

Kent Foster filed documents that are identical except for the subcase numbers. I scanned 33-69 of each document and saved it to the additional numbers. We will put the original documents in the legal files.

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**IN THE DISTRICT COURT OF THE FIFTH JUDICIAL DISTRICT OF THE
STATE OF IDAHO, IN AND FOR THE COUNTY OF TWIN FALLS**

In Re SRBA

A. Subcase 33-69

Case NO. 35976

STATE OF IDAHO)
)ss.
County of Twin Falls)

Charles E. Brockway, affiant herein, deposes and says:

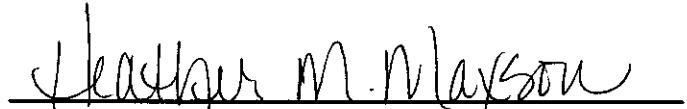
1. Affiant is a licensed professional engineer in the state of Idaho, holds a bachelor of science degree in civil engineering from the University of Idaho, a Master of Science degree in civil engineering from California Institute of Technology and a Doctor of Philosophy degree in water resource engineering from Utah State University. He served on the hydrology staff of the United States Bureau of Reclamation at the regional office in Boise, Idaho and at the research laboratory in Denver, Colorado. For 32 years affiant was on the faculty of the University of Idaho and in charge of research in water resources and irrigation for the university at the research center at Kimberly, Idaho. He is currently the senior member of the firm of Brockway Engineering P.L.L.C.
2. Affiant was retained by Mr. Ed Dumke to provide consultation and advice on water issues in connection with water rights and hydrologic evaluations in connection with the Sagewillow ranch located on Little Lost River. Affiant has

evaluated the depletion effects of additional irrigation scenarios on the Sagewillow ranch to determine the amount and timing of increased depletion which could occur in the Little Lost River downstream.

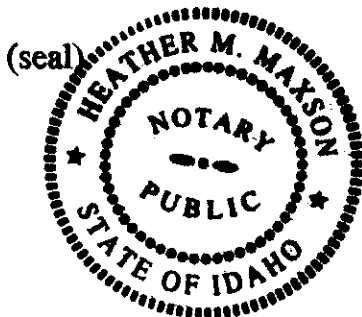
3. Affiant has prepared a report on this analysis, a copy of which is attached hereto and by this reference made a part hereof.
4. Affiant concludes that the resumption of irrigation on Sagewillow does cause depletion in the Little Lost River downstream during the latter part of the irrigation season and that the depletion is proportional to the number of additional irrigated acres.
5. The maximum potential depletion in discharge of Little Lost River due to resumption of irrigation of 978 acres is 5.97 cfs which occurs from the third week in August through the end of the irrigation season.
6. Potential reductions in Little Lost River discharge are less than 10 percent of the average late season September discharge. Changes in discharge of this magnitude or lower would be difficult or impossible to measure with any assurance of accuracy.


Charles E. Brockway

Subscribed and sworn to before me the undersigned notary public, this
11th day of December 2003


Notary Public for Idaho

Residing at Twin Falls, Idaho
My commission expires 2-24-09



CERTIFICATE OF MAILING

I hereby certify that on the 12th day of December, 2003, I mailed the original and copies of this Affidavit of Charles E. Brockway, including all attachments, to the following persons:

1. Original to:
Clerk of the District Court
Snake River Basin Adjudication
253 Third Avenue North
P.O. Box 2707
Twin Falls, ID 83303-2707
2. One copy to the claimant of the water right at the following address:
Name: Sage Willow, Inc.
c/o Holden, Kidwell, Hahn & Crapo, PLLC
330 Shoup Ave., Third Floor
P.O. Box 50130
Idaho Falls, ID 83405-0130
3. Copies to:
IDWR Document Depository
P.O. Box 83720
Boise, ID 83720-0098
Michael C. Creamer
Givens Pursley, LLP
P.O. Box 2720
Boise, ID 83701-2720
Chief, Natural Resources Division
Office of the Attorney General
State of Idaho
P.O. Box 44449
Boise, ID 83711-4449
United States Department of Justice
Environmental and Natural Resource Division
550 West Fort Street, MSC 033
Boise, ID 83724



Kent W. Foster, Esq.

**REPORT ON
DEPLETIONS TO LITTLE LOST RIVER
FROM IRRIGATION ON SAGEWILLOW**

FOR

ED DUMKE

By

Brockway Engineering P.L.L.C.

December 11, 2003

Introduction

Sagewillow ranch is located in the Little Lost River valley approximately 12 miles upstream from the town of Howe. Irrigation is accomplished by diversion from Little Lost River under various water rights which include ground water exchange, re-diversion and from wells pumping directly to irrigation distribution systems.

Concerns have been expressed by downstream water right holders relative to the depletion caused by increased irrigation on Sagewillow, which may impact water right diversion capability.

Aquifer/River Relationships

The aquifer underlying Sagewillow is an alluvial system with water table aquifer confined by consolidated materials along the valley sides. The Little Lost River flows through the valley and gains from or loses to the aquifer depending on the water levels in the aquifer. The aquifer water levels are affected by local geology. Springs occur within the lower parts of the Sagewillow property which are manifestations of higher water tables intersecting the ground surface. As a result, the Little Lost River gains flow within this reach which terminates downstream of the south boundary of Sagewillow just upstream of the Blaine Canal diversion. Downstream of the Blaine Canal diversion, the aquifer water levels are below the stream bottom and the river is a losing reach. The valley aquifer below the Blaine Canal diversion becomes considerably wider and reaches a width of more than six miles near Howe. The stream/aquifer relationships and gaining and losing reaches of Little Lost River are documented in a report by C.E. Brockway titled A Study of Water Transfer Losses –Little Lost River dated February 1993 and appended to this report.

Consumptive depletions occurring from irrigation on Sagewillow affect the total water leaving the ranch both as surface water and as ground water underflow. Specifically, any water pumped from the shallow aquifer on Sagewillow for irrigation results in a net consumptive depletion within the aquifer which ultimately does not reach the Little Lost

River through aquifer flow and emerging springs within the lower part of the ranch and on downstream.

Ground water flows through the shallow aquifer on Sagewillow are governed by the gradient of the water table and the hydraulic conductivity or permeability of the aquifer media. This aquifer, as indicated by lithology documented in driller's logs, consists of sand and gravel with some interbedded clay lenses. The hydraulic conductivity of the aquifer is estimated at approximately 200 ft/day under unit gradient based on the U.S. Bureau of Reclamation Ground Water Manual (1977). The water table gradient can be approximated by the ground surface gradient across the ranch parallel to the direction of flow. This gradient was estimated from topographic data to be 0.0617 ft/ft. Using Darcy's law for flow through porous media, the calculated effective ground water flow velocity is 12.35 ft/day. The irrigation wells for the ranch are located in Sections 1, 6, and 12 and the center of those wells is estimated at 1620 feet up-gradient from the south boundary of the ranch. The estimated travel time for ground water from the wells to the south boundary of the ranch and into Little Lost River through springs is 131 days or 4.37 months (Appendix 1)

Irrigation Depletion Estimates

Vegetation growing on lands overlying the aquifer extracts moisture from the soil profile. This moisture is supplied from irrigation application and/or precipitation. Non-crop vegetation in this area is normally range grass and/or sagebrush, which generally use all of the effective precipitation occurring during the summer season. Irrigated crops require the addition of soil moisture plus the precipitation occurring during the growing season. Therefore, the net depletion occurring from the conversion of natural vegetation to irrigated crop is the difference between the historical non-crop consumptive use and the new crop consumptive irrigation requirement.

In order to evaluate the net depletion from irrigation of additional lands on Sagewillow, the monthly effective precipitation based on the station at Howe and the monthly consumptive irrigation requirement for pasture were utilized.

Testimony by Mr. Jerry Pancheri, operator of the irrigation system on Sagewillow indicated that a total of 2390 acres were irrigated during 1993. Other testimony indicated

that historically the irrigated area on Sagewillow might have been approximately 1412 acres. Therefore, the added acres may have been as much as 978 acres. The attached spreadsheet shows the monthly net depletion due to resumption of 978 acres of irrigation on Sagewillow. It is assumed, based on Mr. Pancheri's testimony, that the irrigation water source for any acres in excess of 1412 was provided from the current wells in the shallow aquifer (Appendix 1).

River Depletion Estimates

The net depletion of the total water resource based on 978 added acres of irrigation is 2464 acre-feet during the growing season. Based on the aquifer properties and water table gradient, it takes approximately 4.37 months (131 days) for this effect to reach the Little Lost River. Therefore, the depletion occurring on April 15 (the official start of the irrigation season) at the wells does not reach the river until August 26 and depletive effects occur during the irrigation season from August 26 to October 15 or 49.5 days. The Little Lost River therefore is subject only to depletions occurring at the wells from April 15 through June 5 or 584.7 acre-feet. This analysis assumes that the full depletive effect is manifested in reduced inflow to Little Lost River. Some of the depletion may result in reduction in ground water underflow, which would reduce the depletion in river flow. Similarly, decreased water levels in a stream can result in increased ground water gradient toward the stream in a gaining reach, resulting in additional induced inflow and reducing the effect of upstream depletions. The estimated depletions in Little Lost River due to resumption of irrigation on land less than 978 acres are shown in Appendix 1.

The reduction in unmeasured inflow to Little Lost River occurs in the gaining reach from the south boundary of Sagewillow to above the Blaine Canal diversion. The estimated maximum reduction in stream flow of 584.7 acre feet averaged over the 49.5 days of the irrigation season during which the reduction takes place could result in a decrease in discharge of 5.88 cfs. The average flow in September of Little Lost River at the USGS gage upstream of Sagewillow near Wet Creek is approximately 56 cfs. The net gain in the river from the Wet Creek gage downstream to the Blaine Canal Diversion is about 10% based on measurements made by C.E. Brockway in October 1992 so the estimated average September discharge at the Blaine Canal diversion is 61.6 cfs. The estimated

maximum reduction in stream flow of 5.97 cfs is 9.7 percent of the September average flow.

Discharge measurements normally utilized for stream flows are generally performed using current meters. The relative accuracy of a current meter discharge measurement depends on the geometry of the channel, roughness of the channel bottom and precision with which the individual velocity measurements are performed. Generally, routine stream flow measurements in natural stream sections are rated ± 5 to 10 percent with a 'good' measurement, according to the USGS criteria, being $\pm 5\%$. The estimated maximum depletion in stream flow of 5.97 cfs, or 9.7 % of the average September flow is within the accuracy range of normal discharge measurements. Changes in discharge below this magnitude, in the 4 to 5 cfs range, would be difficult to measure with any assurance of accuracy.

