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FINAL

SHELL VALLEY WATERSHED LEVEL II STUDY

Prepared for :

WYOMING WATER DEVELOPMENT COMMISSION
HERSCHLER BUILDING ——— CHEYENNE

Prepared by :

HKM ASSOCIATES
ENGINEERS·PLANNERS

JANUARY 1985

0M183.105

SHELL VALLEY WATERSHED
LEVEL II STUDY

Prepared For:

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I GENERAL INFORMATION

CHAPTER I
GENERAL INFORMATION

STUDY OBJECTIVE

Several previous studies have identified a need for additional water for late season irrigation in certain areas of the Shell Valley. These areas include the tributary drainages, the lower end of the Shell Canal and some private diversions on the lower end of Shell Creek (see Figure I.1, General Location Map). Enlargement of Lake Adelaide Dam has evolved as a likely means of providing additional late season water. Timing of the rehabilitation is also important as Lake Adelaide Dam has been identified as needing rehabilitation to meet current dam safety standards.[1/]

On June 27, 1984, HKM Associates entered into a contract with the Wyoming Water Development Commission to conduct the following studies:

1. Geotechnical investigation of Lake Adelaide Dam and potential enlargement.

2. A hydrologic and water rights study of the Shell Valley Watershed.

3. An engineering study of the proposed rehabilitation and associated costs.

4. A study of the financial and economic feasibility of the proposed project.

These studies have been completed and the results are presented in this report.

1/ Phase I Inspection Report, Adelaide Reservoir, Corps of Engineers, 1979.

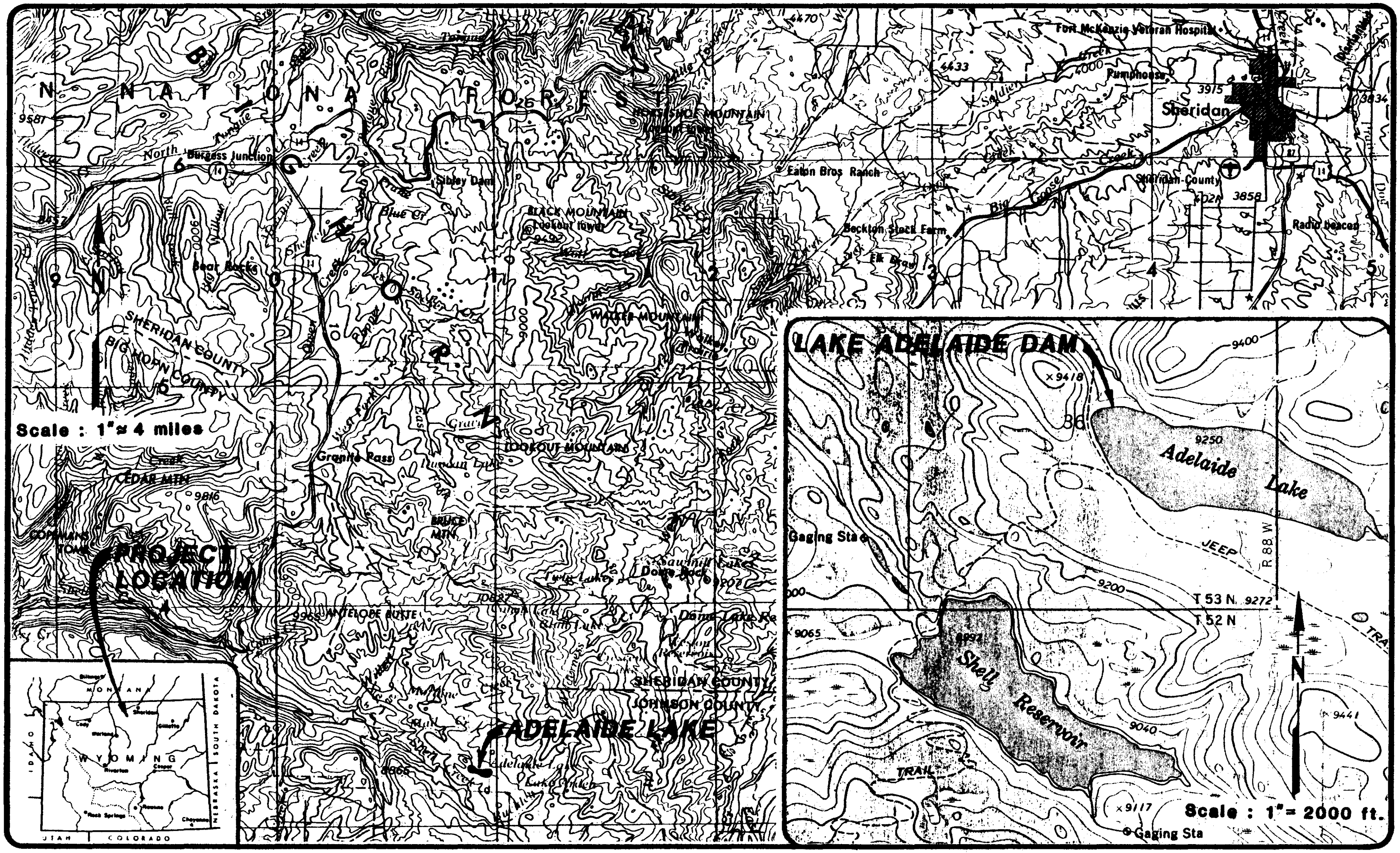
Watershed Description

The Shell Valley Watershed contains over 370,000 acres with Shell Creek as the major drainage. The majority of water available to this drainage originates in the higher elevations of the Big Horn Mountains. Elevations range from 11,000 feet m.s.l. to 3,900 feet m.s.l. within the watershed. There exists a stark contrast between the higher mountain environment and the semi-arid desert environment on the valley floor. Irrigation is necessary to cultivate crops and use of water for this purpose is of prime importance to the community.

The entire watershed is located within Big Horn County, Wyoming. The area is serviced by the Town of Greybull (population of 2000 +) and the community of Shell (population of 50). Several good "farm-to-market" roads traverse the irrigated area and U.S. Highway 14 is a major east-west arterial route. Billings, Montana and Casper, Wyoming are larger service centers for the area.

Climate

The upper basin is mountainous and provides a barrier to movement of moisture laden air from the Pacific Ocean or the Gulf of Mexico, depending upon the type of storm. Mean annual precipitation near the continental divide is in the range of 32 to 36 inches; most of which is snowfall. Intense rainfall is possible as exemplified by the large probable maximum rainfall amounts developed later. Summertime temperatures are much cooler than the basin below as elevations are higher. A mean maximum temperature in July ranges from 70° to 75° F. Wintertime temperatures, although cooler, are not significantly different from the basin below.



LAKE ADELAIDE DAM

GENERAL LOCATION MAP

10M183.105

NOVEMBER 1984

FIGURE I.1

HKM ASSOCIATES

ENGINEERS — PLANNERS

The lower basin can be described as hot and dry in the summer. Temperatures are usually lower and rainfall higher at Shell and further up into the Shell Canyon. However, most of the irrigated land is represented by the basin (Greybull) weather station. Mean annual precipitation at Greybull is in the range of 6 to 8 inches. The majority of the precipitation occurs in April, May and June. Summer temperatures are hot in the valley near the Big Horn River; hotter than most other locations in Wyoming. Temperatures as high as 115° F have been recorded. The mean maximum temperature in July is in the 90° to 95° F range. The hot weather and long periods of sunshine are excellent for growing crops. Weather events, such as high winds and hailstorms, are an unusual occurrence. Irrigation is a must in this semi-arid climate to produce crops.

Additional details on temperature, precipitation, effective precipitation and growing season can be found in the tables summarizing consumptive use and net irrigation requirements. These tables can be found in Chapter IV, Water.

II SHELL VALLEY WATERSHED IMPROVEMENT DISTRICT

CHAPTER II

SHELL VALLEY WATERSHED IMPROVEMENT DISTRICT

HISTORY

The Shell Valley Watershed Improvement District (SVWID) evolved out of years of discussion and interest in further developing water resources in this valley. The SVWID was formed in 1981 as a subdivision of Wyoming State Government. The primary impetus to form the District was the possibility of drilling deep artesian wells to augment irrigation water supplies. The SVWID is governed by a five man board of directors, each with 3 year terms. The District has the right of eminent domain and has taxing authority. The SVWID can contract with federal or state entities for project repayment.

One of the primary purposes of the SVWID was to bring together all of the various private and company organizations into one group. Memorandums of understanding have been drafted with the affected parties within the boundaries of the SVWID to this effect. The SVWID is subservient to and works with the South Big Horn County Conservation District. The District has the flexibility to levy unequal per acre or acre-foot assessments if necessary. If certain areas do not benefit from a project, these areas may be excluded from taxation. Assessment areas and rate schedules are set by a Board of Appraisers and taxation must be approved by vote of members within the District. The SVWID provides a flexible vehicle for the contractual relationships necessary to finance water projects and brings together numerous entities into one planning unit.

The SVWID has made one assessment of $0.60 per acre to date. The physical assets and income are minimal at this point until a project is realized. Therefore balance sheets, statements of income, expenditures and audit reports are not presented.

III LANDS

CHAPTER III
LANDS

LAND USE AND OWNERSHIP

Approximately 370,000 acres lie within the Shell Valley Watershed. Of this area, approximately 11,000 acres or 3 percent are irrigated. Of the remaining acreage, approximately 75% is native rangeland existing in a semi-arid environment and the remaining 25% is forested land with much higher precipitation. Most of the watershed is held in Public Ownership, with less than 15 percent privately held.

Concerning the irrigated land base, a field verification and aerial photography were used to update the tabulations. Nearly 18,000 acres are covered by water rights in the watershed. In 1984, 10,100 acres were irrigated with approximately 660 acres idle but with facilities in place to receive water. Table III.1 summarizes irrigated acres by drainage.

As expected, nearly 75% (7,784 acres) of the irrigated land depends upon Shell Creek for a water supply. The Shell Canal (McDonald Ditch) is the largest diverter, serving an area of approximately 4000 acres. The following cropping pattern was used in the agricultural, economic and consumptive use studies:

Table III.2
Cropping Pattern - Shell Valley

Crop	Acres	Percent
Alfalfa/Pasture	3,477	32.3%
Malt Barley	4,307	40.0%
Sugar Beets	310	2.9%
Corn	2,670	24.8%
TOTAL IRRIGATED	10,764	100.0%
Farmstead/Wasteage	360	

Table III.1

SUMMARY OF IRRIGATED LANDS BY DRAINAGE

DITCH NAME	Total Water Rights	Irrigated Lands			Idle Lands			Total Irr & Idle Acres
		w/water Rights	no/water Rights	Total Irr.	w/water	no/water Rights	Total Idle	
Shell Creek	11,766.07	6,151	1,014	7,165	503	112	615	7,780
Beaver Creek	3,758.48	1,473	368	1,841	11	2	13	1,854
Horse Creek	896.6	436	67	503	0	0	0	503
Trapper Creek	815.24	394	130	524	25	5	30	554
White Creek	227.0	73	0	73	0	0	0	73
Granite Creek (All Domestic = 0.2623 cfs)								
TOTAL	17,463.39	8,327	1,579	10,106	539	119	658	10,764

Service Area

The service area will consist of those irrigated lands within the Shell Valley Watershed Improvement District The acreage of lands that can benefit from an increased water supply is estimated to be 8,000 acres. The service area is generally depicted in Figure III.1. Details of irrigated lands are plotted on U.S.G.S. 7-1/2 minute quadrangle maps found in Appendix D.

Land Capability

A soil survey has been completed by the Soil Conservation Service (SCS) for the Shell Valley irrigated areas, but this survey is not published. The soil series mapping was reviewed for most of the project area in the Greybull SCS Office. This information was used to estimate peak use on-farm irrigation efficiencies and to gain an overview of the suitability of the lands for irrigation.

Many of the valley bottom areas have been in production for nearly 100 years, demonstrating an ability to sustain continued irrigation. Irrigated land capability subclasses in the Shell Creek bottomlands are commonly mapped as IIe, IIw, IIIe, and IIIw with small areas showing drainage and salinity problems. In general, these soils are deep, medium to moderate loam texture with adequate drainage. Slopes are generally less than 1% and the fields have been improved for gravity irrigation.

Soils are similar in the tributary drainages but generally steeper. Slopes of 3% to 5% are not uncommon. These steeper slopes will tend to reduce on-farm irrigation efficiencies.

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Project No. 10M183.105 I.D. No. ______ Date NOV, 1984 Designed ___ Drawn ___ Checked ___ Approved ___

No.	Revision	By	Date

Project Title: SHELL VALLEY WATERSHED LEVEL II STUDY

Sheet Title: SHELL VALLEY WATERSHED IMPROVEMENT DISTRICT

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Sheet No.
FIGURE III-1
of ______

The area served by the McDonald Ditch/Shell Canal can be separated into four areas. The first area is that served by the McDonald Ditch and the upper portion of the Shell Canal. This area reaches from the diversion point to the Shell Canal tunnel and is generally north of U.S. Highway 14. These soils are primarily the Lotswells - Kinnear clay loam series with slopes less than 2%. These soils are quite productive and are similar to the bottomland soils near Shell Creek. The next area is known as "Poverty Flats" reaching from the Shell Canal tunnel to the lands near U.S. Highway 14 and the Garret Lateral. These soils are quite varied but are generally clay - clay loam in texture. Slopes often exceed 2% and the fields are not as improved as in the bottomland areas. These soils require a high degree of management to be productive.

The third area is the lower benches and lands north of U.S. Highway 14. The soils are typically a Lotswell clay loam. Slopes are variable but many of the fields have been improved or converted to sprinkler irrigation. These soils are productive under irrigation.

The fourth area includes the Greybull Heights and small isolated tracts upstream. These soils are either clay loam or sandy loam depending upon their origin. Slopes are commonly greater than 4% and the area is subdivided into small tracts leading to low on-farm water use efficiencies. Some of the tracts are irrigated by sprinkler irrigation, which should improve efficiencies if sets are changed regularly. This area primarily serves as pasture for horses and livestock.

In summary, the irrigated area within the Shell Valley is productive. Most of the land will produce average to above average yields given the management level described in Chapter VII, Project Evaluation.

Land Ownership

There exists four types of enterprises in Shell Valley. There are those operators whose primary interest is intensive farming (i.e. sugar beets) and cattle feeding. There are operators who use the irrigated farm land to support a cattle enterprise, i.e. hay and grain for wintertime feeding. There exists many operators who own small farms, 10 to 50 acres in size, and supplement their income with off-farm employment. The fourth category includes operators who own tracts or lots less than 10 acres in size and hold a full-time job elsewhere for family support.

Most of the irrigated acreage (85% to 90%) is controlled by larger operators. Acreage in the 10 to 50 acre size includes 10% to 12% of the area irrigated. Small tracts and lots occupy less than 2% of the land area.

Analysis of numbers of operators indicates that families are divided equally between the three acreage sizes. One-third of the families receive irrigation water for tracts less than 10 acres in size, one-third for the 10 to 50 acres sizes and one-third of the families have holdings larger than 50 acres.

The proceeding analysis is a factor in determining an equitable financial repayment of work completed on the irrigation systems. The USBR "small loans" program is considered a guideline. Operators who hold lands in excess of 960 acres are not allowed to share in low or zero interest subsidies. HKM Associates did not identify any operator who would fall into this category. Those landholders and parcels less than 10 acres in size are normally considered Municipal and Industrial (M&I) users. M&I users are typically required to repay any loan obligation with interest. Repayment is based on the least cost of alternative water supplies rather than "ability to pay" or payment capacity. It is not uncommon for small users to be assessed on a lump sum basis rather than on an acreage, shares or water delivery basis. Individual record keeping costs tend to be similar whether the user is small or large. Considerably more turnouts must be provided and maintained for small users. Small users impose a heavy peak load requirement on the canal as use is based on convenience rather than a 24 hour per day delivery. For these reasons, it is recommended that small users be assessed a lump sum amount. This amount is developed in the Project Evaluation Chapter.

IV WATER

CHAPTER IV
WATER

WATER REQUIREMENTS

Monthly farm delivery requirements and diversion requirements were developed using both records and calculated consumptive use requirements. Consumptive use and effective precipitation were calculated using the Blaney-Criddle Method, SCS TR-21 version, for the four major crops raised in watershed. Consumptive use values for phreatophytes were also developed. Detailed printouts of consumptive use can be referenced in the files. A typical printout for each crop can be found in Appendix G.

The following paragraphs, as paraphrased from TR-21, summarize the Blaney-Criddle Technique. This process has been computerized by HKM Associates for ease of calculations.

Early in the 1900's researchers found that the amount of water consumptively used by vegetation during their normal growing season was closely related to mean monthly temperatures and daylight hours. Mr. Harry Blaney and Mr. Wayne Criddle developed equations that could be used to transpose the consumptive use data for a given area to other areas for which only climatological data are available. The net amount of irrigation water necessary to satisfy consumptive use is found by subtracting the effective precipitation from the consumptive water requirement.

Numerous climatic factors must be taken into consideration if the net consumptive use of water is to be determined accurately. Of the climatic factors, the effect of temperature, hours of sunshine available for plant growth and effective precipitation are the most important. Other influencing factors, not directly considered by the Blaney-Criddle equation, are:

1. Actual radiation energy received by the plant.

2. Relative humidity.

3. Wind speed.

4. Altitude.

5. Advection.

6. Soil Factors.

7. Plant Factors.

The general effect of varying seasonal radiation can be introduced by computing the length of sunshine during the growing season at various latitudes. As an example, the length of the daytime at the Equator varies little throughout the year, whereas at 50°N. latitude, the length of the day in summer is much longer than in winter. Thus, at equal temperatures, photosynthesis can take place for several hours longer each June day at the north latitude than at the Equator. Growth and water consumption vary with the opportunity for photosynthesis.

The Blaney/Criddle Formula

Disregarding many other influencing factors, consumptive use primarily varies with the temperature, length of day, and available moisture regardless of its source (precipitation, irrigation water, or natural ground water). Multiplying the mean monthly temperature (t) by the possible monthly percentage of daytime hours of the year (p) gives a monthly consumptive-use factor (f). It is assumed that crop consumptive use varies directly with this factor when an ample water supply is available. Expressed mathematically:

u	=	kf, where,
u	=	Monthly consumptive use of the plants in inches.
k	=	Empirical consumptive use coefficient for a month
f	=	Monthly consumptive use factor (product of mean monthly temperature and monthly percentage of daylight hours of the year).
f	=	t x p, where
t	=	Mean monthly air temperature in degrees Fahrenheit
p	=	Monthly percentage of daylight hours in the year. Values of (p) for latitudes 0 to 65 degrees north of the Equator can be found in Tables in TR-21.

And:

U	=	KF = sum of kf, where,
U	=	Consumptive use in inches for the growing season
K	=	Empirical consumptive use coefficient for the growing season. This coefficient varies with the different vegetation being considered.
F	=	Sum of the monthly consumptive use factors for the growing season (sum of the products of mean monthly temperature and monthly percentage of daylight hours of the year).

Note: Values of (t), (p), (f), and (k), can also be made to apply to shorter periods. However, we have found the formula to be most accurate on a seasonal basis.

Following are modifications made to the original formula by the SCS:

k	=	k_t x k_c, where,
k_t	=	A climatic coefficient which is related to the mean air temperature (t). Values of k_t for mean air temperatures from 36 to 100 degrees are shown in Table 4 in TR-21.
k_c	=	A coefficient reflecting the growth stage of the plants. Values are obtained from growth stage coefficient curves given in TR-21 or developed by HKM Associates.

The consumptive use factor (F) may be computed for areas for which monthly temperature records are available. Then, the total crop consumptive use (U) is obtained my multiplying (F) by the empirical consumptive use crop coefficient (K). This relationship allows the computation of seasonal consumptive use at any location for those plants for which values of (K) have been experimentally established or can be estimated.

Growing Season

In utilizing the Blaney-Criddle formula for computing seasonal requirements, the potential growing season for the various species is normally considered to extend from killing frost to killing frost or from the last killing frost in the spring to the end of a definite period of time thereafter. For most crops, this is adequate for seasonal use estimates, but a refinement is necessary to more precisely define the growing season when monthly or short-time use estimates are required. In many areas, records are available from which planting, harvesting and growth dates can be determined. These should be used where possible. In other areas, temperature data may be helpful for estimating these dates. Table IV.1 contains some guides which are helpful in determining these dates.

Since the spring frost date corresponds very nearly with a mean temperature of 55 degrees, it is obvious that many of the common plants use appreciable amounts of water prior to the last frost in the spring and may continue to use water after the first frost in the fall. If non-growing season precipitation is significant it may be necessary to analyze the consumptive use for the entire year. Non-growing season soil moisture gains can be used by the plant growth during the growing season. Since non-growing season precipitation is minimal in the Shell Valley area only the growing season was analyzed.

Table IV.1. A Guide for Determining Planting Dates, Maturity Dates and Lengths of Growing Seasons as Related to Mean Air Temperature

Crop	Earliest Moisture use or planting date as related to mean air temperature	Latest Moisture use or maturing date as related to mean air temperature	Growing Season days
<u>Perennial Crops</u>			
Alfalfa	50° mean temp	28° frost	Variable
Grasses, cool	45° mean temp	45° mean temp	Variable
<u>Annual Crops</u>			
Grain, spring	45° mean temp	32° frost	130 - Max.
Corn	55° mean temp	32° frost	140 - Max.
Sugar beets	28° frost	28° frost	180 - Max.

Source: SCS TR-21

NOTE: The phreatophytes and hydrophytes considered in this report are assumed to have a growing season similar to cool grasses.

Growth Stage Coefficients

As previously stated, another factor which causes consumptive use to vary widely throughout the growing season is the plant itself. Stage of growth is a primary variable that must be recognized since it is obvious that plants in the higher level of maturity will use water at a more rapid rate than will new seedlings. It is also obvious that these variations in consumptive use throughout the growing season will be greater for annual plants than for perennial plants such as alfalfa, permanent pasture grasses, deciduous trees, willows and others.

In order to recognize these variations in consumptive use, plant growth stage coefficients (k_c) have been introduced into the formula. Values of these coefficients are calculated from research data. When values of (k_c) are plotted against time or stage of growth curves, can be developed. Such curves are used to obtain values of (k_c) which, when used with appropriate values of (k_t), will permit a determination of values of monthly or short-time consumptive use coefficients (k).

It is also recognized that value of (k_c) might, to some extent, be influenced by factors other than the characteristics of the plant itself. For this reason, it is not expected that these curves can be used universally. They should, however, be valid over a considerable area and certainly should be of value in areas where no measured consumptive-use is available. However, coefficients developed and calibrated specifically for the area under consideration will give better results.

Net irrigation requirements for each month were calculated by subtracting effective precipitation from consumptive use for each of the four crops and phryeatophytes. See Table IV.2 for phryeatophyte net irrigation requirements. The net irrigation requirement for the four crops was then weighted according to the percentages shown in Table III.2 (Table IV.3). The farm delivery requirement was calculated for each ditch, canal, or tributary drainage by dividing the net irrigation requirement by an approximate on-farm efficiency. The peak use (July-August) on-farm efficiencies were estimated from analysis of predominate slopes, soil types and irrigation practices

TABLE IV.2

Monthly Net Irrigation Requirements For Phryeatophytes

MONTHLY NET IRRIGATION REQUIREMENTS

FILE -- WIRSUMPD
SITE -- SHELL
UNIT -- INCHES
NOTE -- ANY MONTH WITH ####.## INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.00	0.00	0.00	.49	3.50	2.86	11.42	8.48	1.79	.28	0.00	0.00	28.83
1942	0.00	0.00	0.00	1.09	2.21	6.45	11.71	9.13	3.46	.72	0.00	0.00	34.78
1943	0.00	0.00	0.00	1.27	2.48	5.39	11.19	9.33	4.14	1.51	0.00	0.00	35.38
1944	0.00	0.00	0.00	.25	2.73	4.73	9.22	8.47	3.20	1.44	0.00	0.00	30.06
1945	0.00	0.00	0.00	.13	2.24	3.93	11.02	8.11	2.72	1.49	0.00	0.00	29.65
1946	0.00	0.00	.04	2.22	2.42	6.89	12.96	8.62	2.85	.73	0.00	0.00	36.74
1947	0.00	0.00	0.00	.66	3.19	5.97	12.82	9.70	4.46	1.99	0.00	0.00	38.80
1948	0.00	0.00	0.00	1.16	4.01	6.98	10.10	8.88	4.19	1.17	0.00	0.00	36.51
1949	0.00	0.00	0.00	1.45	3.46	6.45	11.16	8.27	3.34	.29	0.00	0.00	34.44
1950	0.00	0.00	0.00	0.00	1.96	5.60	8.54	7.14	2.51	1.64	0.00	0.00	27.31
1951	0.00	0.00	0.00	.44	3.21	4.25	8.94	7.75	3.05	.54	0.00	0.00	28.20
1952	0.00	0.00	0.00	.90	2.84	7.72	9.59	8.57	4.79	1.37	0.00	0.00	35.80
1953	0.00	0.00	0.00	0.00	2.14	6.86	13.44	8.82	4.18	1.35	0.00	0.00	36.79
1954	0.00	0.00	0.00	.59	2.30	6.02	12.83	8.78	4.34	.91	0.00	0.00	35.79
1955	0.00	0.00	0.00	.64	2.68	4.81	10.64	10.16	3.22	1.42	0.00	0.00	33.58
1956	0.00	0.00	0.00	.58	3.56	8.65	10.83	7.35	4.31	1.32	0.00	0.00	36.61
1957	0.00	0.00	0.00	.46	2.54	5.30	12.45	9.10	3.37	.77	0.00	0.00	34.00
1958	0.00	0.00	0.00	.75	4.39	5.79	7.61	9.20	4.38	1.21	0.00	0.00	33.34
1959	0.00	0.00	0.00	.30	1.95	7.91	10.88	8.99	3.20	.51	0.00	0.00	33.75
1960	0.00	0.00	0.00	.98	3.63	7.05	12.97	7.74	3.60	.99	0.00	0.00	36.97
1961	0.00	0.00	0.00	.60	2.75	9.14	11.65	10.34	1.61	.13	0.00	0.00	36.24
1962	0.00	0.00	0.00	.92	2.24	6.56	9.14	7.16	3.83	1.71	0.00	0.00	31.57
1963	0.00	0.00	0.00	.23	3.06	5.55	11.34	9.94	4.29	1.94	0.00	0.00	36.97
1964	0.00	0.00	0.00	.52	2.66	4.17	13.15	5.32	3.76	1.03	0.00	0.00	30.63
1965	0.00	0.00	0.00	1.06	2.20	6.11	10.02	7.11	1.38	1.61	0.00	0.00	29.52
1966	0.00	0.00	0.00	.33	4.22	5.95	13.18	7.74	4.50	1.01	0.00	0.00	36.96
1967	0.00	0.00	0.00	.21	3.17	2.62	11.39	8.86	3.52	1.08	0.00	0.00	30.86
1968	0.00	0.00	0.00	.13	1.47	4.31	10.50	5.42	3.23	1.23	0.00	0.00	26.29
1969	0.00	0.00	0.00	1.34	3.64	2.65	11.63	10.58	4.86	.41	0.00	0.00	35.12
1970	0.00	0.00	0.00	.14	2.95	7.56	11.59	10.28	2.35	.31	0.00	0.00	35.20
1971	0.00	0.00	0.00	.74	2.29	7.86	10.21	10.85	3.08	.07	0.00	0.00	35.12
1972	0.00	0.00	0.00	.85	3.01	7.45	8.17	7.98	3.03	.56	0.00	0.00	31.06
1973	0.00	0.00	0.00	.14	3.58	5.90	9.32	9.14	2.27	2.56	.04	0.00	33.06
1974	0.00	0.00	.16	2.32	2.89	8.44	9.84	7.56	3.77	1.43	.04	0.00	36.46
1975	0.00	0.00	0.00	0.00	1.49	5.30	10.99	8.18	5.21	1.45	0.00	0.00	32.63
1976	0.00	0.00	0.00	.94	3.68	5.79	12.34	7.74	3.09	.72	0.00	0.00	34.82
1977	0.00	0.00	0.00	.90	3.42	8.83	11.55	6.43	3.39	1.05	0.00	0.00	35.64
1978	0.00	0.00	0.00	.34	2.34	6.33	9.39	6.99	2.52	.80	0.00	0.00	28.73
1979	0.00	0.00	0.00	.81	1.90	6.35	11.43	7.26	4.75	1.22	0.00	0.00	33.73
1980	0.00	0.00	0.00	1.06	1.74	6.29	10.33	6.34	2.93	.64	0.00	0.00	29.35
MEAN	0.00	0.00	.00	.70	2.80	6.07	10.96	8.35	3.46	1.06	.00	0.00	33.43
S.D.	0.00	0.00	.02	.53	.73	1.60	1.49	1.31	.91	.54	.00	0.00	3.20
COEF. VAR.	####.###	####.###	5.207	.766	.263	.264	.136	.157	.263	.514	4.414	####.###	.095
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	2.1%	8.4%	18.2%	32.8%	25.0%	10.4%	3.2%	0.0%	0.0%	

SUM OF MONTHLY MEANS 33.4

Table IV.3
Weighted Net Irrigation Requirements for Crops

WEIGHTED IRRIGATION REQUIREMENT

FILE -- 74WIR3A
SITE -- SHELL WY
UNIT -- INCHES
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE 11/21/84

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	.0	2.2	1.9	8.5	4.5	.7	0.0	0.0	0.0	18.0
1942	0.0	0.0	0.0	.1	1.5	5.0	7.7	4.6	1.2	0.0	0.0	0.0	20.3
1943	0.0	0.0	0.0	.4	1.7	3.9	7.0	4.5	1.7	.3	0.0	0.0	19.9
1944	0.0	0.0	0.0	.0	1.7	3.5	6.3	4.4	1.2	.1	0.0	0.0	17.6
1945	0.0	0.0	0.0	.0	.8	2.4	8.2	4.7	1.0	0.0	0.0	0.0	17.4
1946	0.0	0.0	.0	1.0	1.8	5.0	7.4	4.0	1.0	.1	0.0	0.0	20.6
1947	0.0	0.0	0.0	.1	2.1	4.5	9.0	4.9	1.7	.6	.0	0.0	23.1
1948	0.0	0.0	0.0	.3	3.0	5.4	6.5	4.3	1.7	.1	0.0	0.0	21.8
1949	0.0	0.0	0.0	.5	2.6	5.0	7.1	3.9	1.3	.0	0.0	0.0	20.7
1950	0.0	0.0	0.0	0.0	.5	3.6	6.2	4.4	1.0	0.0	0.0	0.0	15.9
1951	0.0	0.0	0.0	.0	1.8	3.0	6.5	4.3	.8	0.0	0.0	0.0	16.6
1952	0.0	0.0	0.0	.1	1.9	5.9	6.4	4.2	1.5	.1	0.0	0.0	20.5
1953	0.0	0.0	0.0	0.0	.7	4.5	10.4	5.6	1.6	.1	0.0	0.0	23.0
1954	0.0	0.0	0.0	.0	1.3	4.4	9.0	4.7	2.0	.1	0.0	0.0	21.7
1955	0.0	0.0	0.0	.0	1.5	3.4	7.4	5.5	1.0	0.0	0.0	0.0	19.1
1956	0.0	0.0	0.0	.0	2.3	6.4	8.1	4.0	1.7	.3	0.0	0.0	23.1
1957	0.0	0.0	0.0	.0	1.3	3.7	9.5	5.0	1.2	.1	0.0	0.0	21.1
1958	0.0	0.0	0.0	.1	2.9	4.2	5.4	4.9	1.9	.2	0.0	0.0	19.9
1959	0.0	0.0	0.0	.0	.9	5.5	8.1	5.2	1.3	0.0	0.0	0.0	21.2
1960	0.0	0.0	0.0	.1	2.5	5.2	9.2	4.0	1.6	.2	0.0	0.0	23.1
1961	0.0	0.0	0.0	.0	1.6	6.9	8.8	5.7	.5	0.0	0.0	0.0	23.7
1962	0.0	0.0	0.0	.0	1.4	5.0	6.2	3.1	1.0	0.0	0.0	0.0	17.0
1963	0.0	0.0	0.0	.0	1.8	3.9	8.7	5.5	2.0	.6	.0	0.0	22.7
1964	0.0	0.0	0.0	.0	1.5	2.8	9.7	2.3	1.5	0.0	0.0	0.0	18.0
1965	0.0	0.0	0.0	.1	1.3	4.6	6.9	3.1	.2	0.0	0.0	0.0	16.4
1966	0.0	0.0	0.0	.0	2.6	4.2	9.9	4.3	2.0	0.0	0.0	0.0	23.2
1967	0.0	0.0	0.0	0.0	1.6	1.4	8.2	5.0	1.6	.1	0.0	0.0	18.1
1968	0.0	0.0	0.0	.0	.4	2.6	7.9	2.8	1.2	.2	0.0	0.0	15.3
1969	0.0	0.0	0.0	.5	2.7	1.7	7.7	5.2	2.1	.1	0.0	0.0	20.3
1970	0.0	0.0	0.0	0.0	1.5	5.4	9.0	6.0	.5	0.0	0.0	0.0	22.7
1971	0.0	0.0	0.0	.0	1.4	6.1	7.4	5.5	.7	0.0	0.0	0.0	21.4
1972	0.0	0.0	0.0	.0	2.0	5.6	5.4	3.9	1.0	0.0	0.0	0.0	18.2
1973	0.0	0.0	0.0	.0	2.5	4.3	6.4	4.8	.7	.6	0.0	0.0	19.6
1974	0.0	0.0	.0	1.1	2.3	6.5	5.6	3.4	.6	0.0	0.0	0.0	19.8
1975	0.0	0.0	0.0	0.0	.3	3.3	8.2	5.4	2.3	.4	0.0	0.0	20.2
1976	0.0	0.0	0.0	.2	2.6	4.5	9.0	3.7	.8	.1	0.0	0.0	21.1
1977	0.0	0.0	0.0	.1	2.5	6.8	7.5	3.0	1.5	.4	.0	0.0	22.0
1978	0.0	0.0	0.0	0.0	1.3	4.8	6.2	3.4	.6	0.0	0.0	0.0	16.5
1979	0.0	0.0	0.0	.1	1.0	4.7	8.4	3.5	1.5	.1	0.0	0.0	19.5
1980	0.0	0.0	0.0	.2	1.0	4.7	6.9	3.0	1.1	.1	0.0	0.0	17.2
MEAN	0.0	0.0	.0	.1	1.7	4.4	7.7	4.4	1.3	.1	.0	0.0	19.9
S.D.	0.0	0.0	.0	.2	.7	1.3	1.2	.8	.5	.1	.0	0.0	2.3
COEF. VAR.	+###.###	+###.###	4.822	1.579	.400	.305	.166	.203	.390	1.240	5.723	+###.###	.117
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.8%	8.8%	22.3%	38.7%	22.1%	6.6%	.8%	0.0%	0.0%	

SUM OF MONTHLY MEANS 20.0

prevalent under that particular system. The Wyoming Irrigation Guide, discussions with SCS technicians and discussions with local farmers were also incorporated.

To calculate a peak diversion requirement, the losses in the canal or ditch and operational wastes must be added to the Farm Delivery Requirement. These losses are reflected in a conveyance efficiency which is defined as that percentage of water diverted which is available for delivery to the farms. Peak efficiencies were estimated from examination of soils, calculation by use of the USBR Moritiz formula and seepage measurements. Table IV.4 details the conveyance efficiencies used for this study.

