ft, inches AWHC4 -- Water holding capacity 0 -- 4 ft, inches AWHC5 -- Water holding capacity 0 -- 5 ft, inches AWHC6 -- Water holding capacity 0 -- 6 ft, inches
D	A15,9F5.2	Crop Information Name -- Crop Identifier (Linkage to CU Data) ADEF -- Allowable soil moisture depletion, % FUR -- Furrow spacing, ft NROF -- Mannings roughness coefficient
E	A80	Consumptive Use File Descriptor
F.1	I5	Soil Classification Position (Section C)
F.2	A15,10F5.1 15X,10F5.1	Crop Area Mix for soil specified in F.1 CNAME -- Crop Identifier Area.1 -- Crop Area using Irrig.Sys. 1 for soil Area.2 -- Crop Area using Irrig.Sys. 2 for soil Area.3 -- Crop Area using Irrig.Sys. 3 for soil ... Area.N -- Crop Area using Irrig.Sys. N for soil
G	A15,10F5.1	Soil Classification service by lateral segments LName -- Lateral Segment Identifier Frac.1 -- Fraction of soil class 1 served by lateral Frac.2 -- Fraction of soil class 2 served by lateral Frac.3 -- Fraction of soil class 3 served by lateral ... Frac.N -- Fraction of soil class N served by lateral

efficiency is not used. The next three elements: SETIME, FLOW, and LENGTH, describe individual furrow characteristics of set time, furrow inflow, and furrow length. The furrow slope is given as SFAC1. The data element identified as SFAC2 is not used for furrow systems. For gradient border irrigation systems, the first data element, ESTEFF, is not used. The next three elements (SETIME, FLOW, and LENGTH) describe the individual border strip characteristics of inflow time (set time), inflow rate, and border length. The data elements SFAC1 and SFAC2 describe the border width and border slope respectively. Contour ditch or wild flooding irrigation methods do not utilize the ESTEFF data element. The next three data elements refer to contour ditch characteristics based the length of ditch used during an irrigation set. For sprinkler irrigation systems which are not linear move or center pivots; the first data element is not used and the remaining element describe a sprinkler lateral line. The spacing between laterals is given as SFAC1. SFAC2 is not used. For center pivot and linear move systems, the program assumes that the application efficiency is readily known and is entered as the first data element.

Following the irrigation system specification, the next data area (Line C, Table x.x) characterizes the various soil

classifications within the area of interest. For each soil class there should be a record corresponding to Line C in the data file and there should also be NSOIL records. Each soil classification should be given an identifier followed by the USDA-NRCS flood intake family number and the available water holding capacity of the soil in one foot intervals to 6 feet. If the soil depth is less than 6 feet the user should still enter values which reflect no additional water holding capacity.

The fifth data area which follows the soils information is the cropping information. For each crop grown in the area of interest there should be a record corresponding to Line D from Table x.x. The crop identifier used must be the same identifier used in the water requirements data file. The additional elements of allowable depletion, furrow spacing, and roughness coefficient should reflect local cropping practices.

The next data record specifies the water requirements data file descriptor. The data file descriptor may or may not contain the path specification depending on the user's installation and file storage procedures.

Up to this point, the data file has been defining the individual characteristics of lateral segments, soils, irrigation systems, and crops. The remainder of the data file specifies the mix of crops, irrigation systems, soils and how the lateral segments serve the irrigated area. First for each soil classification found in the fifth data area, the area for each crop under an irrigation system is specified in blocks. The first data record (Line F.1, Table x.x) of the block identifies the soil classification record position with the soils definition area. It is followed by a record (Line F.2, Table x.x) for each crop grown within the system identifying the number of acres grown under each irrigation system. The areas should correspond to the order in which the irrigation systems were

Bruneau Buckaroo Ditch Irrigation Water Diversion Requirements												
Brockway Engineering -- C.E. Brockway and C.W. Robison												
Dataset Created 12/29/94 -- Modified 4/20/96												
bruneau.dat												
	3	5	11	3								
.80												
Hutch. to End	2.0	2.37	7.50	12.0	0.00	.784						
Jones to Hutch	3.0	4.53	9.00	13.0	0.00	.784						
Div. to Jones	0.0	4.57	10.0	14.5	0.00	.784						
SPRINKLER	80.0	24.0	165.1320	50.								
FURROW .5%	40.0	24.0	12.01320	.005								
FURROW 1%	40.0	24.0	12.01320	.010								
FURROW 2%	40.0	24.0	12.01320	.020								
FURROW 4%	40.0	24.0	12.01320	.040								
Map Unit 10	2.0	1.40	2.80	4.15	5.50	6.90	6.90					
Map Unit 11	2.0	1.80	2.92	4.04	5.50	7.00	7.00					
Map Unit 12	1.2	2.40	4.80	7.20	9.50	11.7	11.7					
Map Unit 50	1.9	1.75	3.55	4.30	4.85	5.40	5.40					
Map Unit 60	1.4	1.85	3.40	5.00	6.55	7.90	7.90					
Map Unit 65	1.5	2.22	4.40	6.60	8.65	10.8	10.8					
Map Unit 70	1.4	2.25	4.65	7.05	9.05	11.1	11.1					
Map Unit 71	1.5	2.30	4.50	6.60	8.80	10.8	10.8					
Map Unit 96	1.6	1.48	2.85	4.20	5.60	7.00	7.00					
Map Unit 100	2.0	1.50	2.90	4.30	5.80	7.40	7.40					
Map Unit 101	2.2	1.20	2.30	3.40	4.60	5.70	5.70					
Alfalfa Hay	60.0	2.50	0.10									
Silage Corn	50.0	2.50	0.04									
Spring Grain	50.0	2.50	0.04									
00001	Map Unit 10 -- 205											
Alfalfa Hay	0.	0.	184.	0.	0.							
Silage Corn	0.	0.	8.	0.	0.							
Spring Grain	0.	0.	13.	0.	0.							
00002	Map Unit 11 -- 832											
Alfalfa Hay	0.	0.	745.	0.	0.							
Silage Corn	0.	0.	35.	0.	0.							
Spring Grain	0.	0.	52.	0.	0.							
00003	Map Unit 12 -- 144											
Alfalfa Hay	0.	129.	0.	0.	0.							
Silage Corn	0.	6.	0.	0.	0.							
Spring Grain	0.	9.	0.	0.	0.							
00004	Map Unit 50 -- 76											
Alfalfa Hay	0.	0.	0.	68.	0.							
Silage Corn	0.	0.	0.	3.	0.							
Spring Grain	0.	0.	0.	5.	0.							
00005	Map Unit 60 -- 545											
Alfalfa Hay	0.	488.	0.	0.	0.							
Silage Corn	0.	23.	0.	0.	0.							
Spring Grain	0.	34.	0.	0.	0.							
00006	Map Unit 65 -- 650											
Alfalfa Hay	0.	0.	0.	582.	0.							
Silage Corn	0.	0.	0.	27.	0.							
Spring Grain	0.	0.	0.	41.	0.							
00007	Map Unit 70 -- 35											
Alfalfa Hay	0.	0.	0.	37.	0.							
Silage Corn	0.	0.	0.	6.	0.							
Spring Grain	0.	0.	0.	10.	0.							
00008	Map Unit 71 -- 11											
Alfalfa Hay	0.	0.	0.	4.	0.							
Silage Corn	0.	0.	0.	0.	0.							
Spring Grain	0.	0.	0.	0.	0.							
00009	Map Unit 96 -- 1											
Alfalfa Hay	0.	0.	0.	0.	0.							
Silage Corn	0.	0.	0.	0.	0.							
Spring Grain	0.	0.	0.	0.	0.							
00010	Map Unit 100 -- 1											
Alfalfa Hay	0.	0.	0.	0.	195.							
Silage Corn	0.	0.	0.	0.	14.							
Spring Grain	0.	0.	0.	0.	21.							
00011	Map Unit 101 -- 1											
Alfalfa Hay	0.	0.	0.	0.	0.							
Silage Corn	0.	0.	0.	0.	0.							
Spring Grain	0.	0.	0.	0.	0.							
Hutch. to End	0.333	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333
Jones to Hutch	0.333	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333
Div. to Jones	0.334	.334	.334	.334	.334	.334	.334	.334	.334	.334	.334	.334