APPENDIX 1

Depletion Analysis-Sagewillow

Evaluation of additional net depletion resulting from irrigation of acres in excess of

Acres irrigated=

1412

Additional acres irrigated

2390

Depletion based on acres irrigated. Acres include all lands irrigated from groundwater and from Little Lost River.

978

Estimated time of travel from wells to springs at end of property=

4.37 months

	Time of Arrival	Days	Area irrigated** acres	Increase Pasture acres	Pasture mm/day	Pasture mm/mo	Pasture ft/mo	Effective Precip mm/day	Effective Precip mm/mo	Effective Precip ft/mo	Net Depletion** mm/mo	Net Depletion** ft/mo	acre ft/mo	Acc. Dep
April	4	8.37	30	2390	978	1.82	54.6	0.179	0.31	9.3	0.031	45.3	0.149	0 145.4 145.4 4
May	5	9.37	31	2390	978	4.57	141.67	0.465	0.76	23.56	0.077	118.11	0.388	379.0 524.3 5
June	6	10.37	30	2390	978	5.77	173.1	0.568	1.07	32.1	0.105	141	0.463	452.4 976.7 6
July	7	11.37	31	2390	978	6.15	190.65	0.625	0.34	10.54	0.035	180.11	0.591	577.9 1554.7 7
August	8	12.37	31	2390	978	4.82	149.42	0.490	0.56	17.36	0.057	132.06	0.433	423.7 1978.4 8
September	9	13.37	30	2390	978	3.42	102.6	0.337	0.37	11.1	0.036	91.5	0.300	293.6 2272.0 9
October	10	14.37	31	2390	978	2.14	66.34	0.218	0.21	6.51	0.021	59.83	0.196	192.0 2464.0 10
November	11						878.38	2.882	3.62	110.47	0.362	767.91	2.519	2464
December	12													
January	13													
	13.5													

Net Effect on River with time lag
Depletion occurs only during the last 49.5 days of the irrigation season

* Based on Allen and Brockway (1983) for Howe Station.

** Range vegetation assumed equal to effective precip.

***Acres above 1412

Depletion from Different Sizes of Irrigated Area

Area irrigated in excess of base irrigated area of 1412 acres

Irrigation Season 15-Apr to 15-Oct or 183 days

River depletion period 49.5 days Aug 26 to Oct 15

Estimated average September discharge-Little Lost River at Blaine Div. 61.6 cfs

Area Acres	Add acres	Total Depletion af	Depletion of River af/day	cfs avg.	% of avg Q
1412	0	0	0	0	0
1500	88	221.7	52.6	1.1	0.54
1600	188	473.6	112.4	2.3	1.15
1700	288	725.6	172.2	3.5	1.76
1800	388	977.5	231.9	4.7	2.37
1900	488	1229.5	291.7	5.9	2.98
2000	588	1481.4	351.5	7.1	3.59
2100	688	1733.3	411.3	8.3	4.20
2200	788	1985.3	471.1	9.5	4.81
2300	888	2237.2	530.8	10.7	5.42
2390	978	2464.0	584.7	11.8	5.97

Estimate of aquifer flow time lag-Sagewillow ground water pumping

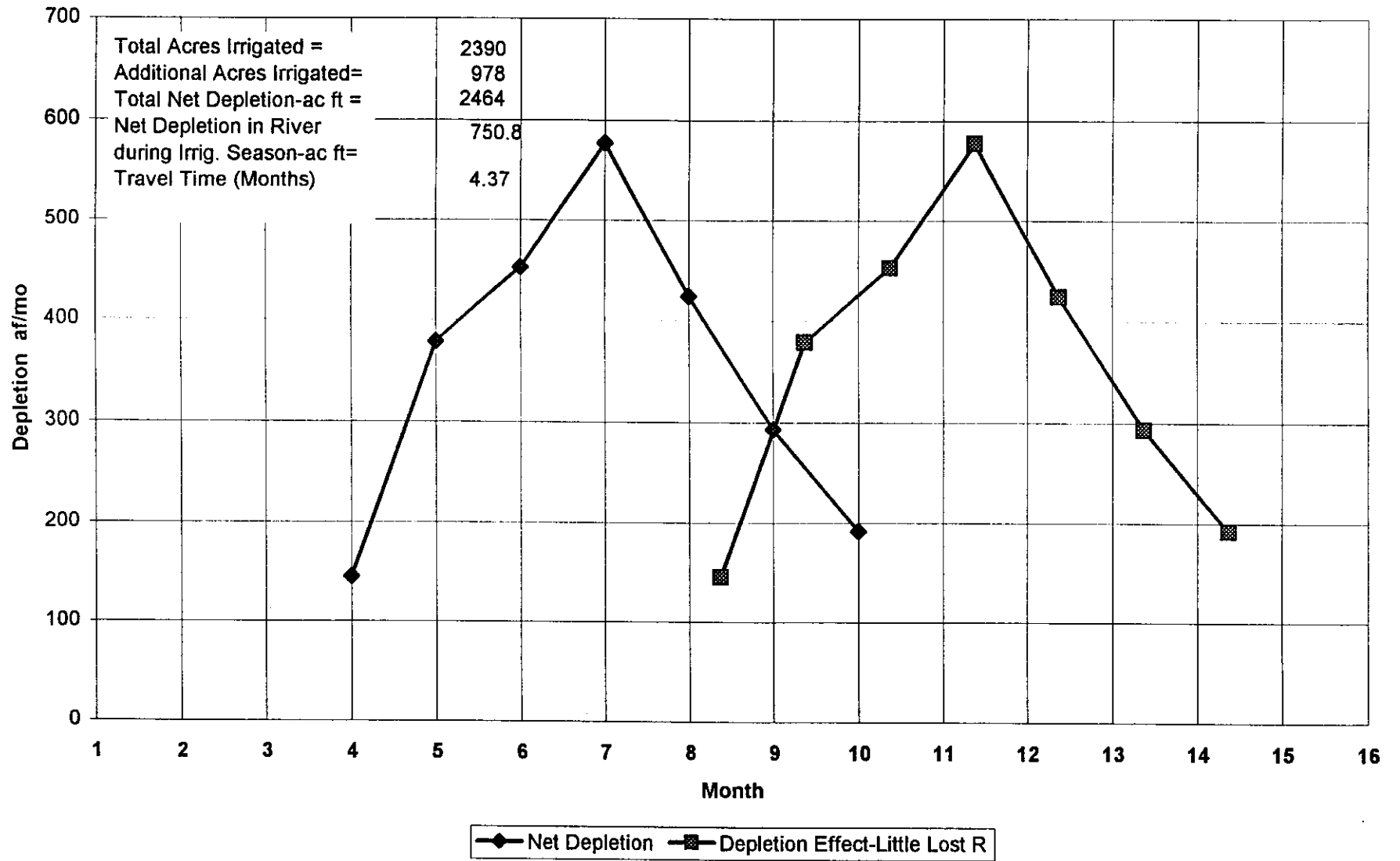
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Assumes irrigation of acres above 1412 is supplied from wells on Sagewillow

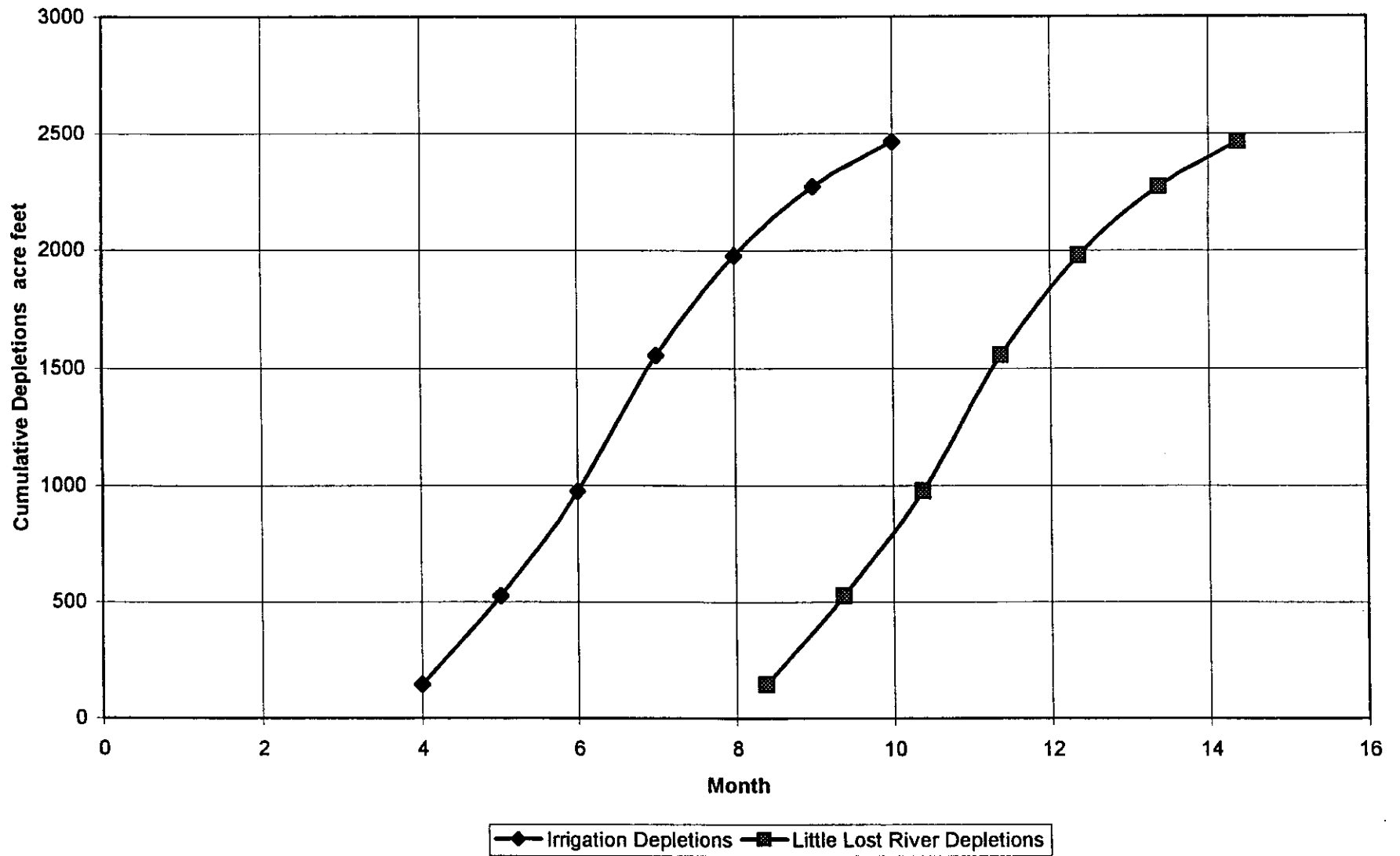
Estimated hydraulic conductivity 200 ft/day Based on drillers logs and USBR Ground-water manual-Clean Sand and Gravel