Table IV.4
Peak On-Farm and Conveyance Efficiencies

Description	On-Farm Efficiency %	Conveyance Efficiency %	Project Efficiency %	Flexibility Factor
White Creek Drg.	40	70	28	1.20
Trapper Creek Drg.	40	70	28	0.80
Horse Creek Drg.	45	75	34	0.90
Upper Beaver Creek	35	75	26	0.90
Lower Beaver Creek	50	75	38	0.90
Fletcher Ditch	30	75	22	1.20
Kershner Ditch	35	65	23	1.20
Frieze Ditch	50	75	38	1.20
Whaley Ditch	60	70	40	0.90
Porter Ditch	60	70	42	0.90
Odessa Ditch	60	75	45	1.00
Red Bluff Canal	45	95	43	1.20
Denney Ditch	50	95	24	1.20
Linn Ditch	50	80	40	1.20

Table IV.4 (continued)

Description	On-Farm Efficiency %	Conveyance Efficiency %	Project Efficiency %	Flexibility Factor
Linn #2 Ditch	45	75	34	1.20
Shell Canal	55	65	35	0.90
McDonald Ditch	(60)	(80)	--	--
Poverty Flats	(45)	(90)	--	--
Garret Lateral	(50)	(95)	--	--
Greybull Heights	(35)	(95)	--	--

The flexibility factor is a value which accounts for how the water is used or diverted into the system as compared to diversions based on crop consumptive use and estimated efficiencies. If the area served by the system is small and the typical irrigators do not irrigate 24 hours per day, 7 days a week, the flexibility factor could exceed 1.00. This allows the irrigator to divert more water than predicted by equation to meet peak crop requirements. For example, if only one turnout was served and the irrigator applied water only one week out of a peak two week period, diversion rates would have to be twice that calculated by equation. The flexibility factor would be 2.00 in this case.

In a large system, with many turnouts, system capacity is seldom available for all irrigators to open their turnouts at the same time. Additionally, many irrigators do not replace all of the soil moisture consumed during the peak use period (usually two weeks to one month). This "mining" of soil moisture allows a flexibility factor of less than 1.00. A third factor is re-use of waste water from field to field which improves overall efficiencies. Commonly larger systems or projects exhibit a flexibility factor of less than 1.00, i.e., less water is diverted than the peak use calculations would indicate given reasonable on-farm and conveyance efficiencies. For this study flexibility factors were determined by comparing limited diversion records to calculated diversion requirements. It is possible in the case of the Shell Canal that diversion capacity does not exist to meet peak crop requirements even with "mining" of soil moisture. This is reflected in the low flexibility factor.

SURFACE WATER SUPPLY

General

The surface water supply within the Shell Watershed was studied to determine if additional water can be stored in Lake Adelaide. Monthly sequential streamflows were developed at these primary locations in Shell Creek Watershed: Shell Creek above Shell Creek Reservoir (USGS Gage No. 06278300), Shell Creek near Shell (USGS Gage No. 06278500) Shell Creek near Greybull (USGS Gage No. 06279090), and Adelaide Creek above Adelaide Reservoir (see Figure IV.1).

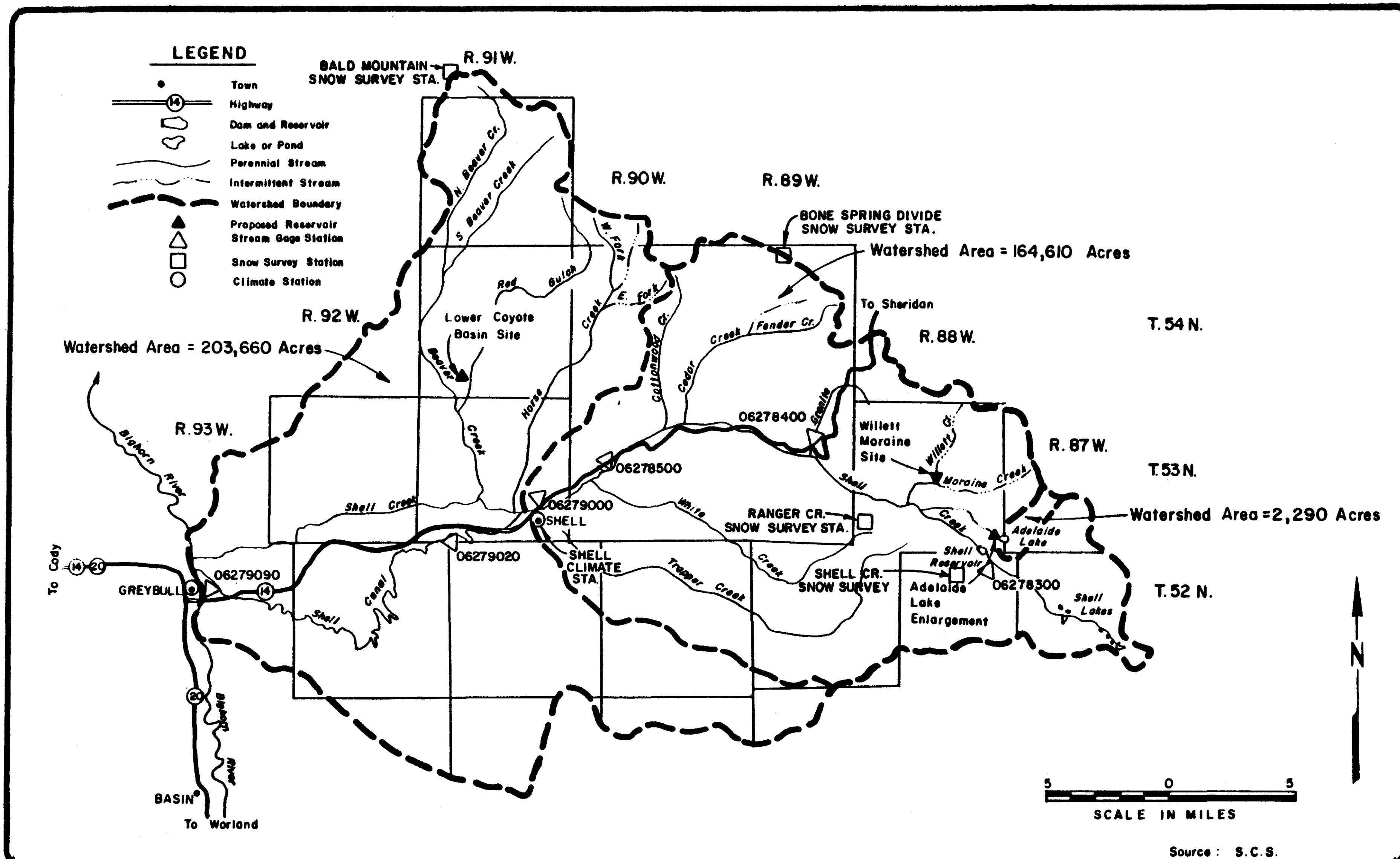
Streamflows at these locations of interest were analyzed on a probability basis. The probability study established watershed yield for different levels of percent chance (e.g., the 50 percent change flow, the 80 percent change flow, etc.). Results of the probability analysis will be of general informational value in assessing the water supply.

Baseline Data

Baseline information for the surface water supply analysis consisted primarily of streamflow data. Climate and snow data were considered, but not directly applied in satisfying study objectives.

Streamflow data within the Shell Creek and Big Horn River basins consist of daily and instantaneous flow measurements. A listing of gages and related statistics is given in Table IV.5.

Climate data consisted primarily of monthly precipitation records. Snow data was used primarily for general information purposes. Because reasonably satisfactory streamflow data is



LAKE ADELAIDE DAM

UPPER AND LOWER SHELL CREEK WATERSHEDS

10M183.105

NOVEMBER 1984

FIGURE IV.1

HKM ASSOCIATES
ENGINEERS — PLANNERS

Table IV.5

Streamgage Stations Within Shell Creek Basin

Station Name	Station No.	Drainage Area (sq.mi.)	Period of Record: Daily or Monthly Discharge (Calendar Yrs.)	Period of Record: Annual Peaks (Water Yrs.)	Period of Record: Instantaneous Readings (Water Years)
Shell Creek above Shell Reservoir, WY	06278300	23.1	1956-current		
Granite Creek near Shell Ranger Station, near Shell, WY	06278400	11.1		1961 - 1974	
Shell Creek near Shell, WY	06278500	145	1940-current		
Shell Creek at Shell, WY	06279000	256	1911-1923		
Red Gulch near Shell, WY	06279020	47.8		1970 - 1981	
Shell Creek at Porter Gulch, near Greybull, WY	06279050	--			1983
Shell Creek near Greybull, WY	06279090	560			1951, 1965-Current

Source: USGS

10M183.105/0615P

available, it is not necessary to develop a watershed model that incorporates snow factors in predicting runoff. A listing of stations is provided in Table IV.6 and IV.7.

Technical Analyses

The following section describes the technical analyses performed in defining the surface water supply of the Shell Creek Watershed. The section is subdivided into two main subject areas: Study Period and Streamflow Hydrology.

Study Period. For the purpose of most water availability studies, it is not sufficient to simply quantify flow for the historic record period of the stream gages of interest. It is necessary to determine the long-term representativeness of a specific study period which commonly does not coincide with the historic record period. To select a representative study period, available long-term and short-term hydrological and climatological data were analyzed.

The preferred method for determining the long-term hydrologic representativeness of a selected study period is to compare the hydrologic characteristics of an abbreviated period for the stream in question to a long-term measured period for the same stream. An alternative method is to identify a hydrologically similar stream in the region having a long period of record and compare the hydrologic characteristics of the selected study period to the total record period. Specific to the Shell Creek Watershed, the streamflow records are not sufficiently complete and extensive to independently establish long-term representativeness.

As a substitute for streamflow records, climatological records for a region can be used in the determination of data and period suitability. Commonly, precipitation records are used for this purpose. While it is not true that there is a direct

Table IV.6

Snow Course Stations Within Shell Creek Basin

Snow Course Name	Number	Elevation	Location
Bald Mountain	7E21 1/	9380	S29, T.56N, R91W
Bone Spring Divide	7E18 1/	9350	Lat 44°40' Long 107°34'
Ranger Creek	7E04	8120	S30, T53N, R88W
Shell Creek	7E23 1/	9580	Lat 44°30' Long 107°26'

1/ SNOTEL site consisting of snow sensor, precipitation gage, and temperature instrument with radio telemetry.

Source: SCS

Table IV.7

Selected Climate Stations Within Bighorn River Basin

Station	Index No.	Latitude	Longitude	Elev (NGVD)	Years of Record Temp	Years of Record Precip	Years of Record Evap
Basin	0540	44°23'	108°03'	3837	73	75	0
Cody	1840	44°33'	109°04'	4990	72	72	0
Deaver	2415	44°53'	108°36'	4105	64	64	0
Greybull	4080	44°29'	108°03'	3790	0	31	0
Lovell	5770	44°50'	108°24'	3837	65	70	0
Powell (F.S.)	7388	44°47'	108°45'	4370	71	73	0
Shell	8124	44°32'	107°46'	4275	11	24	0
Worland	9770	44°01'	107°58'	4060	66	69	0

Source: NWS

relationship between precipitation and runoff, it is generally true that on a long-term basis, precipitation trends are reflected in streamflow trends. Therefore, it is reasonable to use long-term precipitation records and trends as general indicators in the determination of long-term streamflow.

An additional reason for using precipitation records is that generally longer and more complete records exist for precipitation than exist for streamflow. This is the case for the Shell Creek Watershed.

Several regional precipitation gages were evaluated for use in the long-term representative determination including Basin, Lovell, and Worland, Wyoming. The Basin gage was selected for a detailed analysis based on station location and length of measured record (1899-1982). Precipitation data for the Basin station is shown in Table IV.8.

The 40 year period of 1941-1980 was proposed for this study because of the availability of hydrologic data along Shell Creek. Three different methods were used in the determination of long-term representativeness of the 1941-1980 period: cumulative surplus/deficit analysis, statistical parameter review, and graphical analysis. Each method and its respective results are described in detail as follows.

<u>Cumulative Surplus/Deficit Analysis</u>

A cumulative surplus/deficit analysis involves constructing and analyzing a curve which represents the cumulative departure from the normal precipitation for each year. In the cumulative surplus/deficit plot, the departure is indicated on the ordinate, or the vertical axis, and the year of record is indicated on the abscissa, or the horizontal axis. A positive departure from the normal precipitation represents a surplus and a negative departure represents a deficit. For any period of record, the mathematical operation is such that the plot will always start and end at zero.

TABLE IV.8

Basin, Wyoming Historic Monthly Precipitation

TOTAL MONTHLY PRECIPITATION (HISTORIC)

FILE -- BASPREC
SITE -- BASIN
UNIT -- INCHES
NOTE -- ANY MONTH WITH ****.** INDICATES NO DATA AVAILABLE

01/25/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	.18	0.00	.40	.80	.50	1.19	.18	.33	1.58	.59	.42	.60	6.86
1942	.17	.42	.25	.47	1.15	.14	.14	0.00	.72	.99	1.87	.36	6.68
1943	.03	.15	.54	.74	.67	1.29	.30	.13	.11	.44	.32	.29	5.05
1944	.72	.18	.30	2.34	1.50	1.57	.85	0.00	.34	.13	.03	.36	8.31
1945	.21	0.00	.36	.19	1.31	1.69	.57	.83	1.12	.12	.37	.63	7.45
1946	.24	.18	.55	.35	1.07	1.26	.31	.42	1.35	.76	.31	.53	7.82
1947	0.00	.20	.03	1.19	1.76	1.52	.10	.17	1.59	.75	1.48	.03	8.87
1948	.67	.18	0.00	.77	.56	.72	.73	.13	.57	.18	.23	.09	4.87
1949	.17	*****.**	.56	.45	.69	.95	*****.**	*****.**	.57	1.08	0.00	0.00	******.**
1950	.13	0.00	.09	.70	.93	1.16	.96	.25	1.60	.15	.38	.28	6.68
1951	.13	.03	.21	.42	.72	1.22	1.56	.28	.36	.66	.06	.22	5.86
1952	.11	.16	.26	.87	1.12	.91	.68	.26	.15	0.00	.18	.27	4.96
1953	.07	.33	.28	.86	.93	.83	.01	.51	.45	.51	.31	.10	5.23
1954	.10	.05	.49	.70	1.59	.78	.51	.16	.17	.21	0.00	.03	4.78
1955	.14	.12	.26	.42	1.44	1.89	1.51	.06	.36	.07	.39	.36	7.50
1956	.20	.04	.13	.30	.63	.51	.12	.23	0.00	.35	.09	.19	2.78
1957	.28	.09	.24	.26	1.43	1.50	.07	.43	.40	.53	.43	0.00	5.65
1958	.05	.58	.23	.27	.73	1.25	1.00	.28	.05	.08	1.03	.14	5.68
1959	.10	.45	.13	1.62	1.35	2.01	0.00	0.00	1.10	.88	.36	.11	8.11
1960	.08	.13	.15	.25	.16	.64	0.00	.74	.96	.74	.45	.48	4.78
1961	0.00	.13	.67	.45	2.11	.23	.15	.03	1.46	1.38	.50	.28	7.43
1962	.56	.12	.15	.94	2.01	.75	.74	1.49	.50	.08	.30	.11	7.74
1963	.54	.12	.02	1.05	.83	1.79	.20	.07	.92	.32	.30	.49	6.64
1964	.05	.22	.16	1.49	1.13	2.43	.02	1.61	0.00	.11	.38	.42	8.01
1965	.28	.03	.33	.04	.96	1.38	.61	1.16	1.68	.11	0.00	.16	6.73
1966	.04	.04	.42	1.31	0.00	.62	.15	.48	1.12	.02	.14	.15	4.48
1967	.45	.37	.41	.79	.59	4.56	.29	.14	1.29	.16	.04	.83	9.91
1968	.10	.20	.40	.47	1.25	1.86	.11	2.35	.74	.04	.15	.70	8.37
1969	.16	.04	.06	1.38	.59	2.52	.35	.62	.08	.64	.23	.07	6.73
1970	.23	.12	.30	.91	.85	.20	.54	.01	.63	.17	.23	.09	4.27
1971	.20	.34	.55	.72	1.65	.16	.15	.61	.32	2.81	.10	.04	7.64
1972	.23	.07	.03	.41	.38	.92	1.16	.75	.28	.32	.23	.37	5.14
1973	.17	.03	.25	.71	.31	1.22	.73	.51	2.23	.26	.16	.14	6.71
1974	.02	0.00	.09	.24	.94	.27	.79	.20	.32	1.03	.10	0.00	4.54
1975	.36	.10	.07	1.73	2.95	.48	.30	0.00	0.00	1.54	.81	.13	9.06
1976	.03	0.00	.12	.65	.48	1.18	.05	.53	1.25	.31	.39	0.00	4.98
1977	.43	.08	.80	.85	.42	.45	.58	1.07	.71	.04	0.00	.14	5.56
1978	.61	.81	.05	1.63	1.81	.25	.78	.54	1.54	.05	.31	.57	8.94
1979	.23	.13	.02	0.00	2.08	.69	.08	1.25	0.00	.38	.50	.07	5.42
1980	.31	0.00	.09	.35	2.58	1.13	.60	.91	1.45	.86	.25	0.00	8.53
1981	.04	.03	.62	.18	2.74	.30	.43	1.06	.33	1.09	0.00	.59	7.41
1982	.47	0.00	.05	.49	.53	1.24	.56	.57	1.32	.83	.15	.46	6.66
1983	0.00	.02	.23	.41	1.15	1.25	.05	.37	.15	.49	*****.**	*****.**	******.**
MEAN	.21	.15	.26	.72	1.13	1.13	.46	.51	.78	.51	.33	.26	6.57
S.D.	.19	.17	.20	.50	.68	.80	.40	.50	.59	.53	.37	.22	1.62
COEF. VAR.	.877	1.149	.765	.699	.603	.704	.865	.982	.759	1.031	1.117	.845	.246
PERCENT OF ANNUAL MEAN	3.3%	2.3%	4.1%	11.2%	17.4%	17.5%	7.1%	7.9%	12.1%	8.0%	5.1%	4.0%	

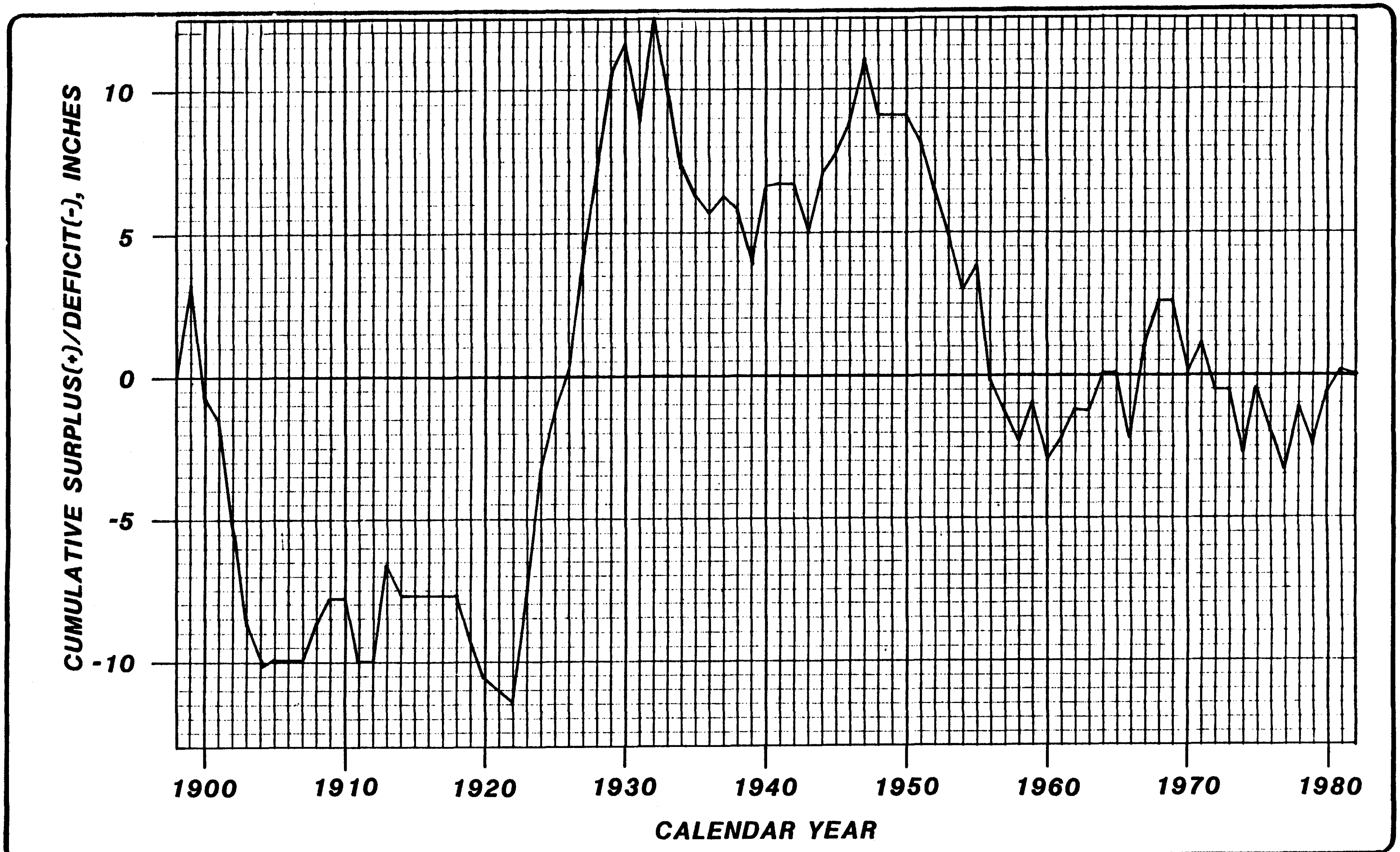
Surplus/deficit curves aid in the identification of surplus periods, of deficit periods, and of severity and extent of one condition or another. They also aid in the determination of variability. The slope of the curve is particularly important in analyzing the graphical plot. The magnitude of the slope and the length of the period until the slope changes are both indications of the magnitude of the cumulative departures and, hence, indications of the magnitude of a deficit period or of a surplus period. An abbreviated period can be compared to a longer period at the station being analyzed to establish the representativeness of the abbreviated period.

Two surplus/deficit curves were developed for the Town of Basin precipitation station. The first plot is for the entire Town of Basin period of record, which is 1899 through 1982 (Figure IV.2). A second plot was made for the abbreviated period 1941 to 1980 (Figure IV.3).

Comparison of Figures IV.2 and IV.3 indicates similarities between the 1941 to 1980 period and the period 1899 to 1982. Both figures exhibit a sustained deficit period in the 1950's, sustained surplus periods in the 1940's and 1960's and average conditions in the 1970's.

Statistical Parameter Review

The second method used in the determination of long-term representativeness consists of examining statistical parameters of monthly and annual precipitation data. The Basin station was used for statistical parameter review. The main parameters evaluated in this analysis are the arithmetic mean, standard deviation, and the coefficient of variation. The arithmetic mean provides a measure of the central or average tendency of precipitation. The standard deviation describes the absolute variation of each set of monthly and annual data. The coefficient of variation describes the relative variation for monthly and annual data for each trial period.



LAKE ADELAIDE DAM

CUMULATIVE SURPLUS/DEFICIT CURVE
BASIN WYOMING 1899-1982

10M183.105

NOVEMBER 1984

FIGURE IV.2

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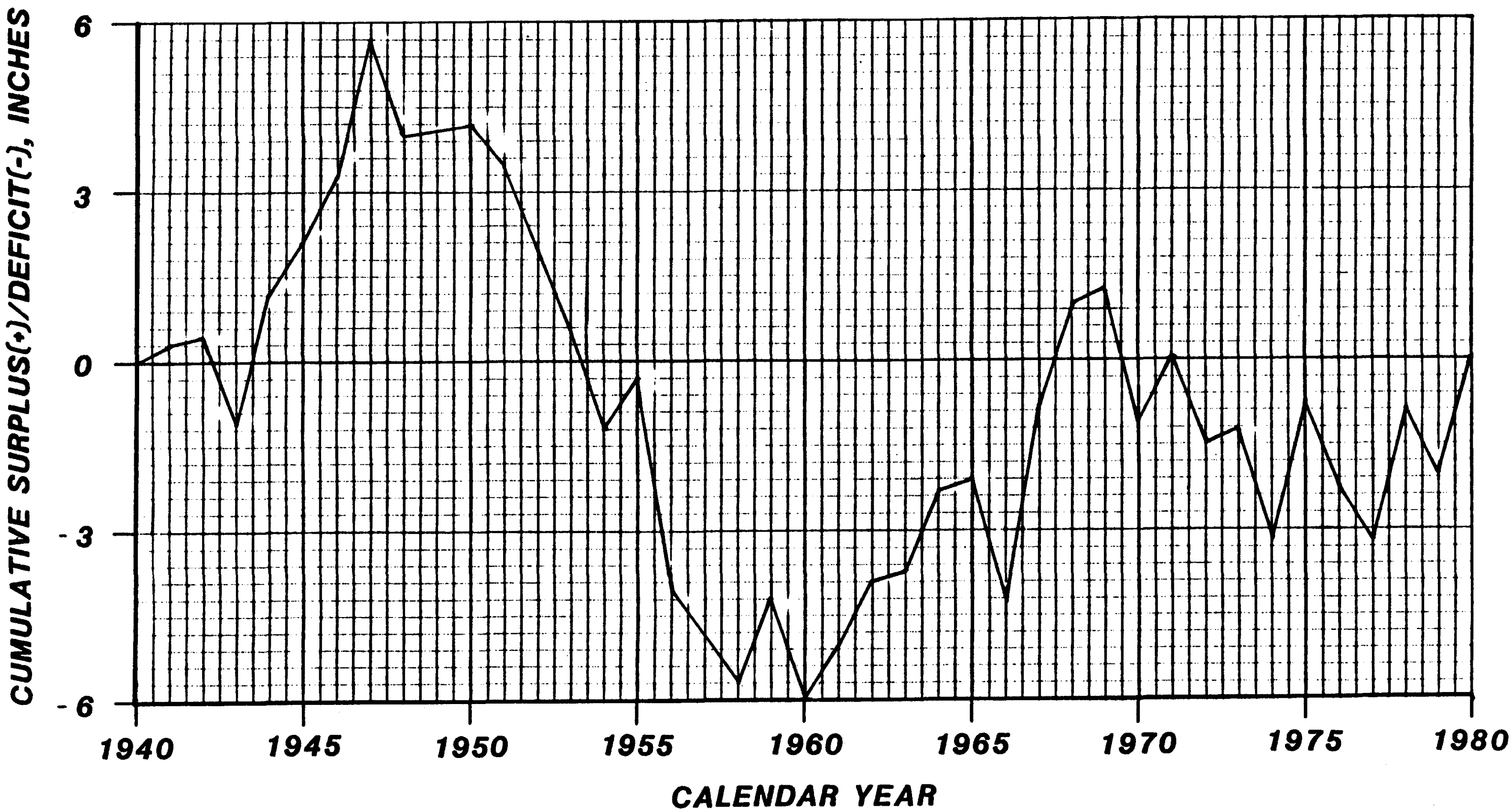

LAKE ADELAIDE DAM

CUMULATIVE SURPLUS/DEFICIT CURVE
BASIN WYOMING 1941-1980

10M183.105

NOVEMBER 1984

FIGURE IV.3

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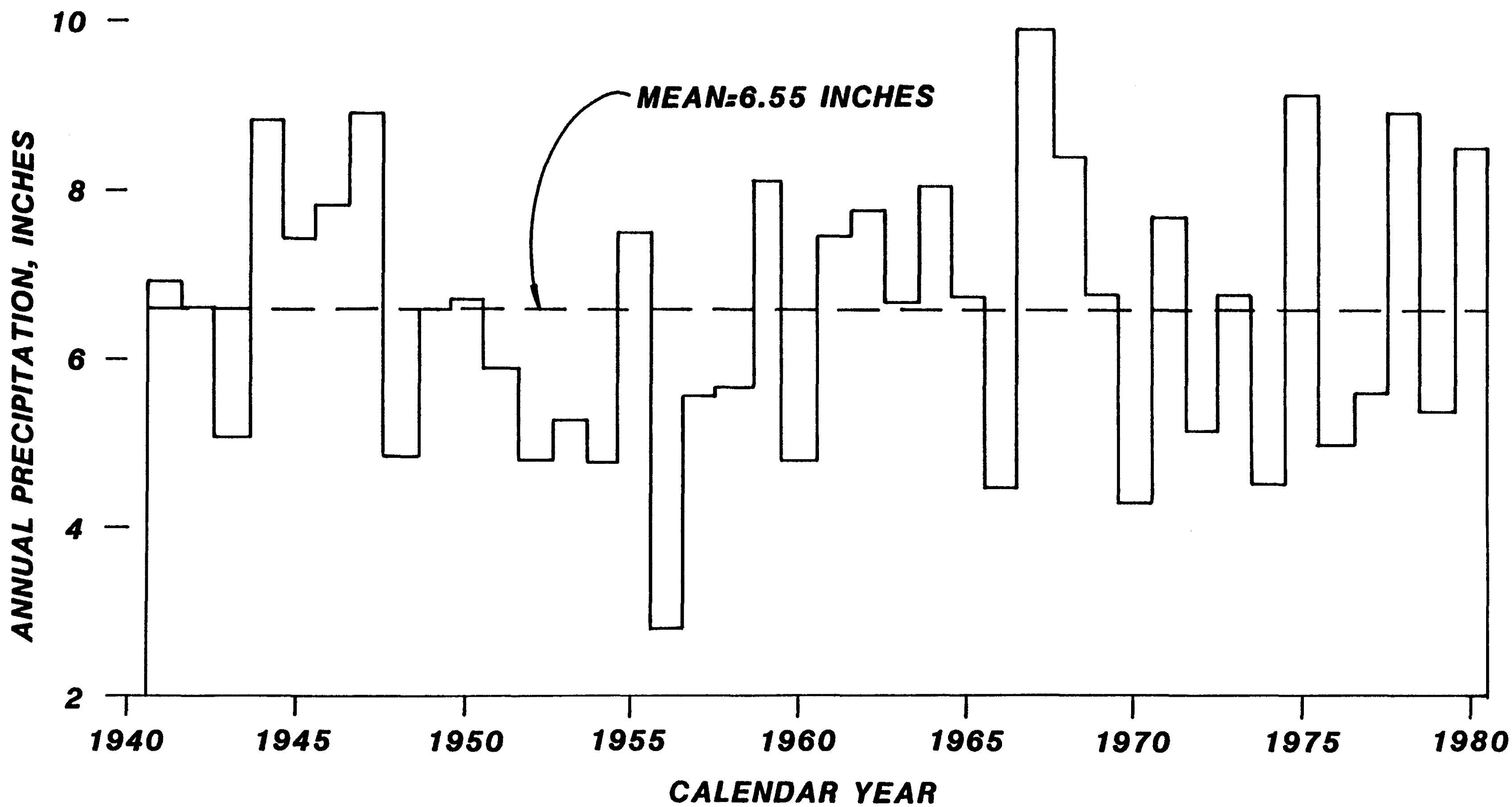
Mean annual precipitation during the 1941-80 period was determined to be 6.55 inches as compared with 6.73 inches for 1899-1982. Hence, mean annual precipitation at Basin was approximately 3 percent lower in the abbreviated period. It should be realized that variability in precipitation conditions is generally dampened during the runoff process. In other words, a 3 percent difference in precipitation values does not necessarily apply with equal magnitude to streamflows. Another point to be factored into the comparison is the accuracy level of actual measured records. The precipitation values are probably no better than a plus-or-minus range of 5 to 10 percent.

The standard deviation (SD) of annual precipitation amounts for 1941-80 is 1.66 as compared with 2.04 for the period 1899-1982. The difference is approximately 19 percent.

The final statistical parameter to be reviewed on an annual basis is the coefficient of variation (CV). For the period 1941 to 1980, the CV is 0.253, and for the long-term period 1899 to 1982, the CV is 0.302. The difference is about 16 percent. The 16 to 19 percent difference in CV and SD for the annual precipitation values does not disqualify the period 1941-80 as being reasonably representative of long-term climate conditions.

Graphical Analysis

An additional way that data and period representativeness can be reviewed is by using a graphical plot. For this study, a plot was made of mean annual precipitation for the Town of Basin station (see Figure IV.4) for the period 1941 to 1980. Observation of Figure IV.4 focuses attention on the variability



LAKE ADELAIDE DAM

ANNUAL PRECIPITATION PLOT
BASIN WYOMING 1941-1980

10M183.105

NOVEMBER 1984

FIGURE IV.4

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and persistence of annual precipitation in the study basin. It is also possible to note the extent of deviation between the annual mean for a specific year and the long-term mean for the study period. The main benefit afforded by use of this type of analysis is that it allows a visual review and verification of which periods are wet and which periods are dry.

Summary

Because precipitation is the primary input parameter which dictates the amount of runoff that will occur, it was concluded that precipitation trends are generally indicative of runoff trends. Within the level of accuracy that can be obtained for a study such as this, the period 1941 to 1980 is considered to be reasonably representative of long-term climatic conditions for the study basin. Using regional precipitation data, it was found that the period 1941 to 1980 is only slightly more deficit than a period which extends back to the late - 1890's. Consequently, the period 1941 to 1980 is considered to be representative of long-term hydrologic conditions as well as climatic conditions.

Streamflow Hydrology. Streamflow quantification studies commonly rely on available hydrologic data. A rule of thumb is that the greater the quantity of available streamflow data and the better the quality of the data, the more accurate the study results will be. Even the most sophisticated hydrologic models may yield poor results when the quantity and quality of available data is limited. The present study is fortunate in that there are reasonably adequate measured streamflow records on Shell Creek and regional streams, and hence, significant synthesization of records was unnecessary. The streamflow hydrology analysis focused on four locations within the Shell Creek Watershed: Shell Creek above Shell Creek Reservoir, Adelaide Creek above Adelaide Reservoir, Shell Creek near Shell, and Shell Creek near Greybull. The study technique and results for each of these locations is described below.

Shell Creek Above Shell Creek Reservoir

The measured period of record for Shell Creek above Shell Creek Reservoir is 1957 to the present (Table IV.9). The USGS notes that these records are good except for the winter period, which are considered only fair. In addition there are no diversions above the gage.

To fill in the missing years (1941-1957) in the study period, a correlation analysis was performed with other streamgages in the basin. The only significant correlation was with Shell Creek near Shell, Wyoming. Monthly regression equations are as follows:

January	$r = 0.03$ 1/			
February	$r = 0.07$ 1/			
March	$r = 0.26$ 1/			
April	$r = 0.83$ 1/			
May	$r = 0.81$ 1/			
June	$Y = 1.93\ X^{0.849}$	$N = 27$	$r^2 = 0.90$	$r = 0.95$
July	$Y = 0.00727\ X^{1.39}$	$N = 27$	$r^2 = 0.94$	$r = 0.97$
August	$r = 0.74$ 1/			
September	$r = 0.64$ 1/			
October	$r = 0.68$ 1/			
November	$r = 0.58$ 1/			
December	$r = 0.32$ 1/			

Where X = monthly flow (AF) for Shell Creek near Shell
Y = monthly flow (AF) for Shell Creek above Shell Reservoir

1/ Not considered to be a significant correlation.