Figure xx. System Definition Data File

defined. If there are five irrigation systems defined there should be five areas specified for the crop. Again, the crop record is repeated until all the crop areas have been defined for the soil and the data block is repeated for all the soil types.

The last data area, identifies the irrigated areas served by each lateral segment. Each lateral segment requires a record corresponding to Line G in Table x.x in the data file. The sequence of the data records must correspond to the sequence in definition area. The record contains the lateral segment identifier followed by the percentage of each soil classification area served by the lateral segment. The percentages must be in the order which the soils were defined.

Program Output

The output from the program consists of the input data sets, the computed crop requirements based on the risk level specified, the on field (farm) application requirements for each crop, irrigation system, and soil type, a summary of the on field (farm) application requirements for the entire area, the flow and loss characteristics associated with each lateral segment for delivery of the on field (farm) application requirements, and a summary diversion requirements for the irrigated area including losses associated with the canal -- lateral distribution network.

¹Jensen, M. E., et al., 1980. Design and Operation of Farm Irrigation Systems, an ASAE Monograph. American Society of Agricultural Engineers, St. Joseph, Michigan 49085.

²Allen, R. G. and C. E. Brockway, 1983. "Estimating Consumptive Irrigation Requirements for Crops in Idaho", Research Technical Completion Report. Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho 83843.

³_____, 1991. "Guidelines for the Evaluation of Irrigation Diversion Rates", Hubble Engineering, Inc. and Associated Earth Sciences, 7025 Emerald, Boise, Idaho 83704.

⁴Trimmer, W. L. and H. J. Hansen, 1986. "Irrigation Scheduling", A Pacific Northwest Extension Publication, PNW 288. Oregon State University Extension Service, University of Idaho Cooperative Extension Service, and Washington State University Cooperative Extension Service.

⁵Larsen, Dorrel C. 1989. "Evapotranspiration Checkbook Method of Irrigation Scheduling for Surface Irrigators", in Proceedings 1989 Energy Efficient Irrigation Practices Handbook. University of Idaho Cooperative Extension Service, Moscow, Idaho 83843

⁶Kennedy, J. B. and A. M. Neville, 1976. Basic Statistical Methods for Engineers and Scientists, Second Edition. IEP, A Dun-Donnelley Publisher, New York, New York 10019.

⁷Allen, R. G. and C. E. Brockway, 1983. "Estimating Consumptive Irrigation Requirements for Crops in Idaho Appendix F", Research Technical Completion Report. Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho 83843.

⁸_____, 1970. Irrigation Guide for Southern and Southeastern Idaho. U. S. Department of Agriculture, Soil Conservation Service, Boise, Idaho.

⁹_____, 1984. National Engineering Handbook. Section 15 IRRIGATION. Chapter 5, Furrow Irrigation. United States Department of Agriculture, National Resource Conservation Service, Washington, D. C.

APPENDIX A

Project/Farm Irrigation Water Requirements Program
by Clarence W. Robison, PE
Initial Coding 15JUL94

Purpose: To compute the diversion volume and rate of water required to irrigate a specified crop distribution on a mix of soil types with various irrigation methods and delivery system at a specified probability level to meet crop water usage and leaching requirements.

Methodology: The Hubble report, Guidelines for the evaluation irrigation diversion rates, is used as the basis for the program. The produce outline by Hubble Engineering involves the following processes.

- Step 1 Collect acreage data on crop-soil-system distribution mix.
- Step 2 Referencing Allen and Brockway collect CU/IR data for area.
- Step 3 Apply level of risk probability based stdev of CU/IR.
- Step 4 CU by AREA Diagram Figure 6.
- Step 5 00 Initial Development
- 1 20 Add Peak ET to Mean ET Ratio as a function of App Depth.
- Compute peak diversion requirements based on CU
- Compute seasonal diversion requirements based on IR
- Section 1.25 Added Contour Ditch Method Evaluation as outlined by the Hubble Report

```

PROGRAM      IRWTREQ
INTEGER      NCANAL, NIRSYS, NSOILS, NCROPS, NPERID
INTEGER      NP2R
CHARACTER*72 ATITLE(1), DUMTIT
CHARACTER*32 ANDATE, TSTAMP
CHARACTER*72 CUFIL
CHARACTER*15 CRNAME(15), SLNAME(15), ISNAME(15), CLNAME(15)
CHARACTER*15 CRNAME[ALLOCATABLE](15),
#            SLNAME[ALLOCATABLE](15),
#            ISNAME[ALLOCATABLE](15),
#            CLNAME[ALLOCATABLE](15)
CHARACTER*6  PRNAME(13)
CHARACTER*6  PRNAME[ALLOCATABLE](13)
REAL         CRDIST[ALLOCATABLE](15,15)
REAL         CRSOIL[ALLOCATABLE](15,15)
REAL         CRINFO[ALLOCATABLE](15,15)
REAL         ISINFO[ALLOCATABLE](15,15)
REAL         SLINFO[ALLOCATABLE](15,15)
REAL         CLINFO[ALLOCATABLE](15,15)
REAL         CRPUSE[ALLOCATABLE](15,15)
REAL         ETPAPP[ALLOCATABLE](15)
REAL         ETPRAT[ALLOCATABLE](15)
REAL         ETP2ND[ALLOCATABLE](15)
REAL         ADEFCT[ALLOCATABLE](15,15)
REAL         PEAKCU[ALLOCATABLE](15,15)
REAL         APPEFF[ALLOCATABLE](15,15)
REAL         DIVREQ[ALLOCATABLE](15,15)
REAL         PEAKRQ[ALLOCATABLE](15,15)
REAL         CRPSUM[ALLOCATABLE](15)
INTEGER      I, J, K, L, FORCE
INTEGER      ERR
INTEGER*2    FUREFF, BOREFF, SPPEFF, CONEFF
LOGICAL      STRNCKF
REAL         CUPROB, X
EXTERNAL     TSTAMP