Ground Surface Elevation	Distance	Gradient	Velocity	Time of	
Wells	South End	Difference		Travel	
ft	ft	ft	ft	ft/ft	ft/day
					days
					months
5320	5220	100	1620	0.06173	12.35
					131.2
					4.37

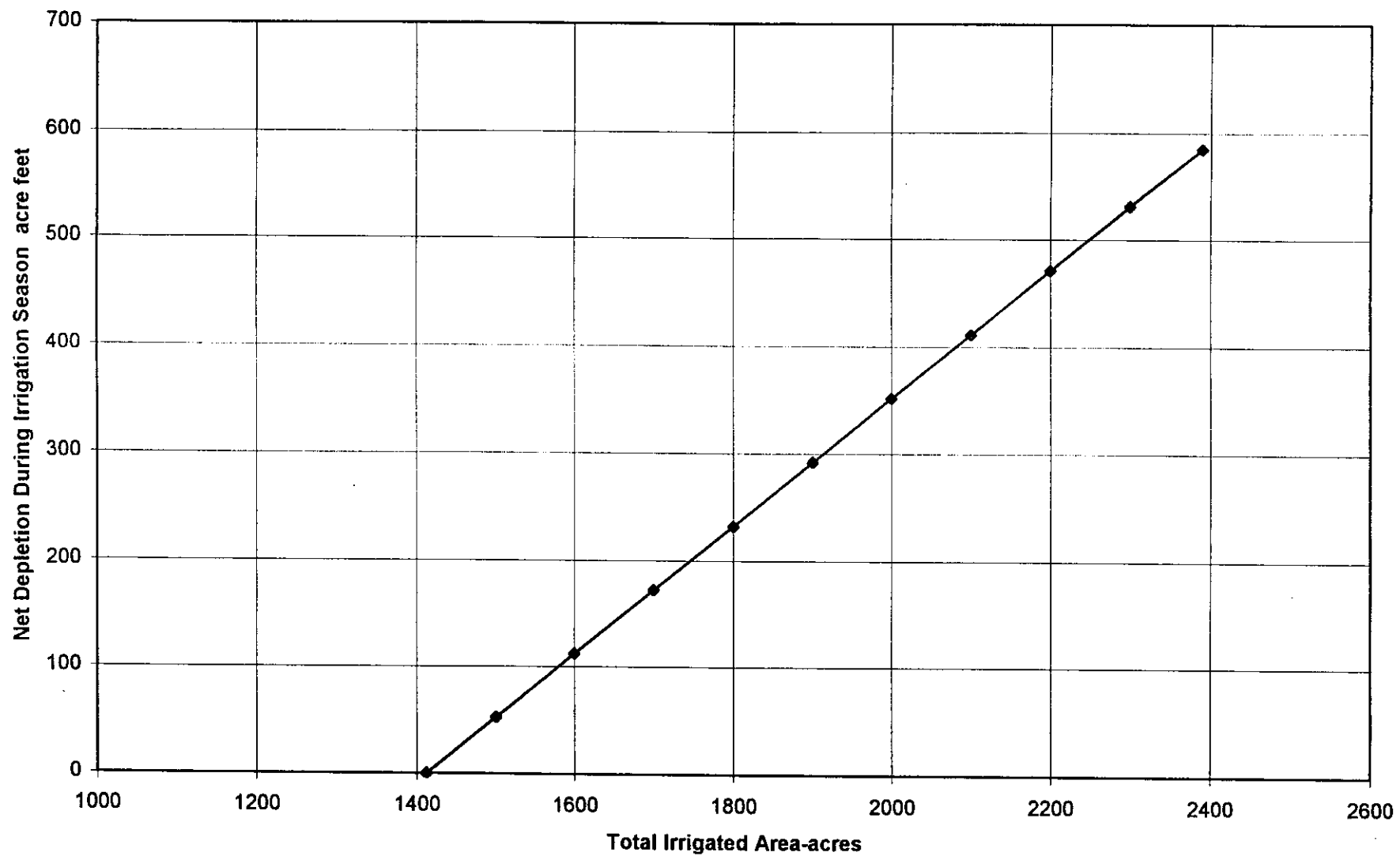
Irrigation Depletion-Sagewillow



Depletions from Sagewillow Irrigation



Net Depletion of Little Lost River from Additional Sagewillow Irrigation



**A STUDY OF WATER TRANSFER LOSSES
LITTLE LOST RIVER**

BY

C.E. BROCKWAY P.E.

FEBRUARY 1993

WATER TRANSFER LOSSES-LITTLE LOST RIVER

INTRODUCTION

The Little Lost River Basin in Idaho lies between the Lost River Range and Lemhi Range of mountains and drains south toward the Eastern Snake River Plain. The Little Lost River is formed by joining of Sawmill Creek and Summit Creek in T10N R26E. Some of the major tributaries include Dry Creek, Wet Creek, Deer Creek, Badger Creek, and Uncle Ike Creek. The river and tributaries support extensive irrigation by individual and cooperative irrigation entities. Most of the tributaries are developed for irrigation and the river is totally diverted for irrigation during the irrigation season.

Water rights within the basin are administered by Water District No 31 with a water master and Board of Directors as authorized under Idaho Code. The regulation of water deliveries is performed by the water master under the direction of the Idaho Department of Water Resources based on valid decreed and licensed water rights and permits and approved transfers. Idaho Code allows for development of surface and ground-water under the prior appropriation doctrine and for transfers and changes in points of diversion of established water rights so long as no injury to other water right holders results. When the point of diversion and/or place of use of an established water right is changed, there is usually a change in the hydrologic balance of the stream-aquifer system compared with the balance prior to the transfer. Determination of that change, and the resultant impact on current right holders, depends on quantification of the change in the reach-gain from seepage or subsurface inflow from the point of the historical diversion to the new point of diversion.

Downstream transfers, when allowed, have usually been assigned some quantify of "shrink" or decrease in diversion allowed to account for the change in water balance. Quantification of the amount of "shrink" allowed in the Little Lost River system is critical to equitable distribution of water under established rights.

The purpose of this report is to review current data on the hydrology of the Little Lost River including measurements of reach gains and losses and to present a concept for allocation of losses to be assigned to transferred water.

PHYSICAL FEATURES OF THE BASIN

The Little Lost River basin comprises a drainage area of approximately 900 square miles with small, short, usually ephemeral streams entering from the east and somewhat longer streams draining from the Lost River Range on the west.

Nearly all of these streams have developed alluvial fans composed of highly permeable materials which increase seepage and decrease surface flows reaching the river. The valley floor, covered with alluvium of varying depths, averages about 6 miles wide. Large masses of bedrock jut into the valley floor from both east and west sides(Clebsch, Waite and Decker, 1974).

RIVER -AQUIFER RELATIONSHIPS

Generally, the aquifer underlying the valley is an unconfined system, however, clay layers may produce localized perched or semi-confined systems. This is especially true near the mouth of the valley near Howe where sediments tend to be more fine- grained as the aquifer integrates with the Snake Plain basalt aquifer. Water tables in the alluvium are generally below the water level in the river; however local geology and rock intrusions cause anomalies in the water table gradient which result in springs and gains to the river (Clebsch, Waite and Decker, 1974). Aquifer water levels adjacent to the river are generally below the river except for a reach beginning below the confluence of Big Spring Creek to just upstream of the USCE structure. Data from Mundorff(1963) indicate that the Little Lost river loses to the aquifer even in the reach parallel to Big Spring Creek.

DISCHARGE MEASURING STATIONS

Gauging stations have been operated by the USGS at three stations on the Little Lost River. The gage Little Lost River near Howe was operated from 1921 through October 1991. This gauging station is located in Sec 11 T6N R28E, approximately 1/4 mile above the Blaine Canal Diversion. The gauging station Little Lost River above Wet Creek near Howe has been operated since January 1958 and is located in Sec 4 T10N R28E approximately 1/4 mile below the mouth of Wet Creek. A station was operated at the mouth of Sawmill Canyon called Sawmill Creek near Goldburg from 1960 through 1973. Daily average discharge is published for each station except when the stations were inoperable due to ice or other factors.

HISTORICAL STREAM LOSS MEASUREMENTS

Several investigators have made measurements of losses in specific reaches of the Little Lost River in connection with litigation and for other studies. Copies of the Idaho Department of Water Resources records containing information on historical measurements of stream losses were furnished by Mr. Tim Luke of the Boise IDWR office.

A series of measurements were made on August 17, 18, and 21 of 1923 by the USGS and reported in a letter to Mr. W.G. Swenson, Idaho Commissioner of Reclamation. These measurements included inflow-outflow on Dry Creek from the Dry Creek Dam to the mouth of Wet Creek, Little Lost River from Raymond Ranch (above Wet Creek) to Holland Ranch (below Badger Creek), Little Lost River from Holland Ranch to above the Blaine County Diversion Canal, and a series of measurements on Sawmill Creek, and Sawmill Ditch. These measurements included estimates of some smaller flows but most were made with current meters. The letter indicates that a heavy rain occurred during the last day of measurement making those measurements in the Sawmill Creek-Sawmill Ditch area 'not altogether favorable'.

The following table summarizes the results of these measurements for Dry Creek-Wet Creek and the Little Lost River:

Reach	Total Inflow	Diversion or Outflow	Loss
	cfs	cfs	cfs
Dry Cr. at mouth of pipeline to Wet Cr. nr mouth	83.12	65.18	17.94 or 21.6%
Little Lost at Raymond ranch(above Wet Cr.)to Holland ranch(below Badger Cr.)	110.82	100.61	10.21 or 9.2%
Little Lost at Holland ranch to above Blaine Div.	112.97	109.71	3.26 or 2.9%
Combine Little Lost at Raymond ranch(above Wet Cr.) to above Blaine Div.	141.91	128.64	13.47 or 9.5%

The 1923 measurements were made on two separate days when the measured difference in discharge of the Little Lost River at Holland Ranch was over 2 cfs.