TABLE IV.9
Shell Creek above Shell Reservoir Historic Monthly Streamflow

MONTHLY STREAMFLOW (HISTORIC)

FILE -- 0627830C
SITE -- SHELL CREEK ABOVE SHELL RESERVOIR
UNIT -- AF
NOTE -- ANY MONTH WITH ####### INDICATES NO DATA AVAILABLE   01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1956	########	########	########	########	########	########	########	########	########	384	268	246	########
1957	184	167	184	238	2550	15540	3060	585	683	560	455	394	24600
1958	263	194	184	149	17730	5910	2450	1330	433	362	356	277	29638
1959	215	167	154	149	1910	15080	2080	505	316	323	244	246	21389
1960	194	179	227	454	5340	9650	1240	468	327	265	245	185	18775
1961	102	84	70	114	8800	6500	718	251	500	1080	656	341	19226
1962	212	181	209	1050	4610	15290	2980	398	526	387	266	213	26827
1963	136	102	100	117	13000	16380	1200	297	304	246	224	168	32774
1964	104	87	101	127	7090	15860	5420	765	795	453	303	209	31314
1965	210	127	140	201	3850	17980	5070	746	389	506	275	185	29679
1966	141	123	145	147	6240	4090	942	413	270	274	230	172	13137
1967	131	85	85	192	8860	17810	5340	764	650	902	438	206	35463
1968	121	113	126	101	3740	21000	4230	2800	2670	988	521	397	36807
1969	137	137	137	474	15720	6090	3770	665	388	411	296	120	28406
1970	107	86	83	73	5230	16680	2880	599	326	272	236	142	26754
1971	101	80	77	110	5790	16180	2420	765	342	381	236	199	26681
1972	132	91	94	145	5540	14040	2760	1790	1060	726	438	269	27135
1973	162	87	85	130	4350	14430	2060	781	1170	529	317	264	24375
1974	164	121	151	357	4590	15580	2520	729	446	313	267	192	25430
1975	158	114	91	82	937	14090	11530	305	257	219	173	147	28603
1976	106	80	81	100	5610	14470	3770	802	537	612	305	168	26641
1977	129	92	99	812	7470	10500	1130	600	575	713	437	267	22974
1978	219	131	167	224	3500	18960	7370	1530	1210	934	422	327	34994
1979	190	148	155	179	5870	10310	2500	1260	704	392	250	150	23108
1980	95	63	95	323	7030	8540	1470	549	980	910	443	206	20764
1981	132	89	90	504	6950	10060	1410	490	311	403	252	170	20861
1982	133	83	91	141	3730	13920	4360	895	628	831	436	261	25509
1983	196	160	190	235	1920	15940	3360	530	336	########	########	########	########
MEAN	156	117	126	256	6263	13383	3262	837	636	532	335	226	26229
S.D.	45	37	45	230	3935	4391	2296	529	490	259	116	73	5525
COEF. VAR.	.290	.318	.357	.398	.628	.327	.704	.631	.771	.486	.348	.323	.210
PERCENT OF ANNUAL MEAN	.6%	.4%	.5%	1.0%	24.0%	51.2%	12.5%	3.2%	2.4%	2.0%	1.3%	.9%	

SUM OF MONTHLY MEANS 26,140.4

A significant correlation did exist with annual flows.

$$Y = 0.305\ X \qquad N = 13 \qquad r^2 = 0.79 \qquad r = 0.89$$

Where X = annual flow (AF) for Shell Creek near Shell
Y = annual flow (AF) for Shell Creek above Shell Reservoir

Annual flows for Shell Creek above Shell Reservoir were generated using this regression equation. Estimated monthly streamflows for June and July were subtracted and the resultant streamflow was divided up between the months of August to May using the monthly distribution exhibited by the historical records of 1958-1980.

The extended streamflow record is shown in Table IV.10. The mean annual flow for the study period is 26,294 AF. This is equivalent to approximately 21.3 inches for the 23.1 square miles drainage basin. It also reduces to 1140 AF/square miles watershed yield.

A probability analysis was performed on the Shell Creek above Shell Creek Reservoir streamflows to identify flow conditions on a probability basis. The analysis was performed on each monthly sequence, and the annual sequence, using the Weibull Plotting Position formula. The Weibull formula takes the following form:

$$\text{Probability (decimal)} = \frac{m}{n+1}$$

Where:
m = rank
n = number of data points in the sequence

MONTHLY STREAMFLOW (HISTORIC & SYNTHETIC)

FILE NAME - 2783FCX1
SITE -- SHELL CREEK ABOVE SHELL RESERVOIR
UNIT -- AF
NOTE -- ANY MONTH WITH ####### INDICATES NO DATA AVAILABLE 01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	260	130	130	391	8464	6283	1024	1172	911	794	529	265	20353
1942	265	132	132	397	8598	9562	1852	1190	926	572	381	191	24198
1943	191	95	95	286	5198	16011	3801	858	657	679	453	226	29560
1944	226	113	113	340	7359	14923	4126	1019	792	537	358	179	30090
1945	179	90	90	269	5818	14140	6418	806	627	347	565	282	30131
1946	232	141	141	423	9173	14372	2643	1270	988	818	545	273	31069
1947	273	136	136	409	8850	12950	4919	1227	954	868	578	289	31599
1948	289	145	145	434	9400	8061	1826	1301	1012	767	512	256	24148
1949	256	128	128	384	8314	11896	1773	1151	895	512	341	171	25949
1950	171	85	85	256	5545	12960	2885	768	597	749	499	250	24850
1951	250	125	125	374	8109	9240	3624	1123	873	827	551	276	25497
1952	276	0	138	414	8960	9847	2647	1241	965	391	261	130	25270
1953	130	65	65	196	4237	15928	2158	587	456	681	454	227	25184
1954	227	114	114	341	7378	7518	1407	1022	795	553	369	184	20022
1955	184	92	92	276	5990	13702	2501	829	645	745	497	248	25801
1956	248	124	124	372	8068	9418	1197	1117	869	384	258	246	22435
1957	184	167	184	238	2550	15540	3060	585	683	560	455	394	24600
1958	263	194	184	149	17780	5910	2450	1330	433	362	356	277	29688
1959	215	167	154	149	1910	15080	2030	505	316	323	244	246	21339
1960	194	179	227	454	5340	9650	1240	468	327	265	245	185	18775
1961	102	84	70	114	3800	6500	718	251	500	1080	666	341	19226
1962	212	181	209	1050	4610	15290	2980	898	526	387	256	218	26827
1963	136	102	100	117	13000	16880	1200	297	304	246	224	168	32774
1964	104	87	101	127	7090	15860	5420	765	795	453	303	209	31314
1965	210	127	140	201	3850	17980	5070	746	339	506	275	185	29679
1966	141	123	145	147	6240	4090	942	413	270	274	230	172	13137
1967	131	85	85	192	8850	17810	5340	764	650	902	438	206	35453
1968	121	113	126	101	3740	21000	4230	2800	2670	989	521	397	36807
1969	197	137	137	474	15720	6090	3770	666	388	411	296	120	28406
1970	107	85	83	73	5280	16680	2880	599	326	272	236	142	26764
1971	101	80	77	110	5790	16180	2420	765	342	381	236	199	25631
1972	132	91	94	145	5540	14040	2760	1790	1060	726	488	269	27135
1973	162	87	85	130	4360	14430	2060	781	1170	529	317	264	24375
1974	164	121	151	357	4590	15580	2520	729	446	313	267	192	25430
1975	158	114	91	82	937	14090	11530	805	257	219	173	147	28603
1976	106	80	81	100	5610	14470	3770	802	537	612	305	163	26641
1977	129	92	99	812	7470	10600	1130	600	575	713	437	267	22974
1978	219	131	167	224	3500	18960	7370	1530	1210	934	422	327	34934
1979	190	148	155	179	5870	10310	2500	1260	704	392	250	150	23108
1980	95	63	95	323	7090	8540	1470	549	980	910	443	206	20764
MEAN	137	113	122	290	6924	12709	3094	934	720	587	381	228	26294

TABLE IV.10
Shell Creek above Shell Reservoir Historic and Synthetic Monthly Streamflow

Table IV.11 presents various percent chance levels for watershed yield.

Adelaide Creek Above Adelaide Reservoir

Inflows for Adelaide Reservoir are based on the streamflows developed at the Shell Creek above Shell Creek Reservoir streamgage. The two drainage basins are located adjacent to each other and have almost the same mean basin elevation. Therefore, the unit discharges developed for Shell Creek above Shell Reservoir are also considered appropriate for Adelaide Creek above Adelaide Reservoir. Total inflow to Adelaide Reservoir also reflects the diversion of water from Buckley Creek and was calculated as follows:

Contribution from Adelaide drainage	0.15 x Shell Cr. Ab Shell Res.
+ Contribution from Buckley Creek diversion	0.14 x Shell Cr. Ab Shell Res.
- Buckley Creek diversion bypass of 2 cfs	0.06 x Shell Cr. Ab Shell Res.
= Total inflow to Adelaide Reservoir	0.23 x Shell Cr. Ab Shell Res.

The mean annual flow for Adelaide Creek above Adelaide Reservoir is 6047 AF. Adelaide Reservoir inflow is presented in Table IV.12. Results of a probability analysis for each month and year using the Weibull Plotting Position Formula is found in Table IV.13.

MONTHLY STREAMFLOW (HISTORIC & SYNTHETIC)

% FIRM YIELD

FILE NAME -- 2733FCX1
SITE -- SHELL CREEK ABOVE SHELL RESERVOIR
UNIT -- AF

01/23/85

%	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
90	104	80	81	101	3524	6304	1181	471	317	272	236	147	20055
80	129	85	86	127	4406	8680	1419	589	388	365	252	171	22542
70	137	90	94	149	5400	9709	1914	734	469	391	270	185	24251
60	166	97	100	198	5801	12317	2432	766	583	508	309	201	25218
50	187	114	124	262	6555	14065	2581	805	658	556	363	222	25875
40	204	124	131	333	7370	14454	2883	970	793	680	437	247	26801
30	223	130	139	373	8252	15465	3726	1142	838	747	454	264	29272
20	254	140	149	406	8848	15994	4209	1233	962	825	509	275	30122
10	272	167	182	451	9377	17717	5411	1327	1055	909	550	323	32656
5	281	180	207	795	15534	18911	7322	1777	1208	985	577	391	35439
2	290	196	230	1092	18150	21367	12278	2981	2932	1096	681	397	37048
1	293	201	237	1190	18995	22203	13934	3395	3531	1134	717	398	37599

TABLE IV.11
Shell Creek above Shell Reservoir Percent Firm Yield

MONTHLY STREAMFLOW (SYNTHETIC)

FILE NAME - AC83FCX1
SITE -- ADELAIDE CREEK ABOVE ADELAIDE RESERVOIR
UNIT -- AF
NOTE -- ANY MONTH WITH ####### INDICATES NO DATA AVAILABLE 01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	59	29	29	89	1946	1445	235	269	209	182	121	60	4681
1942	60	30	30	91	1977	2199	425	273	212	131	87	43	5555
1943	43	21	21	65	1425	3682	874	197	153	156	104	51	6798
1944	51	25	25	78	1692	3433	948	234	182	123	82	41	6920
1945	41	20	20	61	1338	3252	1476	185	144	194	129	64	6930
1946	64	32	32	97	2109	3305	607	292	227	183	125	62	7145
1947	62	31	31	94	2037	2378	1131	282	219	199	132	66	7267
1948	66	33	33	99	2162	1854	419	299	232	176	117	58	5554
1949	58	29	29	88	1912	2735	407	264	205	117	78	39	5968
1950	39	19	19	58	1275	2980	663	176	137	172	114	57	5715
1951	57	23	28	86	1865	2125	833	258	200	190	126	63	5854
1952	63	0	31	95	2060	2264	608	285	221	89	60	29	5812
1953	29	14	14	45	974	3663	496	135	104	156	104	52	5792
1954	52	26	26	73	1696	1729	323	235	182	127	84	42	4605
1955	42	21	21	63	1377	3151	575	190	148	171	114	57	5934
1956	57	28	28	85	1855	2166	275	256	199	83	61	56	5160
1957	42	38	42	54	586	3574	703	134	157	128	104	90	5657
1958	60	44	42	34	4039	1359	563	305	99	83	81	63	6828
1959	49	38	35	34	439	3463	478	116	72	74	56	56	4919
1960	44	41	52	104	1228	2219	285	107	75	61	56	42	4318
1961	23	19	16	26	2024	1495	165	57	115	248	153	78	4421
1962	48	41	48	241	1060	3516	685	205	120	89	61	50	6170
1963	31	23	23	26	2990	3832	275	68	69	56	51	38	7538
1964	23	20	23	29	1630	3647	1246	175	182	104	59	48	7202
1965	48	29	32	46	885	4135	1166	171	89	116	63	42	6826
1966	32	28	33	33	1435	940	216	94	62	63	52	39	3033
1967	30	19	19	44	2037	4096	1228	175	149	207	100	47	8156
1968	27	25	28	23	860	4329	972	643	614	227	119	91	8455
1969	45	31	31	109	3615	1400	867	153	89	94	68	27	6533
1970	24	19	19	15	1214	3836	662	137	74	62	54	32	6155
1971	23	18	17	25	1331	3721	556	175	78	87	54	45	6136
1972	30	20	21	33	1274	3229	634	411	243	165	112	61	6241
1973	37	20	19	29	1002	3318	473	179	269	121	72	60	5606
1974	37	27	34	82	1055	3583	579	167	102	71	61	44	5848
1975	36	26	20	18	215	3240	2651	185	59	50	39	33	6578
1976	24	18	18	23	1290	3328	867	184	123	140	70	33	6127
1977	29	21	22	186	1718	2438	271	138	132	163	100	61	5284
1978	50	30	38	51	804	4360	1695	351	278	214	97	75	8048
1979	43	34	35	41	1580	2371	574	289	161	90	57	34	5314
1980	21	14	21	74	1630	1964	338	125	225	209	101	47	4775
MEAN	43	26	28	66	1592	2923	711	214	165	135	87	52	6047

TABLE IV.12
Adelaide Creek above Adelaide Reservoir Synthetic Monthly Streamflow

TABLE IV.13
Adelaide Creek above Adelaide Reservoir Percent Firm Yield

MONTHLY STREAMFLOW (SYNTHETIC)

% FIRM YIELD

FILE NAME -- AC83FCX1
SITE -- ADELAIDE CREEK ABOVE ADELAIDE RESERVOIR
UNIT -- AF

01/23/85

%	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
90	23	18	18	23	810	1450	271	108	72	62	54	33	4612
80	29	19	19	29	1013	1996	326	135	89	84	58	39	5184
70	31	20	21	34	1242	2233	440	168	107	89	62	42	5577
60	38	22	23	45	1334	2833	559	176	134	116	71	46	5800
50	43	26	28	60	1507	3234	593	185	151	127	83	51	5951
40	47	28	30	76	1695	3324	663	223	182	156	100	56	6164
30	51	30	32	85	1898	3556	857	262	204	171	104	60	6732
20	58	32	34	93	2035	3678	968	284	221	189	117	63	6928
10	62	38	41	103	2156	4074	1244	305	242	209	126	74	7510
5	64	41	47	182	3584	4349	1684	403	277	226	132	90	8151
2	66	45	52	251	4174	4914	2824	685	674	252	156	91	8521
1	67	46	54	273	4368	5106	3216	781	812	260	165	91	8647

Shell Creek Near Shell

The measured period of record for Shell near Shell is 1941 to the present (Table IV.14). The USGS notes that these records are good. It is also noted that there is some regulation by two small reservoirs (Adelaide and Shell) and there are upstream diversions for approximately 80 acres of irrigation below the gage. Winter records for 1972 to the present are missing.

To fill in the missing winter records, a correlation analysis was performed with other streamgages in the basin. There is no significant correlation with other streamgages, however, there is a significant correlation between April through September streamflow and annual streamflow. This is reasonable because there is a logical physical relationship between these values. The selected regression equation is as follows:

$Y = 7.18\ X^{.841}$ $N = 31$ $r^2 = 0.98$ $r = 0.99$

where Y = annual flow (AF) for Shell Creek near Shell
X = April through September flow (AF) for Shell Creek near Shell

Monthly streamflows were generated by subtracting the historic monthly streamflows for the non-winter months from the estimated annual flow and distributing the resultant according to the historical winter monthly distribution. The extended streamflow listing is shown in Table IV.15. The mean annual flow for the study period is 87,594 AF. This is equivalent to about 11.3 inches for the 145 square mile watershed and equates to a 604 AF/square mile watershed yield. Because of the small amount of upstream regulation and depletion, and the good correlation, this estimate is assumed to approximate natural flow.

TABLE IV.14
Shell Creek near Shell Historic Monthly Streamflow

MONTHLY STREAMFLOW (HISTORIC)

FILE -- 0627850C
SITE -- SHELL CREEK NEAR SHELL
UNIT -- AF
NOTE -- ANY MONTH WITH ######## INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1940	########	########	########	########	########	########	########	########	########	3590	2380	1840	########
1941	1850	1670	1910	2080	21690	13720	5060	4710	6050	5860	3510	2740	70850
1942	2470	1910	2000	7360	16540	22500	7750	4840	3310	3050	2740	2560	77130
1943	2380	2060	2320	4100	13200	41290	13000	5240	4130	3030	2700	2260	95760
1944	2160	1970	2100	2220	21660	38020	13730	5210	4470	3380	2860	2420	100260
1945	2330	2030	2120	2090	12100	35670	18950	6560	6240	4370	3320	3020	93800
1946	2620	2340	2950	8220	17710	36360	10010	5310	5830	4900	3830	3270	103350
1947	2770	2480	2510	2790	21800	32160	15650	6130	4930	4110	3620	3420	102430
1948	3000	2410	2460	2600	23620	18400	7670	5340	3180	3000	2710	2600	76990
1949	2280	1850	2050	3170	24140	29100	7510	4500	3840	3070	2600	2300	86410
1950	2140	1860	1900	2620	10120	32190	10660	5980	4430	4200	3030	2520	81700
1951	2040	1790	2020	2350	19690	21610	12560	7100	4170	3380	2740	2520	81970
1952	2390	2020	2040	5460	23020	23290	10020	5800	3480	2340	2330	2300	85040
1953	2350	2030	2220	2100	5700	41040	8650	5470	3590	2680	2520	2580	80930
1954	2350	1980	2070	2450	20200	16950	6360	4200	2140	2170	1830	2000	64750
1955	1800	1740	2020	2270	17720	34370	9620	4810	2940	2600	2430	2410	84730
1956	2270	2270	2370	2560	24250	22100	5650	3930	2650	2290	2130	2090	74620
1957	1870	1690	1910	2000	9950	31830	9500	5750	3960	3080	2570	2390	76500
1958	2100	1330	2090	2000	24540	14350	7510	6310	4130	2760	2440	2350	72410
1959	2160	1760	1930	2250	7010	34010	7800	6010	4240	3230	2400	2350	75200
1960	1960	1850	1800	2520	11190	16610	4970	4710	2860	2370	2020	1980	55340
1961	1770	1490	1590	1720	18120	15520	4250	4160	2990	3250	2900	2480	60240
1962	2030	1860	2000	5410	19630	34660	10600	5460	4200	3380	3070	2560	94960
1963	2150	1950	2030	2360	16810	39870	7530	5210	3490	2380	2620	2310	89260
1964	2180	1940	2080	2020	14560	44950	17500	7040	5250	4130	2960	2880	107490
1965	2570	2070	2180	2600	8030	54500	15840	6940	5530	4220	2850	2620	109960
1966	2360	1990	2220	2190	17470	9700	4510	3550	2270	2370	2130	2130	52890
1967	1740	1560	1980	2050	13420	48180	17300	5760	5470	4950	3600	2980	108990
1968	2550	2200	2260	2239	7150	58910	13310	8280	7990	5760	4540	3710	118890
1969	2850	2320	2550	5440	26920	16150	12840	6220	4260	3320	3000	2720	89100
1970	2410	2120	2190	2190	13940	41260	10860	6180	4430	3060	2540	2530	93710
1971	2390	2040	2200	2410	17220	37970	8700	6900	4140	3720	########	########	########
1972	########	########	2620	2750	15990	38590	10730	7660	5340	########	########	########	########
1973	########	########	2530	2510	20340	36230	8480	5820	4580	########	########	########	########
1974	########	########	########	3210	18030	38260	9960	6980	5100	########	########	########	########
1975	########	########	########	2150	5760	42510	29070	7770	5800	########	########	########	########
1976	########	########	########	2730	17840	39780	11710	7490	5130	########	########	########	########
1977	########	########	########	4220	19210	17140	6110	4340	3230	########	########	########	########
1978	########	########	########	2590	13510	46350	20410	8600	6930	########	########	########	########
1979	########	########	########	3210	21710	27700	10850	9710	7070	########	########	########	########
1980	########	########	########	3280	18030	22130	7830	5740	4460	########	########	########	########
1981	########	########	########	4240	21120	25400	7820	5980	3840	########	########	########	########
1982	########	########	########	1950	11810	36020	15070	5740	5510	########	########	########	########
1983	########	########	########	2370	8450	36030	12530	6690	4810	########	########	########	########
MEAN	2267	1970	2159	3000	16533	31706	10851	5968	4479	3503	2809	2549	85638
S.D.	312	237	267	1424	5612	11626	4861	1290	1238	926	569	415	16569
COEF. VAR.	.137	.120	.124	.474	.339	.366	.447	.216	.287	.264	.202	.162	.193
PERCENT OF ANNUAL MEAN	2.6%	2.2%	2.5%	[illegible]	[illegible]	[illegible]	[illegible]	6.8%	[illegible]	[illegible]	[illegible]	[illegible]	

TABLE IV.15
Shell Creek near Shell Historic and Synthetic Monthly Streamflow

MONTHLY STREAMFLOW (HISTORIC & SYNTHETIC)

FILE NAME - 2785FCX1
SITE -- SHELL CREEK NEAR SHELL
UNIT -- AF
NOTE -- ANY MONTH WITH ####### INDICATES NO DATA AVAILABLE 01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	1850	1670	1910	2080	21690	13720	5060	4710	6050	5360	3510	2740	70850
1942	2470	1910	2000	7360	16540	22500	7750	4840	3310	3050	2740	2560	77130
1943	2380	2060	2320	4100	13200	41290	13000	5240	4180	3030	2700	2260	95760
1944	2160	1970	2100	2220	21660	38020	13790	5210	4470	3380	2860	2420	100260
1945	2330	2030	2120	2090	12100	35670	13950	6560	6240	4370	3320	3020	98800
1946	2620	2340	2950	8220	17710	36360	10010	5310	5830	4900	3830	3270	103350
1947	2770	2480	2510	2790	21800	32160	15650	6130	4990	4110	3620	3420	102430
1948	3000	2410	2460	2600	23620	18400	7670	5340	3180	3000	2710	2500	76990
1949	2230	1850	2050	3170	24140	29100	7510	4500	3840	3070	2600	2300	86410
1950	2140	1360	1900	2620	10120	32190	10660	5980	4490	4200	3030	2520	81700
1951	2040	1790	2020	2350	19690	21610	12560	7100	4170	3380	2740	2520	81970
1952	2390	2020	2040	5460	23020	23290	10020	5800	3480	2840	2390	2300	85040
1953	2350	2030	2220	2100	5700	41040	8650	5470	3590	2680	2520	2580	80930
1954	2350	1980	2070	2450	20200	16950	6360	4200	2140	2170	1830	2000	64750
1955	1800	1740	2020	2270	17720	34370	9620	4310	2940	2600	2430	2410	84730
1956	2270	2270	2370	2560	24250	22100	5660	3930	2650	2290	2130	2090	74620
1957	1870	1690	1910	2000	9950	31830	9500	5750	3960	3080	2570	2390	76500
1958	2100	1330	2090	2000	24540	14350	7510	6310	4130	2760	2440	2350	72410
1959	2160	1760	1930	2250	7010	34010	7800	6010	4240	3230	2400	2350	75200
1960	1960	1850	1800	2520	11190	16610	4970	4710	2860	2370	2020	1980	55340
1961	1770	1490	1590	1720	18120	15520	4250	4160	2990	3250	2900	2480	60240
1962	2030	1360	2000	5410	19630	34660	10600	5460	4200	3380	3070	2560	94960
1963	2150	1950	2030	2360	16810	39870	7580	5210	3490	2880	2620	2310	89260
1964	2180	1940	2030	2020	14560	44950	17500	7040	5250	4130	2960	2880	107490
1965	2570	2070	2130	2600	8030	54500	15840	6940	5530	4220	2860	2620	109960
1966	2350	1990	2220	2190	17470	9700	4510	3550	2270	2370	2130	2130	52890
1967	1740	1560	1980	2050	13420	48180	17300	5760	5470	4950	3600	2980	108990
1968	2550	2200	2260	2230	7150	58910	13310	8280	7990	5760	4540	3710	118890
1969	2850	2320	2550	5440	26920	16150	12840	6220	4260	3320	3000	2720	89100
1970	2410	2120	2190	2190	13940	41260	10860	6180	4430	3060	2540	2530	93710
1971	2390	2040	2200	2410	17220	37970	8700	6900	4140	3720	2318	2158	92166
1972	1919	1599	2620	2750	15990	38590	10730	7660	5340	3312	2434	2248	95242
1973	2011	1775	2530	2510	20340	36230	8430	5820	4530	3295	2579	2436	92586
1974	2149	1363	2006	3210	13030	38260	9960	6980	5100	3235	2532	2391	95716
1975	2110	1828	1969	2150	5760	42510	29070	7770	5800	3284	2570	2423	107249
1976	2142	1856	1999	2730	17840	39780	11710	7490	5130	3188	2495	2356	98716
1977	2079	1802	1940	4220	19210	17140	6110	4840	3280	3189	2496	2357	68653
1978	2080	1802	1941	2590	13510	46350	20410	8600	6930	3299	2582	2438	112532
1979	2151	1865	2008	3210	21710	27700	10850	9710	7070	3254	2546	2405	94479
1980	2122	1839	1980	3280	13030	22130	7830	5740	4460	3292	2576	2433	75762
MEAN	2226	1932	2127	3012	16738	31648	10779	5955	4451	3443	2746	2521	87594

A probability analysis was also performed for these streamflows. The analysis was performed for each month on an annual basis using the Weibull Plotting Position formula. Table IV.16 summarizes the probability levels for watershed yield.

Shell Creek Near Greybull

Shell Creek near Greybull is a water quality gage. Instantaneous streamflow measurements are available generally once a month from the 1960's to the present.

Monthly streamflow estimates were generated by integrating the area under the curve formed by connecting the points of measured streamflow. A review of the results indicates that sufficient points are available to develop a reasonable hydrograph (Table IV.17). This data was used to gain an understanding of the operation of the Shell Valley.

FLOOD HYDROLOGY

Basin Description

A 3.58-square mile (sm) drainage basin feeds the storage project as shown in Figure IV.5. The basin is drained by Adelaide Creek which flows southwesterly to Adelaide Dam. The basin has a length and width of approximately 3.5 miles and 1 mile, respectively. Elevations within the basin range from approximately 9200 feet NGVD at Adelaide Dam to approximately 10,600 feet NGVD at the upper end of the basin. The basin is located in Region 1 of Wyoming as defined by the USGS. Land use in the basin is primarily forest.

MONTHLY STREAMFLOW (HISTORIC & SYNTHETIC)

% FIRM YIELD

FILE NAME -- 2785FCX1
SITE -- SHELL CREEK NEAR SHELL
UNIT -- AF

01/23/85

%	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
90	1852	1672	1910	2023	7238	15583	5120	4230	2868	2608	2193	2132	65141
80	2014	1773	1971	2110	11372	17392	7510	4816	3236	2372	2432	2300	74736
70	2036	1828	1999	2223	13639	22241	7765	5219	3665	3053	2503	2351	77032
60	2140	1852	2012	2354	16648	30192	8669	5463	4151	3188	2555	2395	83073
50	2155	1864	2045	2515	17715	34190	9935	5780	4250	3252	2530	2430	89190
40	2276	1962	2096	2600	18084	36303	10702	6082	4476	3297	2706	2504	94171
30	2357	2027	2197	2773	20047	38491	12305	6485	5121	3380	2860	2594	95746
20	2406	2068	2308	3266	21706	41216	13694	7028	5518	4126	3024	2708	101996
10	2615	2315	2528	5436	24088	46210	17480	7753	6220	4846	3591	3016	108840
5	2855	2406	2616	7264	24525	54184	20337	8583	7062	5719	3819	3412	112403
2	3025	2492	3009	8374	27348	59703	30628	9909	8155	5878	4657	3762	120034
1	3032	2521	3144	8727	28324	61511	34179	10364	8532	5919	4958	3881	122641

TABLE IV.16
Shell Creek near Shell Percent Firm Yield

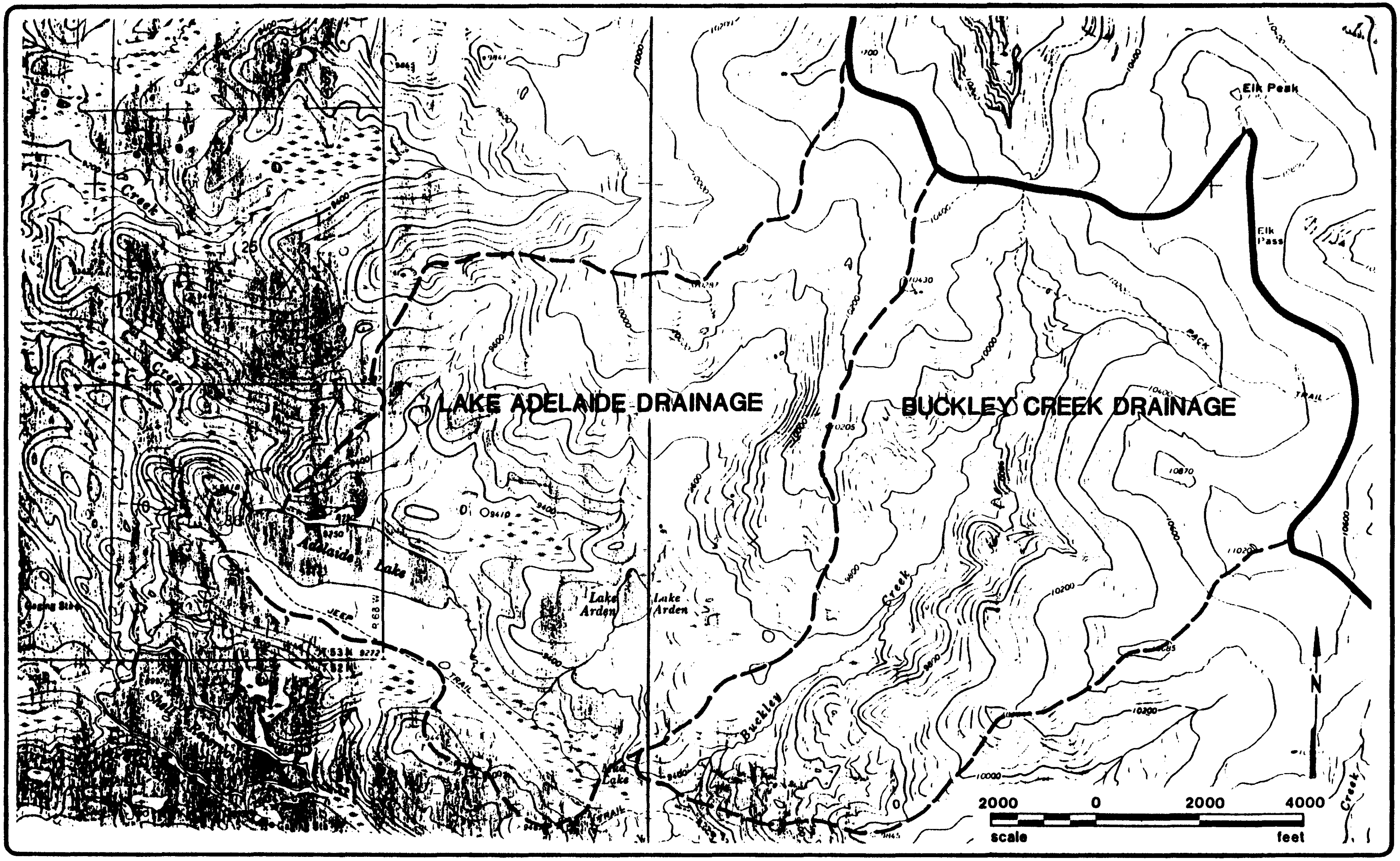
TABLE IV.17
Shell Creek near Greybull Historic Monthly Streamflow

MONTHLY STREAMFLOW (HISTORIC)

FILE -- GREYBULC
SITE -- SHELL CREEK NEAR GREYBULL
UNIT -- AF
NOTE -- ANY MONTH WITH ####### INDICATES NO DATA AVAILABLE 01/24/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1968	********	********	********	********	********	********	********	********	********	7763	5603	4623	********
1969	3928	5987	6171	8749	30753	21793	8736	3713	3488	5771	7327	7922	114398
1970	5739	3303	4400	3335	15120	38596	8377	2939	5747	5694	5758	5146	105164
1971	4299	3738	4328	4621	9241	47659	9429	2900	3590	8168	5838	4372	108633
1972	4314	3923	5017	3927	29037	59916	12296	4463	3596	6907	4948	4539	142838
1973	3822	4669	5196	3450	15122	60122	15557	3171	4336	4951	5318	4944	130658
1974	4669	4032	4248	2704	13650	71547	30754	2854	2730	3504	4824	4981	150547
1975	4498	4765	6530	4720	1400	56219	75329	5013	2643	3941	6562	7143	189813
1976	5429	4974	5690	3757	10460	29546	9551	4678	3394	5306	5961	5980	95726
1977	6465	5634	4802	12105	19505	10163	3967	3053	3281	3720	4755	6243	83698
1978	6141	5151	5869	6591	31847	11121	35918	8227	6890	6878	5802	5338	136273
1979	4450	5534	13078	9220	29002	41838	11541	5367	3623	5414	3424	2685	135176
1980	2236	2204	3047	2485	14130	24293	4016	1346	1305	2988	3465	2793	64913
1981	2201	2071	1915	5211	65368	41414	7994	2390	2550	********	********	********	********
MEAN	4553	4345	5410	5490	21895	40325	13039	3394	3632	5461	5434	5208	121490
S.D.	1386	1217	2629	2887	16037	20331	19960	1674	1416	1644	1153	1483	33351
COEF. VAR.	.304	.280	.485	.525	.734	.504	1.106	.429	.389	.301	.212	.284	.274
PERCENT OF ANNUAL MEAN	3.7%	3.5%	4.4%	4.4%	17.7%	32.6%	14.6%	3.1%	2.9%	4.4%	4.4%	4.2%	

SUM OF MONTHLY MEANS 123,591.9



LAKE ADELAIDE DAM

LAKE ADELAIDE DRAINAGE BASIN

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FIGURE IV.5

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Baseline Data

Streamflow Data. Adelaide Creek is ungaged.

Soils Data. No soil survey data was available for the Adelaide Dam drainage basin.

Climate Data. Precipitation, temperature and snow water equivalent (SWE) is available at the Shell SNOTEL Station.

Size and Hazard Rating

The Corps of Engineers (COE) Phase I Investigation of Adelaide Dam established the project rating as intermediate in size with a high downstream hazard potential. The hydraulic height from dam crest to toe is 31 feet, and capacity to the dam crest is 1920 acre-feet (AF).

An analysis of various breach scenarios of the existing dam was performed. The resulting outflow from the dam was routed downstream to the town of Shell using the HEC-1 computer model. The routing indicates a breach could impact numerous habitable structures and cause extensive economic loss which would put the dam in the high hazard potential classification.

Based on the size and hazard rating, the recommended spillway design flood (SDF) will be the probable maximum flood (PMF). The PMF is defined as the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that may be reasonably possible in a region.