```

```

C
C *** Start things off with opening message.
WRITE(*,*) ' Project/Farm Irrig. Water Requirements'
WRITE(*,*) ' Clarence Robison, PE'
WRITE(*,*) ' Version 1.25'
WRITE(*,*) ' irwtreq (-i:input) [-o:output]'
write(*,*) ' '
CALL STARTS

C
C *** Ok. Files have been opened -- time to proceed.
FORCE = 0
ANDATE = TSTAMP()
READ(5,10) ATITLE
WRITE(6,20) ' ',ANDATE,ATITLE

C
C *** Read in the filenames containing the cu/ir data
READ(5,10) CUFIL
OPEN(7,FILE=CUFIL,STATUS='OLD',Iostat=ERR)
IF( ERR.NE.0 ) THEN
    WRITE(6,999) 'I/O Error:',ERR,' Opening '//CUFIL
    WRITE(*,999) 'I/O Error:',ERR,' Opening '//CUFIL
    WRITE(*,10) ' Program terminating'
    STOP
ENDIF
READ(7,10) DUMTIT
READ(7,21) NP2R, NPERID
C
C ALLOCATE( PRNAME(NPERID+1), STAT=ERR )
READ(7,10) DUMTIT
READ(7,10) DUMTIT
READ(7,30) (PRNAME(I),I=1,NPERID)
CLOSE(7,STATUS='KEEP')

C
C *** Read control info -- Number of classifications
READ(5,21) NCANAL,NIRSYS,NSOILS,NCROPS,FORCE
READ(5,22) CUPROB
WRITE(6,23) CUFIL,CUPROB*100.0,NCANAL,NIRSYS,NSOILS,NCROPS,NPERID

C
C *** Now, allocate memory category names, info., and data
ALLOCATE(
C #
C # CLNAME(NCANAL),
C # ISNAME(NIRSYS),
C # SLNAME(NSOILS),
C # CRNAME(NCROPS),
C # CRPSUM(NCROPS),
C # ETPAPP(NP2R),
C # ETPRAT(NP2R),
C # ETP2ND(NP2R),
C # ISINFO(NIRSYS,5),
C # SLINFO(NSOILS,6),
C # CRINFO(NCROPS,3),
C # CLINFO(NCANAL,9),
C # CRDIST(NIRSYS,NCROPS,NSOILS),
C # CRSOIL(NCROPS,NSOILS),
C # CRPUSE(NCROPS,NPERID+1,3),
C # ADEFCT(NPERID,NCROPS,NSOILS),
C # DIVREQ(NPERID,NCROPS,NSOILS,NIRSYS),
C # PEAKRQ(NPERID,NCROPS,NSOILS,NIRSYS),
C # PEAKCU(NPERID,NCROPS,NSOILS),
C # APPEFF(NPERID,NCROPS,NSOILS,NIRSYS), STAT=ERR)
IF(ERR.NE.0) THEN
    WRITE(*,13) 'MEM Error:',ERR,' allocating data space'
    GOTO 9000
ENDIF

C
C *** Read in category names and info -- same order as limits
C Canal/Lateral Info --
C name, upseg, length, width, area, type, fac1, fac2
DO 1000 I=1,NCANAL
    DO J=1,12
        CLINFO(I,J) = 0.0
    ENDDO
1000 READ(5,25) CLNAME(I),(CLINFO(I,J),J=1,12)
C irrsys ass.eff set.time flow.gpm length width slope

```

```

DO 1010 I=1,NIRSYS
1010 READ(5,25) ISNAME(I), (ISINFO(I,J),J=1,6)
C soil intake fam awc.1 awc.2 awc.3 awc.4 awc.5
DO 1020 I=1,NSOILS
1020 READ(5,25) SLNAME(I), (SLINFO(I,J),J=1,6)
C crop all def fur spa fur rough
DO 1030 I=1,NCROPS
1030 READ(5,25) CRNAME(I), (CRINFO(I,J),J=1,3)
C
C *** Write out Catagory Information
C Canal/Lateral Info
WRITE(6,32)
DO 1100 I=1, NCANAL
L = CLINFO(I,5)
K = CLINFO(I,1)
IF( L.EQ.0 ) WRITE(6,33) I,CLNAME(I),K,(CLINFO(I,J),J=2,4)
# 'Specified S=',CLINFO(I,6), 'cfs/mi'
IF( L.EQ.1 ) WRITE(6,33) I,CLNAME(I),K,(CLINFO(I,J),J=2,4)
# 'Moritz C=',CLINFO(I,6), 'ft/day'
IF( L.EQ.2 ) WRITE(6,33) I,CLNAME(I),K,(CLINFO(I,J),J=2,4)
# 'Etchverry is',CLINFO(I,6) 'ft/day K='
CLINFO(I,7)
IF( L.EQ.3 ) WRITE(6,33) I,CLNAME(I),K,(CLINFO(I,J),J=2,4)
# 'Worstell is',CLINFO(I,6), 'ft/day'
IF( L.LT.0 OR L.GT.3 ) WRITE(6,13) CLNAME(I), I
# 'Error Unknown Seepage Method'
1100 CONTINUE
C
C *** Irrigation System Information
WRITE(6,35)
DO 1110 I=1,NIRSYS
IF( STRNCMP(ISNAME(I)(1:3), 'PIV') ) THEN
K = 1
WRITE(6,37) ISNAME(I), (ISINFO(I,J),J=1,K)
ELSEIF( STRNCMP(ISNAME(I)(1:3), 'FUR') ) THEN
K = 5
WRITE(6,36) ISNAME(I), (ISINFO(I,J),J=1,K)
ELSEIF( STRNCMP(ISNAME(I)(1:3), 'CON') ) THEN
K = 5
WRITE(6,36) ISNAME(I), (ISINFO(I,J),J=1,K)
IF( ISINFO(I,3)/ISINFO(I,5)/4.488 .GT. 1.0 ) THEN
WRITE(6,11) 'Warning: Q >= 1cfs/100ft'
ENDIF
ELSE
K = 5
WRITE(6,37) ISNAME(I), (ISINFO(I,J),J=1,K)
ENDIF
1110 CONTINUE
WRITE(6,40)
DO 1120 I=1,NSOILS
1120 WRITE(6,42) SLNAME(I), (SLINFO(I,J),J=1,6)
WRITE(6,45)
DO 1130 I=1,NCROPS
1130 WRITE(6,46) CRNAME(I), (CRINFO(I,J),J=1,3)
C
C *** Read crop mix by soil by crop by system
DO 1200 K=1,NSOILS
READ(5,50) L
DO 1200 J=1,NCROPS
1200 READ(5,52) CRDIST(I,J,K), (CRINFO(I,J),J=1,3)
C
C *** OUTPUT CROP DISTRIBUTION
DO J=1,NCROPS
CRPSUM(J)=0.0
ENDDO
WRITE(6,20) CHAR(12), ANDATE, ATITLE
DO 1230 K=1,NSOILS
WRITE(6,54) SLNAME(I) ' by Irrigation System' (I=1,NIRSYS)
DO 1220 J=1,NCROPS
CRSOIL(J,K) = 0.0
DO 1210 I=1,NIRSYS
CRSOIL(J,K) = CRSOIL(J,K) + CRDIST(I,J,K)
CRPSUM(J) = CRPSUM(J) + CRSOIL(J,K)