On May 4 and 5, 1926 Mr G.G. Paulsen, assisted by Mr. Nephi Hansen, water master for Little Lost River, made a series of measurements on Dry Creek and the Little Lost River as reported in a letter from Mr. Paulsen to W.G. Swendsen on May 14, 1926. A summary of those measurements is as follows:

Reach	Total Inflow	Diversion or Outflow	Loss
	cfs	cfs	cfs
Dry Creek Dam to Mouth of Wet Creek	35.58	23.74	11.84 or 33%
Little Lost above Wet Creek to wagon bridge 1 1/2 miles above Holland ranch	87.85	84.37	3.48 or 3.96%
Little Lost River above Holland ranch to above Blaine Div.	117.22	108.98	8.24 or 7.03%
Combine Little Lost above Wet Creek to above Blaine Div.	124.77	113.05	11.72 or 9.4%

On August 25, 1928 the USGS reported in a letter to Mr Geo. N. Carter, Idaho Commissioner of Reclamation on discharge measurements made on August 19, 20, 1928 to determine losses from Dry Creek to the Blaine Diversion. The following summarizes those findings:

Reach	Total Inflow	Diversion or Outflow	Loss
	cfs	cfs	cfs

Div. canal below end of Dry Creek pipe line to Corral Cr. at mouth	20.3	14.5	5.8 or 28.6%
Corral Cr. at mouth to Wet Creek at mouth	27.64	23.67	3.97 or 14.4%
Little Lost below Wet Cr. to above Knollin Ranch	51.21	42.18	9.03 or 17.6%
Little Lost above springs at Knollin Ranch to below springs at Knollin R.	43.3	42.9	0.4 or 0.9%
Little Lost below springs at Knollin R to Blaine Div.	66.93	62.18	4.75 or 7.1%
Combine-Little Lost below Wet Cr. to Blaine Div.	77.55	63.38	14.17 or 18.3%

A series of measurements were made by E.G. Bailey of the USGS on July 25, 1932 and reported in a letter to R.W. Faris, Idaho Commissioner of Reclamation on August 4, 1932 by T.R. Newell, District Engineer, USGS Boise. These measurements appear to be useful; however, the copy from the IDWR files is not readable.

The USGS measured 18 sites from Wet Creek above Corral Creek to the Little Lost River above the Blaine Diversion on September 5, 6, 1933 as reported in a letter from T.R. Newell to R.W. Faris on September 19, 1933. The analysis of these measurements is not as complete as previous USGS communications; however, a summary of the measurements is as follows:

Reach	Total Inflow	Diversion or Outflow	Loss
	cfs	cfs	cfs

Wet Cr. above Corral Cr. to Wet Cr. at mouth	18.60	14.02	4.58 or 24.6%
Little Lost below Wet Cr. to above Knollin ranch	21.16	12.03	9.13 or 43.1%
Little Lost below Knollin ranch to Blaine Div.	36.19	31.3	4.89 or 13.5%
Combine Little Lost below Wet Cr. to Blaine Div.	44.85	32.13	12.72 or 28.4%

E.G., Bailey of the USGS reported on measurements made on the Little Lost River and tributaries obtained during August 25-28, 1935. He was assisted by N.W. Hansen. Measurements were made at 31 sites on Dry Creek, Wet Creek, Sawmill and Little Lost River. Some measurements concerned with the old Sawmill By-pass canal and the Summit Creek canal. The following is an extract and compilation of pertinent loss calculations based on Mr. Bailey's report of measured flows:

Reach	Total Inflow	Diversion or Outflow	Loss
	cfs	cfs	cfs
Wet Creek above Corral Cr. to Wet Cr 0.3 mi. above mouth	21.66	17.88	3.78 or 17.5%
Little Lost below Wet Cr to above Knollin ranch	34.77	24.17	10.66 or 30.5%
Little Lost above conf. w/ Spring Cr to above Blaine Div.	45.03	41.09	3.94 or 8.7%

The IDWR files contain a list of measurements for 11 stations made on May 15 and 16, 1968 titled Wet Creek and Little Lost River Loss Measurements. There is no indication of the location of the 11 stations or who made the

measurements. Calculations include a list of percentage losses from Dry Creek Ditch to the various stations as follows:

Loss from Dry Creek Ditch To:	Loss
Station No. 2	1.0%
Station No. 3	7.9%
Station No. 4	10.7%
Station No. 5	--
Station No. 6	17.1%
Station No. 7	17.5%
Station No. 8	20.1%
Station No. 9	30.2%
Station No. 10	Gain
Station No. 11	40.7%

Station No 11 was listed as the Howe Station which is likely the USGS gage operating as Little Lost River near Howe in 1968 which was the gage upstream of the Blaine Canal Diversion.

Clebsch, Waite and Decker (1974) discuss river channel gains and losses and point out that some 'losses' may actually return to the stream down the valley where the stream gains through spring flows and/or unmeasurable ground-water inflow. This publication does not provide detailed data on the quantity of stream loss or gains but does point out that the river gains or loses based on adjacent aquifer water levels. Mundorf, Broom and Chabot (1963) provided insight to the intricate relationships of the ground-water system and the river based on measurements of some 40 different sites including the main river, tributaries, and spring inflows. The purpose of this study was to define the hydrology of the Little Lost River basin and apparently no detailed analysis of flow data was performed.

RECENT MEASUREMENTS OF LOSSES

In order to define reach gains and losses, a series of measurements of the river and inflows and outflows was performed on October 27, 1992 by C.E. Brockway P.E. and Clearance W. Robison P.E. During this period of the year, aquifer levels are normally lower than late spring or early summer due to ground-water inflow recession and any affects due to irrigation pumping. Since the Upper Snake River and tributaries have experienced a drought since 1987, general aquifer water levels are likely lower than normal historical levels. Gains to the Little Lost River should be expected to be lower than normal and losses to be

higher. River and inflowing streams and springs were measured using current meters and operating diversions were measured through the diversion measuring structures, usually submerged orifices. Current meter measurements were made using Ott propeller type meters using standard measurement procedures. All operating diversions were measured. Some diversions, although closed, were leaking but the leakage was not significant.

Measurements were made beginning early the morning of October 27, 1992 using two water measurement teams. Each team measured a series of sites as measurement proceeded from the road bridge at the mouth of Sawmill Canyon downstream to the last diversion at Mr. Bob Mays near Howe. No water was flowing in Little Lost River below the Mays diversion. Measurement proceeded downstream so that the time between successive measurements used for loss calculations would be minimized and the diurnal fluctuations in flow would not be significant.

Duplicate measurements at two sites were made by each team to assure that differences between measurements by different personnel were not excessive.

Measurements were also made on the lower reach of Summit Creek just upstream from the confluence with Little Lost River and on Wet Creek beginning below the Dry Creek Hydro inflow to the county road bridge upstream of the confluence with Little Lost River.

Locations of each measurement site were determined using USGS 7.5 minute topographic maps and river mile locations were determined using a distance wheel on the USGS maps.

Calculation of losses between river measuring stations was based on the sum of inflows minus the sum of outflows in the reach. Inflow includes all measured surface inflow including the river at the upstream end of the reach and outflows include all diversions and the flow of the river at the downstream end of the reach. Table 1 shows the measurements made at each site, the river mile of each site progressing upstream from the Bob May diversion, and the calculated gain or loss in the river reach.

Figure 1 shows the measured losses between each measuring site on the topographic map and Figure 2 shows the loss per mile between stations. Figure 3 is a plot of the loss for each reach as a percentage of total inflow into the reach. The river loses between the mouth of Sawmill Canyon and the USGS gage below Wet Creek then gains approximately 1.5 cfs per mile between the USGS gage and Badger Creek. The highest losing reach, about 3.8 cfs per

mile, is between Badger Creek and below Big Spring Creek. Below Big Spring Creek to the USCE structure, the river gains approximately 4.8 cfs per mile which is consistent with the higher aquifer water levels as indicated by Clebsch, Waite and Decker, 1974. Downstream of the USCE structure, the river is a continuously losing reach. The 1992 measurements indicated a net loss of 78% in the reach from the Sawmill Canyon road to the May Diversion based on the summation of losses by individual sub-reach for the length of the river.

The Bureau of Land Management has made several sets of measurements to determine stream discharges in connection with applications for maintenance of instream flows. Measurements have been made on Wet Creek, Badger Creek, Deer Creek, Big Spring Creek and Warm Springs Creek. However, apparently no measurements have been made on Little Lost River. Wet Creek measurements were made during 1990, 1991, and 1992 at six sites beginning at the US Forest Service boundary downstream to the confluence with Little Lost River. Inflow to Wet Creek and diversions from the creek may have been measured but were not reported in data received from the BLM so stream losses cannot be determined. Differences in stream flows on tributaries such as Badger Creek were also reported but it is not clear whether any diversions or inflow were occurring between measuring points.

CONCEPTS FOR ESTIMATING LOSSES

Decisions on whether or not transfers should be allowed are dependent on the determination of whether or not injury may occur to senior water right holders or whether mitigation for injury can be effected by proper conditions attached to the transfer. On the Little Lost River, all loss measurements, current and historical, indicate that the river experiences a net loss of flow over the full length of the valley. However, there are reaches of the river which experience significant gains. Transfers of water rights for significant distances downstream to new points of diversion should recognize that transferred water is subject to a reasonable loss along with other allocated water in the stream. When additional water is carried in a stream, the water level is raised an amount depending on the stream geometry. This rise in water level increases the wetted or seeping area of the stream and causes increased pressure on the wetted area. Figures 4 and 5 show graphically the effect on the stream channel due to increased stream flow. If the water level is below the stream water level, the stream is losing water and the increased stream flow increases the loss, Figure 3. If the water level in the aquifer is above the stream water level, the stream is gaining

and the increased stream flow causes a decrease in the ground-water gradient toward the stream and decreases the inflow or gain, Figure 4. The theory, held by some, that downstream transfer of water and the resulting increase in stream flow does not increase stream losses or decrease ground-water inflow is not valid. The concept that the "new" water essentially rides on top of the "old" water with no change in net stream loss is not valid. Unfortunately, precise mathematical quantification of changes in natural stream losses is not possible. However the determination of the feasibility of transfer applications, and the equitable administration of approved transfers, depends on whether reasonable procedures for assigning losses or 'shrink' to water transferred downstream to new points of diversion can be developed.

Since it is not hydraulically possible nor economically feasible to install continuous discharge measuring devices at a sufficient number of sites along the river to document losses or gains for short reaches, some simplified but equitable method with reasonable hydrologic justification must be adopted.

Uniform Linear Losses

One procedure is to utilize a linear relationship between percentage of total inflow and distance with the relationship based on measured losses in the main stream and accounting for all inflows and diversions. Using a uniform linear loss distribution averages the total loss over the reach and gives credit for gains to transferred water. Figure 5 shows the uniform linear relationships from below Sawmill Canyon road to the May diversion for the 1992 loss measurements. Using this relationship, the loss assign able to a transfer from point A to point B in Figure 5 is 56 percent minus 15 percent or 41 percent.

Uniform Linear Loss over Sub-reaches

Using this procedure, the loss rate between measuring stations is assumed uniform and full credit for gain is given to transferred water. This method recognizes the differences in gains and losses between subreaches; however, there is a question as to whether the transferred water should share fully in the natural gain over a sub-reach. Figure 6 shows a plot of percentage losses for the 1992 measurements from Sawmill Canyon road to the May Diversion. Using this procedure, the assigned loss for a transfer from point A to point B would be 95 percent minus 40 percent or 55 percent, Figure 6.