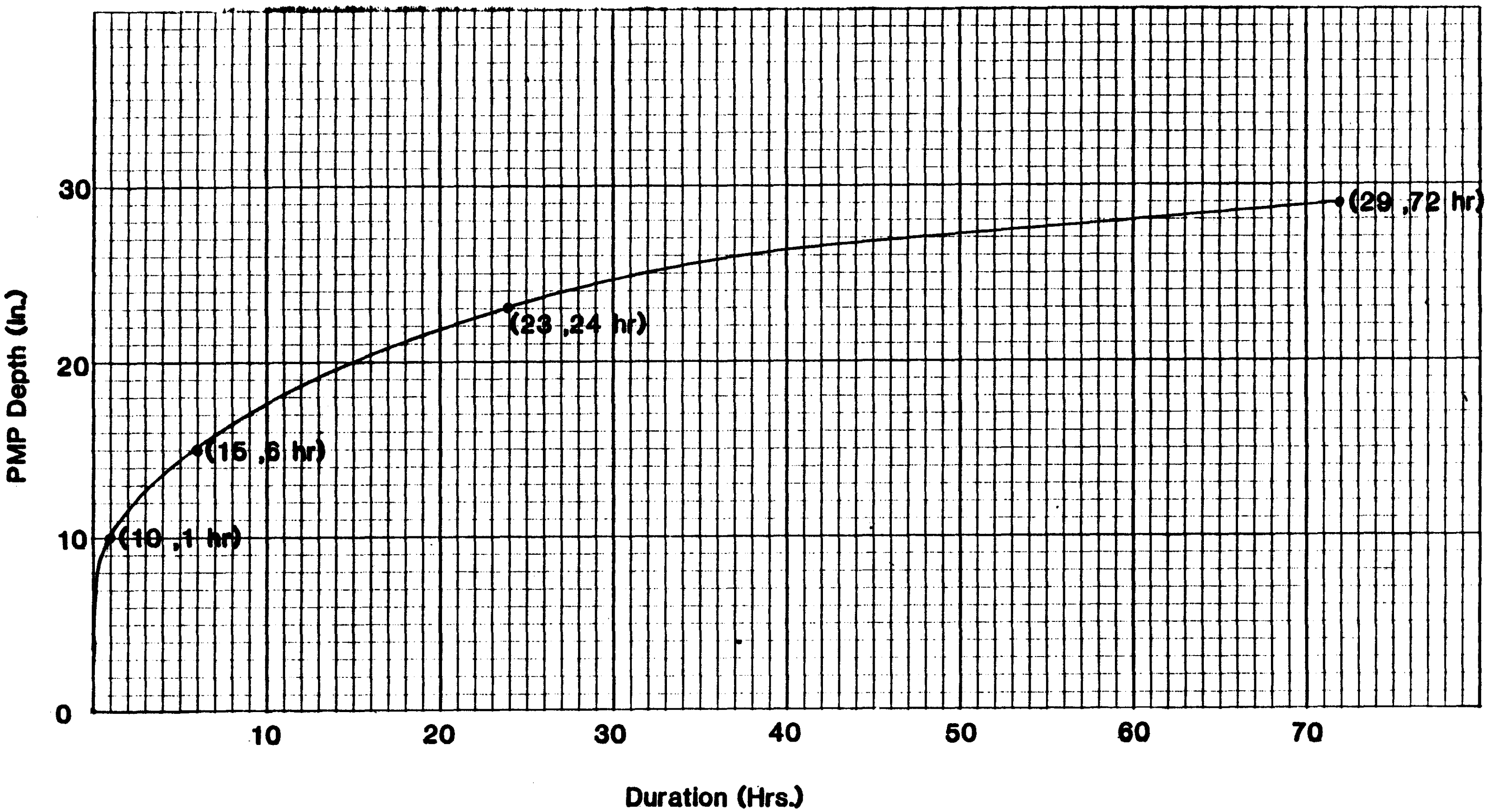
Technical Analysis

Probable Maximum Flood.

Probable Maximum Precipitation

The probable maximum precipitation (PMP) is the theoretical maximum depth of precipitation for a given duration that is physically possible at a certain time of year (2). The 72-hour duration PMP was derived using techniques to be included in Hydrometeorological Report (HMR) 55. HMR 55 is the result of a joint effort between the NWS, the COE, and the USBR. HMR 55 identified areas of valleys and plateaus that are sheltered by the first upslope ridges from the strong continuous moisture inflow expected to produce and sustain large area general storms. Local storms, which are much smaller than general storms applicable to the rest of the HMR 55 area, can flourish in these sheltered areas with the greatly reduced moisture inflow and energy available behind the first upslopes. The Adelaide Dam drainage basin falls within one of the three major sheltered areas. The eastern local storm boundary runs generally along the top of the Big Horn Mountain range in this part of Wyoming. Within the Big Horn Mountains, areas of high elevations are generally controlled by the general storm PMP, while at lower elevations the local storm may control. HMR 55 indicates that for the most part, local storms control the elevations below about 10,000 feet. HMR 55 also indicates that whenever a local storm PMP is computed, it should be compared to the general storm PMP to determine the critical amount. The Adelaide Dam drainage basin has a mean basin elevation of approximately 10,000 feet and the general storm PMP was found to be the critical amount. The 72-hour general storm PMP generates 29 inches of precipitation. A plot of the 72-hour depth-duration relationship is shown in Figure IV.6.

A comparison was made with the Savageton, Wyoming storm of September 27-October 1, 1923. Savageton is located at latitude 43°52' and longitude 105°47' and has an elevation of 5100



LAKE ADELAIDE DAM

DEPTH DURATION CURVE: 72 HOUR GENERAL STORM PMP

10M183.105

NOVEMBER 1984

FIGURE IV.6

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feet. This storm generated a 10 sm, 6 hour precipitation of 6.0 inches which is 40 percent of the 6 hour PMP. The maximum precipitation for the 108-hour storm period was 17.1 inches which is 59 percent of the 72-hour PMP.

Seasonal Variation

HMR 55 provides only all-season PMP estimates. However, the dates of important storms in the region suggest that the all-season PMP will occur from early summer through fall.

Placement Over Basin

The Adelaide Dam drainage area is small enough that it would be completely covered by the general storm.

Subbasins

The Adelaide Dam drainage basin is divided into three subbasins to better reflect the rainfall-runoff process in the basin.

Time Distribution of Rainfall

A 60-minute time increment is selected in order to give good definition to the rising limb of the hydrograph. Incremental values from HMR 55 depth-duration relationship were rearranged to form a critical design distribution based on the recommendations of the National Research Council (2) for areas where no predominant rainfall pattern is evident from past records.

Antecedant Storms

The possibility of an antecedent storm(s) was accounted for by assuming saturated ground conditions prior to the occurrence of a PMP.

Antecedant Snowpack and Snowmelt Floods

Methods of estimating snowmelt have been developed by the COE (26). The snowmelt evaluation of the Adelaide Dam basin was accomplished through use of snowmelt indicies, also called the degree-day method:

$$SNWMT = COEF\,(TMPR - FRZTP)$$

Where

- SNWMT = the melt in inches per day
- TMPR = the air temperature in °F
- FRZTP = the temperature in °F at which snow melts
- COEF = the melt coefficient in inches per degree-day

In order to evaluate the significance of snowmelt in the Adelaide Dam basin, a critical temperature sequence must be selected. A review of the Shell SNOTEL records indicates that significant amount of snow can be present as late as June. HMR 55 indicates that the PMP in this area is most likely to occur in the months June - September. Therefore, June temperatures were reviewed. A 3-day period is selected to be consistent with the duration of the PMP. The highest mean temperature in June with snow on the ground was 44°F. It is assumed that a mean daily temperature of 44°F could persist for 3 consecutive days.

A review of the Shell SNOTEL records indicates that a melt coefficient of 0.10 is possible.

The temperature at which snow melts was set at 32°F.

Substituting these parameters into the degree-day method yields a maximum 3-day melt of 3.6 inches. A review of the June SWE records at the Shell SNOTEL Station shows a SWE in excess of 3.6 inches is common on June 1. The snowmelt was added to the PMP to reflect the combined PMP and snowmelt event which is possible in June.

Loss Rates

Loss rates were estimated based on calibration of runoff events in the Shell Dam drainage basin. It is assumed that similar soil conditions exist in the Adelaide Dam drainage basin. A retention rate of 0.05 inches/hour was selected for development of the PMF.

Base Flow

In the case of a small basin, the mean annual flow is a reasonable base flow to be added to the principal flood. The mean annual runoff above Adelaide Dam is insignificant relative to the magnitude of the PMF and was not included.

Runoff Model

Hydrologic calculations were performed using the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM). SWMM is a comprehensive mathematical model for simulation of runoff quantity and has been used extensively in the United States and other countries. SWMM has been used by the U.S. Army Corps of Engineers (COE) in dam hydrologic studies. The use of the SWMM model was also justified by simulation of known flood events in the adjacent Shell Dam drainage.

SWMM requires the following input for each of the subbasin areas.

1. Width
2. Area
3. Percent impervious
4. Slope
5. Resistance factor for impervious and pervious areas
6. Depression storage for impervious and pervious areas
7. Loss rate

Subbasin width represents the physical width of overland flow from the subbasin. Widths were estimated using maps of the area, information developed during calibration known events in the Shell drainage, and comparison the computed PMF hydrograph with other regional PMF estimates.

Subbasin areas were measured from USGS maps of the area. The total contributing area upstream of the Adelaide Dam is approximately 3.58 square miles.

The percentage of impervious area and slope were estimated from maps and field reconnaissance.

The resistance factor was selected based on information in the SWMM manual. A Manning's n of 0.014 was used for impervious areas and a value of 0.40 was used for pervious areas (forest).

Depression storage was also estimated using information found in the SWMM manual.

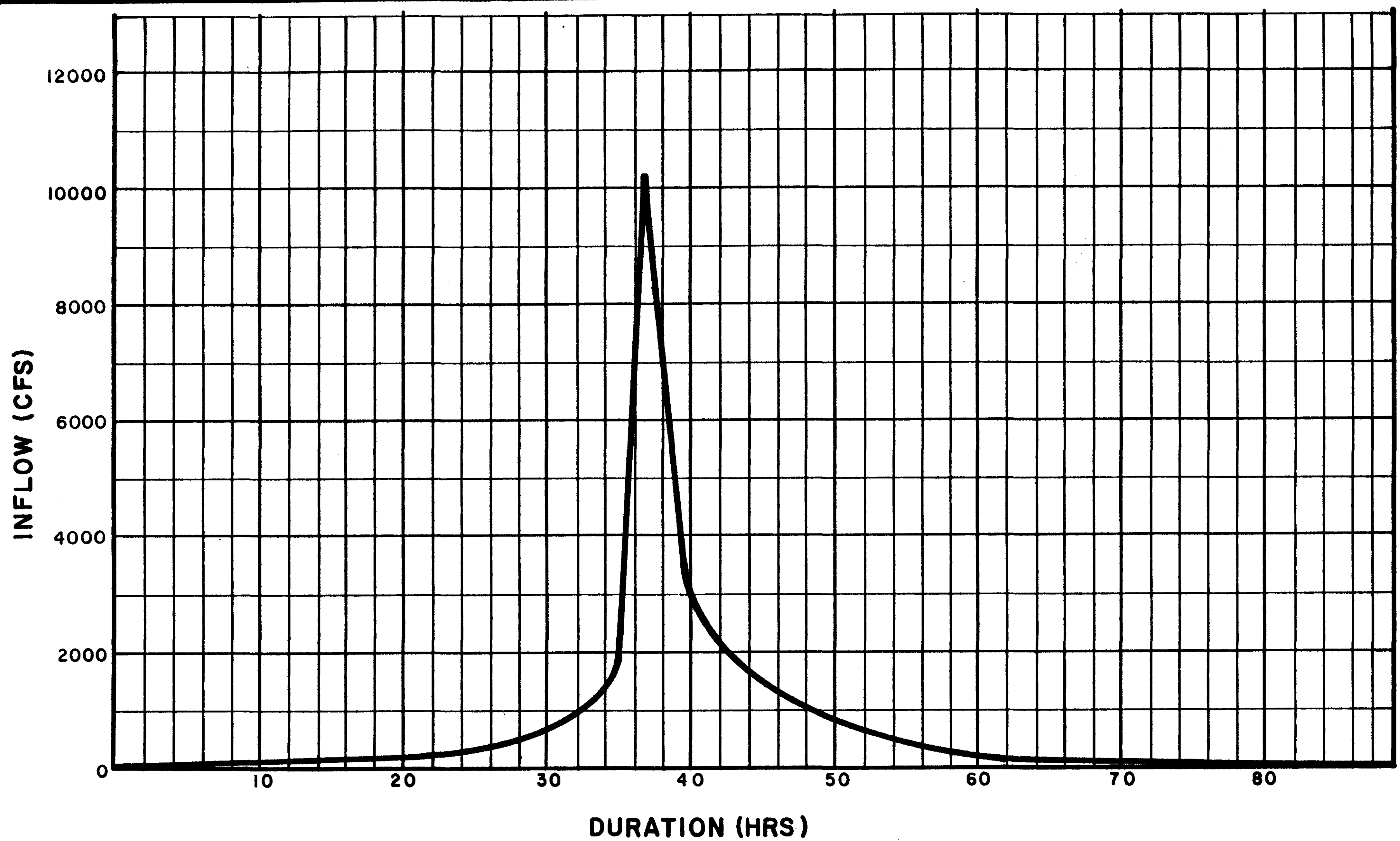
The PMF hydrograph is shown in Figure IV.7. The PMF hydrograph has a peak discharge of 10,300 cfs and a 72-hour volume of 5200 AF.

Credibility of Maximum Flood Estimate

To reinforce the credibility of the peak discharge of 10,300 cfs, a comparison was made with historical peak discharges. The United States Geological Survey (USGS) has developed a plot of the maximum known floods in Region 1 (Techniques for Estimating Flow Characteristics of Wyoming Streams, Water Resources Investigation 76-112, Lowham, 1976). For a drainage area of 3.58 sm, the maximum known flood is approximately 200 cfs. The computed peak discharge of 10,300 cfs is approximately 50 times as large as the estimated maximum known peak discharge for the basin.

The Creagher formula is an extensively used empirical formula which describes the relationship between drainage area and maximum observed flood discharges (Safety of Existing Dams, National Research Council, 1983):

$$Q = 46\ CA^{(0.894)A^{-0.048}}$$



LAKE ADELAIDE DAM

PMF INFLOW HYDROGRAPH

10M183.105

NOVEMBER 1984

FIGURE IV. 7

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where Q = total discharge in cubic feet per second
A = drainage area in square miles = 3.58 sm
C = coefficient dependent on drainage basin characteristics, a value of 100 is recommended for comparison with the PMF

$$Q = 46(100)(3.58)^{0.894(3.58)^{-0.048}}$$

$$Q = 13,400 \text{ cfs}$$

Based on past work in this region, it is felt that the Creagher formula estimates total discharges which are too high. For example, the peak for Middle Creek Dam in Montana is 32,400 cfs, which is only 57 percent of the Creagher formula estimate. The Middle Creek Dam drainage basin also in a sheltered area similar to the Adelaide drainage basin. The computed peak of 10,300 cfs is approximately 75 percent of the predicted by the Creagher formula which is felt to be acceptable.

The National Research Council has published enveloping PMF isolines that extend west to the 103 meridian (Safety of Existing Dams, National Reserach Council, 1983). By extending the lines across the border to the Adelaide Dam basin, the PMF peak discharge is estimated to be approximately 10,000 cfs.

Spillway Design Flood

The Spillway Design Flood (SDF) is the PMF plus a constant inflow of 550 cfs to reflect the maximum capacity of the proposed diversion from Buckley Creek during an unusual flood event.

100 Year Flood

The USGS has developed relations for estimating the flood magnitudes for ungaged sites in Wyoming (Techniques for Estimating Flow Characteristics of Wyoming Streams, Water Resources Investigation 76-112, Lowham, 1976). The Adelaide

Dam drainage basin falls in Region 1 identified by the USGS. The 100 year flood-frequency equation for Region 1 is as follows:

$$P = 2.57A^{0.75} E^{1.53}$$

where P100 = Peak discharge for 100 year recurrence interval in cfs

A = Drainage area in square miles = 6.96

E = Mean basin elev. in thousands of feet = 9.88

$$P100 = 2.57\,(6.96)^{0.75}\,(9.88)^{1.53} = 366$$

Note that this flood estimate is based on the combined area of Adelaide Creek above the dam and Buckley Creek above the diversion. The Buckley Creek diversion is designed to divert 100 year flood flows.

WATER RIGHTS

There are 17,463.39 acres within the Shell Creek drainage which currently have valid water rights. An inventory of the existing adjudicated water rights was developed based on the "State of Wyoming tabulation of Adjudicated Water Rights in Water Division No. three" as compiled by the State Board of Control. Additional "Permits in Good Standing" were included as the result of a review of records at the State Engineer's office in Cheyenne, Wyoming. Copies of all certificates of appropriation, permits in good standing, and any accompanying maps were obtained.

The point of diversion of each ditch and individual water right boundaries were mapped on mylar USGS quad base maps. If there were discrepancies between the legal descriptions on the permit or certificate and those illustrated by the associated map, boundaries were plotted to accurately reflect the stated area of the land with water rights.

Current irrigation and idle lands were mapped on the quad maps using the SCS 1969 irrigated land study as a base. Field reviews were made to update the 1969 information to current status. Phreatophytes were mapped directly from USDA aerial photography used in the 1969 SCS studies. Of the 10,764 acres of irrigated and idle lands mapped, 9,070 acres have valid water rights.

Appendix E lists in downstream order the facility name, each associated permit number, water right acreage, the status of each right - adjudicated (A) or permit in good standing (P), total water right diversion rate and the currently irrigated or idle lands served by that facility. Note that stock reservoirs were not included in this table.

Tract numbers on the base maps tie individual water right or use areas to a specific facility as listed in Appendix E. Rights for which the original point of diversion and means of conveyance was changed are shown listed under the facility which serves as the current source of supply.

There are a few cases of lands receiving duplicative water rights. These overlaps are noted as a part of the water right tabulations in Appendix E.

WATER UTILIZATION

River Basin Model

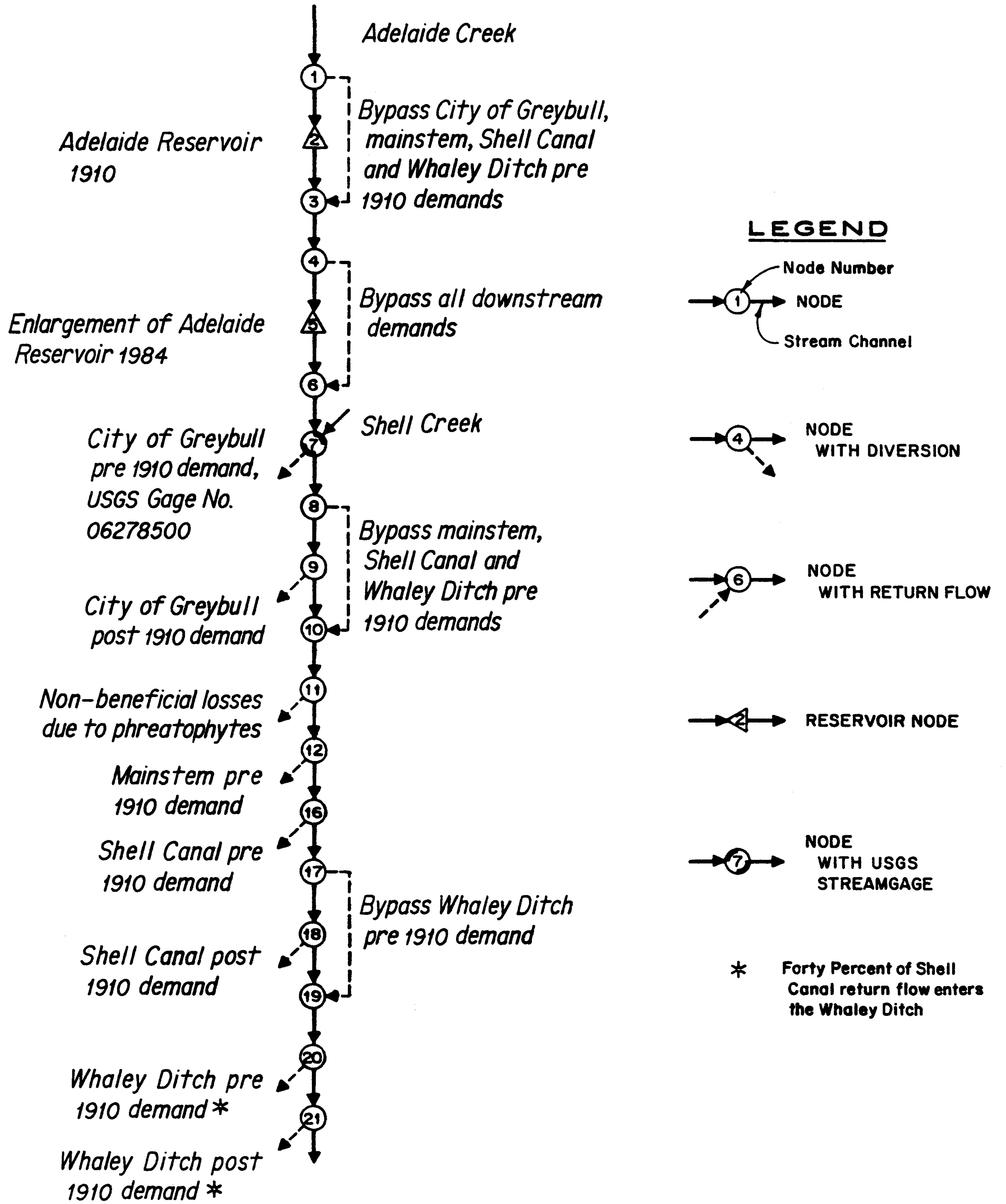
The U.S. Army Corps of Engineers HEC-3 computer program, Reservoir System Analysis for Conservation was chosen for use in this study. HEC-3 operates on a monthly time step. The model is able to simulate the Wyoming water rights priority system by passing flows at every node corresponding to downstream demands having senior rights. Where model accuracy was not reduced, several rights were "lumped together" as one node. Where several rights are included at each node, several "key" priority dates were utilized instead of using an individual breakdown of all rights. The "key" priority dates are as follows:

- Pre 1910 - Rights senior to the existing Adelaide Reservoir
- 1910 - Existing Adelaide Reservoir
- 1935-1980 - Rights junior to the existing Adelaide Reservoir
- 1984 - New storage in Adelaide Reservoir

Model node points were specified downstream of Adelaide Reservoir to the "critical point" in the Shell Valley, just downstream of the Whaley Ditch. The diversion for the Shell Canal, the largest diversion along Shell Creek, is located upstream of the Whaley Ditch. Return flow from the Shell Canal does not re-enter the system until downstream of the Whaley Ditch diversion. Therefore, the lowest streamflows along Shell Valley occur just below the Whaley Ditch diversion. Diversions downstream of this point are relatively small and can be served primarily by return flow. The major tributaries in this reach that support irrigation (Trapper and Horse Creeks) were not operated because in dry years there will be little water available for use along Shell Creek. These conclusions are based on a review of streamflow records, diversion records, previous modeling by others, and discussions with local people familiar with the basin. Figure IV.8 illustrates how Shell and Adelaide Creeks were incorporated in the model.

Operation Criteria

The following node by node description presents the operation criteria used in the HEC-3 model. Listings of all diversions listed below can be found in Appendix I.



LAKE ADELAIDE DAM

RIVER BASIN MODEL

SHELL AND ADELAIDE CREEKS

10M183.105 NOVEMBER 1984

FIGURE IV.8

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Node 1. Node 1 is on Adelaide Creek above Adelaide Reservoir. Streamflow is presented in the surface water supply section of the report. A diversion equal to 16% of all downstream pre 1910 demands is made at this node. This percentage was equivalent to the portion of the total drainage area above the diversion which is located above Adelaide Reservoir. These demands are senior to storage in the existing Adelaide Reservoir (priority date, August 8, 1910).

Node 2. Node 2 is the existing Adelaide Reservoir. Reservoir evaporation is considered to be insignificant. Reservoir seepage is included in flows normally passing down Adelaide Creek. After rehabilitation, seepage is assumed to be insignificant.

It is anticipated that when the Shell Canal receives a full water supply, return flows from the Shell Canal can satisfy shortages that exist along the Whaley Ditch. Therefore, Adelaide Reservoir releases are made to the Shell Canal only. The justification for this assumption is as follows. First, the amount of return flow available to the Whaley Ditch from the Shell Canal was estimated as follows:

100%	amount of water diverted to Shell Canal
-35%	amount consumed by crops
65%	amount available for return flow[1/] along entire length of canal
x40%	portion of return flow from Shell Canal (McDonald Ditch) available to Whaley Ditch and irrigated land below
x90%	portion of return flow available in month of diversion assuming some of the return flow is ground water
23.4%	amount of Shell diversion available as return flow to Whaley Ditch

1/ Non-beneficial losses due to phreatophytes accounted for at node.

Next, the ratio of Whaley Ditch demand to Shell Canal demand was calculated to determine what portion of the Whaley Ditch demand could be satisfied by Shell Canal return flows:

$$\frac{\text{Whaley Ditch Demand}}{\text{Shell Canal Demand}} = \frac{1052 \text{ ac}/40\% \text{ eff}}{3955 \text{ ac}/35\% \text{ eff}} = 23.3\%$$

Since 23.4% of the water diverted to Shell Canal should be available as return flow to Whaley Ditch and Whaley Ditch demand is 23.3% of Shell Canal, the assumption to release additional Adelaide Reservoir water only to Shell Canal appears valid. This means when Shell Canal demands are satisfied 8 out of 10 years, it is reasonable to assume that Whaley Ditch will also receive a full supply 8 out of 10 years as a result of increased return flows. The remainder of the irrigated land downstream from the Shell Canal and Whaley Ditch diversions are also benefited by the enlarged project as these lands will be served primarily by return flow as well. Observations, flows along Shell Creek, operation studies and discussions with the water commissioner reinforce this conclusion.

Node 3. Diversions made at Node 1 to bypass the existing Adelaide Reservoir return to Adelaide Creek at Node 3.

Node 4. A diversion is made at Node 4 equal to all downstream pre 1984 demands. This limits storage in an enlarged Adelaide Reservoir to a 1984 water right.

Node 5. Node 5 represents the enlarged Adelaide Reservoir. Reservoir seepage and evaporation are set equal to zero.

Node 6. Diversions made at Node 4 to bypass the enlarged Adelaide Reservoir are returned at this node.

Node 7. The confluence of Shell Creek and Adelaide Creek occurs at Node 7. Streamflows equal those of the Shell Creek near Shell gage presented in the surface water supply section.

Streamflow losses below Adelaide Reservoir are assumed to be reflected in these streamflow records. The operation of Shell Reservoir is not anticipated to change and therefore Shell Reservoir was not operated in this study. A diversion is made at this node for pre 1910 City of Greybull demand of 1.3 cfs.

Node 8. Node 8 is a diversion equal to all downstream pre 1910 demands. This limits the remaining City of Greybull demand at Node 9 to a post 1910 priority.

Node 9. A diversion of 0.3 cfs to the City of Greybull with a post 1910 water right priority is made at Node 9. The City of Greybull reports that they divert a constant 1 mgd.

Node 10. Diversions made at Node 8 return to Shell Creek at Node 10.

Node 11. Node 11 is a diversion for non-beneficial losses due to phreatophytes. A total of 233 ac of cottonwoods and saltgrasses were mapped along the Shell Valley upstream of the Whaley Ditch diversion. The diversion at Node 11 was set equal to the net irrigation requirement of these phreatophytes as computed in the water requirements section of the report.

Node 12. Small mainstem Shell Creek diversions above the Whaley Ditch diversion were "lumped together". The depletion resulting from these diversions was set equal to the net irrigation requirement for these crops. This is assumed to be valid because the diversions are relatively small and located near to Shell Creek so return flow is available to the next downstream diversion in a short period of time. Diversions at Node 12 are for small mainstem diversions having pre 1910 water rights:

User	W.R. Date		Acreage
Smith	1976	-	13 ac
Drwenski	1980	-	1 ac
Frieze	1887	-	26 ac
Kershner	1893	-	50 ac
Kershner	1895	-	157 ac
Rath	1895	-	57 ac
Frieze	1900	-	421 ac
Frieze	1900	-	31 ac 2/
Frieze	1908	-	4 ac
Rath and Early	1908	-	6 ac
Unknown	1/	-	8 ac
			774 ac

Net irrigation requirements for these lands are presented in the water requirements section. An additional 2 ac with a priority date of 1935 is located along the mainstem of Shell Creek. The demand for these 2 ac is insignificant and did not justify a separate post 1910 node.

1/ in use, no right

2/ idle

Node 16. Diversions to the Shell Canal having pre 1910 water rights were made at Node 16:

W.R. Date		Acreage
1886	-	153 ac
1887	-	222 ac
1893	-	55 ac
1897	-	419 ac
1897	-	8 ac1/
1899	-	166 ac
1905	-	465 ac
1905	-	123 ac
1905	-	3 ac1/
1907	-	20 ac
1908	-	489 ac
1908	-	56 ac1/
1909	-	1247 ac
1909	-	400 ac1/
		3826 ac

Diversions to the Shell Canal are based on calculated net irrigation requirements, on-farm and conveyance efficiencies and flexibilty factors. Calibration was accomplished using information developed as part of the USBR Total Water Management Study. Diversions were initially estimated by taking the weighted irrigation requirement times the acreage listed above and divided by the efficiency given in the water requirements section. These estimated diversions were compared to diversion records compiled during the USBR total water management study. The flexibility factors represent the ratio of historic diversion measurements to the calculated diversion estimates. It is assumed that these factors are representative

1/ idle

of other years during the study period of 1941-1980. Therefore, all estimated diversions were multiplied by these flexibility factors listed as follows:

Month	Monthly Flexibility Factor
May	2.3
June	1.2
July	0.9
August	1.2
September	3.1
October	3.6

Final diversion estimates were limited to a maximum of 1 cfs per 35 acres.

Node 17. A diversion equal to Whaley Ditch pre 1910 demand was made at Node 17. This limits diversions to the Shell Canal at Node 18 to a post 1910 water right priority.

Node 18. Post 1910 rights along the Shell Canal are diverted at Node 18:

W.R. Date		Acreage
1941	-	73 ac
1959	-	33 ac
1963	-	23 ac
		129 ac

Diversion requirements were calculated as described for Node 16.

Node 19. Diversions made at Node 17 return to Shell Creek at Node 19.

Node 20. Pre 1910 Whaley Ditch diversions are made at Node 20:

W.R. Date		Acreage
1889	-	127 ac
1893	-	523 ac
1899	-	100 ac
1901	-	176 ac
1905	-	14 ac
1906	-	79 ac
1906	-	30 ac
		1019 ac

Diversion estimates were prepared in the manner described for Node 16. The same flexibility factors were used for Shell Canal and Whaley Ditch.

Node 21. Diversions for the remaining post 1910 Whaley Ditch demand is served from Node 21:

W.R. Date		Acreage
1945	-	26 ac
1948	-	7 ac
		33 ac

The demands were calculated as described for Node 20. Diversions were estimated as for Node 16, with the exception that the diversions were limited to 1 cfs per 70 acres.

A sample HEC-3 output for one year is provided in Appendix I.

Reservoir Yield

Operations studies are a function of reservoir size and project demands for irrigation, instream flow and minimum pool. The reservoir was operated at various sizes to determine the optimum size needed to satisfy project demands. Active storage fell within the range of 1571 AF (existing) up to approximately 5000 AF (topographic potential). The existing pool has a priority date of 1910 and the enlargement was assigned a priority of 1984.

Irrigation demand was determined as described in previous sections. The goal of these operation studies was to meet these demands in eight out of ten years. Demands were diverted at the project canal headgates.

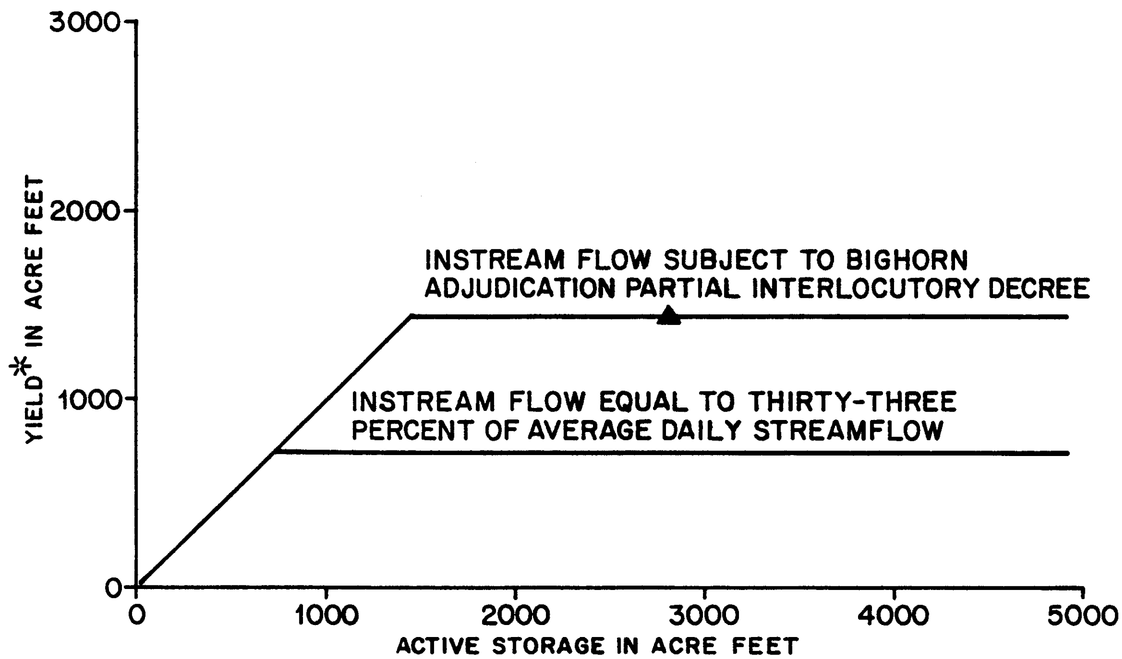
Operation studies were conducted at two instream flow levels. First, instream flows subject to the limitations imposed by the Big Horn Adjudication Partial Interlocutory Decree were considered. A review of the document and discussions with the State Engineers Office indicate that the enlargement of Adelaide Reservoir would receive a senior water right to the instream flows found in the decree. For the purpose of evaluating the enlargement of Adelaide Reservoir, this is the same as saying there is no instream flow requirement. Secondly, instream flow was set equal to thirty-three percent of the average daily streamflow for a given calendar month or reservoir inflow, whichever is lessor. This was accomplished by removing thirty-three percent of the streamflow from the model.

Operation studies were performed with the following minimum pool criteria. First, no minimum pool requirement was used except for the dead pool at the outlet works elevation of 219 AF located below the outlet works. Secondly, the minimum pool volume was established at twenty percent of the total pool volume. Thirdly, the minimum pool was set in order that the twenty percent minimum pool could be met in eight out of ten years.

All permutations of these criteria were addressed in the operation studies. The results of these studies are discussed below.

Yield is the amount of water that can be supplied from the reservoir during the study period 1941-1980. This was determined by reviewing the critical period of the study period. The operation studies indicate that the critical period occurred in the early 1960's. The studies indicate that demands in 1960 were high enough to deplete reservoir storage, even with the Adelaide Reservoir sized at the topographic potential. Therefore, in the year 1961, which had high net irrigation requirements like those of 1960, there is no carryover storage and the amount of water that can be supplied (yield) is equal to the amount of reservoir inflow only. With instream flow requirements subject to the Bighorn Adjudication Interlocutory Decree, the storable inflow is 1444 AF. With instream flow equal to thirty-three percent of average daily streamflow, the storable flow is equal to 710 AF. The proposed reservoir size has no impact on yield because under either instream flow requirement, the storable flow is less than the existing active storage pool. Minimum pool requirements do not impact yield either. Refer to the storage-yield curve (Figure IV.9).

In order to better understand the impacts of enlarging Adelaide Reservoir, a plot of storage versus percent chance water supply was developed (Figure IV.10). The figure indicates that with instream flow requirements subject to the Bighorn Decree, project demands can be met in eight of ten years. With the minimum pool set equal to the dead pool of 219 AF, the required total storage volume would be 3019 AF (an increase of 1229 AF). With the minimum pool equal to twenty percent of the total pool volume, the total reservoir storage would be 3500 AF (an increase of 1710 AF). The proposed reservoir enlargement described in this report is based on a total pool volume of



▲ 80 Percent chance full water supply to SVWID Lands diverting from Shell Creek.

* Yield is the amount of water that can be supplied from the reservoir during the study period 1941-1980 based on the critical year of 1961. YIELD curves were not extended further because topographic potential was reached.