```

```

1220 WRITE(6,56) CRNAME(J), CRSOIL(J,K), (CRDIST(I,J,K), I=1,NIRSYS)
1230 WRITE(6,10) ' '
WRITE(6,57)
WRITE(6,58) (I, ISNAME(I), I=1,NIRSYS)
C
C *** Ok, crop irrig reqs data
CALL IRREQP(CRPUSE, CUPFILE, CUPROB, CRNAME, NCROPS, PRNAME, NPERID,
# NP2R, ETPAPP, ETPRAT)
C
C *** Ok, Now determine Allowable deficit for each crop and soil.
WRITE(6,20) CHAR(12), ANDATE, ATITLE
WRITE(6,60) 'Allowable Soil Water Deficit -- inches', CUPROB*100.0,
# 'IR'
DO 1400 K=1,NSOILS
WRITE(6,62) SLNAME(K), (PRNAME(I), I=1,NPERID)
CALL COMADF(NPERID, NCROPS, NSOILS, CRINFO, SLINFO, CRPUSE,
# ADEFACT, K, CRNAME)
1400 CONTINUE
C
C *** Compute Peak Consumptive Use Requirement
WRITE(6,20) CHAR(12), ANDATE, ATITLE
WRITE(6,60) 'Peak Consumptive Use based on Peak:Mean(ASWD)',
# CUPROB*100., 'CU'
C
C *** FIRST PERFORM SPLINE FIT ON THE PEAK ET TO APP, DEP CURVE
CALL SPLINE(ETPAPP, ETPRAT, NP2R, 1.0E31, 1.0E31, ETP2ND)
DO 1500 K=1,NSOILS
WRITE(6,62) SLNAME(K), (PRNAME(I), I=1,NPERID)
DO 1480 J=1,NCROPS
WRITE(6,65) CRNAME(J)
DO 1460 I=1,NPERID
IF(CRPUSE(J,I,2).LE.0) THEN
PEAKCU(I,J,K) = 0
WRITE(6,66) ' --'
ELSE
CALL SPLINT(ETPAPP, ETPRAT, ETP2ND, NP2R, ADEFACT(I,J,K), X)
PEAKCU(I,J,K) = CRPUSE(J,I,3)*X
WRITE(6,67) PEAKCU(I,J,K)
ENDIF
1460 CONTINUE
1480 WRITE(6,10) ' '
1500 CONTINUE
C
C *** Proceed with Irrigation Application Efficiency Analysis
DO 3000 L=1,NSOILS
DO 2000 K=1,NIRSYS
C *** Loop for excluding printouts associated with zero acres
zero = 0.0
DO J=1,NCROPS
zero = zero + crdist(k,j,1)
ENDDO
IF( zero .le. 0.001) goto 1900
WRITE(6,20) CHAR(12), ANDATE, ATITLE
WRITE(6,70) 'Irrigation System Analysis', SLNAME(L)
WRITE(6,72) ISNAME(K)
IF( ISNAME(K)(1:3).EQ.'FUR' ) THEN
WRITE(6,80) (ISINFO(K,J),J=2,5)
WRITE(6,79) '**CROP** ', (PRNAME(I), I=1,NPERID)
DO J=1,NCROPS
IF( CRDIST(K,J,L).LE.0.0 ) THEN ! No crop
ELSE
WRITE(6,65) CRNAME(J)
DO I=1,NPERID
IF( ADEFACT(I,J,L).GT.0.0 ) THEN
ERR=FUREFF(ADEFACT(I,J,L), ISINFO(K,5), CRINFO(J,2),
ISINFO(K,4), ISINFO(K,3), CRINFO(J,3), ISINFO(K,2),
SLINFO(L,1), EFF )
IF( EPR.EQ.-1 ) THEN
WRITE(6,83) ' 000 '
APPEFF(I,J,L,K) = ISINFO(K,1)
ELSEIF( ERR.EQ.1 ) THEN
APPEFF(I,J,L,K) = EFF
WRITE(6,82) EFF, ' '

```



```

435      ENDDO
436      WRITE(6,10)
437      ENDDIF
438      ENDDO
439      WRITE(6,10)
440      WRITE(6,84)
441      * = Insufficient application
442      ELSEIF( ISNAME(K)(1:3) EQ. 'PIV' ) THEN
443      WRITE(6,88)
444      WRITE(6,79) '**CROP**', (PRNAME(I), I=1,NPERID)
445      DO J=1,NCROPS
446      IF( CRDIST(K,J,L) LE 0.0 ) THEN ! No crop
447      ELSE
448      WRITE(6,65) CRNAME(J)
449      DO I=1,NPERID
450      IF( ADEFCT(I,J,L) GT.0.0 ) THEN
451      EFF=ISINFO(K,1)
452      APPEFF(I,J,L,K) = EFF
453      WRITE(6,82) EFF,
454      IF(FORCE.NE.0.AND.APPEFF(I,J,L,K) LE ISINFO(K,1)) THEN
455      DIVREQ(I,J,L,K)=CRDIST(K,J,L)/ISINFO(K,1)*100.0
456      *CRPUSE(J,I,2)
457      PEAKRQ(I,J,L,K)=CRDIST(K,J,L)/ISINFO(K,1)*100.0
458      *PEAKCU(I,J,L)
459      ELSE
460      DIVREQ(I,J,L,K)=CRDIST(K,J,L)/APPEFF(I,J,L,K)*100.0
461      *CRPUSE(J,I,2)
462      PEAKRQ(I,J,L,K)=CRDIST(K,J,L)/APPEFF(I,J,L,K)*100.0
463      *PEAKCU(I,J,L)
464      ENDDIF
465      ELSE

```

Charles E. Brockway, P.E., Ph.D.

**Brockway Engineering
706 Sunrise Blvd North
Twin Falls, ID 83301**

(208) 736-8543
(208) 736-8506 FAX
E-mail: cebrock@micron.net

July 1998

Present title:

Senior Member-Brockway Engineering P.L.L.C

Formerly-Research Professor - Civil and Agricultural Engineering: Supervision of research conducted by the University Water Resources Research Institute and the College of Engineering at Kimberly, Idaho. Graduate student supervision and directed studies instruction in Water Management and Water Resources related subjects.

Associate Director - Idaho Water Resources Research Institute

Summary of education beyond high school:

Institution, Degree, Year

University of Idaho 1955-59, B.S.-Civil Engineering, 1959

California Institute of Technology 1959-60, M.S.- Civil Engineering, 1960

University of Colorado, Denver, Colorado, Management, 1963

University of Denver; Denver, Colorado, Civil Engineering, 1964

Utah State University, Ph.D.-Water Resources Engineering, 1977

Number of years service on this faculty: 32

Date of original appointment: 1965

Dates of advancement in rank:

Associate Research Professor: 1974

Professor-50% Agricultural Engineering, 50% Civil Engineering : 1978

Subjects and courses taught:

CE 500, CE 600, CE 502

Summary of academic experience:

University of Idaho - Research Professor - Civil and Agricultural Engineering, 1978-

University of Idaho - Associate Research Professor, Civil Engineering, 1974-78

University of Idaho - Assistant Research Professor, Civil Engineering, 1965-74

Boise College - Instructor in Engineering, 1961-63

Summary of other experience:

University of Idaho - USAID Pakistan Project on Irrigation Systems Management
Research, 1984 -

U.S. Bureau of Reclamation - Hydraulic Research Laboratory, Denver, Colorado -
Hydraulic Research Engineer, 1963-65

U.S. Bureau of Reclamation - Boise, Idaho - Hydraulic Engineer, 1961-63

Converse Foundation Engineering, Inc. - Pasadena, California - Foundation Engineer,
1960-61

California Institute of Technology - Pasadena, California - Assistant Project
Engineer, U.S. Public Health Service Research Project, 1959-60

Consultant:

Twin Falls Canal Company - Twin Falls, Idaho - Hydrology and water use.