Figure 7 shows a comparison of the procedure for loss assignment using a uniform linear distribution and uniform linear loss over sub-reaches.

Uniform Linear Loss without Gain Allowance

A third alternative procedure for loss assignment is to assign losses to transferred water over sub-reaches where loss occurs but not allow any credit for natural gain to the transferred water. This procedure is based on the premise that the natural gain is not affected by the additional water in the stream or at least is not affected significantly. Using this procedure could result in estimated losses over long reaches of greater than 100 percent and is not recommended. Losses in tributaries can be developed using similar procedures. The 1992 loss measurements included only the reach of Wet Creek from the Dry Creek Hydro inflow to the County Road bridge above the mouth which exhibited a loss of 17.25 percent. Historical measurements indicate losses on Wet Creek from either the confluence of the old Dry Creek flume or from Corral Creek at 17 to 24 percent. A reasonable loss value for the reach from the Dry Creek Hydro to the mouth of Wet Creek is 20 percent.

CONCLUSIONS

The hydrogeology of the Little Lost River is complex and results in river-aquifer exchanges which make definition of stream losses or gains difficult. Historical measurements of losses have concentrated on the Dry Creek-Wet Creek segment and on the Little Lost River from the Wet Creek confluence down to the Blaine Canal Diversion. Water diversions transferred downstream should share in the natural losses experienced over the length of the transfer and new diversions decreased appropriately. Operating losses cannot be adequately defined by location or seasonally without a planned program of water measurement specifically designed to define the losses by river reach. Any procedure for allocation of transfer losses should be based on a consistent water measurement program and the losses updated as new measurements become available. The procedure should be usable by the water master without extensive mathematics and applicable to all transfers. Stream losses and gains calculated from the series of water measurements made on October 27, 1992 are reasonable estimates of current losses and gains for the reaches measured. Comparisons of the 1992 measured losses with historical losses are reasonable except for measurements made in the early 1920's.

RECOMMENDATIONS

1. A water measurement program on the Little Lost River and tributaries designed to define losses on the main river and pertinent tributaries should be initiated. Consideration should be given to defining seasonal and climatic variations in loss rates.

2. Consideration should be given to re-activating the USGS gage above the Blaine Canal diversion to provide another real-time measurement of river flow at two points for assistance in water distribution and regulation and to provide data for loss determinations.
3. A program for annual maintenance and evaluation of water measurement devices on all diversions and tributary inflows where possible should be implemented. Currently some diversion structures and measuring devices are in need of repair or cleaning and are likely not providing accurate measurements of diverted water. Provisions for measuring devices on major tributaries would provide additional data for continuing loss measurements.
4. A procedure to assign losses to downstream water transfers should be adopted and implemented with the 1993 irrigation season. In light of the large variation in losses and gains in the Little Lost River and the difficulty in defining the beginning and end of specific gaining or losing reaches, the recommended procedure is to use a uniform linear estimate of the percent loss. This procedure can be based on the 1992 measured loss rates for initial values and can be structured for any initial starting point. The losses used in the estimates should be updated based on the water measurement program.
5. Consideration should be given to providing real or near real-time notification to the water master of the operations of exchange wells so that timely allocation of river flows based on priorities can be made.

TABLE 1 LITTLE LOST RIVER REACH GAIN ANALYSIS

DISCHARGE MEASURED OCTOBER 27, 1992 C.E. BROCKWAY P.E. AND C.W. ROBISON P.E.
ALL KNOWN MEASUREABLE INFLOW AND DIVERSIONS ACCOUNTED FOR

RIVER MILE STATIONS OF WATER MEASUREMENT SITES

DATA OBTAINED BY DISTANCE WHEEL ON USGS QUAD SHEETS

SCALE 1 INCH= 2000 FT

SITE	DIST	DISCH	REACH LOSS(-) GAIN(+)	TOTAL REACH INFLOW	TOTAL REACH OUTFLOW	GAIN(+) LOSS(-) %	LOSS OR GAIN/MI cfs	DESCRIPTION
	Miles	cfs	cfs	cfs	cfs			
28	0.00	11.51						BOB MAYS DIV. NO FLOW PAST THIS DIVERSION
27	0.57	3.60	-13.28	49.27	35.99	-26.95%	-4.57	LEO AND ISHAM DIVERSION
26	2.66	20.88						HARTMAN DIVERSION STRUCTURES
25	2.91	49.27						LITTLE LOST RIVER ABOVE HARTMAN DIV.
24	3.98	3.46						HAWLEY/NORRIS EAST DIVERSION
23	3.98	4.58	-2.92	61.44	58.52	-4.76%	-0.48	HAWLEY/NORRIS WEST DIVERSION
22	6.70	5.34						THREE WELLS INFLOW
21	7.83	1.21						BLAINE DIVERSION
20	8.98	56.10						LITTLE LOST RIVER AT USCE STRUCTURE
19	9.32	5.22	18.31	37.79	56.10	48.45%	4.69	SPRING INFLOW
18	12.88	32.57						LITTLE LOST RIVER BELOW BIG SPRING CREEK
17	12.92	17.37	-43.17	75.74	32.57	-57.00%	-3.74	BIG SPRING CREEK INFLOW AT CONFLUENCE
16	24.41	58.37						LITTLE LOST BELOW DEER AND BADGER CREEK
15	24.43	0.17	9.13	49.24	58.37	18.54%	1.56	DEER CREEK INFLOW
14	24.45	2.76						BADGER CREEK INFLOW
10	30.28	46.31						LITTLE LOST RIVER AT USGS GAGE
13	30.44	17.74						WET CREEK INFLOW

LOSSES.XLS

9A	31.99	1.42	-0.77	48.50	47.73	-1.59%	-0.16	DAVE ANDREASON DIVERSION SPRING INFLOW(BLACK CREEK) SUMMIT CREEK INFLOW
9	33.30	9.93						
8	35.13	6.15						
7	35.15	14.68						LITTLE LOST RIVER ABOVE SUMMIT CREEK SPRING INFLOW PANCHERI HYDRO INFLOW
6	35.42	3.61	-2.53	17.21	14.68	-14.70%	-1.59	
5	36.16	1.33						
3	36.74	12.27						LITTLE LOST RIVER @SHEARING CORRALS WARM CREEK INFLOW LITTLE LOST AT SAWMILL CANYON ROAD
2	44.15	5.88	-8.38	20.65	12.27	-40.58%	-1.08	
1	44.47	14.77						
WET CREEK								
13	0.00	17.74						CONFLUENCE WITH LITTLE LOST RICK PANCHERI DIVERSION WET CREEK BELOW HYDRO
	0.84	0.42	-3.78	21.94	18.16	-17.25%	-1.45	
12	2.61	21.94						
11	2.62	10.85						HYDRO PLANT INFLOW
SUMMIT CREEK								
7	0.00	14.68						CONFLUENCE WITH LITTLE LOST J ANDREASON DIVERSION(LEAK) SUMMIT CREEK
	1.63	0.00	5.37	9.31	14.68	57.68%	3.08	
4	1.74	9.31						

LITTLE LOST RIVER UNMEASURED GAIN/LOSS OCTOBER 27, 1992

Observation
Subbasin area for
flow data were
Little Lost River
Subbasin bound
Divide between upper
lower parts of the
Approximate contact
bedrock and alluvium
Location of long-term
Approximately
(see fig. 1)