LAKE ADELAIDE DAM

STORAGE-YIELD CURVES

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FIGURE IV.9

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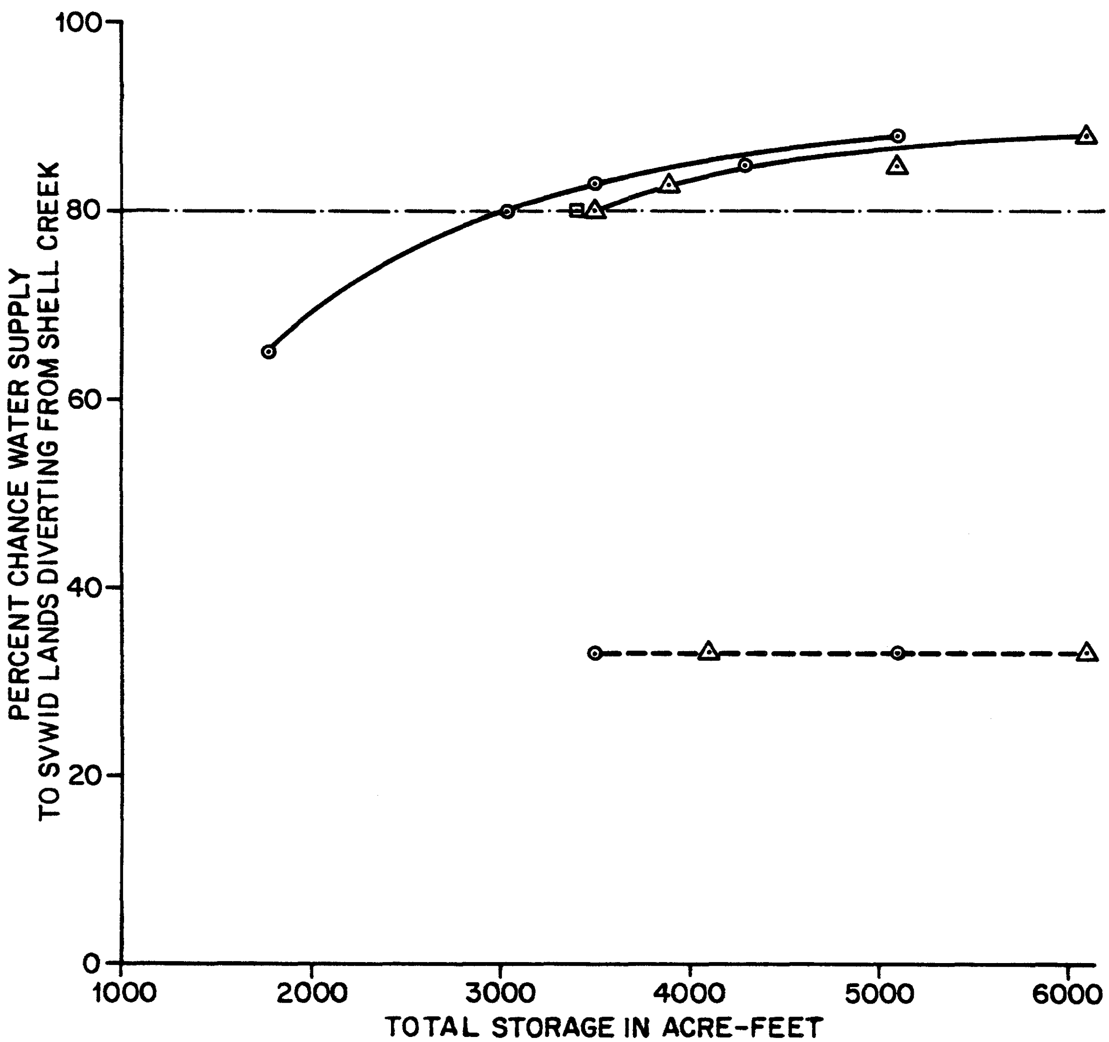

▣ Minimum Pool Volume Twenty Percent of Total Pool Volume in 8 Out of 10 Years

⊙ Dead Pool at Outlet Works Level (219 AF)

△ Minimum Pool Volume Twenty Percent of Total Pool Volume in All Years

——— Instream Flow Subject to Bighorn Adjudication Partial Interlocutory Decree

– – – Instream Flow Equal to Thirty-three Percent of Average Daily Streamflow

LAKE ADELAIDE DAM

STORAGE-PERCENT CHANCE WATER SUPPLY CURVES

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FIGURE IV.10

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3500 AF. The figure also shows that with instream flow set equal to thirty-three percent of average daily streamflow, a full water supply can be supplied to project lands in only 3.5 out of 10 years as compared with 6.5 out of 10 years under current conditions. In order to meet the 20 percent mininum pool criteria in 8 out of 10 years and satisfy demands in 8 out of 10 years, a total storage volume of 3420 AF would be required.

WATER QUALITY

Water quality for irrigation in the upper diversions near Shell is excellent. The water quality degrades as the stream progresses to the Greybull River, primarily from concentrating effects and return flows from irrigation. Examination of water quality records for Shell Creek near the Greybull River from 1965 to 1982 indicate that the water is suitable for irrigation. Total dissolved solids (TDS) are typically highest during the low flow periods of August and September. A typical low flow TDS is 1000 to 1100 ppm. Electrical Conductivity (EC_w) is typically 1400 to 1500 micromhos. The EC_w will not cause a yield reduction for barley, corn, sugar beets or alfalfa (See Ayers, 1975 ASCE Specialty Conference). The Sodium Adsorption Ratios (SAR) are within recommended guidelines and will not cause soil permeability problems. No salt exists in concentrations that would cause root or foliar toxicity. Dissolved nitrate concentrations are commonly below levels which may affect sugar beet quality. In summary, the water is suitable for irrigation throughout the length of Shell Creek.

V PLAN OF DEVELOPMENT

CHAPTER V
PLAN OF DEVELOPMENT

PHYSICAL PLAN

The selection of a plan for rehabilitation of Lake Adelaide Dam considered several design objectives. The first consideration was to size the dam to provide an 80% chance diversion requirement to the irrigated lands diverting from Shell Creek. This requires enlarging Adelaide Reservoir to a total capacity of 3500 AF as described in Chapter IV, Water.

A second consideration was the spillway system with respect to current Dam Safety Standards. Because of the size of the dam and potential for damage and loss of life downstream, the spillways were designed to safely accommodate the Probable Maximum Flood. This is accomplished by use of flood surcharge storage, discharge through the principal spillway and excavation of an auxiliary spillway in the borrow area south of the dam. The principal spillway consists of an 8 foot and 5 foot diameter glory hole incorporated into the outlet works system. This spillway is designed to handle the 100 year flood frequency events.

A third consideration is rehabilitation of the outlet works and enlargement of the dam without taking the existing dam out of service. Improvement of the existing outlet works can be made by jacking a cement-mortar lined steel pipe into the existing conduit. An inclined service gate will be installed on the upstream side of this pipe for control of outlet works releases. A new larger outlet conduit will be installed beneath the new embankment to enlarge the dam.

The embankment to enlarge the dam will be placed on the downstream side. However, the first order of business will be construction of a cutoff trench to minimize the underseepage now occurring. This trench will consist of either a combination of excavation and drilled caisson wall or a slurry wall. Then the embankment can be brought up to an elevation approximately 20 feet higher than the existing dam crest.

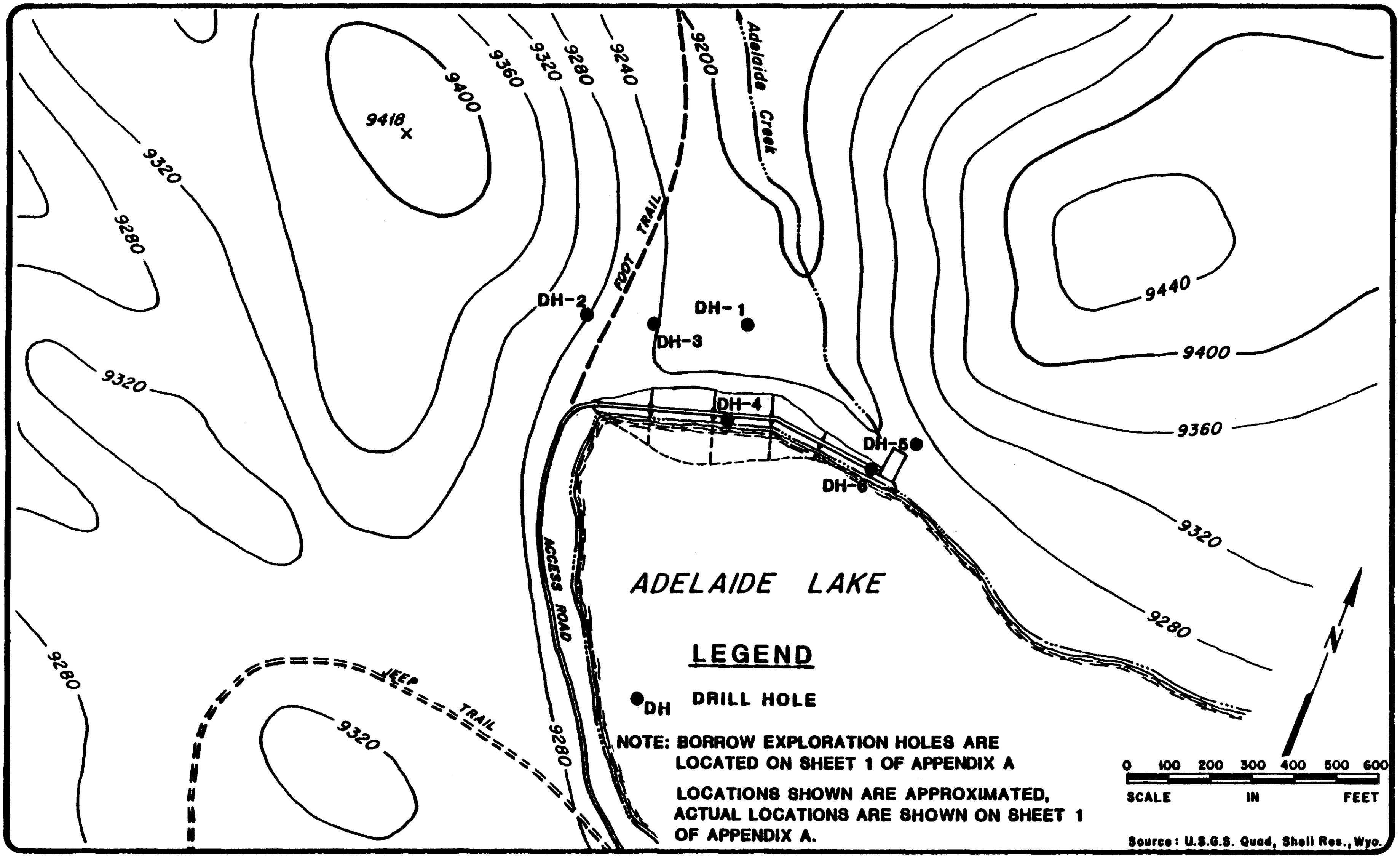
GEOTECHNICAL INVESTIGATION

A field exploration program was performed during the period from July 23 through August 14, 1984. The purpose of the program was to identify the existing soil profile and engineering soil characteristics on which to base design criteria for enlarging Lake Adelaide Dam. This investigation consisted of exploration borings using a truck mounted drill rig, and a geologic investigation. This section of the report summarizes the work performed during these field investigations. The findings during these field investigations are summarized in the subsequent sections.

Exploration Borings

The field drilling program included 16 exploration borings located as shown on Figure V.1 and on Sheet No. 1 in Appendix A of this report. The locations and elevations of the borings were surveyed by HKM Associates.

The drilling was performed by Rollins, Brown & Gunnell, Inc., (RBG) Provo, Utah under the direction of an HKM professional engineer and professional geologist. The drill rig used was a truck mounted CME-55. The borings were advanced using an NX (2.97 inches O.D.) size rock bit and core barrel.



LAKE ADELAIDE DAM

FIELD EXPLORATION PROGRAM

10M183.105

NOVEMBER 1984

FIGURE V.1

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The borings were extended to depths of from 5.0 to 78.5 feet. Ground water levels were measured and soil samples were taken for field classification during the field drilling. Continuous logs of the holes were made and are detailed on the Logs of Exploration Holes, Sheet No. 1 in Appendix F.

Standard penetration resistance tests (N values on logs) were conducted in the exploration borings to obtain soil samples and to provide an indication of the relative density and strength of the subsoils. Several disturbed samples were also recovered from the drill cuttings. Undisturbed 2.5-inch diameter, thin-walled tube samples were recovered from the existing embankment fill and NX core samples were obtained in the foundation and abutment bedrock materials as the drilling progressed. The samples were carefully sealed in plastic to preserve their natural moisture content. The undisturbed tube samples were sealed and carefully boxed for transportation.

All samples recovered during the exploration program were then taken to HKM laboratories and inventoried. A few samples, selected for engineering strength tests, were sent to RBG laboratories in Provo, Utah for testing. The remainder of the samples were analyzed for physical characteristics at the HKM laboratory. Photos of the NX core samples can be examined in the design file at the HKM Associates office in Billings, Montana.

Six (6) of the holes, Drill Hole (DH) Nos. 1-6, were made at the area of the existing embankment to investigate the foundation and abutment conditions for the proposed improvements. Ten (10) borrow exploration holes were made on the west side of the lake to evaluate potential construction materials. The informational goals of each of these holes is described in Table V.1.

Table V.1

Informational Goals of Exploration Borings

Drill Hole No.	Purpose
1	To investigate the foundation at the new dam axis, and to evaluate stability and seepage control needs
2	To investigate the left abutment at new dam axis and determine suitability for the new embankment
3	To investigate the foundation and seepage along the new dam axis
4	To investigate the center section and foundation of the existing dam; critical for stability analysis
5	To investigate the right abutment of the proposed axis
6	To investigate the right abutment of the existing dam
101-103, 105	To investigate an original borrow area and evaluate the soils for construction material
104, 106-108	To investigate the potential spillway and to evaluate the material as borrow.
109	To evaluate a new potential borrow area
110	To investigate an alternative spillway site and evaluate the materials for potential borrow

The locations of DH Nos. 1-6 were selected by HKM and approved by personnel from the Wyoming Water Development Board and the Forest Service prior to drill pad construction and drilling. Lath was placed at each hole for identification. Drill pad construction is described later in this section.

<u>Field Permeability Tests</u>

During the subsurface investigation, in-place permeability tests were performed in the embankment soils, the overburden soils and in the bedrock. The purpose of these tests was to determine the consistency of the soil permeability rates and to establish criteria for seepage analyses. These tests were performed in accordance with procedures used by the U.S. Bureau of Reclamation Designation E-18. Water losses were measured, in gallons per minute, using constant pressure heads. The results of the permeability tests are presented on the Log of Exploration Holes shown on Sheet No. 1 of Appendix F. The results of this information was used to calculate seepage quantities.

<u>Drill Pad Construction</u>

Drill pads were constructed at DH Nos. 1, 2, 3 and 6 for the purpose of access by the drill rig. These pads were constructed using a crawler tractor with a dozer blade. The pads were constructed with a balanced cut and fill except at DH-6 where fill was hauled to the pad from the old borrow area located west of the reservoir.

Trees were removed from the pad area by pushing them over with the dozer or by cutting. Removal of these trees was approved by the Forest Service prior to the pad construction as described previously in this section.

Monitoring Tubes and Hole Completion

Monitoring tubes were placed in DH 1-6 to monitor piezometric ground water surfaces. These are 3/4 inch diameter schedule 40 PVC pipes, slotted in the lower end. Two tubes were placed in DH-4 to monitor the pressure head at different elevations in the same hole. Each tube was plugged on the lower end and capped on the upper end with a push-on cap. A collar was also placed around the upper end of the tube to provide future access as described in the next subsection.

The depths of the drill holes and installed monitoring tubes are summarized in Table V.2, Drill Hole Completion. This information is also detailed on the Logs of Exploration Holes, Sheet 1 of Appendix F. All the hole are backfilled with on-site silty or clayey sand and gravel.

Table V.2
Drill Hole Completion

Drill Hole	Hole Depth (ft)	Monitoring Tube Depth (ft)	Perforation/Material
1	60.5	58.5	Perforated below 5', in foundation gravel
2	58.5	58.5	Perforated in bottom 20', in abutment bedrock
3	58.0	58.0	Perforated in bottom 20', in foundation
4	78.5	78.5	Perforated in bottom 20', in bedrock
4	78.5	78.5	Perforated in bottom 10', in sandfill
5	60.0	60.0	Perforated in bottom 20', in abutment bedrock
6	50.0	50.0	Perforated in bottom 20', in abutment bedrock. Gravel backfill from 15 to 50', sandfill above 15'

Table V.2 (continued)

Drill Hole	Hole Depth (ft)	Monitoring Tube Depth (ft)	Perforation/Material
101	10.5	none (-)	Backfilled with drill cuttings
102	5.0	--	
103	20.0	--	
104	20.0	--	
105	7.5	--	
106	8.0	--	
107	21.0	--	
108	9.5	--	
109	10.0	--	
110	20.0	--	

NOTE: Hole locations for DH 1-6 are shown on Figure Hole location for DH-101 through 110 are shown on Sheet 1 in Appendix A.

Drill Hole Caps

Collars and caps have been constructed for each of the drill holes. The collars consist of a 6 inch diameter casing about 2 feet long placed around the top of each monitoring tubes to allow future access. Push-on caps have been placed both on the 6 inch casing and the 3/4 inch tubes. The caps are buried below ground to reduce vandalism. A metal pin is buried adjacent to the cap to enable location by metal detector, if required. An exception to this procedure was warranted at Drill Hole No. 1 where the cap is about 6 inches above ground to reduce the potential for inundation during high volume discharge from the low level conduit.

Reclamation

Reclamation was performed throughout the entire work area on August 14, 1984. This work consisted of:

- Shaping the drill pads
- Filling wheel ruts
- Limbing the trees
- Reseeding disturbed areas

The drill pads were regraded where appropriate to conform to the natural topograph. The pad at DH-1 was left approximately level (originally had about 2:1, horizontal to vertical) to allow rapid revegetation. Wheel ruts were also graded to approximately conform to the original contour. Near the stream channel, the ruts were not completely filled.

All trees which had been cut down or pushed over by the dozer were limbed with the exception of a few branches on the undersides of some large trees. Additionally, trees which had been cut down or pushed over along the sides of the access road were limbed.

Seed was spread over all disturbed areas at the damsite. This included, drill pad, wheel ruts, stream banks, camping area access trails and the disturbed original borrow area. The seed was a mix variety which was specified by the Forest Service. It was spread by hand broadcasting at a rate of about 16 lbs per acre.

The seed mix consisted of:

- 1 lb sweetgrass
- 5 lbs brome grass
- 5 lbs bluegrass
- 5 lbs orchard grass

GEOLOGIC INVESTIGATION

Geologic Setting

The reservoir is formed in a glacial basin in Precambrian granitic terrain along the west edge of the crest of the Bighorn Mountains. With the exception of scattered small areas of bedrock outcrops, glacial deposits form the valley walls and valley floor below the dam. These deposits consists of a heterogeneous mixture of silt, sand and rock. Undoubtedly, the glacial deposits form the valley floor beneath the reservoir. Minimal clay was noted in the glacial deposits during this investigation. The silt and sand are angular crystals and appear to be the result of weathering of bedrock evenly dispersed across the valley floor during and after glacial transport. No evidence of alluvial deposits in the valley floor was noted other than the armoring immediately underlying the stream proper.

The Bighorn Range consists of an exposed northwest-trending core of metamorphic and igneous rocks of Precambrian age with a thick overlying sequence of Paleozoic and Mesozoic sedimentary rocks along its flanks. The sedimentary rocks dip away from the core into bordering basins where they are covered by continental sedimentary rocks of Tertiary age that lap onto the sides of the range and in some localities onto the crystalline core.

The crystalline rocks of the core exhibit a long and complex Precambrian history of regional and local metamorphism, plutonism, and tectonism. Subsequent erosion formed a rather uniform surface of low relief. During Paleozoic and most of Mesozoic time, the Precambrian rocks were part of a stable platform upon with a thick succession of sedimentary rocks were deposited. The present day Bighorn Range began to form in Late Cretaceous time, by upwarping of the range and downwarping of large basins to the east and west. (Kilsgaard, Ericksen, Pattern and Bieniewski, 1972, Mineral Resources of the Cloud Peak Primitive Area, Wyoming USGS Bulletin 1371-C.)

Local Geology

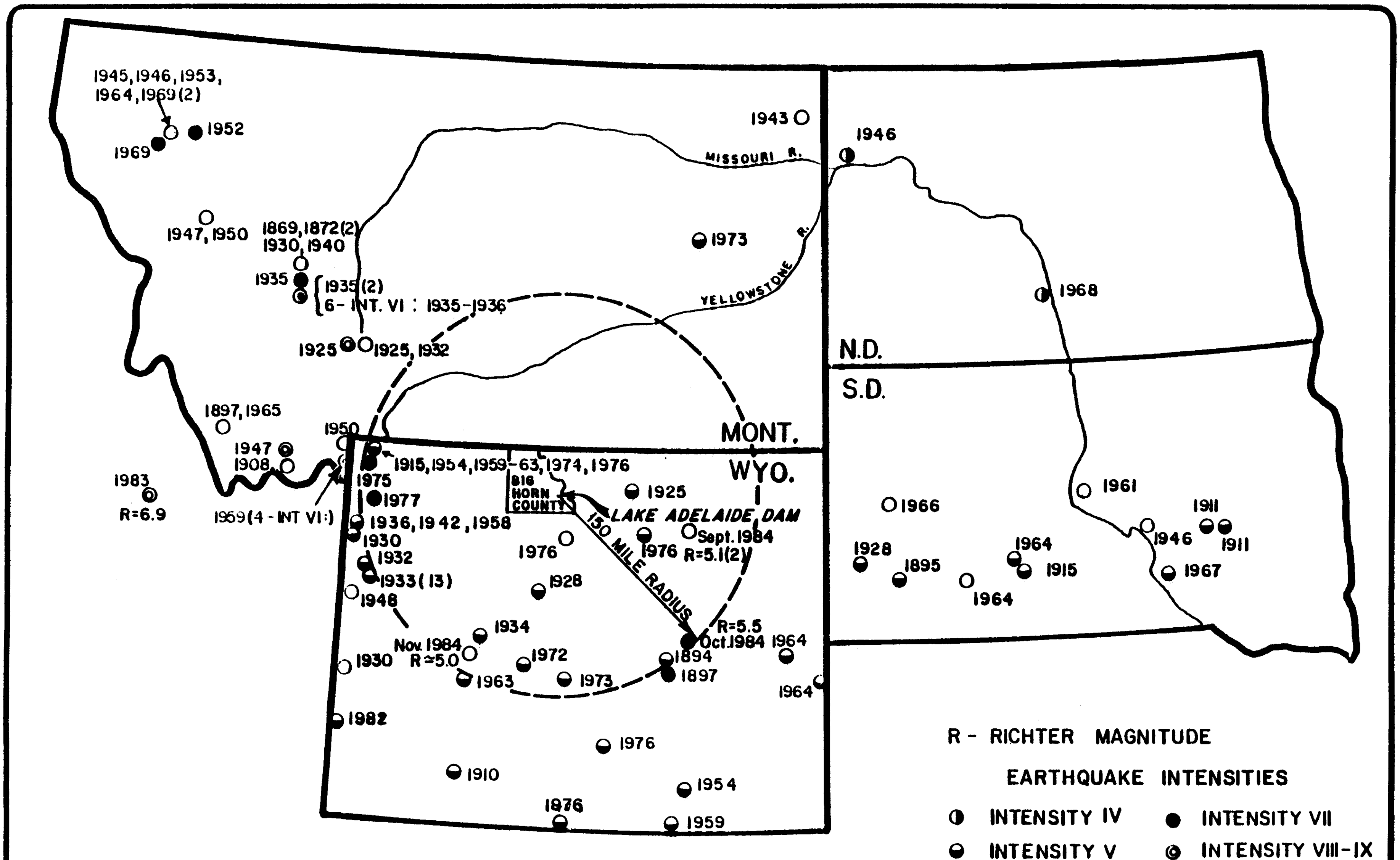
The core of the Bighorn Range is underlain by a complex of rocks. In the Lake Adelaide area, granitic rocks are dominant. Gray biotite granite is the principal granitic rock, although red granite, gray quartz diorite, and quartz monzonite are common. This lithologic variation is evident in the Lake Adelaide area as bedrock in the left abutment is a red granite while the bedrock forming the left abutment is a gray quartz monzonite.

Glacial deposits cover the left abutment. The right abutment, however, is exposed and is a steep slope composed of large talus blocks. In-place bedrock on the right abutment exhibits a random joint pattern and the talus blocks are the result of breakage along these zones of weakness. No prominent faults were noted in the reservoir area. The great majority of the basin is covered by glacial deposits which would mask evidence of faults.

Examination of cores obtained during the drilling program shows the bedrock is highly weathered to depths of about 20 feet below the bedrock surface. Fracturing and joints also extend beneath the surface. However, the fractures and joints have healed due to the formation of clay minerals and as a result, the bedrock is relatively water tight.

Historic Seismicity

A history of earthquakes in the region has been obtained from the National Geophysical and Solar Terrestrial Data Center in Boulder, Colorado. The history indicates that about 13 events with intensities of V or greater have been recorded within a 150 mile radius of the embankment as shown on Figure V.2. Apparently no earthquakes have occurred within the recording period with Richter magnitude greater than 6. Some large earthquakes have occurred in the Yellowstone Park area at locations near or slightly more than 150 miles from the site.



SOURCE: U.S.G.S. Earthquake Information Bulletins and National Geophysical and Solar Terrestrial Data Center

LAKE ADELAIDE DAM

AREA SEISMICITY MAP

10M183.105 NOVEMBER 1984

FIGURE V.2

HKM ASSOCIATES
ENGINEERS·PLANNERS

Based on the information available, little or no quantitative data exists as to how the damaging action of an earthquake in the site area may diminish as a function of distance between the dam sites and the epicenter or fault where the waves are generated. The following relationship represents a probable attenuation of damaging action.

Radial Distance From Epicenter/Fault	Probable Attenuation of Damaging Action
	Lake Adelaide Dam may experience:
0-10 miles	No diminuation of damaging movements which may occur at the fault.
at 50 miles	50 to 75% of the damage which could be expected near the fault.
at 150 miles	Little damage compared to what could be expected near the fault.

Seismic Design Considerations

Lake Adelaide Dam is located in seismic zones 2 as identified by the U.S. Corps of Engineers seismic zone map. Zone 2 exhibits potential for moderate damage from seismic action. Based on the seismic history and the moderate potential for damage, a seismic coefficient of 0.05 was used to represent the horizontal acceleration created by seismic waves during an earthquake event. This value is applied in the psuedostatic method of analysis for embankment stability described later in this report.

GEOTECHNICAL ANALYSIS

Laboratory Analysis

Representative field samples were selected for laboratory testing after careful visual examination of the soil and consideration of the design criteria. The physical soils property tests were performed in the HKM laboratory and the engineering property tests were performed by Rollins, Brown and Gunnell, Inc. in Provo, Utah.

Test	Purpose of Test
Natural Moisture Content (ASTM D-2216)	To determine the natural (in situ) water content and to correlate the moisture contents with the phreatic surface.
Atterberg Limits (ASTM D-423 & D-424)	To provide an indicator of the shear strength and compressibility of the soil.
Particle-Size Distribution (ASTM D-422)	To determine the grain sizes of the soils for classification and identification of physical characteristics.
Natural Unit Density (ASTM D-2937)	To determine the (in situ) dry unit weight of the soil.
Unconfined Compression (ASTM D-2938)	To determine the shear strength parameters of the bedrock.
Moisture - Density Curve (ASTM D-698)	To determine the relationship of water to the density of soil during a compaction or remolding process.

Test	Purpose of Test
Direct Shear (ASTM D-3080)	To determine the consolidated drained shear strength of the soils.
Triaxial Shear	To determine the consolidated drained shear strength of the soils.

The laboratory tests were performed in strict accordance with applicable ASTM procedures. A Summary of the Laboratory Test Results is presented on Sheet No. 1 of Appendix F. Additional test data for individual tests is detailed on Plate Nos. 1-15 of Appendix F.

Subsurface Conditions

General. This section of the report describes the physical and engineering characteristics of the subsoils. These characteristics were determined by field and laboratory tests. Laboratory test results indicating the physical characteristics of the soils are presented in plates 1-15 in Appendix F. A reference relating the laboratory test results to the material in the field is presented on Table V.3.

Table V.3
Reference of Laboratory Soils Test Results

Zone Material	Plate No. (Appendix F)
Foundation sand	1, 2 & 4
Foundation gravel	5
Existing embankment	3 & 6
Original and potential borrow source	7, 8, 13 & 15
Proposed spillway excavation and potential borrow sources	9, 10, 11, 12 & 14

Ground water measurements are also presented in this section of the report. The presence of water in the foundation abutments and the existing embankment are also described.

Embankment Soils

Existing Embankment. The existing embankment is a homogeneous rolled earthfill structure 719 feet long, 31 feet high at maximum section and 15 feet wide at the crest. Test results indicate that the embankment soil is a gravelly sand with a 8 to 10 percent fines, passing the 200 sieve. Tests indicate that the material is granular, nonplastic. This material has a dry unit weight of 125 pounds per cubic foot and an internal angle of friction of 36°.

Standard penetration resistance (N values) tests performed in the embankment indicate values range from 7 to 18 blows per foot. Permeability test results indicate values vary from 44 to 1900 feet per year, an average rate of about 80 feet per year appears to be representative of this material.

In Drill Hole No. 4 organic material was encountered at a depth of 28.5 feet. The presence of this material suggests that all of the topsoil may have not been removed at the time of the original construction.

The embankment is considered semi-pervious based on a representative permeability rate of about 80 feet per year.

The following classifications are generally used, particularly by the U.S. Bureau of Reclamation, to describe the permeability of soils:

Permeability in Feet Per Year	Description
less than one	impervious
1-100	semi-pervious
greater than 100	pervious

Riprap. The riprap on the upstream face of the dam is a well indurated monzonite (granite). It is loose rock with an estimated average size of about 8 inches in diameter. It appears to be approximately 1-1/2 feet thick and it is underlain by the gravelly sand described in the previous subsection.

Abutments

Left Abutment. Both abutments consist of bedrock overlain by thin layers of glacial material. The left and right designation for the abutments is determined by looking downstream.

Glacial Deposits. Findings indicate that the left abutment is composed primarily of monzonite overlain by sandy gravel. The gravel has a permeability ranging from 16 to 6600 feet per year and averaging about 2000. N values range from 50 to near 100 blows per foot. The gravels, cobbles and boulders are typically subrounded to angular.

Bedrock. The monzonite bedrock has a permeability of from about 1 to 11 feet per year. The rock quality designation (RQD) varies from 70 to 100 percent and averages about 95 percent. The permeability test results and the RQD suggest that this material is competent and will provide an adequate abutment for the proposed structure.

The RQD is a method of estimating the insitu rock quality. RQD values are presented on the Logs of Exploration Holes sheet of Appendix F. The relationship between these values and the rock quality is represented in Table V.4.

Table V.4

Rock Quality

RQD (%)	Rock Quality
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
0-25	Very Poor

Right Abutment.

Glacial Deposits. Bedrock outcrops high on the right abutment. A sand and gravel glacial material covers the lower areas between the boulders. The glacial material is a relatively thin (7.8 to 16.5 feet in DH Nos. 5 and 6) layer of very dense sandy gravel and large loose boulders. The boulders are up to 20 feet in diameter.

Bedrock. The bedrock in the right abutment consists of fractured granite. This rock is fractured to a depth of at least 60 feet. The rock quality designation for this material varies from 0 to 92 and averages about 50. This suggests that the quality of the rock is fair. The dry unit weight of this rock is 158 pounds per cubic feet. The unconfined compressive strength is 77 kips per square foot.

Permeabilities in the right abutment are also low suggesting that very little water is seeping through the highly fractured rock. Results of the permeability tests indicate that the rate in the upper 10 feet of the bedrock is about 1900 feet per year. The average permeability in the bedrock below a depth of about 10 feet is only about 4 feet per year. Close examination of rock cores taken from the right abutment indicate that the fractures are filled with a clayey sand material which has effectively decreased the permeability of the rock.

During the field investigation several very small springs were observed in the rock outcrop on the right abutment. These springs appear to be merging from fractures in the rock. These springs will be accounted for in the design of the right abutment of the proposed structure.

Landslide. An ancient landslide has been identified on the right abutment. This slide is very old and appears stable at present. It appears that the failure plane of the slide is relatively deep within the abutment. Cores taken from drill hole no. 5 in the right abutment suggest that the slip plane may be as deep as 35 feet. Because considerable glacial material has been deposited in the valley floor, a large amount of weight has been added to the toe of the slide, thus creating stable conditions.

In the design configuration of the proposed structure, the contact area between the embankment and the slide may be reduced by paralleling the existing embankment. This would place the proposed embankment slightly upstream of the slide area. A portion of the downstream toe of the proposed embankment will be in the area of the slide. However, this encroachment does not appear to pose a significant risk to the structure.

Foundation

The foundation material in the valley floor consists of silty sand and sandy gravel underlain by bedrock at a depth of about 48 feet. Permeabilities in the sandy gravel are very high and extremely variable. Test results varied from 100 to 55,000 feet per year. In general the permeabilities appear to be higher as shown on Sheet No. 7 of Appendix A.

N values in these material were very high with an average of near 100 blows per foot. In general the foundation soils appear to be of high internal strength and to have low compressibility.

Bedrock in the foundation area consists of monzonite. Under the existing embankment this monzonite appears to be highly weathered with an RQD averaging about 28 indicating poor quality. The dry unit weight is 142 pounds per cubic foot. The unconfined compressive strength of the monzonite is 59 kips per square foot. The permeability test results indicate rates of less than 100 feet per year throughout the monzonite bedrock in the foundation area.

In the area of DH-1 (at the downstream toe of the proposed embankment) the bedrock quality is higher. The RQD averages 87 and the permeability is less than 4 feet per year.

Borrow Areas

Proposed Spillway Area. The predominant material along the alignment of the proposed spillway (DH 104, 106-108) is silty sand. At isolated locations (DH-7) a sandy gravel was encountered underlain by silty sand at a depth of about 13 feet. Many large cobbles and boulders are scattered throughout the area. The silty sand has 15-19 percent passing the No. 200

sieve and is granular nonplastic. The maximum dry density is about 134 pounds per cubic foot (Plate No. 14) with an optimum moisture content of 7.4 percent. This material could provide a high strength semi-pervious soil compacted into the proposed embankment.

Alternate Borrow Sources.

An original borrow area, located in the area of DH - 101, 102, 103 and 105, contains predominantly silty sand similar to the sand previously described in the proposed spillway area with slightly more fine material (25%). Many large cobbles and boulders are scattered throughout this area. Processing of this material would require screening off the larger (+ 6-inch) material.

Borrow materials in the areas of DH 109 and 110 are very similar to the silty sand previously described. The distance from these borrows areas to the proposed axis is greater.

GROUND WATER AND SEEPAGE

Ground water elevations were measured at the time of completion of the exploration holes. At the conclusion of the field exploration each of the holes were again measured to determine fluctuations on the ground water levels. Table V.5 presents the original measured elevations and the water levels measured on August 14, 1984.

Table V.5

Ground Water Measurements

Drill Hole No.	Depth Upon Completion (ft)	Depth 8/14/84 (ft)
1	4.0	4.0
2	24.0	24.0
3	10.7	10.7
4 (alluvium)	7.0	12.5
4 (bedrock)	7.0	24.0
5	10.9	10.9
6	9.8	9.8

Based on these readings the phreatic surface through the embankment appears to be high. Ground water appears to be seeping from the downstream toe of the embankment in small rivlets. It does not appear that any of the seepage is carrying fines with it, suggesting that piping is not a problem. Ground water at the toe of the existing embankment is at the ground surface along most of the length of the structure. The ground water elevations throughout the foundation area of the proposed structure appear to be at or near the ground surface.

Ground water in the left abutment does not appear to be a problem. Permeabilities in the right abutment suggest that seepage is not a problem. However, because of the presence of seepage and a highly fractured nature of the right abutment, it appears prudent to include a drainage system in the design of the right abutment contact.

DESIGN

Dam Enlargement

Available Material. As indicated earlier in this report, the dam site is located in a glaciated area and the only material available for construction of a dam is a silty gravelly sand. Tests performed on the available material indicate that the amount of silt and clay size particles varies from about 15 to 23 percent; the amount of sand particles varies from 58 to 60 percent, while the gravel is in the range of 17 percent. The existing embankment was constructed from the silty sand, and laboratory tests performed on samples of this material indicate a textural range similar to that indicated above. Field permeability tests performed on the material in the existing embankment varied from 44 feet per year to 990 feet per year.