North Side Canal Company-Jerome, Idaho- Hydrology and water use

Micron Technology-Ground water and water supply

J.R. Simplot Company- Land disposal of processing waste, water supply, water rights

City of Twin Falls-Water supply and hydrology

Idaho Trout Processors-Hydraulics and water supply

Cedar Mesa Reservoir and Canal Co., Redding, California - Water management
consultant.

Clear Springs Trout Company, Buhl, Idaho - Water supply and distribution systems.

Idaho Power Company, Boise, Idaho - Relationships of groundwater and surface water
- Upper Snake River Basin - water right adjudication.

Idaho Department of Fish and Game - Evaluation of groundwater stream relationship
for litigation - Parma vicinity.

Blaine County, Idaho - Waste disposal systems for high density rural subdivisions.

Reynolds and West Reynolds Irrigation Districts - Irrigation water requirements,
systems analysis.

U.S. Bureau of Reclamation (was Maricopa County Water District) - Arizona. Flood
study.

Office of Technology Assessment - U.S. Congress - Irrigation Distribution Systems.

U.S. Department of Justice - Indian Water Rights

Montgomery Engineers - Ground-water quality evaluations

J.U.B. Engineers, Twin Falls, Idaho - Ground-water and hydraulics

Amalgamated Sugar Company, Idaho- Hydrology and waste disposal

Registered Professional Engineer: Idaho and Colorado

Special Awards or Honors:

Recipient of Bausch & Lomb Science Award

Member - Phi Beta Sigma, Freshman honorary, University of Idaho

Outstanding Freshman Engineer Award - University of Idaho, 1955

Member and secretary of Sigma Tau, National Engineering Honorary

Member and Vice-president of ASCE student chapter, University of Idaho

University of Idaho undergraduate scholarship 1957-58, 1958-59

Honorary Membership ASTM, 1959

Special Awards, cont'd.

U. S. Army National Defense Transportation Award, 1958
Distinguished Military Graduate - University of Idaho
Top Ten Graduating Senior - University of Idaho, 1959
No. 2 in graduating class of 889, University of Idaho, 1959
Representative of USBR Division of Research at 1963 Intergovernmental Training Program, Denver, 1964
Scholarship - University of Denver, Graduate School of Management, 1964
National Science Foundation Fellowship - Utah State University, 1967-68
Outstanding Young Engineer Award for Idaho, National Society of Professional Engineers, 1968
Engineer of the Year, 1997 American Society of Agricultural Engineers
Idaho Water Users Hall of Fame-1998

Membership in professional and scholarly organizations:

National Society of Professional Engineers, 1967 - present
Idaho Society of Professional Engineers, 1967 - present; President 1978
American Society of Civil Engineers - Irrigation & Drainage Division Committee
Chairman:
1) Operation and Maintenance of Irrigation and Drainage Systems, 1975-1981
2) Water Quality Committee, 1980-1984, Chairman
3) Task Committee on Guidelines for Erosion and Sediment Control in Irrigated Agriculture, 1980-1983, Chairman
4) Publications Committee, 1985-1992
Research Society of America
National Council of Examiners for Engineering and Surveying, 1981-1991
Idaho Board of Professional Engineers and Professional Land Surveyors, 1981-1991, Chairman
American Water Resources Association

Offices held in such organizations:

National Society of Professional Engineers
Member - Young Engineers Committee, 1973-74
Chairman - Young Engineers Committee, 1975-77
Member - President's Committee on Board of Directors Organization, 1977
Member - Registration and Qualification for Practice Committee, 1979-81
Chairman - Registration and Qualification for Practice Committee, 1982-84
Member - Participating Organizations Liaison Committee to NCEE, 1982-84
Idaho Society of Professional Engineers
President, 1978
President, Magic Valley Chapter, 1970-71
Member - State Ethical Practices Committee, 1966, 1977
Member - State Intersociety Relations Committee, 1968
Member - State Nominating Committee, 1975-76

Offices Held, cont'd.

Member - Board of Directors, 1972-73

Member - Board of Directors, Past President Chairman - Nominating Committee,
1979

State Director - Representative for Idaho to NSPE, 1982-83

Nominating Committee for Idaho Board of Professional Engineers & Land
Surveyors member.

American Society of Civil Engineers

Member - Operation and Maintenance of Distribution Systems Committee -
Irrigation and Drainage Division, 1975-81

Chairman - Irrigation and Drainage Division, Operations and Maintenance
Committee, 1977-79

Member - Water Quality Committee, Irrigation and Drainage Division, 1980-84

Chairman - Water Quality Committee, Irrigation and Drainage Division, 1982-84

Member - Task Committee on Water Measurement, 1980-83

Chairman - Task Committee on Guidelines for Erosion and Sediment Control in
Irrigated Agriculture, 1984 - Present

Member - Publications Committee, 1985 - Present

Corresponding Member - ASCE Irrigation and Drainage Division Committee on
Operation and Maintenance of Irrigation Systems

Reviewer - ASCE Irrigation and Drainage Division Committee on Publications

Idaho Board of Professional Engineers and Land Surveyors

Member, 1981 -

Vice Chairman, 1983-1984

Chairman, 1984 - 1986, 1990 - 1992

National Council of Engineering Examiners

Assistant Vice President, Western Zone

Member, Professional Examinations Advisory Committee

Member, Committee on Uniform Procedures and Legislative Guidelines, 1984

Member, Communications and Publications Committee, 1983

Member, Uniform Examinations and Qualifications Committee, 1984 - Present

Member, Committee on Examination Policies and Procedures, 1987 - Present

Member, Advisory Committee on Council Activities, 1986 - 1987

Assistant Vice President - Western Zone, 1986 - 1987

Member, Fundamentals Examination Review Committee, 1986 - Present

Scholarly and creative activity:

Research:

- Development of systems analysis procedures for optimization of irrigation system designs with environmental, physical, and social constraints.
- Evaluation of crop consumptive use, irrigation requirements, and methods of determining basin depletion from agricultural development.
- Systems analysis of water use to develop mathematical methods for studying complex groundwater-surface water systems - mathematical modeling of aquifers.
- Ground water quality and river system water quality evaluations for nutrient load determination and river system modeling.
- Development of guidelines for design of sediment removal facilities for on-farm and irrigation distribution system wasteways.
- Evaluation of attainable impacts on water quality of irrigation return flows due to implementation of best management practices for sediment and nutrient control.
- Evaluation of alternate energy sources for irrigation and municipal needs in Idaho.
- Analysis of operation and maintenance costs of water distribution systems and determination of the relationship of costs to known physical and organizational parameters and water use efficiency.
- Evaluation of the economic potential for use of geothermal hot water and steam in Idaho.
- Study of the movement of water from canals to local water tables under saturated and partially saturated conditions.
- Studies of the mechanisms of microbial action, sedimentation and soil-water-chemical interactions involved in natural sealing phenomenon in canals and reservoirs.
- Evaluation of irrigation management practices for sustained land disposal of geothermal fluids.
- Evaluation of practices and systems for controlling sediment and other pollutant losses from irrigated lands.
- Investigation of the response of aquifer systems to changes in recharge or withdrawal due to change in land use.
- Evaluation of procedures for estimating crop water requirements.
- Development of cost effective procedures and equipment for measurement of irrigation diversions and power use in open and closed systems.