**GAIN +
LOSS -
CFS**

**TOTAL
UNMEASURED NET
LOSS IN 44.5 MILES
43.61 CFS**

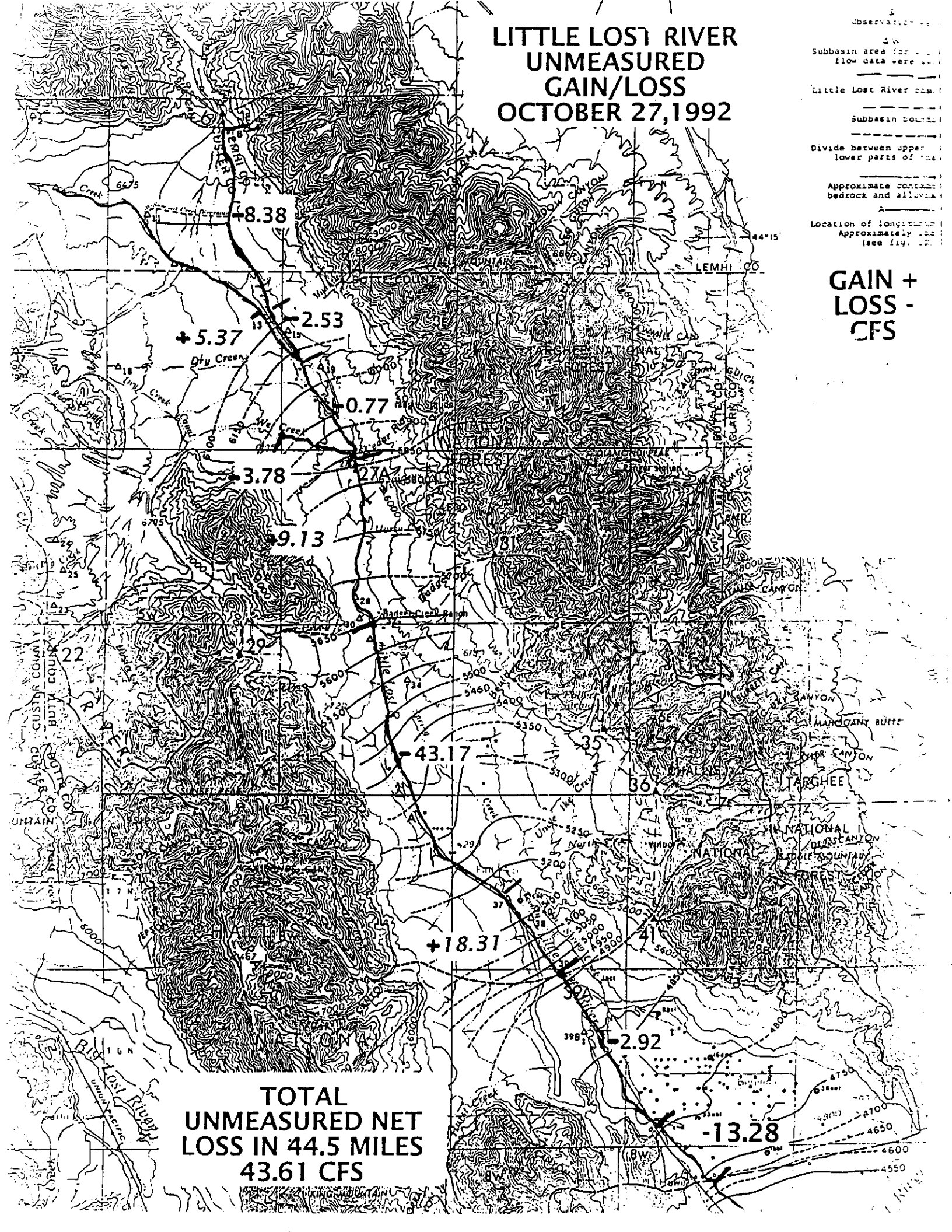


FIGURE 2

Little Lost River
Reach Gain Per Mile

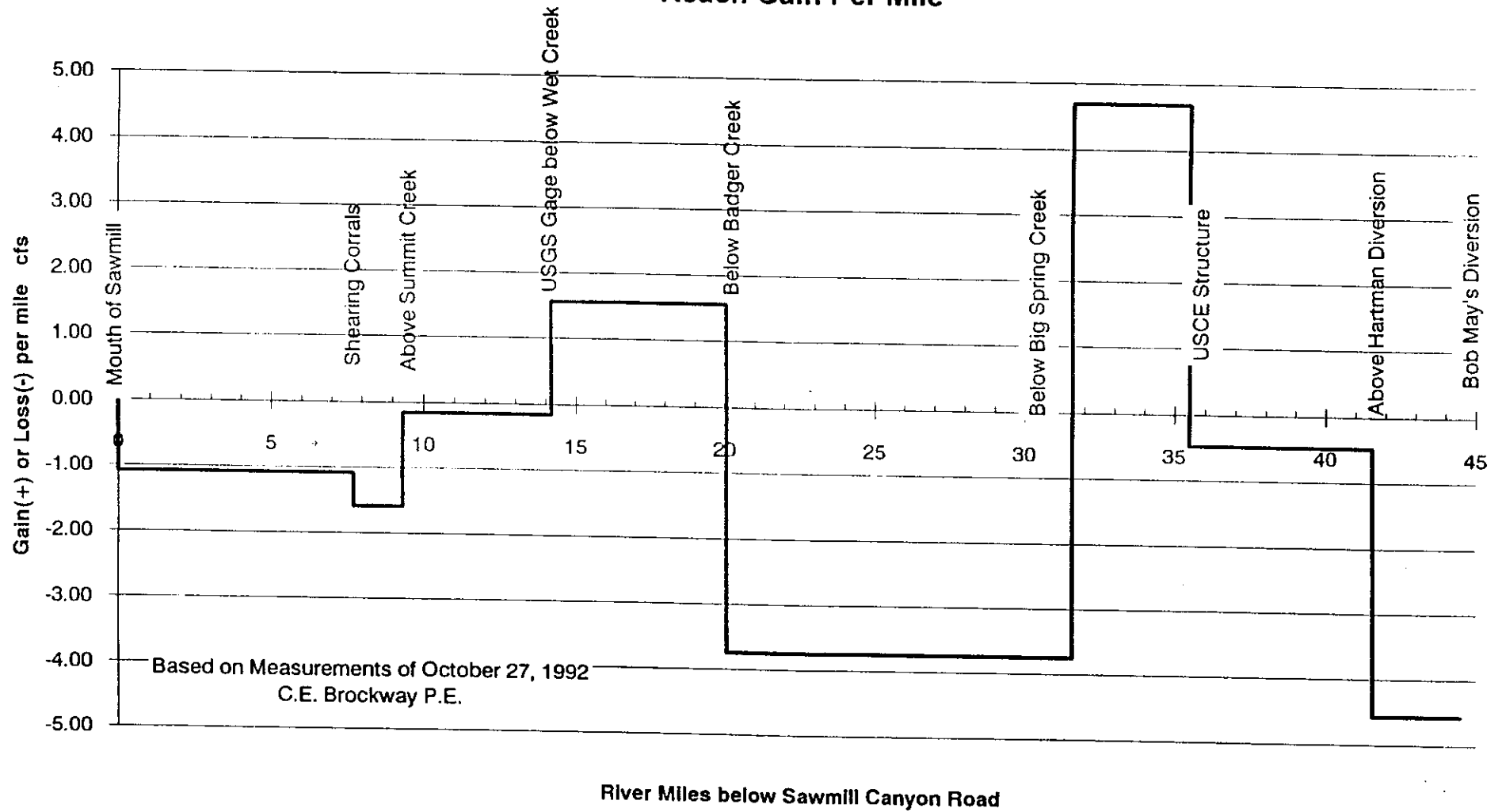


FIGURE 3
Little Lost River
Percent Reach Gain/Loss by Sub-reach

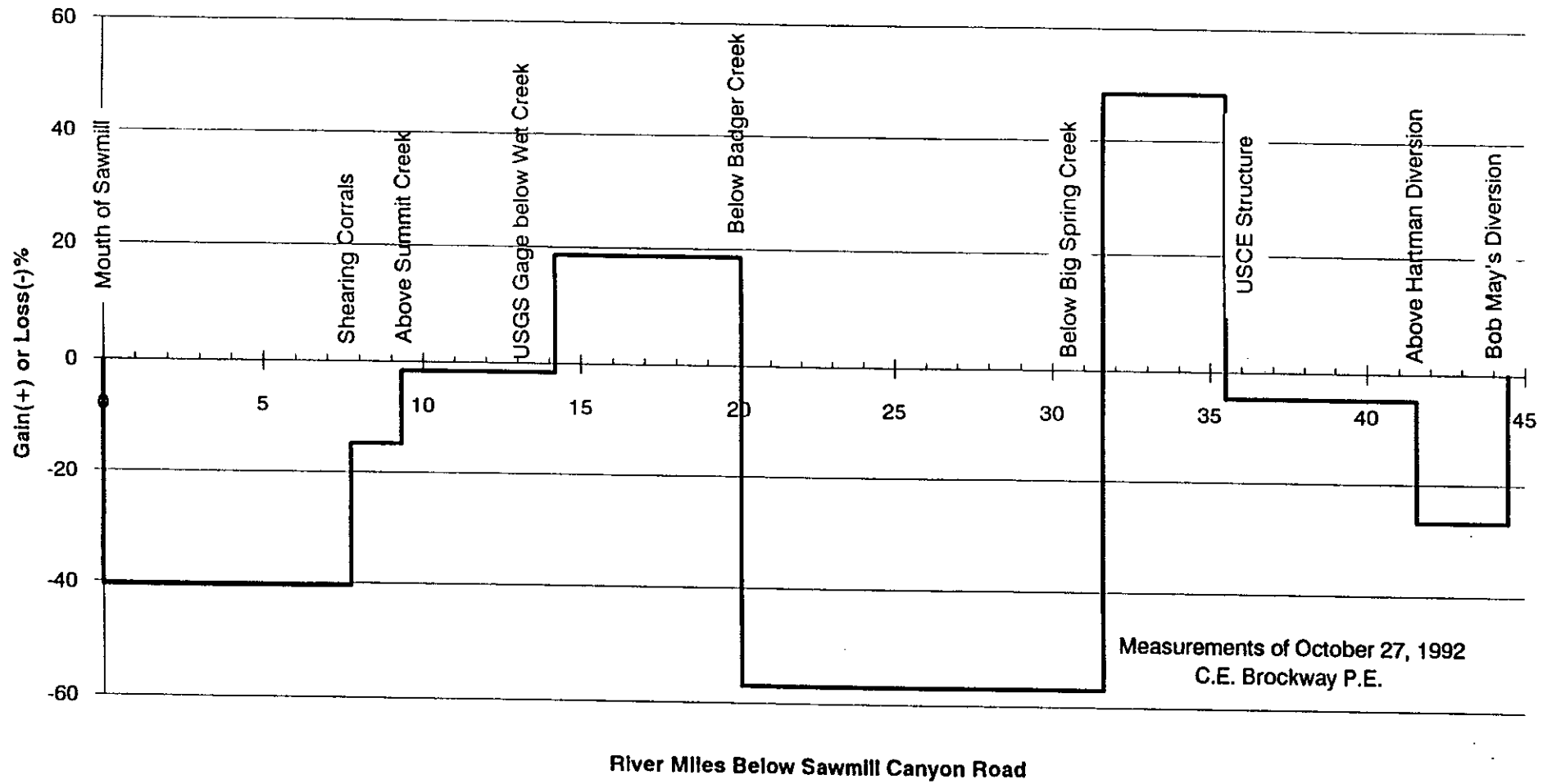
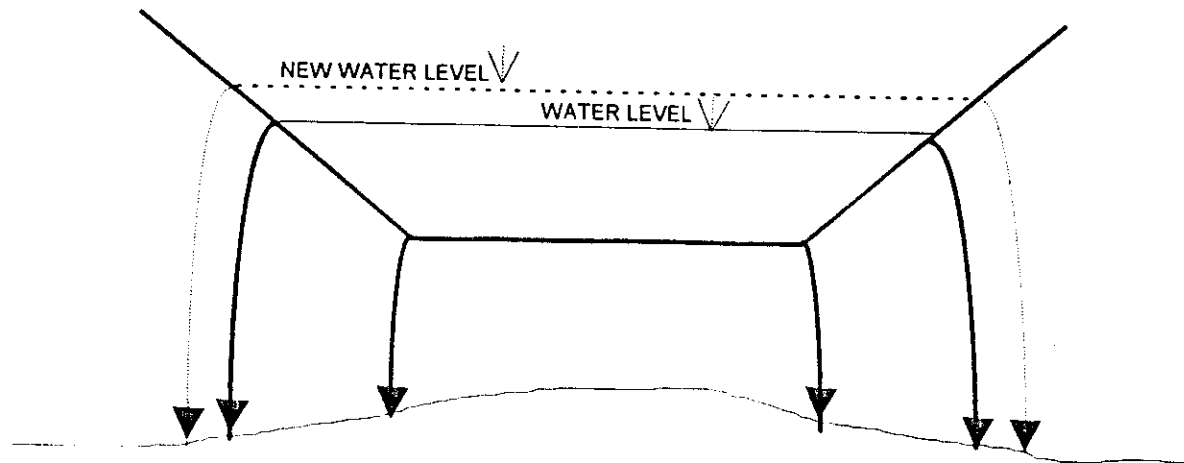
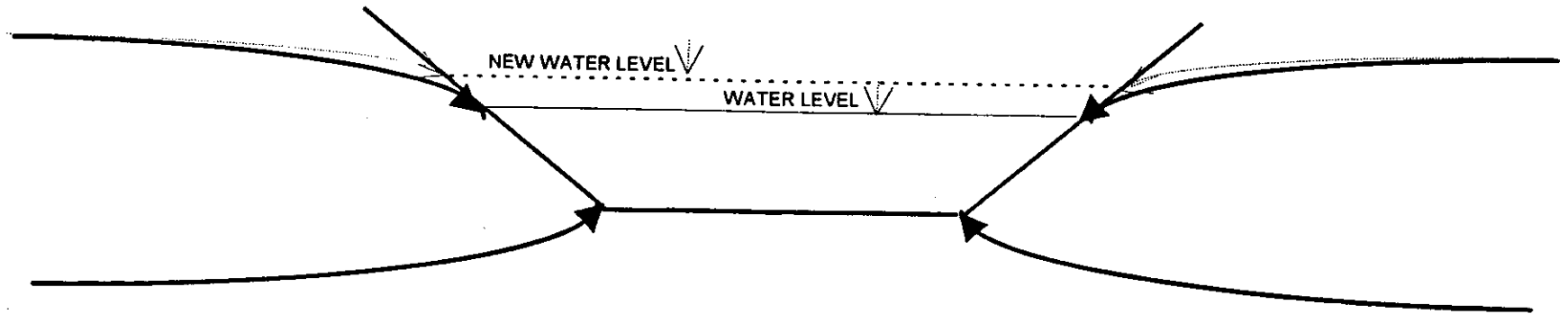