Laboratory tests performed on the silty sand densified to 95 percent of the maximum laboratory density, as determined by ASTM D 698, indicates a permeability coefficient of 5.6 feet per year. This permeability coefficient is considerably less than the permeability coefficient obtained from the material within the embankment, and the differences between the field and laboratory permeability coefficient can partially be accounted for by the differences in the in-place density condition.

Embankment Cross Section. Since the selection of the materials in the immediate vicinity of the site is limited, a homogeneous type structure is contemplated for the proposed embankment modification. Side slopes of 3 horizontal to 1 vertical have been used for the upstream slope, and 2 horizontal to 1 vertical have been used for the downstream slope. The adequacy of these slopes will be demonstrated later in the report.

It should be recognized, that while material within the modified embankment section is relatively homogeneous, the entire structure, including the existing facility and the foundation, is heterogeneous and anisotropic. It is expected that the permeability coefficients of the modified embankment section will be considerably less than those for the existing structure and that the permeability coefficients for the foundation will be many times greater than the embankment materials.

Dam Alignment. The topography of the dam site along with the existing dam is presented on Sheet 1 of Appendix A. It will be observed that the topography narrows sharply where the existing dam is located and continues downstream for a considerable distance. The existing topography dictates that the dam be enlarged by construction downstream from the existing centerline. As indicated earlier in this report, the dam will be raised 20 feet in order to obtain the required storage. A plan view of the proposed enlargement is also shown on Sheet 1 of Appendix A. The alignment shown constitutes the only feasible alignment for the proposed facility.

Foundation Treatment

Cutoff Trench. The results of the subsurface investigation indicate that the depth of the bedrock through the maximum section is relatively deep. The subsurface investigation also indicates that the permeability of the overburdened material is relatively high with permeability coefficients varying from 7,000 to 55,000 feet per year. Visual observations downstream from the existing structure indicate that considerable seepage is occurring beneath this facility. It is necessary therefore, that any new construction must have as its basic objective the reduction of seepage in the overburden materials in the stream bed. This objective can be accomplished by excavating the existing granular materials and replacing them with the less pervious materials from the proposed borrow areas.

It should be noted that several problems exist in constructing a cutoff trench for the proposed facility. The only logical place to construct the cutoff trench is at the downstream toe of the existing facility. The cutoff trench must be constructed with side slopes sufficiently flat that instability problems will not exist. Furthermore, since considerable seepage is occurring through the foundation materials, the cutoff trench must be dewatered in order to permit the placement of the backfill material. Another factor which influences the construction of a cutoff trench in this area involves the nature of the overburden material in the area where the proposed cutoff will be located.

Results of the subsurface investigation indicate that a considerable number of large cobbles and boulders exist in the upper portion of the soil profile in this area.

We propose to dewater the site by constructing five drainage wells along the downstream slope of the existing facility. The approximate location of the drainage wells are presented in Appendix A. If the cutoff trench is excavated completely to bedrock along the maximum section, side slopes approaching 2 horizontal to 1 vertical are necessary to provide stable slopes on the upstream side of the excavation. This condition requires the construction of a cutoff trench approximately equal in volume to the dam enlargement above ground. An alternate to constructing a fully penetrating earth cutoff would be to construct a partial earth cutoff combined with a caisson wall extending to bedrock. Under this condition, a cutoff trench would have side slopes of 1.5 horizontal to 1 vertical and would extend to a depth of approximately 35 feet below the existing ground surface at the maximum section.

The profile of the dam enlargement along the proposed alignment is presented on Sheet No. 2 of Appendix A. The area to be covered by the caisson wall is shown in the profile in this figure. An alternate to constructing the caisson wall would be to eliminate it entirely. This consideration appears to have some merit since the results of the field permeability tests performed in Test Hole No. 1, which was located downstream from the cutoff trench area, indicate that the permeability coefficient of the subsurface material in the 20 foot section above the bedrock is substantially less than the permeability coefficient in the area where the partial cutoff trench is located.

An alternate to constructing either a partial or complete earth cutoff would be to use a slurry trench cutoff extending to bedrock. The proposed location of a slurry trench cutoff is shown as an alternate in Appendix A for various cross sections through the dam. The principle objection to a slurry trench cutoff is associated with the excavation of the large boulders in the subsurface material using the slurry trench excavating technique.

It is our opinion that considerable difficulty may be encountered in excavating the large boulders with the slurry trench excavating equipment. However, the cost for constructing a slurry trench may be less expensive than either a fully penetrating or a partially penetrating earth cutoff. The slurry trench should be considered as a primary approach for decreasing flow through the foundation materials. It is our recommendation, therefore, that either a slurry trench, or a partially penetrating earth cutoff with a caisson wall be considered for the proposed facility. Additional drilling may indicate that the boulders in the profile are not as extensive as the present subsurface investigation indicate and that a slurry trench cutoff may be more cost effective than an earth cutoff.

Foundation Grouting. The results of the field permeability test, performed during the subsurface investigation, indicate that the bedrock material has permeability coefficients generally less than 100 feet per year. It should be noted, however, that the subsurface investigations performed to date do not fully define the permeability characteristics of the right abutment. With the exception of this area, however, it is our opinion that the permeability of the bedrock materials is sufficiently low that grouting of the foundation bedrock is not warranted.

Our experience indicates that in general when the permeability coefficient is less than 100 feet per year, very little improvement can be obtained in the permeability characteristics of the bedrock material. For this reason, we recommend that no attempt be made to grout the foundation bedrock in either the left abutment or below the overburden materials in the stream bed. Additional drilling will be required to determine if grouting of the right abutment will be required.

Foundation Stripping. The major problem associated with foundation stripping exists along the right abutment. The bedrock conditions in the right abutment are very irregular with overlaps and protrusions dominating the surface conditions. In order to provide a satisfactory surface for compacting materials adjacent to the bedrock, the entire right abutment must be stripped to remove the irregular surface which exists in this area. It is anticipated that considerable blasting will be required to provide a relatively smooth slope at this location.

As indicated earlier in this report, considerable seepage is occurring through the foundation bedrock and the area downstream from the existing dam is in a marshy condition. Dewatering of the site will be required before stripping operations can be performed. The stripping operations should include removal of all vegetative matter which covers the site, along with the organic top soil throughout the area.

Internal Drainage

An adequate internal drainage system is essential for the stability of the proposed structure. The internal drainage system for the proposed facility includes: (1) Chimney Filter and Pipe Drains, (2) Right Abutment Drainage Blanket and (3) Right Abutment Drainage Wells.

Chimney Filter and Pipe Drains. Since the available embankment material limits the cross section of the embankment enlargement to a homogeneous type structure, it is imperative that a chimney drain be constructed within the embankment to prevent seepage water from intercepting the downstream face. The proposed location of the chimney filter for various cross sections is shown in Sheet No. 3, Appendix A. It will be observed that the chimney filter is 4 feet wide and has its upstream surface adjacent to the center line of the dam. The recommended gradation of the filter material for the chimney filter drain is shown in Sheet No. 3, Appendix A.

It is anticipated that processing of the material in the available borrow areas will be required to obtain the filter gradation indicated in Sheet No. 3, Appendix A. Since the cost of the filter material will be relatively high, the filter drain does not extend to the downstream toe of the proposed facility. We recommend that pipe drains be installed at locations as shown in Sheet No. 1, Appendix A, to permit any water entering the filter drain to be discharged to the downstream toe of the dam. The pipe drains are 8 inches in diameter and are located on a concrete cradle (see sheets 1 and 3, Appendix A). The details of the connection between the filter and the drain line are also shown in Sheet No. 3, Appendix A.

Right Abutment Drainage Blanket. As indicated earlier in this report, additional subsurface investigations will be required to fully define the permeability characteristics of the right abutment. The geology of the abutment, along with visual observation of the existing conditions, indicates that some seepage may occur through the right abutment. In order to eliminate the buildup of pore pressures between the embankment and the abutment, an abutment drainage blanket will be placed between the bedrock and the embankment fill downstream from the chimney filter. The location of this drainage blanket is shown approximately in Sheet No. 1, Appendix A.

As indicated above, stripping of the bedrock to provide a relatively smooth surface will be required before the placement of the drainage blanket can be performed.

Right Abutment Drain Wells. In the absence of more information on the permeability characteristics of the right abutment, we believe that drainage wells will be required in the right abutment to intercept any flow which tends to move around the right end of the dam. The drainage well will consist of a 4-inch hole extending to a distance of 100 feet into the right abutment. The 4 inch hole will be cased with 3-inch slotted PVC pipe. Each drainage well will terminate in the drainage blanket located along the interface between the abutment and the fill material. The location of the drainage wells, along with the typical section, are shown in Sheet No. 2 of Appendix A.

Slope Stability Considerations

A slope stability analysis has been performed for the following cases: (1) The downstream slope of the dam during the cutoff trench construction, (2) The upstream slope of the dam during sudden draw down, (3) The downstream slope of the dam during steady state seepage conditions and (4) A pseudostatic analysis for cases 2 and 3 above.

In performing the stability computations, a computer model of Spencers Method has been used. Spencers Method satisfies both force and moment equilibrium, and is considered to be a satisfactory method of slope stability analysis. The shear strength parameters for the proposed embankment material have been determined from triaxial tests, and the results of these tests indicate that if the material is densified to an in-place unit weight equal to 95 percent of the maximum laboratory density as determined by ASTM D-698, a friction angle of about 39 degrees is obtained with 0 cohesion. In performing the stability computations, a friction angle of 37 degrees has been assumed in the analysis for the embankment material.

The results of the subsurface investigation indicates that all of the overburden materials in the stream bed is granular type soils in a relatively dense condition. A friction angle of 36 degrees has been used to characterize this material.

Stability of the Existing Structure. Evidence exists that not only has seepage occurred through the foundation material below the base of the dam, but that the downstream slope of the embankment has been historically saturated. Local slumping of the downstream face has occurred which could have only taken place if the embankment materials were saturated. Evidence also exists which indicates that rock was placed in the scarp of a slide on the downstream portion of the dam in an attempt to stabilize the area. Saturation of the downstream face at first appears to be incompatible with the characteristics of the foundation material. As indicated earlier in this report, the permeability coefficient for the foundation materials are substantially greater than the permeability characteristics of the embankment. If the embankment were homogeneous and isotropic, the high pervious material in the foundation would tend to act like a large horizontal underdrain. The phreatic surface would then exist at the toe of the dam. The subsurface investigation indicated that the permeability characteristics within the embankment vary considerably, and that the distinct possibility exists that channelization can occur through the existing embankment. Under these conditions water channeling through the existing embankment would readily intersect the downstream face. This water would contribute to the slumping which has occurred. If the entire mass of sand on the downstream portion of the dam becomes saturated by continued seepage through this material a slope stability failure could occur again in this area. Furthermore, it is our opinion, that a factor of safety against a slope stability failure in this area is relatively low, and we recommend that if the project does not proceed as presently contemplated that remedial measures be taken to prevent saturation of the downstream face.

A possible approach to preventing saturation of the downstream slope is to use vertical drain wells located along the axis of the dam. A series of vertical drain wells located approximately 10 feet apart and extending into the pervious material in the foundation would tend to function like a chimney drain and prevent the saturation of the downstream face of the dam. Vertical drains have been used in a number of locations with success.

<u>The Downstream Slope During Construction of the Cutoff Trench</u>. A slope stability analysis has been performed for the downstream slope of the dam with a cutoff trench constructed on side slopes of 1 to 1 and 1.5 to 1. In performing this analysis, it has been assumed that the ground water level will be located at the base of the dam, upstream from the wells. The approximate location of the cutoff trench for the maximum section is shown in Sheet No. 3, Appendix A. The results of the stability analysis indicate that the factor of safety for the partial cutoff trench having side slopes of 1 horizontal to 1 vertical is about 1.05. If the side slopes are flattened to 1.5 horizontal to 1 vertical, and if the drainage wells are effective in intercepting the seepage occurring through the

foundation materials, a factor of safety of about 1.25 is obtained. The failure surface for this condition is shown in Sheet No. 5, Appendix A. While this factor of safety is not sufficient for long term stability it will be adequate during construction.

It is recommended that the cross sections shown in Sheet No. 3 be used for the construction of the cutoff trench.

Upstream Slope During Sudden Draw Down. A stability analysis was performed for the upstream slope of the enlarged embankment under sudden draw down conditions. Since the permeability of the subsurface material beneath the dam is highly pervious relative to the embankment material, the flow lines will be essentially vertical under the sudden draw down conditions, and the pore pressures within the embankment will approach zero. The results of the stability computations for the conditions assumed above indicate a factor of safety of 2.3. Since the sudden draw down case is not a catastrophic type situation, a factor of safety of 1.3 is generally considered to be satisfactory. The location of the critical failure surface for this condition is shown in Sheet No. 6, Appendix A, along with the shear strength parameters used in the analysis.

It is possible that some pore pressures will exist within the embankment during the sudden draw down conditions due to the anisotropic and nonhomogeneous characteristics of the embankment. However, it is our opinion, that a factor of safety of 2.3, will cover any adverse affects associated with the development of high pore pressures.

Downstream Slope During Steady State Conditions. Since the chimney drain will be located near the center of the dam, the entire downstream portion of the dam will remain unsaturated during the steady state seepage condition. The equihydraulic headline distribution developed during the seepage analysis was used in this analysis to specify pore pressure throughout the dam. An effective stress analysis was performed to determine the factor of safety for this case.

The shear strength parameters used in this analysis are tabulated in Sheet No. 6, Appendix A. The results of the stability analysis indicate a factor of safety of 1.62 for the downstream slope under steady state seepage conditions.

The location of the critical failure surface for this case is also presented in Sheet No. 6, Appendix A. A factor of safety of 1.5 is generally considered satisfactory for the downstream face under steady state seepage conditions. It is apparent that the calculated factor of safety is greater than the normally accepted value which indicates that the stability of the downstream slope will be satisfactory under the design considered.

Seismic Stability Considerations. The proposed dam is located in Seismic Zone 2 and has a low potential for seismic activity. Algermission and Associates, of the U.S. Geological Survey, indicate that the horizontal acceleration which has a 90 percent probability of not being exceeded in 50 years is about 0.04 g. They also indicate that the horizontal acceleration which has a 90 percent probability of not being exceeded in 250 years is about 0.07 g.

Under seismic activity an earth dam usually only experiences a massive failure when either liquifaction of the embankment or the foundation can occur. Otherwise, the dam experiences deformation depending on the magnitude of the earthquake and the character of the soil.

While a pseudostatic analysis does not provide reliable information on the dynamic stability of an earth dam, it does perhaps provide some indication of the safety against excessive deformation. A pseudostatic analysis has been performed for both upstream and downstream slopes considered in the static analysis. The critical failure surface obtained in the static analysis for both the upstream and downstream slopes were used in this analysis. In the analysis a horizontal force equivalent of 0.05 g was applied at each slice. The results of the analysis indicate a factor of safety of at least 2.0 for the sudden draw down case and 1.4 for the steady state seepage case. It is our opinion that if the materials within the proposed embankment addition are densified to 95 percent of the maximum laboratory density as determined by ASTM D1557-78 that the structure will be safe during the expected seismic action.

Seepage Considerations

Existing Structure. It is our understanding that the major portion of the seepage from the reservoir basin for the existing facility is occurring through the overburden material beneath the base of the existing dam. As indicated earlier in this report, the permeability coefficients obtained during the subsurface investigations are relatively high in the foundation area indicating that a substantial amount of water can seep through the foundation zone. In order to obtain an indication of the magnitude of the seepage losses, a seepage analysis was performed using a finite element computer program developed by the Corps of Engineers and designated as SSFP. A considerable variation occurred in the permeability coefficients through the existing cross section of the dam and foundation. The results of the subsurface investigation indicate that the permeability coefficients of the foundation material beneath the dam varied from about 7,500 to 55,000 feet per year. A seepage analysis has been performed for the existing structure assuming that the amount of flow through the embankment is insignificant compared to the seepage through the foundation area. The results of this seepage analysis indicates that the amount of water flowing through the foundation amounts to approximately 4 cubic feet per second which is equivalent to about 8 acre feet per day. The seepage loss at this rate throughout the entire year results in a loss of about 2920 acre feet. It is our understanding that a loss of about 2500 hundred acre feet has been observed during past periods of time. As a result of the high permeability coefficients in the foundation area, it is apparent that a fully penetrating cutoff section will be required to reduce the seepage losses throughout the foundations to a tolerable magnitude.

The Enlarged Embankment. A seepage analysis has also been performed for the proposed embankment section as shown in Sheet No. 7, Appendix A. The analysis assumes a partial earth cutoff combined with a caisson wall extending to bedrock. The permeability coefficients for each of the sections of the embankment and foundation are shown in Sheet No. 7, Appendix A. The equihydraulic headline distribution for this condition is presented in Sheet No. 8, Appendix A. In performing this analysis it has been assumed that the loss in head through the foundation material is insignificant compared to the embankment. This means that the line designated as ABCD in Sheet No. 8, Appendix A is an equipotential line. The results of the seepage analysis indicates that approximately 0.2 to 0.3 cfs will flow through the embankment and the foundation materials. Additional seepage may occur through the bedrock in the right abutment. The magnitude of this seepage cannot be estimated at the present time.

Slope Protection

Since the proposed site is located in a glaciated area, an abundant supply of material that can be used for slope protection for the proposed facility is immediately available. The existing slope protection appears to have performed satisfactorily and the amount of new slope protection will be limited to the proposed embankment enlargement. We recommend that the slope protection be 1.5 feet thick with a 12 inch thick filter layer underlying the riprap material. The recommended gradation for the riprap and for the filter beneath the riprap is presented in Sheet No. 1, Appendix A.

Freeboard

The freeboard requirement was estimated using techniques developed by the COE (28). A design wind having a velocity of 64 mph and a duration of 10 minutes was selected. Using this design wind, the wind setup and wave runup were calculated to be 0.1 feet and 2.7 feet, respectively. Wind setup reflects the higher pool elevation at the downwind area of the pool. The total wave height, above the still reservoir pool, is estimated to be 2.8 feet.

By placing riprap on the downstream face of the embankment, short duration wave overtopping can be tolerated, as in a rainfall event. For this reason, the reservoir pool was allowed to rise to the dam crest during the PMF routing. During the PMF, waves could conceivably overtop the dam for 5-1/2 hours. This length of time is not long enough to result in a dam breach from wave action.

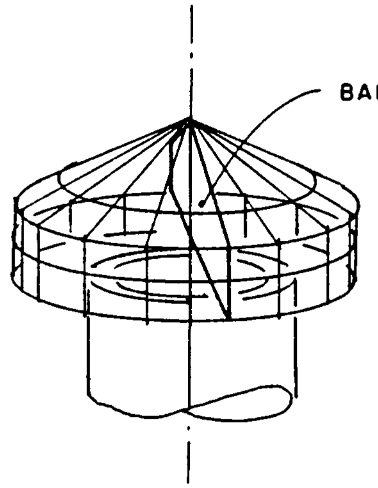
The 100-year flood, however, is more likely the result of a snowmelt event, in which peak flows could last several days. For this event, adequate freeboard must be maintained. The proposed principal spillway would provide a minimum of 5.4 feet of freeboard during the 100-year flood.

Principal Spillway and Outlet Works

The existing outlet works conduit was inspected on July 12, 1984. The conduit is constructed from reinforced concrete pipe sections 8 feet long. The joints appear to be gasketed; similar to a "lock-joint" manufactured at one time in Casper, Wyoming. A field inspection report is included in Appendix C of this report. From this inspection it was concluded that the outlet conduit is in a poor state of repair and should be rehabilitated or replaced. The first four sections upstream from the outlet are in poor condition and should be replaced irregardless of the outcome of this proposal.

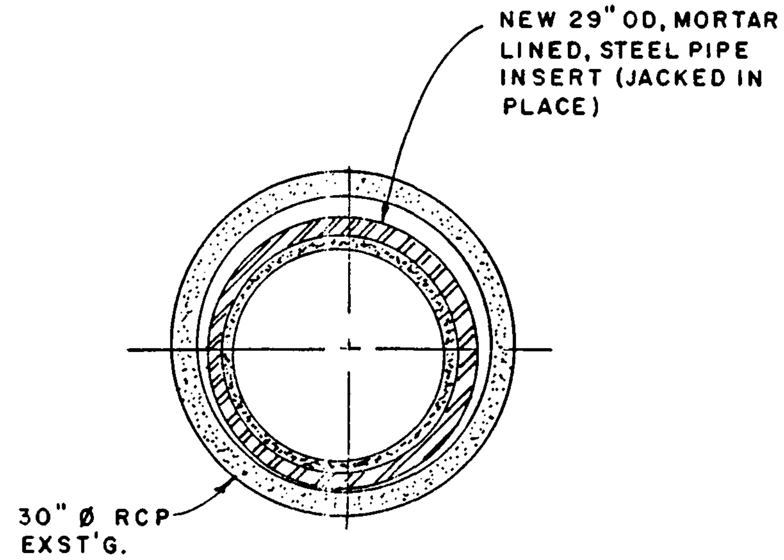
As shown in Figure V.3, the proposed morning glory spillway is located near the end of the fourth joint of pipe. The existing dam must be excavated back to this point. The outlet conduit will be rehabilitated by jacking a cement-mortar lined steel pipe into the conduit. The pipe will be heavy wall for long life, with welded joints and approximately 29 inches outside diameter. The pipe will be jacked through the existing slide gate and the gate will be abandoned. A new sluice gate will be installed on the upstream toe of the dam as shown in Figure V.3. This will allow this portion of the outlet conduit to be rehabilitated without excavating the existing conduit and taking the dam out of service.

The outlet conduit downstream of the morning glory spillway will be new pipe. This pipe will be pretensioned concrete cylinder pipe, reinforced concrete pipe or cement-mortar lined steel pipe with a protective coating. The best type of pipe will evolve out of the final design. This pipe is sized to handle the 100 year inflows from the morning glory spillway. The outlet section of the principal spillway consists of a concrete headwall and well graded riprap to prevent erosion downstream of the dam. It is felt that property sized riprap will have greater longitivity in this climate than an exposed concrete stilling basin. In addition, the use of riprap will result in lower tailwater which would allow adequate ventilation necessary for open channel flow in the conduit. This ventilation will reduce the instabilities that are typical of conduit spillways during high flows.



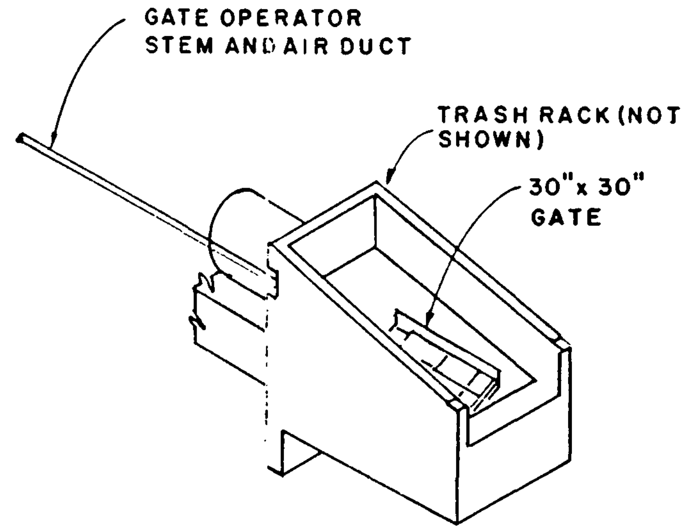
CONICAL TRASH RACK AND BAFFLE

NTS



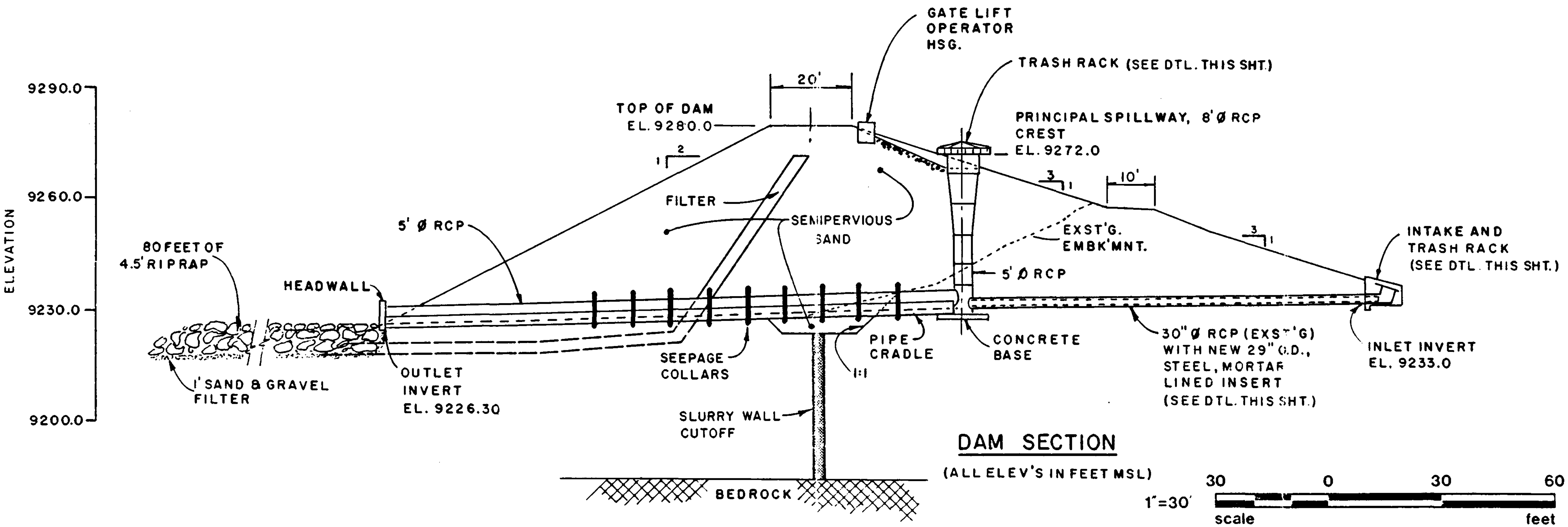
OUTLET PIPE INSERT

NTS



INCLINED GATE INTAKE

NTS



DAM SECTION

(ALL ELEV'S IN FEET MSL)

FIGURE V.3

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LAKE ADELAIDE DAM

PRINCIPAL SPILLWAY AND OUTLET WORKS

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Several types of principal spillways were considered for this dam. Any type of chute spillway on or near the dam embankment was discounted as problems arising during an unusual flood event could result in a dam breach. The existing rock lined spillway could breach the embankment if high flows occurred. Neither abutment lends itself topographically to a chute type spillway. The amount of concrete used in this dam should be limited as aggregate sources are limited and this climate degrades exposed concrete rapidly. Tunneling through either abutment would be prohibitively expensive for this size of dam. These considerations lead to use of precast concrete manhole sections to form a morning glory type of spillway. This type of spillway can be constructed quickly which is important in this short season area. The quality control can be maintained at the plant. Additionally, the spillway will not be damaged if an unusual flood event should occur. For these reasons, a morning glory type of principal spillway was chosen to handle the routed 100 year flood peak of 366 cfs.

Auxiliary Spillway

The basic concept of the auxiliary spillway is to pass any flood larger than the 100 year flood up to the probable maximum flood (PMF). The spillway itself will sustain damage but the dam will not be overtopped and breached. This spillway will be constructed as a part of the borrow for the dam embankment. The spillway is located as shown on Sheet 9 of Exhibit A and is a trapezoidal earth channel. The crest is 155 feet wide narrowing to a channel 20 feet wide with 2:1 side slopes. The flow from this spillway will be directed to a point just below Shell Reservoir so as not to add to the Shell Reservoir spillway capacity. This spillway, combined with the principal spillway, will pass the routed PMF flood, which peaks at 6470 cfs; the largest flood thought to be hydrometerologically possible. The actual cost of constructing this spillway is minor as the borrow is needed to raise the embankment.

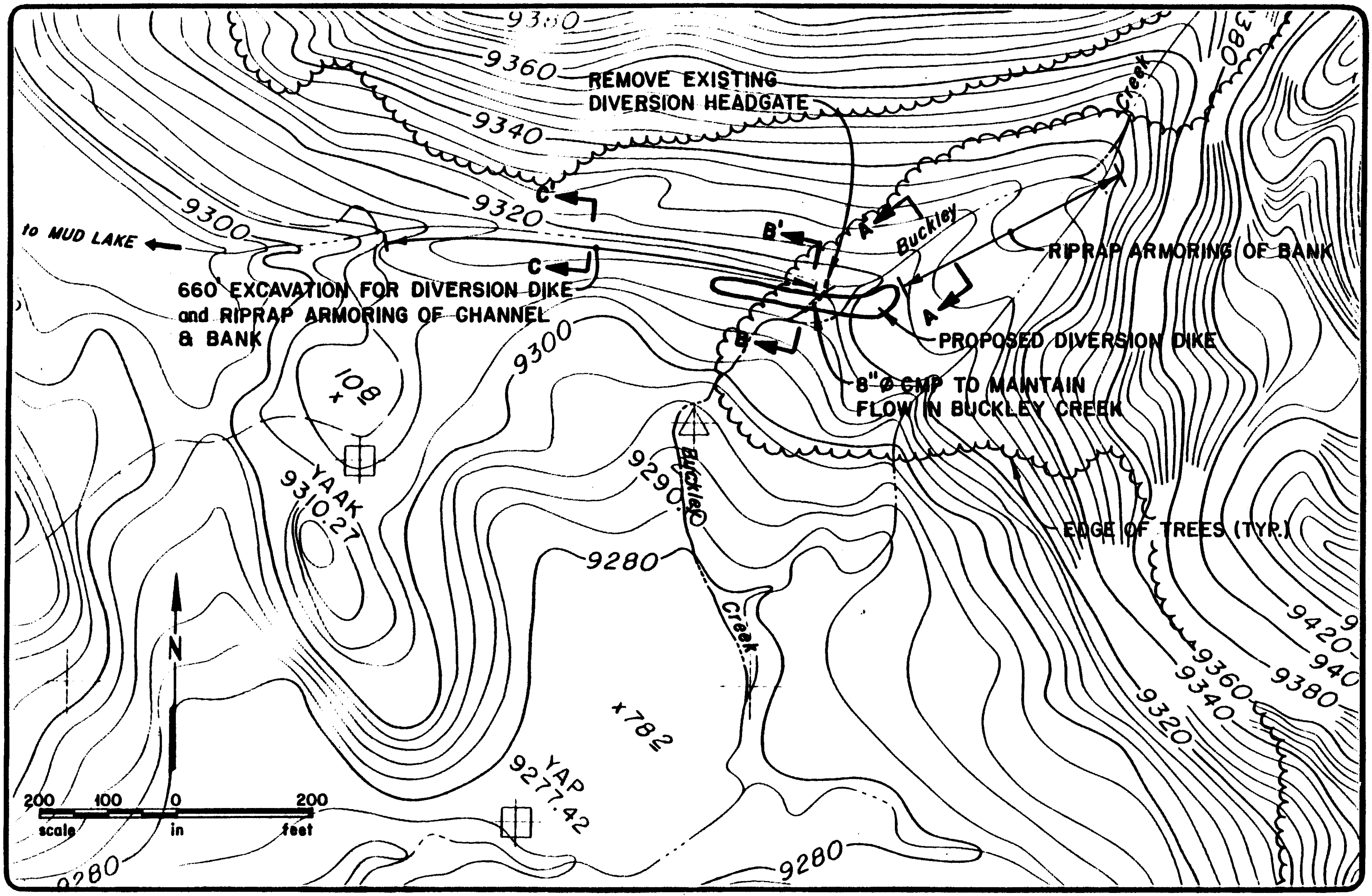
Buckley Creek Diversion

The existing Buckley Creek Diversion consists of a steel plate diversion across Buckley Creek with a slide gate turnout discharging to a ditch flowing into Mud Lake. Buckley Creek has eroded a channel around the steel plate diversion. The present system passes most of the flows down Buckley Creek with a small portion diverted to Mud Lake which flows into Lake Adelaide.

The proposed Buckley Creek Diversion will consist of a dike across Buckley Creek at the location of the existing diversion. The existing diversion ditch will be enlarged to provide material for the dike and to carry the 100 year flow of 220 cfs into Mud Lake and Adelaide Creek. The dike is designed as a homogeneous fill section with a graded gravel filter drain in the downstream toe. An 8-inch diameter corrugated metal pipe through the dike will allow an instream flow of 1-2 cfs to pass on down Buckley Creek. Both faces of the dike will be stabilized with 18-inch riprap. Riprap will be placed along the channel 350 feet upstream from the dike to contain flood flows and prevent erosion. The diversion ditch will be riprapped for a length of 660 feet, which includes the entire excavation area. Riprap and homogeneous fill will be obtained by sorting materials during excavation of the diversion ditch. This method of construction will cause little surface scarring and provide channel riprap with a minimum of handling. Details of the proposed diversion are shown in Figure V.4 and Figure V.5.

Access Road

It is our understanding that the existing dam was constructed about 1915 with teams of horses, wagons, and slips. Mobilization of this equipment did not require an improved access road. Today's equipment will be mechanical, much larger



LAKE ADELAIDE DAM

BUCKLEY CREEK DIVERSION
LOCATION MAP

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FIGURE V.4

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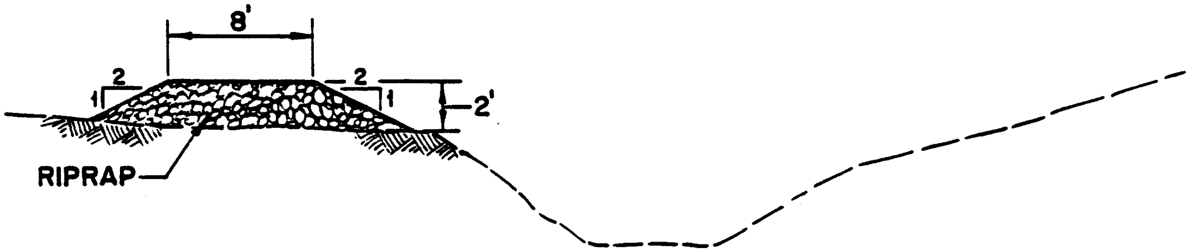
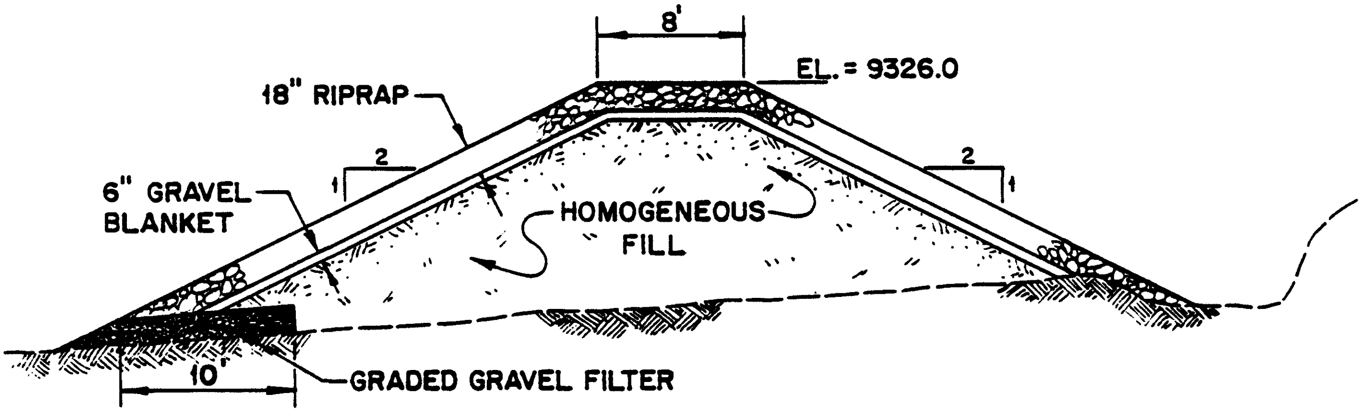


TYPICAL BANK RIPRAP

SECTION A - A' (SEE FIG. V.4)

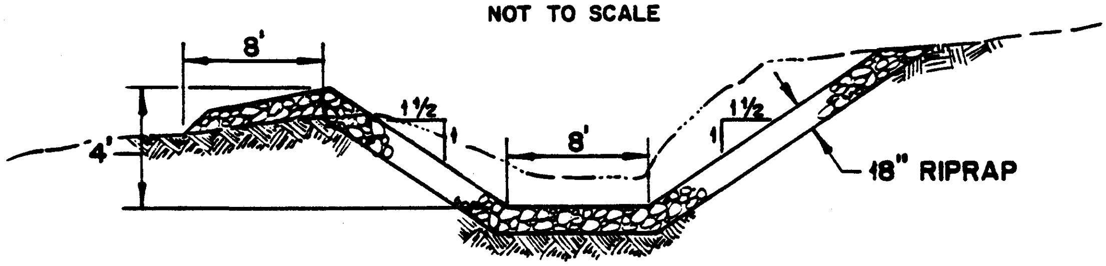
NOT TO SCALE



TYPICAL DIVERSION DIKE SECTION

SECTION B - B' (SEE FIG. V.4)

NOT TO SCALE



TYPICAL DITCH SECTION

SECTION C - C' (SEE FIG. V.4)

NOT TO SCALE

LAKE ADELAIDE DAM

BUCKLEY CREEK DIVERSION
TYPICAL SECTIONS

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FIGURE V.5

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in size, and will require an improved access road to travel to the dam. A good road will also encourage maintenance of the dam as access will be much easier. An improved access road will be important to the Contractor in meeting the optimistic construction schedule described in Chapter VI.