Community services and other relevant activities:

- Member - Intermountain District Church of the Nazarene; Camps Board - 1976 - 1984; Board of Church Properties - 1976-79
- Member - Twin Falls City Planning and Zoning Commission 12/78-9/79
- Member - College of Southern Idaho Geothermal Energy Commission
- Member - Governor's Committee on Energy Use - 1980-81

Member - Idaho Technical Advisory Committee for Sediment in Surface Water
Chairman - Snake River Technical Advisory Committee - Idaho Legislative Council,
1983-85

Advisor - Governor's Snake River Advisory Committee - 1985

Member - Water Resources Foundation Board of Directors - 1985

Chairman - Idaho Technical Committee on Hydrology

Member - Idaho Department of Health & Welfare Sediment Criteria Committee

Member - Snake Plain Advisory Committee of Idaho Department of Health &
Welfare

Member - Idaho Water Users Water Quality Committee - 1980-

Member - INEL Dose Evaluation and Risk Assessment Committee

Member - Columbia River System Operations Review

Member - Mid Snake River Nutrient Management Advisory Committee

Member - Mid Snake River Irrigation Water Quality Coordination Committee

Technical Advisor - Middle Snake River Committee

Member - Liaison Committee, U.S. Geological Survey National Water Quality
Assessment Program, Snake River Basin.

Member - Snake River Studies Committee, Idaho Department of Water Resources

Member - City of Twin Falls Wellhead Protection Committee

Publications:

Brockway, C.E. 1964. Progress Report - Investigation of a Seepage Meter Designed by
the Agricultural Research Service -- Lower Cost Canal Lining Program. Bureau of
Reclamation Hydraulic Branch HYD-529.

Brockway, C.E. 1964. Flow Resistance Coefficients of Three Sizes of Cast-in-Place
Concrete Pipe. Bureau of Reclamation Hydraulic Branch, HYD-533, 1964.

Brockway, C.E. 1965. Investigation of the Effect of Turnout Geometry on the
Registration Accuracy of a Propeller-Type Open Flowmeter. Bureau of Reclamation,
HYD-545, 1965.

Brockway, C.E. 1966. Groundwater Investigations and Canal Seepage Studies.
Engineering Experiment Station, University of Idaho, Progress Report No. 1, 1966.

Schuster, J.C. and C.E. Brockway. 1967. Investigation of a 4-Inch Magnetic Flowmeter.
Bureau of Reclamation, HYD-574.

Worstell, R.V. and C.E. Brockway. 1967. Estimating Seasonal Changes in Irrigation
Canal Seepage. Presented at Spokane, Washington, October 20, 1967.

Worstell, R.V. and C.E. Brockway. 1967. Groundwater Investigations and Canal Seepage
Studies. Engineering Experiment Station, University of Idaho, Progress Report No.
2.

- Bloomsburg, G.L. and C.E. Brockway. 1968. Movement of Water from Canals to Groundwater Tables. Research Technical Completion Report, Idaho Water Resources Institute.
- Worstell, R.V. and C.E. Brockway. 1968. Field Evaluation of Seepage Measurement Methods. Presented at 2nd Seepage Symposium, Phoenix, Arizona, February 1968.
- Bondurant, J.A., C.E. Brockway, and R.V. Worstell. 1968. Plastic Casings for Soil Cores. Soil Science, Vol. 107, No. 1.
- Herbig, A.E. and C.E. Brockway. 1970. Operations and Maintenance Costs of Irrigation Distribution Systems. Proceedings, National Irrigation Symposium, Lincoln, Nebraska.
- Bondurant, J.A., C.E. Brockway, and R.V. Worstell. 1971. Systems Analysis of Irrigation Water Management in Eastern Idaho. Progress Report No. 1, University of Idaho Engineering Experiment Station.
- Brockway, C.E. 1971. What Does it Cost to Operate an Irrigation District?. Proceedings, Fifth Regional Water Users' Conference, Bakersfield, California.
- Bondurant, J.A., R.V. Worstell, and C.E. Brockway. 1972. Water Resources Management in the Upper Snake River Valley. Proceedings, Irrigation & Drainage Division, Specialty Conference, ASCE, Spokane, Washington.
- Nichols, C.R., C.G. Warnick, and C.E. Brockway. 1972. Geothermal Water and Power Resources Exploration and Development for Idaho. Research Technical Completion Report, University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. 1972. Estimating Irrigation Distribution System Operation and Maintenance Costs. Paper presented at the Annual Meeting, Pacific Northwest Region ASAE, Calgary, Alberta, Canada, October 10-12, 1972.
- Bondurant, J.A., R.V. Worstell, and C.E. Brockway. 1973. Implications of Changes in Water Management in the Upper Snake River Basin. Paper presented at the ASCE Water Resources Conference, Washington, D.C., January, 1973.
- Brockway, C.E. 1973. Investigation of Natural Sealing Effects in Irrigation Canals. Research Technical Completion Report, Project A-023-IDA, Idaho Water Resources Research Institute.
- Reese, D.L. and C.E. Brockway. Operation and Maintenance Costs on Irrigation Distribution Systems. Progress Report, University of Idaho, College of Engineering.

- de Sonnevile, Jos L.J. and C.E. Brockway. 1973. Systems Analysis of Irrigation Water Management in Eastern Idaho. Research Technical Completion Report, Project B-018-IDA. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Reese, David L., H.F. Mayland, and C.E. Brockway. 1973. Alternative Methods of Estimating Snow Water Parameters. Water Resources Research, Vol. 9, No. 5.
- Bondurant, J.A. and C.E. Brockway. 1974. Operation and Maintenance Costs on Irrigation Distribution Systems. Proceedings, VIIIth International Congress of Agricultural Engineering, Flevohof, Netherlands.
- Bondurant, J.A. and C.E. Brockway. 1974. Sediment Ponds Clean Irrigation Runoff Water. Idaho Farmer.
- Brockway, C.E. 1974. Water Resources of the Upper Snake River Basin. Proceedings, National Environmental Research Park Symposium, Idaho Falls, Idaho.
- Watts, F.J., C.E. Brockway, and A.E. Oliver. 1974. Analyses and Design of Settling Basins for Irrigation Return Flow. Research Technical Completion Report, Project A-042-IDA. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Warnick, C. and C.E. Brockway. 1974. Hydrology Support Study, A Case Study of Federal Expenditures on a Water and Related Land Resource Project. Boise Project, Idaho and Oregon Project C-4202. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. 1975. Energy Plant Siting Position Paper. Idaho Society of Professional Engineers, February, 1975 (member of Committee on Energy Plant Siting).
- Bondurant, J.A., M.J. Brown, and C.E. Brockway. 1975. Some Aspects of Sedimentation Pond Design. Proceedings, National Symposium on Urban Hydrology and Sediment Control, Lexington, Kentucky.
- Brockway, C.E. 1975. Issues Involved in Peoples Choices in Resources-Water. Idaho Academy of Science, Caldwell, Idaho.
- Brockway, C.E. 1975. Science in Idaho's Future. Idaho Academy of Science, Panel Symposium.
- Claiborn, B.A. and C.E. Brockway. 1975. Impact of Changes in Irrigation Water Management in Eastern Idaho. Research Technical Completion Report, Project A-