FIGURE 4
SEEPAGE FROM OPEN CHANNELS
LOSING REACH TO GROUND-WATER



ASSUME UNIFORM MEDIA
INCREASED WATER LEVEL CAUSES INCREASED WETTED AREA PLUS INCREASED PRESSURE ON CHANNEL BOTTOM
CAUSING INCREASED SEEPAGE

FIGURE 5
SEEPAGE FROM OPEN CHANNELS
GAINING STREAM FROM GROUND-WATER



ASSUME UNIFORM MEDIA
INCREASED WATER LEVEL CAUSES DECREASED INFLOW INTO STREAM
BY DECREASING GRADIENT TOWARD STREAM

FIGURE 6
Little Lost River
Uniform Linear Loss

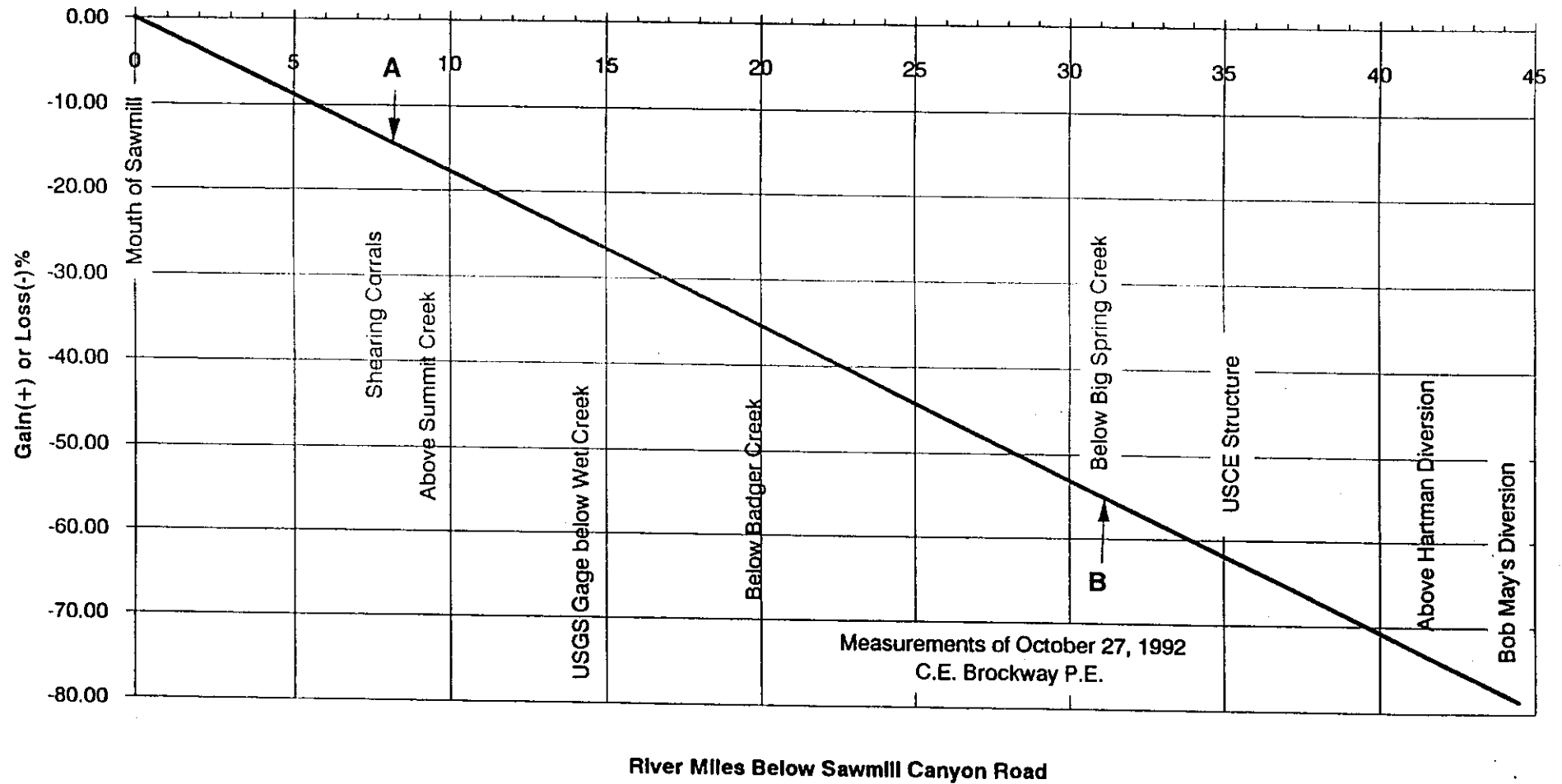


FIGURE 7
Little Lost River
Cumulative Percent Loss

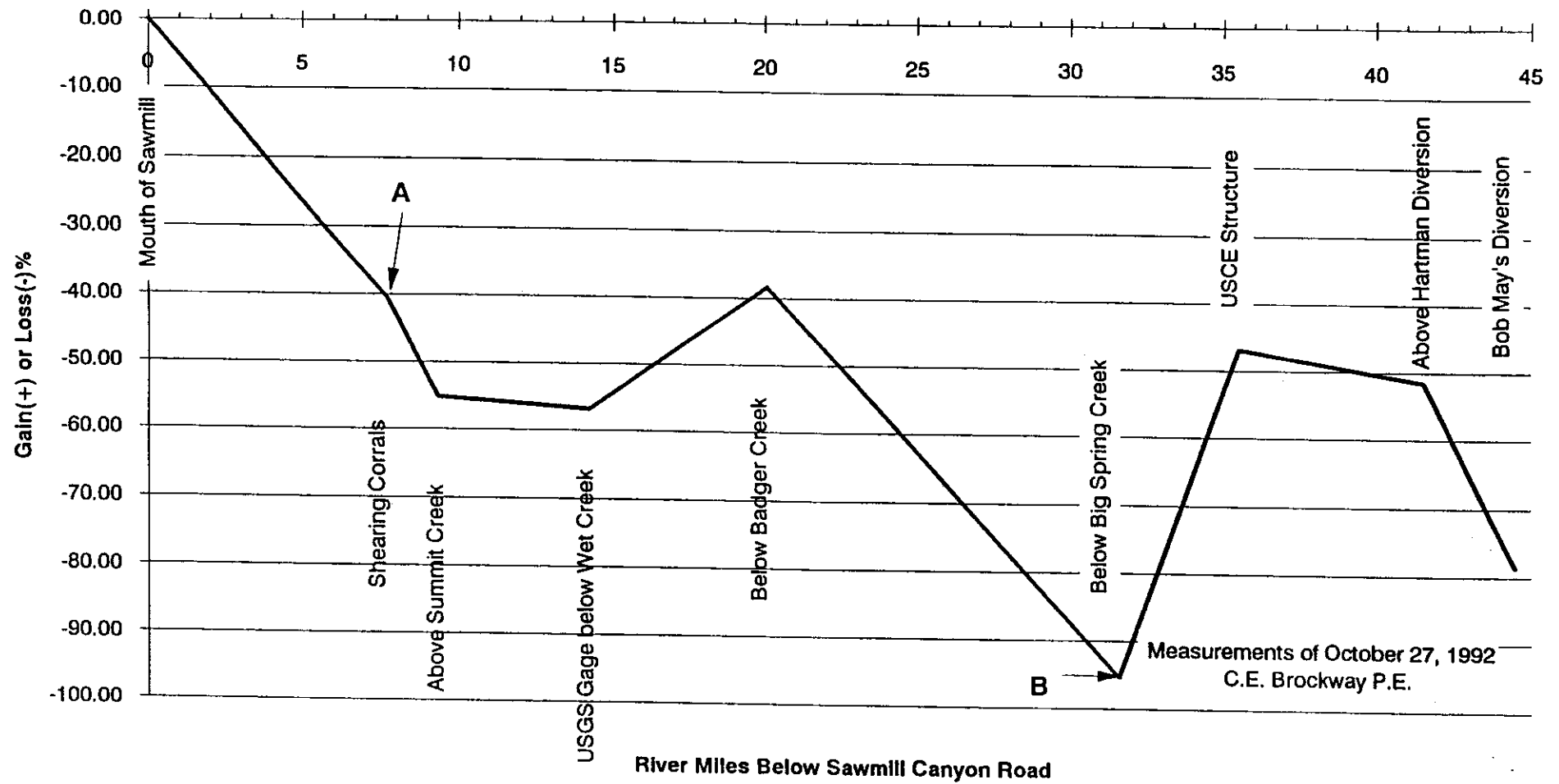