The access road will likely be a controversial issue. There are two factions involved; those wanting to limit access to the area and those desiring to improve access for recreational purposes. The Forest Service has indicated that if access is improved that sanitary and campground facilities must be provided to accommodate the additional people. It is not the purpose of this report to treat the environmental issues of an improved access road and campground facilities. Enough reconnaissance design was completed to develop low level cost estimates for these facilities and these costs are included as a part of this project. It is suggested that the Forest Service be involved in the final design of both the access road and campground facilities.

An alternate plan is to close the access road after construction from Shell Dam to Lake Adelaide Dam. This may not be practical because 1) the access road must be an improved, gravel surfaced road to accommodate modern construction equipment; 2) once the road is open, a portion of this public will expect it to remain so and; 3) an improved road will encourage maintenance of the dam which is important.

The access road branching from the road near the divide to Shell Dam will essentially remain in the same location and alignment. The road will be surfaced with gravel as a single lane with turnouts provided at approximate 1000 foot intervals. Cross drainage will be provided where needed and provisions to control erosion made. Grades may be lessened near Shell Dam and the switchbacks will be made somewhat wider.

The existing trail from Shell Dam to Lake Adelaide presently has numerous steep grades; some exceeding 30 percent. It is proposed that this trail be closed and seeded to grass. The location for the new road is shown on Sheet 10 of Exhibit A which allows much flatter grades. Construction of this road will be similar to the divide to Shell Dam road; single lane with turnouts and cross drainages.

A typical cross section of the access road is also presented on Sheet 10 of Exhibit A. This design is partially based on Forest Service standards for a logging road. The final design will likely change after input from Forest Service personnel. This presentation will provide a starting point for review as well as a reconnaissance estimate of costs.

Campground Facilities

Improved access roads will result in increased recreational activities on Lake Adelaide and the surrounding area. The Forest Service has indicated that facilities must be provided to accommodate the recreationists. This will reduce environmental problems from human waste, garbage accumulations, camping near the lake, uncontrolled campsites, fire, etc. It is proposed to provide 10 campsites on the ridge on the vicinity of the old dam tender's cabin. (See Sheet 10 of Exhibit A.) The access road would travel through this area and spur roads would branch off to each campsite. Picnic tables and fire pits with grates would be provided at each site. A centrally located pit toilet would be provided for the campsite. If possible, a well with a hand pump would be provided. A well may be very difficult to develop in this area, however. It is expected that the Forest Service would be involved with the design details of this campground area.

DESIGN SUMMARY

Table V.6 has been prepared to provide a comparison of the existing situation and the proposed design. Figure V.6 is presented to show elevation versus area and capacity.

In summary, it is proposed to enlarge the dam to provide 1700 acre feet of additional capacity. The outlet works will be replaced and a new glory hole principal spillway will be provided. An auxiliary spillway will be provided to protect the dam against any flood event. Additional water will be diverted from Buckley Creek. An improved access road and campground facilities will be provided as a part of this project. The new dam will be larger and much safer than the older dam.

Table V.6
LAKE ADELAIDE DAM AND RESERVOIR
PRINCIPAL CHARACTERISTICS SUMMARY TABLE

Parameter	Existing	Proposed
Structural Height (ft)	30	50
Dam Crest Elevation (ft MSL)	9,260.0	9,280.0
Normal Water Surface Elev. (ft MSL)	9,256.0	9,272.0
Minimum Pool Level (AF)	219 2/	700 3/
Active Storage Capacity (AF), 1984	1,575	2,800
Total Storage Capacity (AF), 1984	1,794	3,500
PMF Peak Inflow (cfs)	1/	10,300
PMF Peak Outflow (cfs)	1/	6,470
100 Yr. Peak Outflow (cfs)	1/	366
Maximum 100 Yr. W.S. Elev. (ft MSL)	1/	9,274.6
Spillway Design Flood	500 cfs ±	PMF 2/
Maximum W.S. Elev. (ft MSL)	1/	9,279.9
Freeboard at Maximum W.S.	1/	0.1

1/ No information is available on hydrologic investigations used in the design of the original structure.
2/ Equal to dead pool at outlet works level.
3/ Equal to 20 percent of total pool volume

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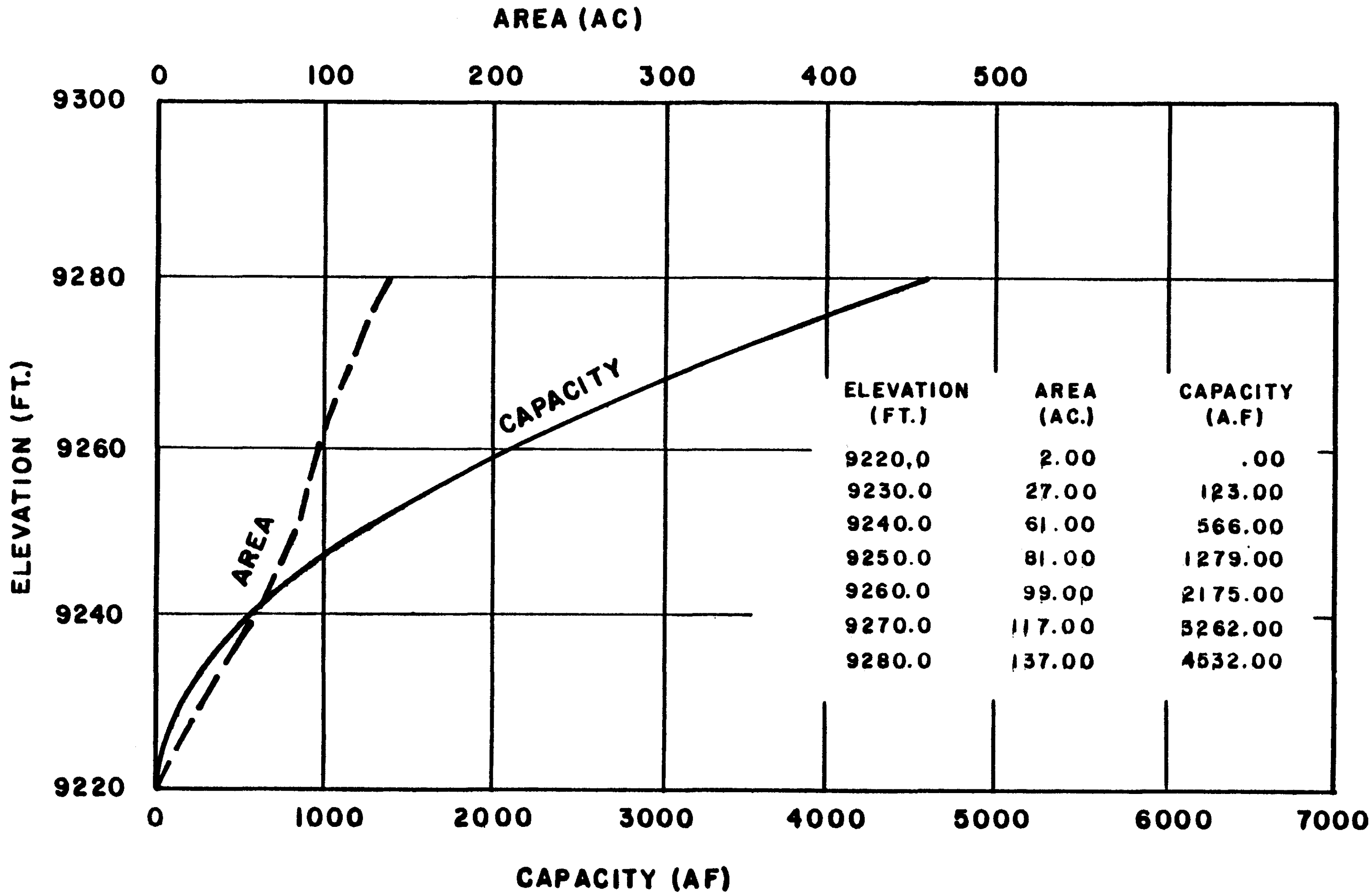

ELEVATION (FT.)	AREA (AC.)	CAPACITY (A.F)
9220.0	2.00	.00
9230.0	27.00	123.00
9240.0	61.00	566.00
9250.0	81.00	1279.00
9260.0	99.00	2175.00
9270.0	117.00	3262.00
9280.0	137.00	4532.00

LAKE ADELAIDE DAM

ELEVATION-AREA-CAPACITY CURVES

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FIGURE V. 6

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RESERVOIR SEDIMENTATION

The sediment yield of the drainage basin has an affect upon its useful life and eventual storage capacity. The drainage does not appear to generate significant sediment as native grasses are well established, considerable bedrock exposure exists and there is minimal disturbance, such as roads, logging, etc. During the summer of 1984, the natural lake was cross-sectioned and was found to be 10 to 15 feet deep in places. The reservoir is 70 years old. The fact that the natural lake has not filled with sediment is evidence that sediment inflows are very low in this drainage.

A topographic survey was completed in 1911 as a part of the water right application. During the fall of 1974, a topographic survey was completed as a basis for a water right amendment. These surveys essentially identified the configuration of the lake water surface. The 1974 survey was based on three elevations; the normal water surface of 9260 feet m.s.l. (HWL of El. 496 on 1974 survey); an existing water surface El. 9241 m.s.l. at the time of the survey (September 15, 1974); and a low water surface of El. 9233; apparently determined by sounding. A second survey and topographic mapping was completed 10 years later (September 11, 1984). Comparison of these three surveys indicates very little deposition has taken place. Given the accuracy of the surveys, it would be difficult to exactly quantify accumulations. It is estimated that deposits were less than 20 acre feet in the recent 10 year period or 2 acre feet per year. The sediment yield would be 0.6 AF/sq. mi./year.

Considering the Buckley Creek Diversion, the drainage area is approximately 7 square miles. Given a 100 year period and a 0.6 AF/sq. mi. deposition rate approximately 420 AF would be yielded to the reservoir. Assuming a 90 percent trap efficiency 375 AF of capacity would be lost. Considering 300 AF of dead storage (natural lake) and bank storage, the reservoir will not be affected by sediment given a 100 year period. Sediment accumulations are likely to be less than predicted.

EXISTING DAM SAFETY CONSIDERATIONS

If Lake Adelaide Dam is not enlarged as proposed, the owners (Shell Canal Company) should plan to upgrade the existing dam to present day standards. Specifically the following problems should be corrected:

1. The existing outlet works is in need of repair. Pressure flows from cracks in the conduit could remove significant amounts of embankment resulting in a breech. Collapse of the conduit could cause erosion as well. It is recommended that the existing conduit be replaced or a liner inserted as suggested in this chapter.

2. The spillway system will not pass the PMF as identified using HMR 55 precipitation values. Two options may be considered. An auxiliary spillway could be excavated in the location planned for the enlarged dam. The second option would be to armor or protect the crest and downstream face with large riprap or soil-cement such that overtopping would not result in a breach.

3. As discussed in the Design Section of this chapter, the stability of downstream slope is questionable. Remedial measures could include installation of vertical drain wells approximately 10 feet apart or flattening the slope to a stable configuration.

Preliminary cost estimates have been developed for this work. It is estimated that the remedial work will equal approximately 75% of the construction cost of the enlarged dam. It is much easier to construct the auxiliary spillway if the crest of the dam is 20 feet higher. If present day dam safety standards are to be followed, all things being equal, the enlarged dam proposal would be the logical choice.

VI ESTIMATED COSTS

CHAPTER VI
ESTIMATED COSTS

ESTIMATES OF COST

Estimates of cost have been prepared for the construction of the Lake Adelaide Dam enlargement and associated facilities. They are based on the criteria and general design considerations presented in Chapter V.

The total estimated construction cost of the project, based on projected January 1987 cost levels is $2,068,100.00. This estimate includes direct construction costs, a 20% allowance for contingencies, inflation, cost of investigations, engineering and construction administration, interest during construction and WWDC participation. A summary of these costs appears in Table V1.2

Projected Future Costs

It is anticipated that contracts for construction of this project could not be awarded before June of 1987. On the basis of past history, an allowance should be made for inflation above July 1984 cost levels used to develop direct costs. Although difficult to predict, an allowance of 20 percent has been included to accommodate a reasonable cost escalation. It is hoped that actual inflation will be much less.

Special Use Permit, Environmental Assessment

The dam, Buckley Creek Diversion, auxiliary spillway and access road are located on United States Forest Land; therefore no land acquisition or right-of-way costs are necessary. There will be a cost to acquire the Special Use Permit and accommodate its provisions or environmental mitigation. This cost will be an unknown until Forest Service response to this project is known. However, a cost of $50,000 is included as a representation.

Engineering and Administration

No contracts for engineering, other than the feasibility study, have been entered into by the WWDC; therefore these costs are based on estimates. These estimates include additional field drilling and surveying, the preparation of plans and specifications, field inspection and construction administration and development of an operations manual.

In addition to the engineering, the WWDC will incur certain administrative costs. These costs have not been included in the estimates.

A total estimated cost of 20 percent for additional field drilling, engineering and administration has been applied to the construction cost estimates.

Estimated Direct Cost to Project Facilities

Estimates of direct costs have been prepared for guidance in project evaluation given information available at the time of the estimate. Final costs will vary from these estimates due to better detail, changing market condition, changes in project scope and other factors. However, costs developed in this report should be sufficiently accurate to make financial decisions and obtain funding. Direct costs or those costs obtained from unit cost extensions are summarized in Table VI.1.

Table VI.1

ESTIMATED DIRECT COST OF PROJECT FACILITIES

Proposed Facility	Estimated Direct Cost
Principal Spillway and outlet works	$ 175,000
Auxiliary Spillway	270,000
Dam Enlargement	541,000
Buckley Creek Diversion	30,000
Campground Facilities	50,000
Access Road	86,000
TOTAL DIRECT COST	$1,152,000

Interest During Construction

If financial aid is obtained as part of a Federal Program, such as the USBR Small Loans Act, agricultural users may not have to repay the loan with interest. However, the Shell Valley Watershed Improvement District users may be required to repay their allocated portion with interest. It is suggested that these users be required to repay interest during construction (IDC) on the loan amount of $550,000.00. Computations for a typical IDC are shown in Table VI.4. Actual IDC will depend upon how loan funds are distributed.

CONSTRUCTION PROGRAM

Preconstruction

The exact program for construction for a project of this scope depends to a great extent upon the date the money becomes available. It has been assumed that the legislative approval granted, and the contract validation with the District successfully completed by June 1, 1986. This is the date assumed that the money will become available.

Table VI.2

SUMMARY OF ESTIMATED PROJECT COSTS

Total Direct Cost		$1,152,000
Contingencies (20%)		230,400
Subtotal		1,382,400
Project cost increase (20%)		276,480
Subtotal		1,658,880
Engineering (9%)		150,000
Construction Administration (11%)		182,500
Subtotal		1,991,380
Interest during construction (IDC)		16,720
Special use permit, Environmental Assessment		50,000
Water rights		10,000
TOTAL CONSTRUCTION COST		$2,068,100
Feasibility Report		$ 150,000
TOTAL PROJECT COST		$2,218,100
Less WWDC contribution		1,688,100
Special use permit, Environmental Assessment	50,000	
Water rights	10,000	
Feasibility report	150,000	
State Sponsored grant	1,458,100	
Shell Valley Watershed Improvement District Loan (based on 25% of Total Project Cost less IDC)		$ 550,000

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The design is to be finished, complete with approved plans and specifications, by January 1, 1987. A contract would be awarded by June of 1987.

Construction Period

The construction of project facilities is estimated to require 2 years. This allows sufficient time considering the 3 and 4 month construction season at this location. The proposed facilities are to be ready to receive water by November 1, 1988. A schedule for Expenditure of Funds is shown in Table VI.3.

Table VI.3

SCHEDULE FOR EXPENDITURE OF FUNDS 1/

Fiscal Year	Function	Loan Funds	Contributed Funds
1987	Water Rights, Permits		$ 60,000
	Engineering		150,000
	Construction Contracts	$275,000	560,000
1988	Engineering		182,500
	Construction Contracts	$275,000	548,880
	TOTAL LOAN FUNDS ADVANCED	$550,000	$1,501,380

1/ Funds do not include IDC or feasibility report costs

It is envisioned that the Contractor would start on the access road construction in late July of 1987. Mobilization could then begin and camps set up. As soon as Lake Adelaide is emptied (by September 1) the cutoff trench construction can begin. A goal would be completion of the cutoff trench that fall and early winter. The outlet works should also be completed.

As soon as the weather allows the next spring, the embankment could be started. The construction of the auxiliary spillway would progress as a part of the borrow for the embankment.

After high water, the Buckley Creek Diversion would be constructed. The embankment would be topped out in late fall and the Environmental Mitigation work can be completed. The dam would be ready for storage of water the next spring. This construction sequence should allow enlargement of the dam without losing a storage season.

ANNUAL OM&R (OPERATION, MAINTENANCE, AND REPLACEMENT) COSTS

It is projected that OM&R costs will be 1.00 per AF by 1988. These costs include a minimal amount for a dam tender, administrative costs and costs for annual maintenance of control gates, riprap, etc.

Table VI.4

Interest During Construction

Year of Construction	Loan Funds	1/2 Current Year Loan Funds	Sum Previous Year Loan Funds	Sum Previous Years Interest	Amount For Computing Interest	4% Interest
1987	275,000	137,500	0	0	137,500	5,500
1988	275,000	137,500	275,000	5,500	418,000	16,720
			TOTAL INTEREST DURING CONSTRUCTION			$16,720

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Table VI.5
LAKE ADELAIDE
ESTIMATE OF DIRECT CONSTRUCTION COSTS

Principal Spillway and Outlet Works

Item	Quantity	Unit	Unit Cost	Total
Mobilization	Lump Sum			10,000
Concrete	175	CY	$ 500	$87,500
24"x24" Sluice Gate	500	LB	2.50	1,250
Gate Lift and Assec.	Lump Sum			1,800
1-1/2" Dia. Encased Stem	150	FT	12.50	1,875
Trash Racks	2865	LB	2.00	5,730
Conduit				
29" O.D. Steel, Cement Mortar Lined	130	LF	80	10,400
96" dia. to 60" dia. RCP Transition	20	LF	250	5,000
60" dia. Tee	1	Ea	2500	2,500
60" dia. Pipe	175	LF	125	21,875
Large Riprap	950	CY	10	9,500
Filter Gravel	185	CY	12	2,220
Excavation	2000	CY	2.00	4,000
Compacted Fill	270	CY	5.00	1,350
Dewatering				10,000
Principal Spillway & Outlet Works Total				$175,000

Auxiliary Spillway

Item	Quantity	Unit	Unit Cost	Total
Mobilization	Lump Sum			20,000
Clearing and Grubbing	3	Ac	$1000	$ 3,000
Excavate, Load, and Haul to Dam1/	100,000	CY	2.50	250,000
Auxiliary Spillway Total				$270,000

1/ 40,000 CY are required for auxillary spillway channel; 60,000 CY are required as additional borrow for dam embankment.

Table VI.5 (continued)

LAKE ADELAIDE

ESTIMATE OF DIRECT CONSTRUCTION COSTS

Embankment Slurry Trench Cutoff

Item	Quantity	Unit	Unit Cost	Total
Mobilization	Lump Sum			$ 60,000
Clearing Foundation	Lump Sum			3,000
Process (remove large rock for riprap) and Compact Earthfill in Embankment 1/	92,000	CY	$ 1.00	92,000
Slurry Trench	20,400 ft^2	FT	$11.00	224,400
Filter Material (chimney drain and riprap bedding)	7,636	CY	$10.00	76,360
Loose Rock Riprap	4,185	CY	$10.00	41,850
Preparation of Rock Surfaces	3,287	CY	$ 5.00	16,430
Horizontal Drainage Well	400	FT	$50.00	20,000
Drain Pipe (Including cradle)	240	FT	$29.00	6,960
SLURRY TRENCH CUTOFF TOTAL				$541,000

1/ 40,000 CY are required for auxillary spillway channel; 60,000 CY are required as additional borrow for dam embankment.

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Table VI.5 (continued)

LAKE ADELAIDE

ESTIMATE OF DIRECT CONSTRUCTION COSTS

Earth Cutoff and Caisson Wall (Alternative)

Item	Quantity	Unit	Unit Cost	Total
Mobilization	Lump Sum			$ 60,000
Clearing Foundation	Lump Sum			3,000
Excavation Cutoff Trench	41,000	CY	$ 3.00	123,000
Caisson Wall	1,875 ft^2	FT	$90.00	168,750
Process (remove large rock for riprap) and Compact Earthfill in Embankment 1/	133,000	CY	$ 1.00	133,000
Additional Excavation from Borrow	45,000	CY	$ 2.50	32,500
Filter Material (chimney drain and riprap bedding)	7,636	CY	$10.00	76,360
Loose Rock Riprap	4,185	CY	$10.00	41,850
Preparation of Rock Surfaces	3,287	CY	$ 5.00	16,435
Dewatering Wells (12")	200	FT	$60.00	12,000
Horizontal Drainage Well	400	FT	$50.00	20,000
Drain Pipe (including cradle)	240	FT	$29.00	6,960
EARTH CUTOFF AND CAISSON WALL TOTAL				$693,855

1/ 40,000 CY are required for auxillary spillway channel; 60,000 CY are required as additional borrow for dam embankment.

Table VI.5 (continued)
LAKE ADELAIDE
ESTIMATE OF DIRECT CONSTRUCTION COSTS

Buckley Creek Diversion

Item	Quantity	Unit	Unit Cost	Total
Mobilization	Lump Sum			$ 2,000
Excavate and Place				
Homogeneous Fill for dike	525	CY	$ 4.00	2,100
Riprap (18")	1,700	CY	14.00	23,800
Gravel Drain	50	CY	12.00	600
8" CMP	50	FT	10.00	500
Remove Existing				
Diversion Structure	1	LS	------	1,000
	Buckley Creek Diversion Total			$ 30,000

Campground Facilities

Item	Quantity	Unit	Unit Cost	Total
Pit Toilet, installed	1	Ea.	$30,000	$ 30,000
Picnic tables	10	Ea.	200	2,000
Fire pits and grates	10	Ea.	100	1,000
Sitework, clearing, etc.	Lump Sum			5,000
Trash cans, signing, misc.	Lump Sum			2,000
Well with pump	Lump Sum			10,000
	Campground Facilities Total			$ 50,000

Table VI.5 (continued)

LAKE ADELAIDE

ESTIMATE OF DIRECT CONSTRUCTION COSTS

Access Road

Item	Quantity	Unit	Unit Cost	Total
County Road to Shell Reservoir (14,000 ft):				
Earthwork	2,000	CY	$ 2.00	$ 4,000
Gravel Surfacing	5,000	CY	7.50	37,500
18" CMP Culverts	150	Ft.	20.00	3,000
		Subtotal		44,500
Shell Reservoir to Adelaide (5,000 ft):				
Clearing	6	AC	$1,000	$ 6,000
Earthwork	10,000	CY	2.00	$20,000
Gravel Surfacing	1,800	CY	7.50	13,500
18" CMP Culverts	100	Ft.	20.00	2,000
		Subtotal		$41,500
Access Road Total				$86,000

VII PROJECT EVALUATION

CHAPTER VII
PROJECT EVALUATION

INTRODUCTION

The primary purpose of this chapter is to present an estimate of a typical farmer's ability to pay for additional water developed by the Lake Adelaide Enlargement. This analysis develops a foundation for the financial program presented in Chapter VIII. An estimate of indirect benefits stemming from increased agricultural activity and an estimate of benefits from irrigating additional land is also presented in this chapter.

It is understood that there is no "typical" farmer in the Shell Valley Watershed. For example, younger farmers with a heavy debt load are going to be less financially stable than established farmers. Sugar beet farmers exhibit a different repayment ability as compared to livestock and feed enterprises. It is also understood that markets fluctuate considerably and weather poses a constant risk. For example, a 2% reduction in "prices received" would totally eliminate any payment capacity for additional irrigation water. For these reasons, it is recommended that the loan be repayed within a reasonable range of the estimated ability to pay. Actual percentages are negotiable; for purposes of this report a range of 75% to 125% is assumed. During the poor years 75% would be paid and during the good years 125% would be paid, averaging 100% over the term of the loan.

Over 10,000 acres are irrigated in the Shell Valley Watershed. Of this area it is estimated that 8,000 acres are within the boundaries of the Watershed Improvement District. It is assumed that 5,000 acres may benefit from additional storage water. Of this acreage, it is estimated that approximately 660 acres not presently irrigated would require a full measure of late season supplemental water (new lands or idle lands). The remaining acreage would receive an additional late season supply, particularly during dry years. These assumptions provide a basis for the following Agricultural Economic Analysis.

AGRICULTURAL PAYMENT CAPACITY

Introduction

This phase of the project evaluates the economic consequences of the proposed modifications to Lake Adelaide which are designed to increase its storage capability. A reasonable portion of the cost of the project must be borne by those who receive benefits from it. Therefore, this section evaluates the ability of the agricultural water users, in the Shell Valley area, to pay for their allocated project costs.

Methodology

The determination of agricultural water users' ability to pay for the proposed project generally follows guidelines and procedures approved by the Bureau of Reclamation. Budgets were prepared for a representative farm operation in the Shell Valley. The representative farm is of the size to provide reasonably full-time employment to the farm operator and an adequate return to his labor, management, and equity. The farm size, crop mix, machinery complement, farming practices, and other data for the representative farm were determined via personal interviews with Shell Valley farmers, businessmen, and local officials. The budgets prepared for this farm use yields which reflect the "with project" scenario.

Area farmers indicated that yields could be increased, on the average, at least 10% if adequate water was available. Therefore, the ability to pay, presented in this section, assumes that the project is completed and additional water is supplied to farmers.

Data, Assumptions, and Analysis

The representative farm used to determine repayment capacity consists of 300 acres of which 290 acres is farmed, 5 acres is waste (for roads and ditches), and 5 acres is reserved for the farmstead. The land base is valued at $1,000 per acre. The tillable acres are classified as Class A irrigated agricultural land for tax purposes.

The material costs and machinery complements are derived primarily from "Costs of Producing Crops, Worland Area, Wyoming, 1981-82", Bulletin 664R which was published by the Agricultural Extension Service, University of Wyoming in December of 1981. This information was updated to reflect 1984 prices. In addition, data gathered from personal interviews were used to supplement and refine the budgets. The Bureau of Reclamation recommends that interest, return to equity, and depreciation be calculated using current equipment prices. It was decided that some machinery on any typical farm will be "used" equipment and thus, some adjustments in machinery prices were made. A sinking fund approach was used to calculate depreciation. The interest rate employed was 14.85 percent. It is assumed that the operator would hire part-time, seasonal help.

The sales prices for crops used in the budgets are normalized prices as reported by the Bureau of Reclamation, Upper Missouri Region, Billings, Montana, except where noted otherwise. It is important to note that present market prices are below these normalized prices, reflecting a depressed agricultural economy. However, market prices have also been above normalized prices in the past 5 years. Since market prices are a sensitive input to payment capacity calculations, the normalization process has been adopted to smooth out historical fluctuations. Data for taxes on land, machinery, and improvements were provided by the Big Horn County Assessor's Office.

The crop mix for the representative farm is considered under two different scenarios -- "with" and "without" sugar beets. The inclusion of sugar beets, as a potential crop for the representative farm, is justified because a few farmers currently produce beets in the Shell Valley. The production of sugar beets is likely to increase a farmer's ability to pay for supplemental water. However, the "typical" farmer in the Shell Valley does not raise beets and will probably have a lower repayment capacity. For informational purposes, it was decided to include beet production in one of the two scenarios. In addition, there is some uncertainty over the continued production and refining of sugar beets in the area. This should be considered when a final evaluation of long-term repayment capacity is formulated.

The crop mix in the first scenario consists of 95 acres of alfalfa hay, 115 acres of malting barley, 40 acres of corn for grain, and 40 acres of corn for silage. While it is unlikely that a single producer would produce small acreages of both corn for silage and grain, each was included to reflect their impact on production in the valley. The return over variable costs is $69,856 and the return over both variable and fixed costs is $15,563. (Appendix B). From this, an allowance for the opportunity cost of operator labor and management is subtracted. Previously, interest and a return to equity on the operator's dwelling was included as a production fixed cost. However, it can be argued that this reflects a farm perquisite and, therefore, is added to obtain an adjusted net farm income of $2,262. This results in a repayment capacity per acre of

$7.54. Since the variable costs of production includes a $7.00 per acre charge for water, this figure represents the ability for the representative farm to pay for supplemental water. The $7.54 repayment capacity is generated because of the increased yields associated with the additional water and the use of normalized prices, which are generally higher than current market prices.

The second scenario considers the production of sugar beets. In this case, the crop mix of the representative farm includes 70 acres of alfalfa hay, 120 acres of malting barley, and 100 acres of sugar beets. The methodology and procedures are similar to the first scenario. The return over variable and fixed costs totals $20,914 and results in an adjusted net farm income of $7,613. The repayment capacity per acre equals $25.38 and is generated through an increase in yields and the use of normalized prices, which are higher than current market prices.

Conclusions

An incremental payment capacity for supplemental water of $7.54 per acre is generated for a representative 300 acre farm that produces alfalfa hay, malting barley, corn for grain, and corn for silage. An incremental payment capacity of $25.38 per acre is generated for a representative 300 acre farm that produces alfalfa hay, malting barley, and sugar beets. These figures are developed after allowing for variable costs of production, fixed costs, interest and a return to equity on land, machinery, and improvements, and a return to the operator's labor and management.

Each payment capacity figure was calculated using a procedure recommended by the Bureau of Reclamation. This procedure includes the use of sinking fund depreciation and normalized prices. In each case, the payment capacity is generated via a projected increase in production over current average yields and the use of normalized prices. If present market prices are used in the analysis, the payment capacity would be zero.

AGRICULTURAL BENEFITS

Introduction

Agricultural benefits, as a result of the Lake Adelaide rehabilitation project, can be classified into two categories -- direct and indirect benefits. The direct benefits can be further separated into two types. The first considers the added net farm income of the estimated increase in production as a direct result of an increase in the water supply. The second considers the added net farm income which is generated when additional water allows the use of currently idle or newly developed lands within the Shell Valley Watershed Improvement District.

The indirect benefits are those which are caused by increases in direct agricultural benefits. Increases in the purchase of production inputs generate additional economic activity. Therefore, indirect agricultural benefits will be calculated for the land that is currently idled, but would be placed in production if adequate water was available. Indirect benefits associated with the 10% production increase on currently irrigated land are assumed to be insignificant since the only input, which is assumed to change, is the use of additional water. Technically, there may exist a slight increase in the use of output oriented production items (e.g. grain bins, commodity transportation, etc.), however, it is assumed that these effects would be insignificant.

Increases in Yields

Direct agricultural benefits are generated because of an increase in net farm income which results from an increase in production. During personal interviews with area farmers, most indicated that their yields suffered slightly because of a lack of water. On average, most indicated that yields could be increased at least 10% over current yields if adequate water were available. This production increase results in an average increase of net farm income for all crops, except sugar beets, (alfalfa hay, malting barley, corn for grain, corn for silage) of $31.71 per acre. This assumes that the producers are charged $7.54 per acre (their ability to pay) for the additional water. All other costs are held constant, although slight increases in harvest costs may be incurred. However, these would probably be minimal. It is estimated that 4,028 acres may benefit from additional storage and produce a crop other than sugar beets. Therefore, total net farm income from these crops could have been increased by a total of $127,728 (see Appendix B).

The direct benefits from the increased yield of sugar beets is calculated separately because the higher net return per acre would distort the average. This return can be applied to only 310 acres (which is approximately the number of acres of beets produced in 1984). It is assumed that all commercial irrigators and all crops would have to be charged a similar rate for additional water. Therefore, $7.54 of additional water costs per acre is included. The total increase in net farm income, as a result of increased sugar beet yields, is $20,900.

Finally, the total direct agricultural benefits of the increased production is estimated at $148,628 annually.

Use of Additional Irrigable Land

Direct agricultural benefits would also be generated in the form of additional net farm income if an increase in the supply of water would allow additional lands to be irrigated. Currently, 660 acres of land are idle. It is assumed that this land is of poorer quality than that which is currently irrigated. Therefore, sugar beets are excluded as a potential crop alternative for the new land. In addition, the yields of the remaining potential crops (alfalfa hay, malting barley, corn for grain, corn for silage) have been reduced from the levels in the payment capacity budgets to current average levels as reported by area farmers (without the project) to reflect the poorer quality land. It is assumed that this idled land would be reassessed from Class C grazing land to Class B irrigated land which would increase taxes by $41.25 per acre. Additional breaking and clearing costs would be incurred as well.

The average increase in net farm income per acre from these four crops is $126.20. This figure multiplied by the number of idled acres results in an increase in direct agricultural benefits of $83,544 (Appendix B).

Indirect Agricultural Benefits

Changes in economic activity of one sector of an economy cause corresponding changes in other sectors. These "ripple" effects are best measured through the use of a multiplier which is calculate by an input-output (I-O) model. In this project, the use of an output multiplier is appropriate since it measures the total change in the output of an economy that results from a change in the output of a single sector. An appropriate output multiplier for crop production for Wyoming was not found. However, economists at Montana State University, Bozeman, have recently completed a state-of-the-art I-O model for Montana. It is assumed that the agricultural economies of Montana and Wyoming are similar. Therefore, the results of the Montana I-O model are used in this project. The Montana model indicates that the output multiplier for all crops is 1.73. This figure indicates that $1.73 of total output is generated in the economy for every $1.00 of output generated in crop production. The total output includes the original $1.00 change. Therefore, it can be stated that an additional $0.73 of output is generated in an economy for every $1.00 generated by crop production.

Calculation of the indirect benefits requires that the output multiplier be multiplied by the total revenue that is generated on the idled lands. The average total revenue per acre of the idled land is $359.57. This figure multiplied by 662 acres results in an increase in the output of agriculture of $238,035. The output multiplier multiplied by $238,035 results in $411,800 of total output being generated in the economy (including the original $238,035). Therefore, the additional indirect agricultural benefits equals the difference between the two figures, or $173,765.

Summary

The increase in direct agricultural benefits, as a result of increased yields, is estimated as $148,628 (see Appendix B worksheets). The increase in direct agricultural benefits, as a result of the use of current idle land, is estimated as $83,544. The additional indirect agricultural benefits is estimated as $173,765 (see Appendix B worksheets). Therefore, the total direct and indirect agricultural benefits that result from the proposed project is estimated to be $405,937 per year.

Increased Yields	$148,628
Idle Land	83,544
Indirect Ag Benefits	173,765
TOTAL	$405,937

COST - BENEFIT ANALYSIS

The total project cost of the Lake Adelaide Rehabilitation is $2,218,100.00 as developed in Chapter VI. These costs must be analyzed so as to compare with benefits. A 50 year term is assumed based on past State loans and the expected life of 50 years for the dam before major repairs are needed. For comparison purposes a 40 year term is also shown. Both of these terms are conservative as the existing dam has experienced 70 years of service. Considering the fact that sedimentation is minimal, a 100 year life for the dam and reservoir basin would not be unreasonable.