- 040-IDA. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Bondurant, J.A., C.E. Brockway, and M.J. Brown. 1976. Characterizing Irrigation Return Flow Streams. 7th U.S. Technical Conference and 10th ICID Congress.
- Brockway, C.E. 1977. Vegetative Buffer Strips for Sediment Retention in Irrigation Runoff. Proceedings, ASCE Irrigation and Drainage Division Specialty Conference on Water Management for Irrigation and Drainage, Reno, Nevada.
- Brockway, C.E. 1977. Sediment Ponds for Irrigation Return Flow and Potato Fresh Pack Effluent. Research Technical Completion Report, Project A-042-IDA. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Fitzsimmons, D.W., G.C. Lewis, J.R. Busch, G. M. McMaster and C. W. Berg. 1977. On-Farm Methods for Controlling Sediment and Nutrient Losses. Proceedings, National Conference on Irrigation Return Flow Quality Management, Fort Collins, Colorado.
- Brockway, C.E. 1977. Investigation of Natural Sealing Effects in Irrigation Canals. Ph.D. Dissertation, Utah State University.
- Brockway, C.E. and K.P. Grover. 1977. Water Management and Groundwater in the Henry's Fork-Upper Snake River Basin of Idaho. Research Technical Completion Report, ASCE Henry's Fork Project, Idaho Water Resources Research Institute.
- Bondurant, J.A., M.J. Brown and C.E. Brockway. 1977. Predicting Irrigation Return Flow Rates. ASAE-SW-192.
- Claiborn, Brent and C.E. Brockway. 1977. Predicting Attainable Irrigation Efficiencies. ASCE.
- Grover, K.P. and C.E. Brockway. 1978. Evaluation of Urbanization and Changes in Land Use on the Water Resources of Mountain Valleys. Research Technical Completion Report. Project B-038-IDA. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Robbins, C.W. and C.E. Brockway. 1978. Irrigation Water Salt Concentration Influences on Sediment Removal by Ponds. Soil Sci. Soc. Am. J. 42:478-481.
- Longley, T.S., C.E. Brockway, and E.C. Larsen. 1978. Low Energy Sprinkler Equipment. ASAE Annual Meeting, Spokane, Washington. PN-78-406.
- Brockway, C.E. 1978. Systems Analysis of Irrigation Water Use in Eastern Idaho. OWRT.

- Brockway, C.E. 1978. Alternative Irrigation Systems for Flood Damaged Irrigation Lands Below Teton Dam. Research Technical Completion Report, Idaho Water Resources Research Institute.
- Busch, J.R., R.G. Allen and C.E. Brockway. 1978. Irrigation Rehabilitation Plans in the Teton Flood Area. ASCE Convention and Exposition, Chicago, Illinois.
- Allen, R. G. , J. R. Busch, and C.E. Brockway. 1979. Optimal Irrigation Systems Subject to Available Resources Constraints. IX Congress CIGR 1979.
- Brockway, C.E. 1979. Relationship of Costs and Water-Use Efficiency for Irrigation Projects in Idaho. Research Technical Completion Report, University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. 1979. Effects of Changing Irrigation Efficiencies on Water Supplies. ASCE Irrigation and Drainage Division Specialty Conference. Albuquerque, New Mexico.
- Brockway, C.E. 1979. Snake Plain Aquifer Model Studies. Idaho's Water, September 1979. Vol. 6, No. 4.
- Brockway, C.E., editor. 1980. Manual on Operation and Maintenance of Irrigation and Drainage Districts, American Society of Civil Engineers, prepared by Committee on Operation and Maintenance of Irrigation and Drainage Division.
- Allen, R.G. and C.E. Brockway. 1980. Problems in Developing and Applying an Optimal Irrigation Plan. ASCE Journal of the Water Resources Planning and Management Division, Vol. 106, No. WR 1.
- Mayland, H.F. and C.E. Brockway. 1980. Frequency Analysis of Western Snow Data. Proceedings. 1980 ASCE Watershed Management Symposium, Boise, Idaho.
- Robison, C.W. and C.E. Brockway. 1980. Vegetal Filters for Controlling Sediment in Irrigation Return Runoff. Proceedings. 1980 ASCE Irrigation and Drainage Division Specialty Conference. Boise, Idaho.
- Busch, J.R. and C.E. Brockway. 1980. Systems Approach to Irrigation Planning Research. 1980 ASCE Irrigation and Drainage Specialty Conference, Boise, Idaho.
- Brown, M.J., C.E. Brockway, and J.A. Bondurant. 1981. Ponding Surface Drainage Water for Sediment and Phosphorus Removal. Transactions ASAE, Vol. 24, No. 6, pp. 1478-1481.

- Brockway, C.E. and R.G. Allen. 1982. Impact of the Energy Crisis on Irrigation and Drainage, Part IV: System Design and Management Practices to Reduce Energy Requirements and Consumption. Paper presented at the 9th Congress of the International Committee on Irrigation and Drainage, National Conference. Jackson, Mississippi.
- Everts, Chris and C.E. Brockway. 1982. Reducing Soil Losses with Filter Strips. Current Information Series No. 587. University of Idaho College of Agriculture. January 1982.
- Luttrell, S.P. and C.E. Brockway. 1982. Impacts of Individual on-site Sewage Disposal Facilities on Mountain Valleys - Phase I. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Wells, R., C.E. Brockway, and J. R. Busch. 1983. Management, Maintenance and Operation of Pump Supplied Irrigation Resources Projects. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Freeman, G., C.E. Brockway, and R.G. Allen. 1983. Management and Systems for Water and Energy Savings, Bruneau Proj, Idaho. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Allen, R.G., C.E. Brockway, and J.L. Wright. 1983. Weather Station Siting and Consumptive Use Estimates. Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers.
- Allen, R.G. and C.E. Brockway. 1983. Estimating Consumptive Irrigation Requirements for Crops in Idaho. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Allen, R.G. and C.E. Brockway. 1983. Weather and Consumptive Use in the Bear River Basin, Idaho during 1982. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Allen, R.G. and cb31983. Operation and Maintenance Costs and Water Use by Idaho Irrigation Projects. Proceedings of the 1983 Specialty Conference, Irrigation and Drainage Division, American Society of Civil Engineers, Jackson Hole, Wyoming.
- Allen, R.G. and C.E. Brockway. 1983. Estimating Consumptive Use on a Statewide Basis. Proceedings of the 1983 Specialty Conference, Irrigation and Drainage Division, American Society of Civil Engineers, Jackson Hole, Wyoming.