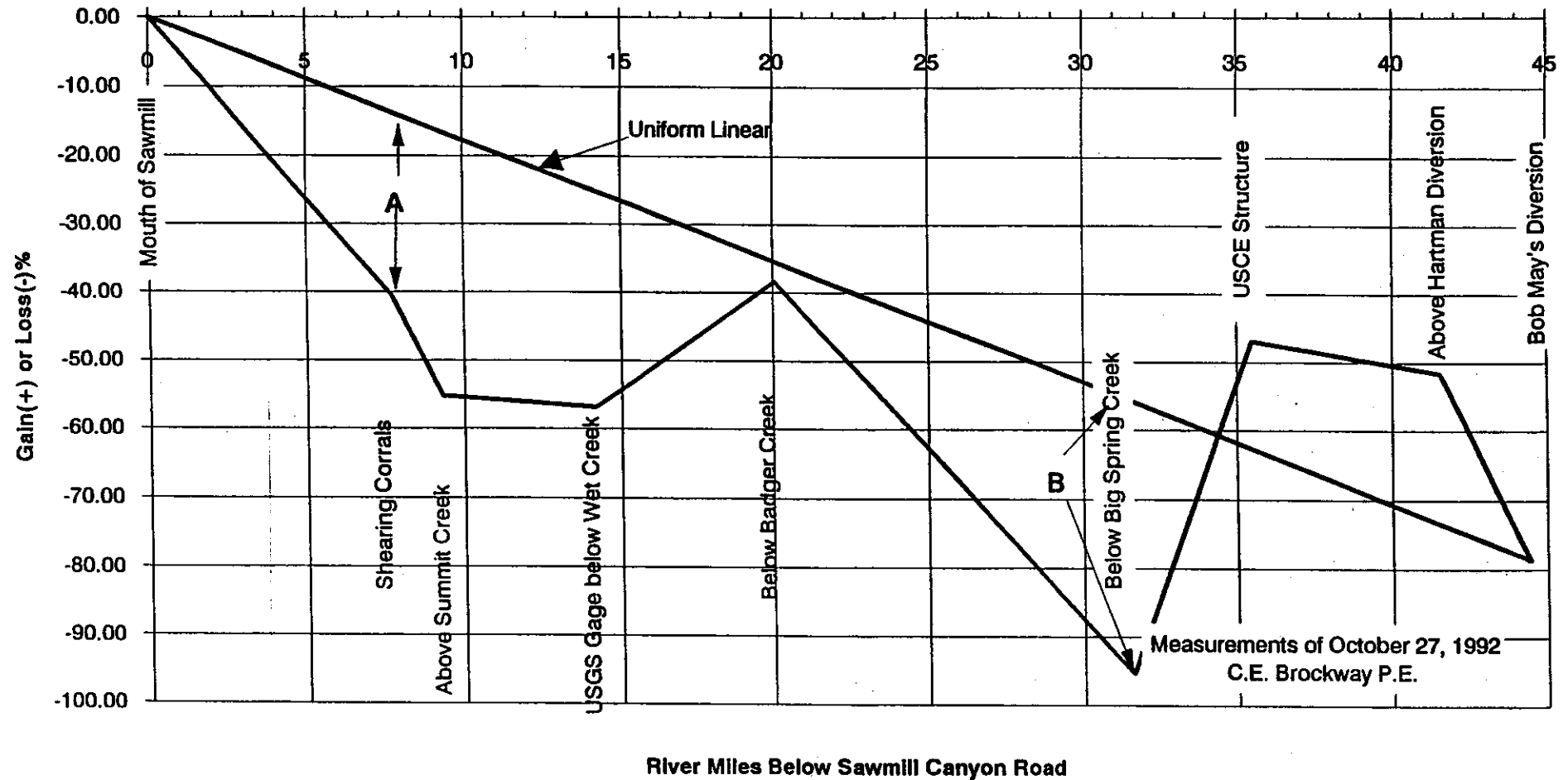
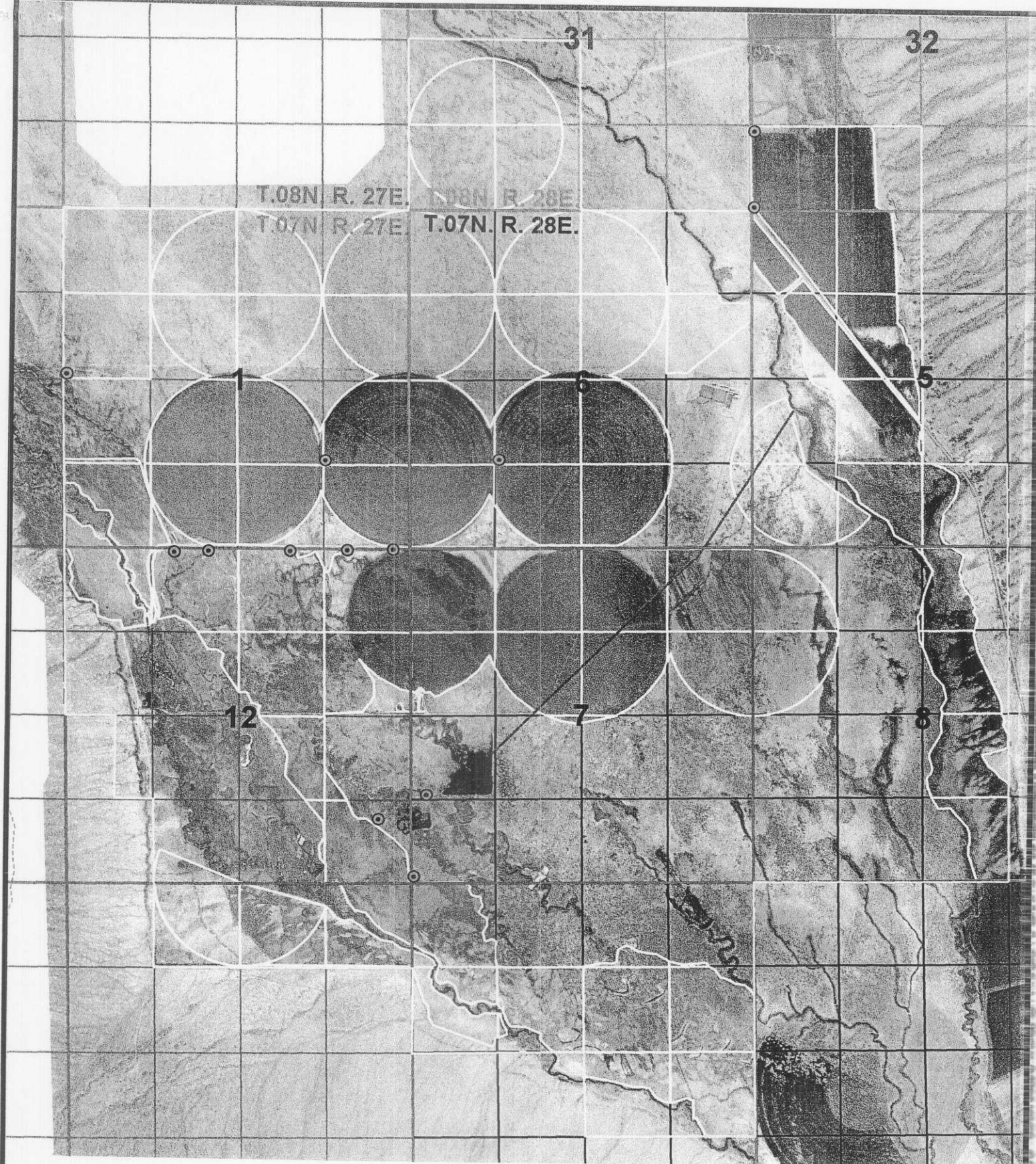


FIGURE 8
Little Lost River
Comparison of Cumulative and Uniform Linear Percent Loss



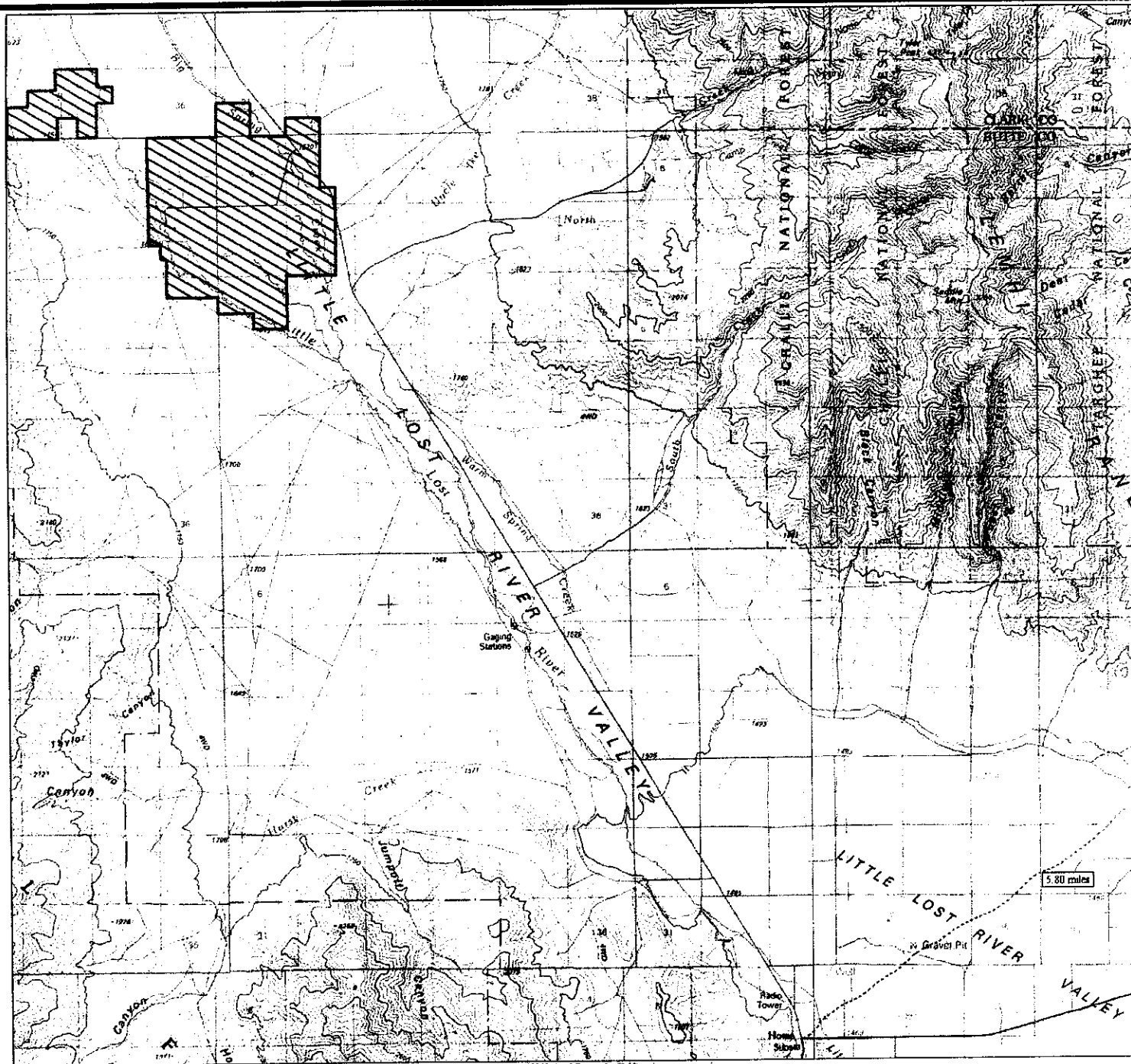


**SAGEWILLOW INC. - DUMKE
POTENTIAL IRRIGATION AREAS
AERO-GRAPHICS PHOTO 8/2003**

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- Wells.shp
- Property bndry.shp
- Sections.shp
- ▤ Pipeline.shp
- ▨ Irrigated area.shp
- ▧ Ditches.shp
- ▩ 8n27e.shp
- 7n28e.shp
- 7n27e.shp
- ▬ 40s8n28e.shp





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