- Johnson, G.S. and C.E. Brockway. 1983. Users Manual for University of Idaho Ground-Water Flow Model and Recharge Program. Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Johnson, G.S., C.E. Brockway, and S.P. Luttrell. 1984. Application of a Numerical Ground-Water Flow Model to the Mud Lake Area in Southeastern Idaho. Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Johnson, G.S., C.E. Brockway, and S. Ramseyer. 1984. Water Resource References for the Snake River Basin Above Swan Falls. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Luttrell, S.P. and C.E. Brockway. 1984. Impacts of Individual On-Site Sewage Disposal Facilities on Mountain Valleys - Phase II - Water-Quality Considerations. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Robison, C.W., C.E. Brockway, C.W. Robbins, and G. S. Johnson. 1984. Evaluation of Irrigation Management Procedures for Geothermal Effluent. Completion Report, University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Fitzsimmons, D.W. and C.E. Brockway. 1984. Irrigation Systems Management Research Design. Final report submitted to USAID/Pakistan under contract no. 391-0467-C-00-4028 prepared by Research Definition Team in cooperation with Washington State University and Development Alternatives, Inc. University of Idaho, Moscow, ID. 354 p.
- Johnson, G.S., C.E. Brockway, J.L. Wright, and A.L. Coiner. 1984. Remote Sensing for Irrigated Crop Water Use Phase I. Technical Completion Report, Idaho Water Resources Research Institute, submitted to NASA-Ames Research Center.
- Johnson, G.S., C.E. Brockway, and A.L. Coiner. 1985. Evaluation of Methods for Estimation of Aquifer Recharge from Precipitation on Semi Arid Lands. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. and G.S. Johnson. 1985. Calibration of the Snake Plain Aquifer ground-water flow model. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Johnson, G.S., C.E. Brockway, and S.P. Luttrell. 1985. Ground-water model calibration for the Henry's Fork Recharge Area. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.

- Brockway, C.E. 1986. Remote sensing for crop water use. Presented at Idaho Potato School January 29, 1986, Pocatello, Idaho.
- Robison, C.W. and C.E. Brockway. 1986. Modelling erosion and sedimentation in irrigation. Presented at ASCE Water Forum '86, at Long Beach, CA, August, 1986.
- Brockway, C.E. 1987. Swan Falls Data and Research Program Status Report by Idaho Technical Committee on Hydrology. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. and C.W. Robison. 1987. Evaluation of Closed Conduit Measuring Devices for Irrigation Diversions. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. and C.W. Robison. 1987. Pump System Evaluation Using Microprocessor-Based Monitors. American Society of Agricultural Engineers, Paper No. 87-3502. Presented at the ASAE International Winter Meeting December 15-18, 1987, Chicago, IL, December 1987.
- Brockway, C.E. 1987. Report on "Evaluation of the Idaho-USGS Cooperative Water Data Collection Program". A Report to Ken Dunn, Director of the Idaho Department of Water Resources from the Idaho Technical Committee on Hydrology.
- Hill, R.W., C.E. Brockway, et al. 1987. Duty of Water Under Bear Rive Compact: Field Verification of Empirical Methods. Summer 1987 Progress Report to the Bear River Commission.
- Robison, C.W. and C.E. Brockway. 1987. Demonstration of Monitors for Pumping Stations. Research Technical Completion Report for the Idaho Department of Water Resources, Contract No. DWR-86-03-21-704-37. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- France, K.E. and C.E. Brockway. 1987. Flow measurement using ramped broad crested weirs. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Robison, C.W. and C.E. Brockway. 1987. Demonstration of monitors for pumping stations. Research Technical Completion Report, contract no. DWR-86-03-21-704-37. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. and C.W. Robison. 1988. Development and Demonstration of Pump Station and Surface Diversion Monitor Systems for Water and Energy Efficiency Improvements. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.

- Brockway, C.E. and C.W. Robison. 1988. Water Resources Data and Management Model for Beaver Creek, Camas Creek and Mud Lake Area of Eastern Idaho. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Hill, R.W., C.E. Brockway, R.D. Burman, L.N. Allen, and C.W. Robison. 1989. Field Verification of Empirical Methods for Estimating Depletion; Research Report 125; Utah Agricultural Experiment Station, Logan, Utah, Two Volumes.
- Brockway, C.E. 1989. Mud Lake Standing Operating Procedures. Draft operating procedures manual for Mud Lake Water Users and Water District 31.
- Robison, C.W., C.E. Brockway, T. Gray, and T. Henschied. 1990. Irrigation Water Allocation System for Bell Rapids Mutual Irrigation Company.
- Brockway, C.E., C.W. Robison and J.S. Kolar. 1991. Municipal Pump Monitor Demonstration Project. Final Report to the Idaho Department of Water Resources. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Hamilton, B. and C.E. Brockway. 1991. Effects of Non-Continuous Turnout Operation on the Aberdeen-Springfield Canal System. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Sandoval, V.B. and C.E. Brockway. 1991. Ground-water Investigations for the Fremont-Madison Irrigation District, Southeastern Idaho. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Sandoval, V.B. and C.E. Brockway. 1992. Water Rights Accounting on the Upper Snake River, Water District 01, Southeastern Idaho. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID. In press.
- Brockway, C.E. and C.W. Robison. 1992. Middle Snake River Water Quality Study, Phase I: Final. Technical completion report submitted to Idaho Department of Health and Welfare, Division of Environmental Quality. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E., C.W. Robison, G.S. Johnson. 1992. Evaluation of Water Quality in Shallow Ground-water Systems. Final Report to the Division of Environmental Quality, Contract No. 82-600945. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Robison, C.W. and C.E. Brockway. 1991. Operations Manual for Electronic Pumping System Monitors. Research Technical Completion Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.

- Robison, C.W. and C.E. Brockway. 1992. "Thinking about Post-Project Evaluation - START NOW!". In: Proceedings of the National RCWP Symposium - 10 Years of Controlling Agricultural Nonpoint Source Pollution: The RCWP Experience. Orlando, Florida. September 13-17, 1992. US-EPA Office of Research and Development Office of Water, Washington DC. EPA/625/R-92/006.
- Brockway, C.E., H. Neibling, C.W. Robison, S.J. Trundy, and A. Wetzstein. 1992. Water Quality Project, Twin Falls and North Side Canal Companies First Quarterly Report, June 1- September 30, 1992.
- Brockway, C.E., H. Neibling, C.W. Robison, S.J. Trundy, A. Wetzstein, and J.F. Hansen. 1992. Water Quality Project, Twin Falls and North Side Canal Companies Second Quarterly Report, October 1 through December 31, 1992.
- Brockway, C.E. and C.W. Robison. 1992. Middle Snake River Water Quality for Snake River at Star Falls. Submitted to B and C Energy. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E. and C.W. Robison. 1992. Middle Snake River Water Quality for Kanaka and Boulder Rapids. Submitted to L.B. Industries. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.
- Brockway, C.E., H. Neibling, and C.W. Robison. 1993. Water Quality Project, Twin Falls and North Side Canal Companies Third and Fourth Quarterly Report, January 1, 1993 to June 30, 1993.
- Brockway, C.E. et al. 1993. Proposed Nutrient Management Plan for Middle Snake Irrigated Agriculture. Submitted to Idaho Department of Health and Welfare Division of Environmental Quality by the Mid Snake Irrigation Water Quality Coordination Committee.
- Carter, D.L., C.E. Brockway, and K.K. Tanji. 1994. Controlling Erosion and Sediment Loss from Furrow-Irrigated Cropland. *Journal of Irrigation and Drainage Engineering*, American Society of Civil Engineers. 119(6):975-988.
- Brockway, C.E. and A. Kahlown. 1994. Big Wood River-Silver Creek Hydrology Study. Quarterly Reports.
- Brockway, C.E. and A. Kahlown. 1994. Hydrologic Evaluation of the Big Wood River and Silver Creek Watersheds, Phase I. Final Report. University of Idaho, Idaho Water Resources Research Institute, Moscow, ID.