Three interest rates are presented, 8%, 9% and 10%. These are rates that are typical of bond rates, the Federal Discount Rate and long term returns on investments of the Wyoming Water Development Account funds. The following matrixes of benefit cost/ratios are presented.

Benefit/Cost Ratios
Direct Benefits Of $232,172

Interest Rate	Term	
	40 years	50 years
8%	1.25	1.28
9%	1.13	1.15
10%	1.02	1.04

Benefit/Cost Ratios
Direct and Indirect Benefits Of $405,937

Interest Rate	Term	
	40 years	50 years
8%	2.18	2.23
9%	1.97	2.01
10%	1.79	1.82

DAM SAFETY BENEFITS

A clear weather breach of the existing dam was simulated using the Corps of Engineers' HEC-1 computer model. The peak discharge at Shell was found to be 9200 cfs. Techniques used on other projects[1/] were used to estimate the probable cost of damages attributable to this event. Based on the analysis, the cost of damages was found to be $1.4 million. These costs are simply reported here but are not included as benefits in this analysis.

SUMMARY

A total payment capacity for water in the Shell Valley has been estimated to be $14.54 per acre. Assuming a $7.00 per acre existing charge, $7.54 may be available for additional payment for supplemental water. Any additional debt not yet incurred should be subtracted from this value, i.e. the Shell Canal project which is pending. It is important to note that present market conditions would allow no payment capacity. However, long term markets must be considered in this analysis.

1/ ECO Northwest, Ltd., "Probable Maximum Flood Damage Estimates Hyalite Reservoir", Working Paper #1, Submitted to HKM Associates, June, 1984.

From the standpoint of the State of Wyoming, the investment is a feasible one. Benefits exceed costs in all of the various scenarios presented. This analysis does not include recreational and flood control benefits. These benefits are likely minimal, however.

VIII FINANCIAL PROGRAM

CHAPTER VIII
FINANCIAL PROGRAM

INTRODUCTION

Numerous State and Federal programs are in place to finance water development projects. The Federal programs, with the possible exception of the USBR Small Loans Program, have not been a viable source of revenue recently. It is assumed that the funding mechanism for this project will be a low interest loan and grant from the Wyoming Water Development Account. It is assumed that the feasibility study costs will be directly funded from the Water Development Account and the District will eventually repay a portion of these costs if a project should materialize.

The Board of Directors of the Shell Valley Watershed Improvement District has requested a loan of 25% of total project cost with a term of 50 years and an interest rate of 4%. Given a total project cost less IDC of $2,201,380.00 (see Table V1.2, Chapter VI), 25% of this value would equate to a loan of $550,000.00 (rounded). The annual loan repayment would be $25,602.61 (50 years, 4%, CRF - 0.04655).

RECOMMENDED PROGRAM

The exact financial program cannot be defined until the following factors are known:

1. The number of acres which will be assessed.
2. The number of small users with a flat rate assessment.
3. The expected O&M charges.
4. The size and establishment rate of an emergency fund.
5. Any special conditions imposed during legislative approval.

A typical financial program is presented here for purposes of discussion. This program is based on assumptions for the first four factors listed in the previous paragraph. It is assumed that the assessment base would range from 5,000 to 8,000 acres. This base would include many of the irrigators under the Shell Canal, those irrigators with junior priorities and irrigators wishing to develop new lands. The assessment base will evolve out of a poll of the membership of the District.

It is assumed that 25 small users would be involved irrigating tracts less than 10 acres in size. It is suggested that these users be assessed $100.00 per year. This value is based in part upon assessment of this type by other entities and, in part, by analysis of alternative costs of supplying this water, such as wells, pumping from the Big Horn River, etc. This assessment would include O&M charges, emergency fund reserves, etc. and would generate $2,500.00 per year.

The O&M charge necessary to operate this reservoir is estimated to be $1.00 per AF of active storage. This would require $3,280.00 of revenue to be generated by assessment. The $1.00 per AF is typical of reservoirs of this size. This value will likely be reduced or increased to meet needs on a year to year basis.

It is generally recommended that an emergency operating reserve of twice the annual O&M revenue be established. This fund would be available for unusual repairs or unforeseen expenses should they occur. This account could be established over a 5 to 10 year period and would total $6,560.00 when established.

The following summary table is presented:

Loan Repayment	$25,604.00	(4% - 50 years)
O&M	3,280.00	($1 per AF active storage)
Emergency Reserve	656.00	(10 year period)
Total Revenues Needed	$29,540.00	
Less Small Tract Charge	2,500.00	
Balance	$27,040.00	

Assessment per acre with 5,000 acre base: $5.41

Assessment per acre with 8,000 acre base: $3.38

APPENDIX A

APPENDIX A

LAKE ADELAIDE DAM

PLANS AND DETAILS

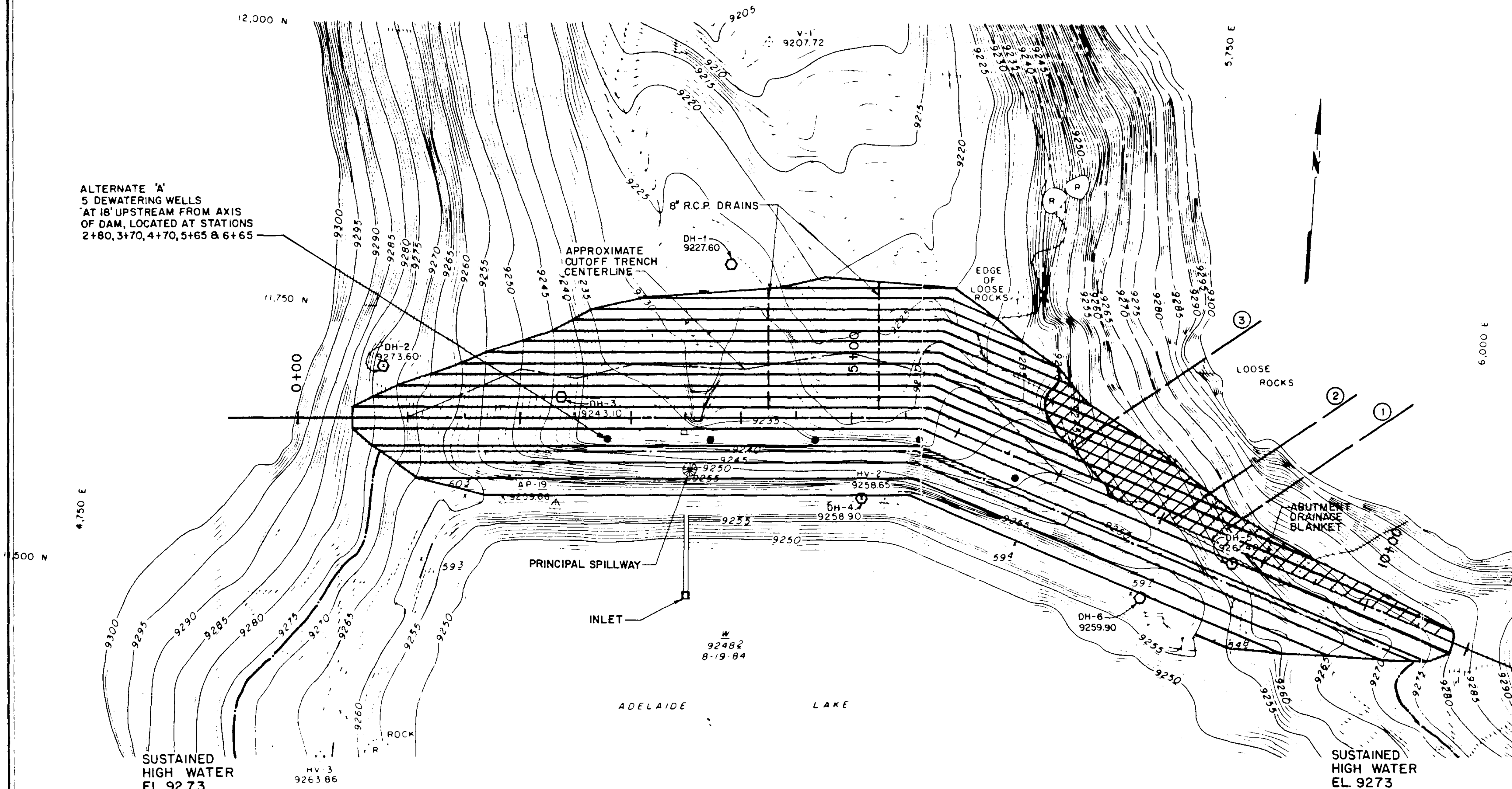
10M183.105/0608P

CHIMNEY DRAIN & RIPRAP

SIEVE SIZE	% FINER
4"	100
2"	75-100
1"	65-85
1/2"	55-75
NO. 4	40-60
NO 10	25-45
NO 20	15-35
NO. 40	5-25
NO 100	0-15
NO 200	<5

RIPRAP

SIEVE SIZE	% FINER
18"	100
12"	90-100
6"	80-90
3"	68-80
2"	60-70



HORIZONTAL DRAIN WELL

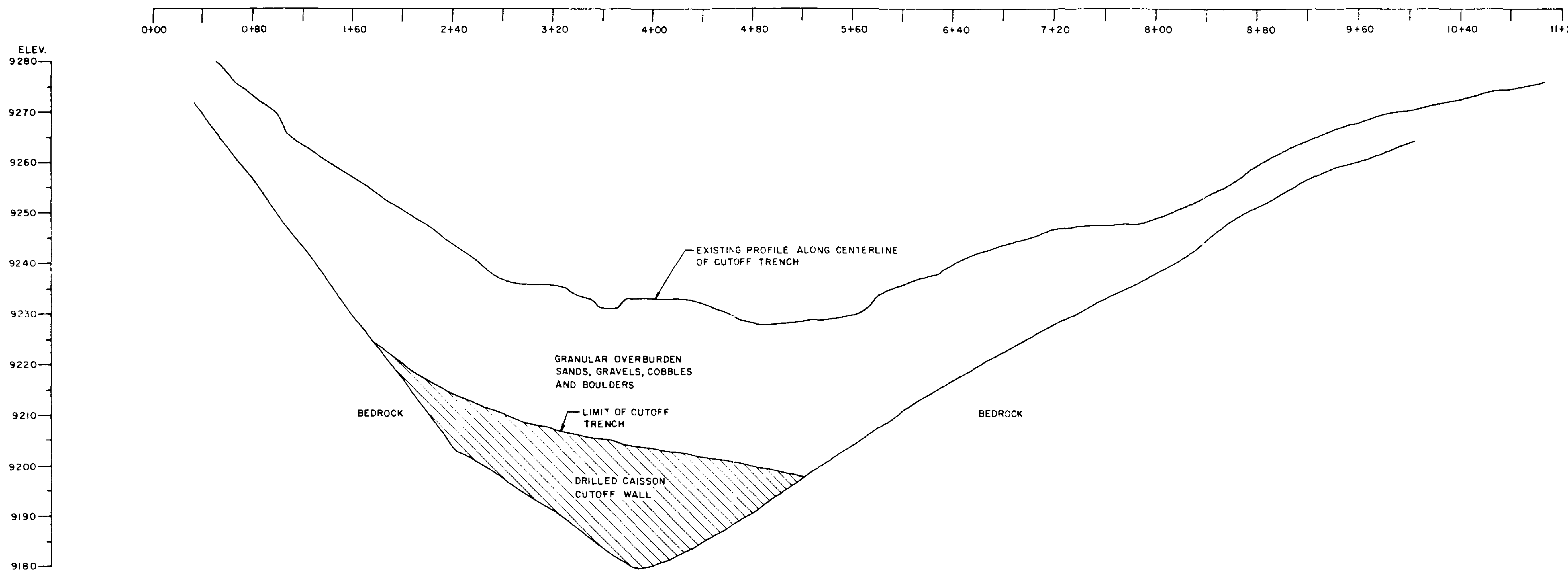
(1) 15' BELOW CREST — EL. 9265

(2) 25' BELOW CREST — EL. 9255

(3) 35' BELOW CREST — EL. 9245

HORIZONTAL DRAINAGE WELL 3" PERF. PVC. PIPE
PERFORATION — 0.028" SLOTS, 4 SLOTS/INCH,
SLOT CENTERS @ 120°.

NOV, 1984	ROLLINS, BROWN AND GUNNELL, INC. PROFESSIONAL ENGINEERS	LAKE ADELAIDE ENLARGEMENT SHELL VALLEY PROJECT	WYOMING WATER DEVELOPMENT COMMISSION	PLAN VIEW OF DAM	1



NOV. 1984

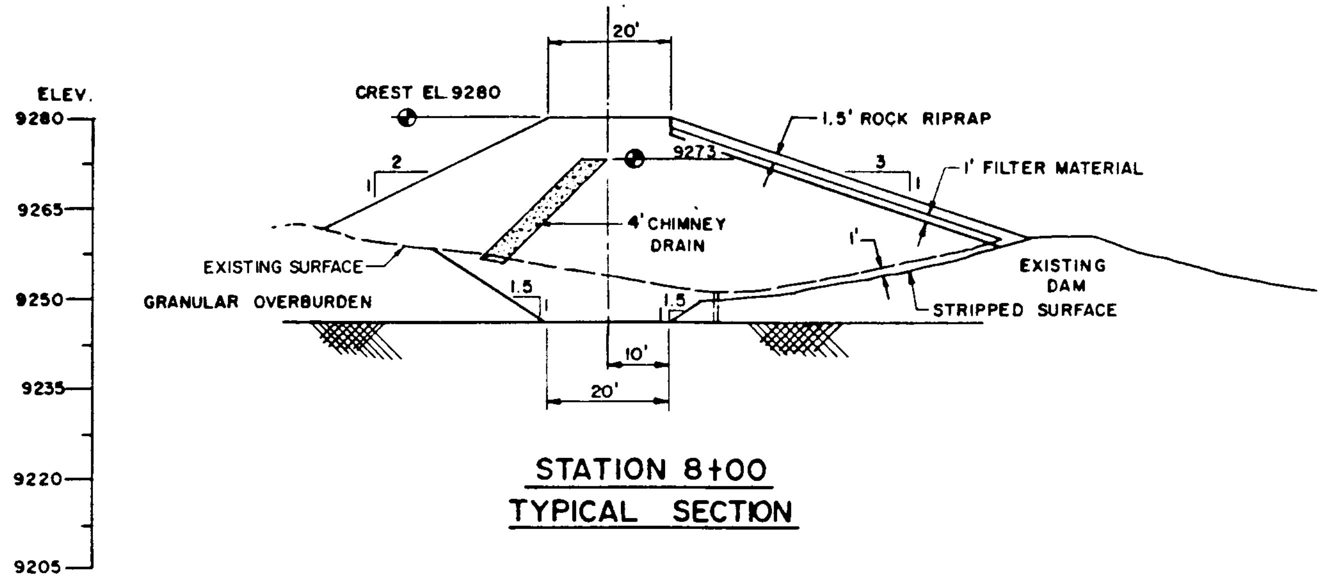
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

LAKE ADELAIDE ENLARGEMENT
SHELL VALLEY PROJECT

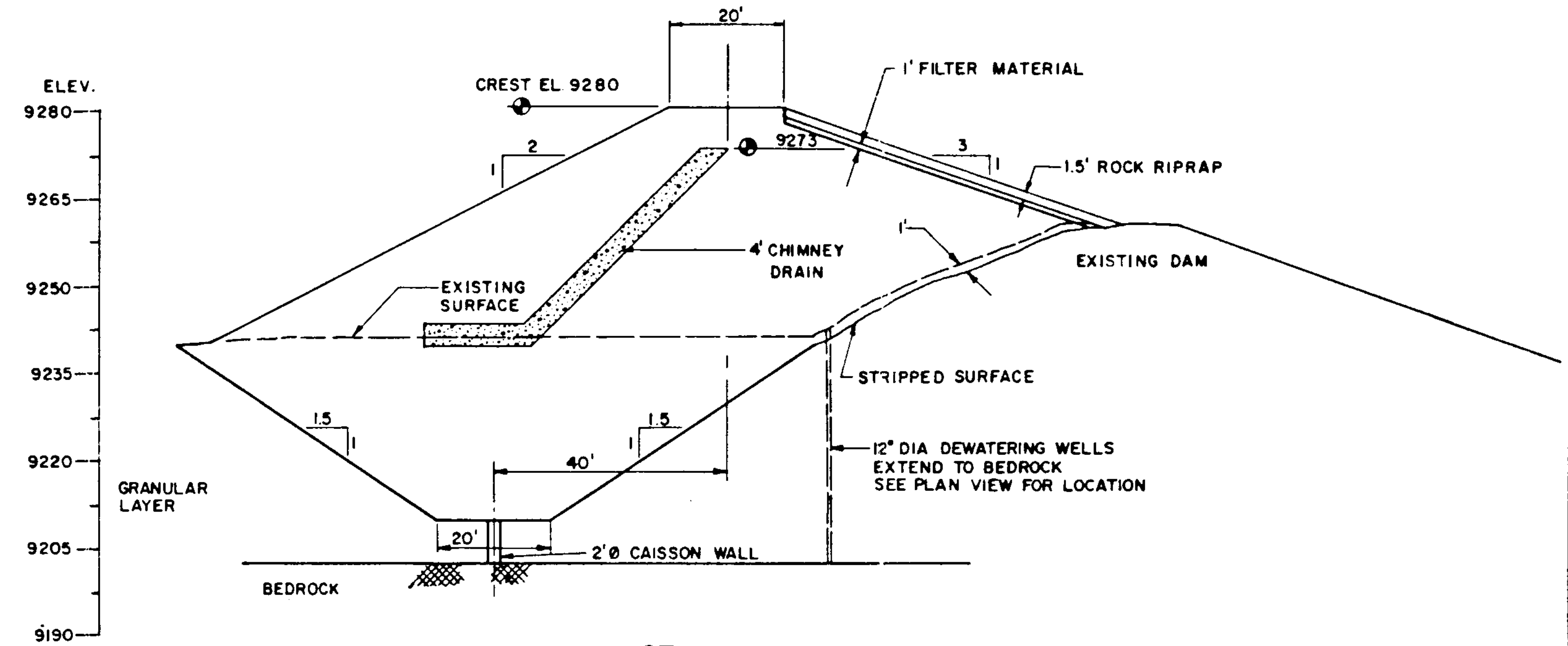
WYOMING WATER DEVELOPMENT COMMISSION

SECTION ALONG AXIS OF DAM

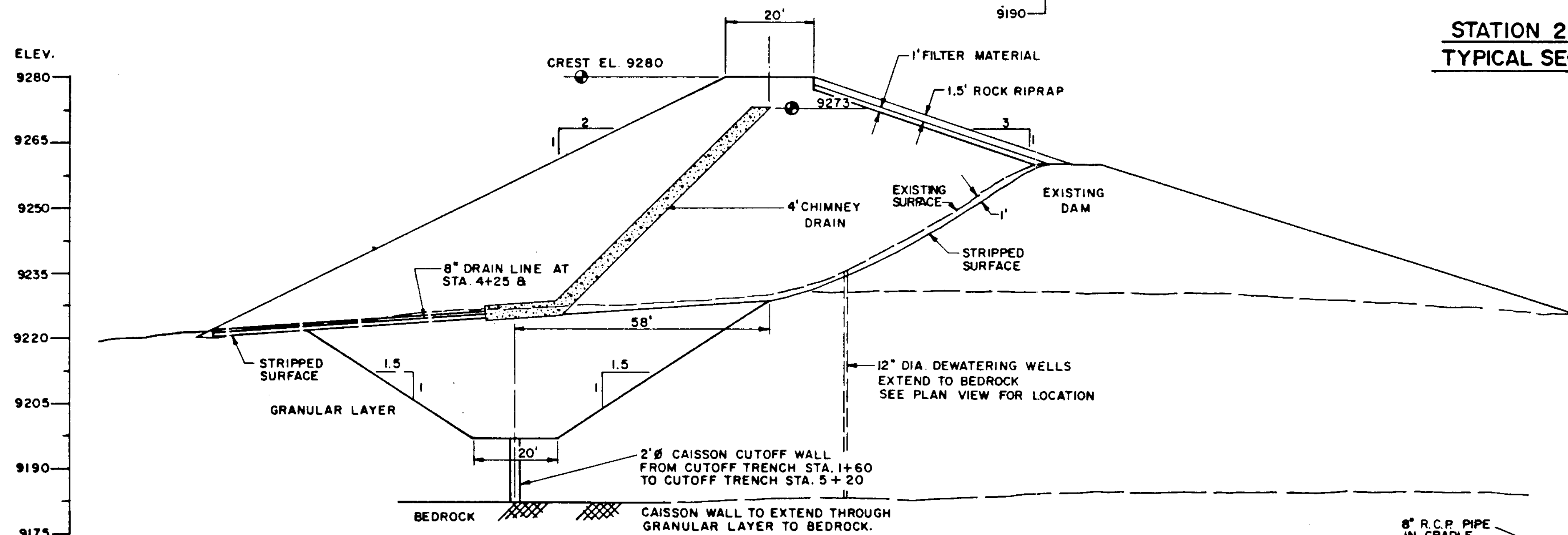
SHEET
2



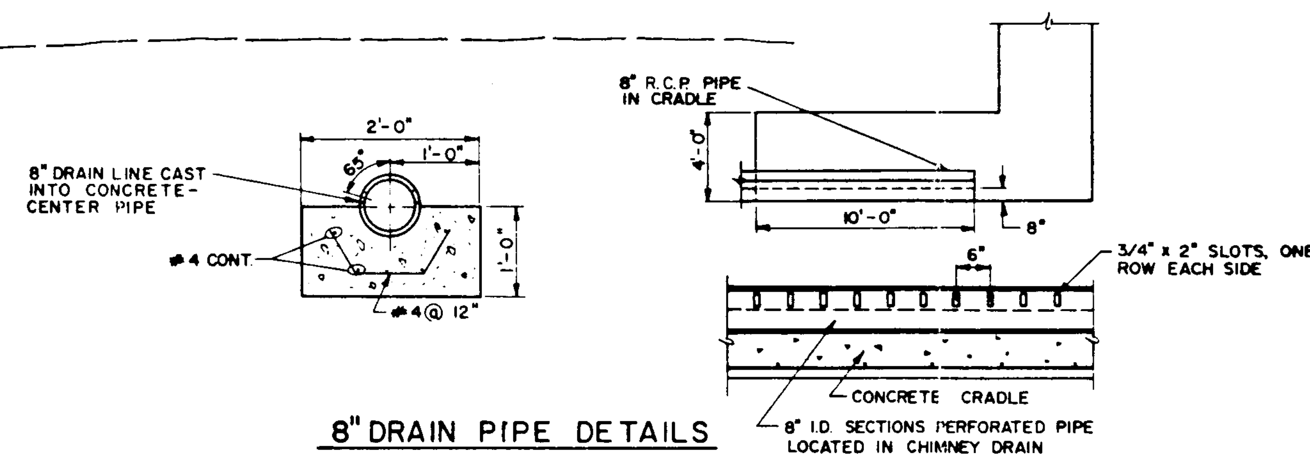
STATION 8+00
TYPICAL SECTION



STATION 2+50
TYPICAL SECTION



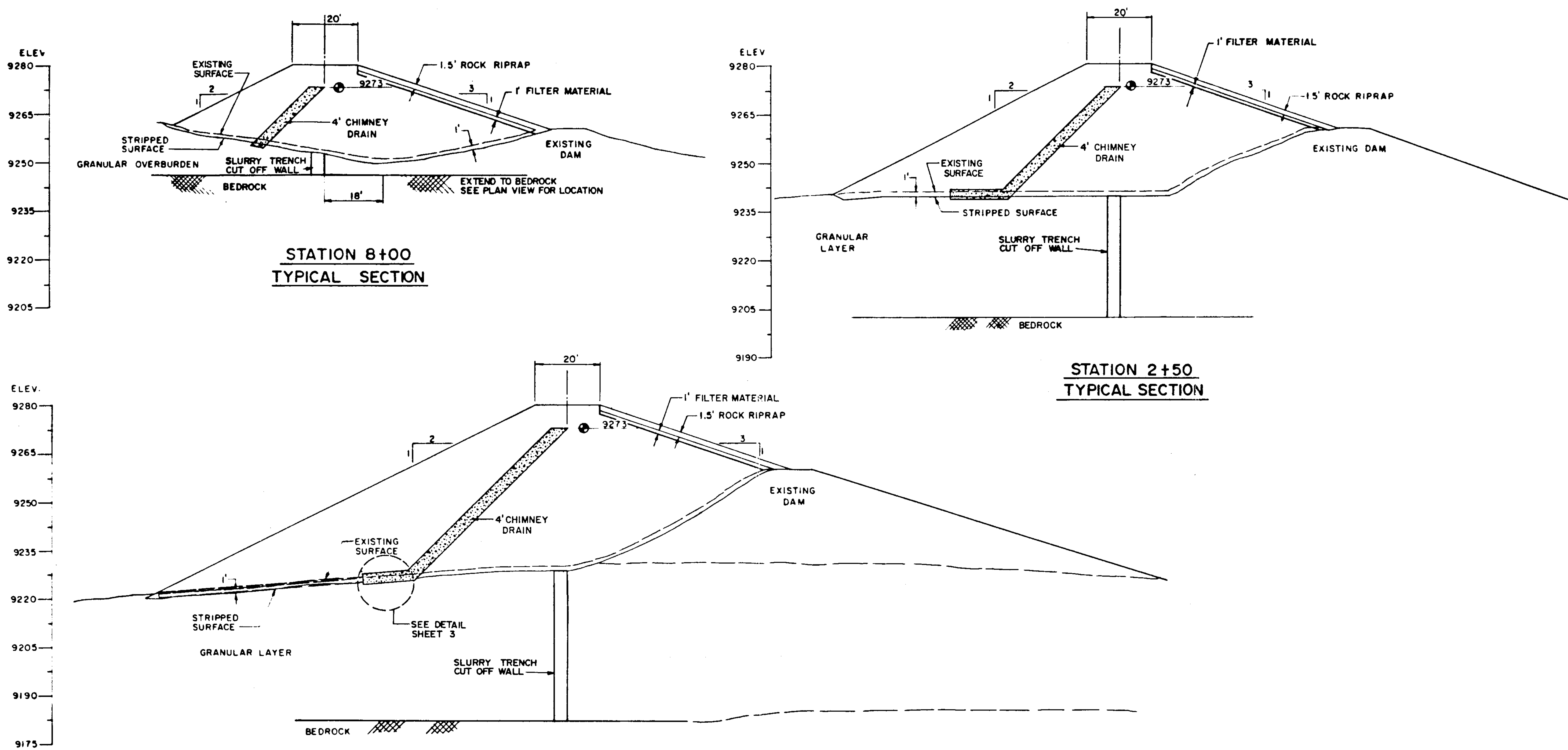
STATION 4+86
MAXIMUM SECTION



8" DRAIN PIPE DETAILS

15 0 15 30
scale feet

REVISIONS	DESIGNED BY / DRAWN BY / CHECKED BY — DATE NOV. 1984	ROLLINS, BROWN AND GUNNELL, INC. PROFESSIONAL ENGINEERS	LAKE ADELAIDE ENLARGEMENT SHELL VALLEY PROJECT	WYOMING WATER DEVELOPMENT COMMISSION	MAXIMUM & TYPICAL SECTIONS ALTERNATE A	SHEET 3



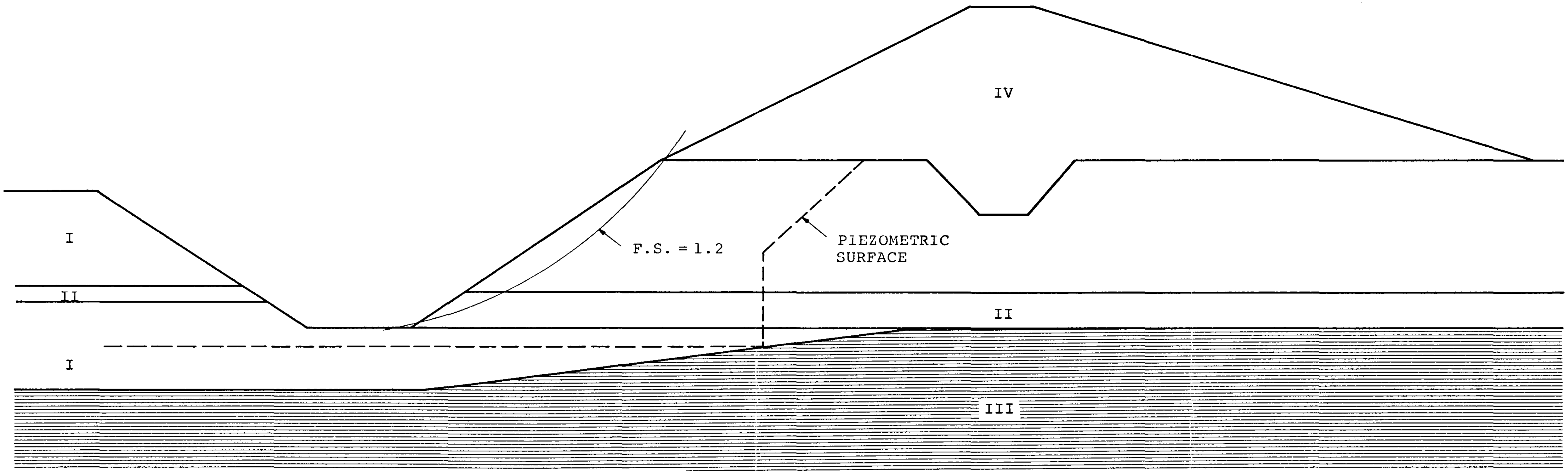
STATION 8+00
TYPICAL SECTION

STATION 2+50
TYPICAL SECTION

STATION 4+86
MAXIMUM SECTION

	NOV, 1984	ROLLINS, BROWN AND GUNNELL INC	LAKE ADELAIDE ENLARGEMENT SHELL VALLEY PROJECT	WYOMING WATER DEVELOPMENT COMMISSION	MAXIMUM & TYPICAL SECTIONS	SHEET 4

ZONE	MATERIAL TYPE	φ (degrees)	γ (pcf)	COHESION (psf)
I	Sandy Gravel with Cobbles & Boulders	37	130	0
II	Silty Sand	35	110	0
III	Bedrock Monsonite	40	140	500
IV	Silty Sand	36	120	0
V	Sand and Gravel	36	125	0
VI	Silty Sand	37	125	0



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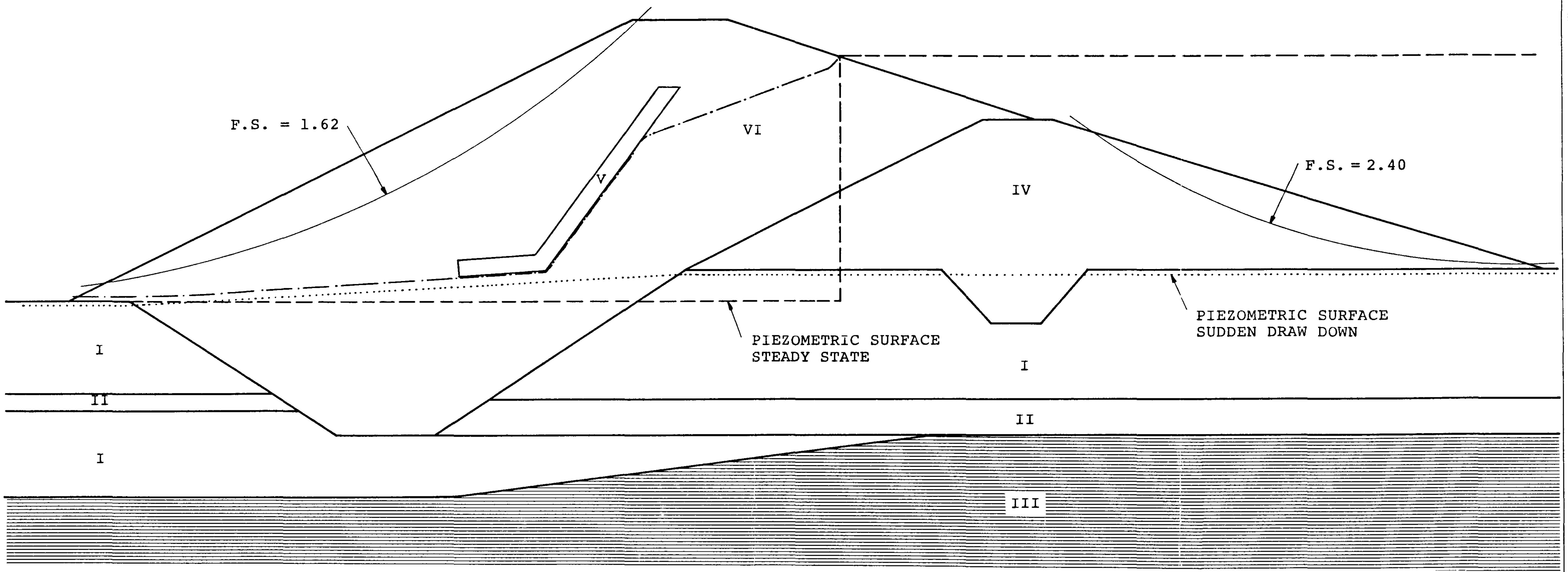
STABILITY ANALYSIS - CONSTRUCTION CASE
LAKE ADELAIDE DAM

SHEET NO. 5

ZONE	MATERIAL TYPE	ϕ (degrees)	γ (pcf)	COHESION (psf)
I	Sandy Gravel with Cobbles & Boulders	37	130	0
II	Silty Sand	35	110	0
III	Bedrock Monsonite	40	140	500
IV	Silty Sand	38	120	0
V	Sand and Gravel	38	125	0
VI	Silty Sand	37	125	0



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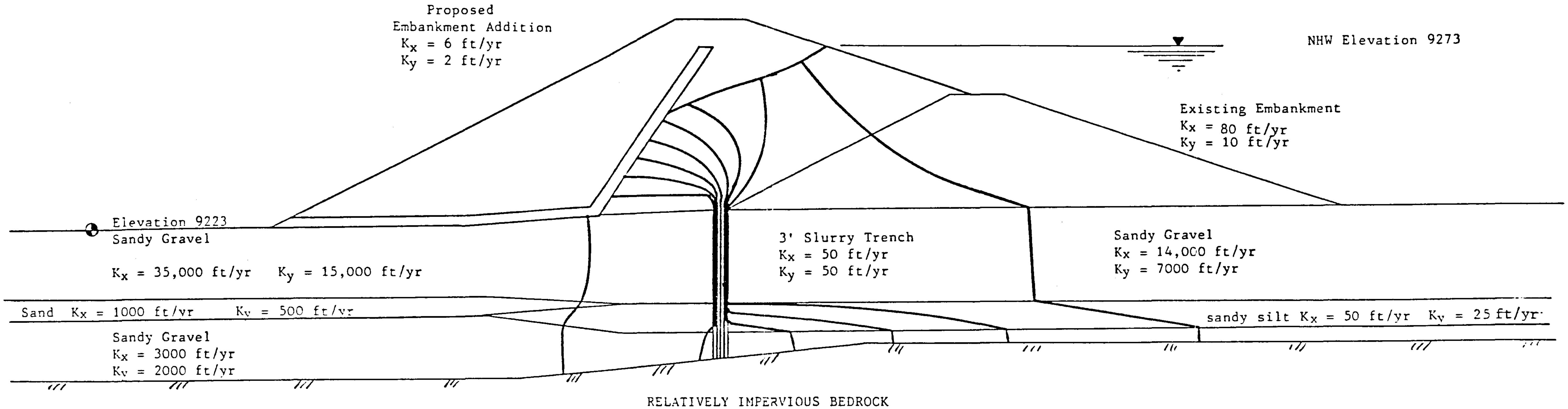
STABILITY ANALYSIS - DAM ENLARGEMENT
LAKE ADELAIDE DAM

SHEET NO. 6



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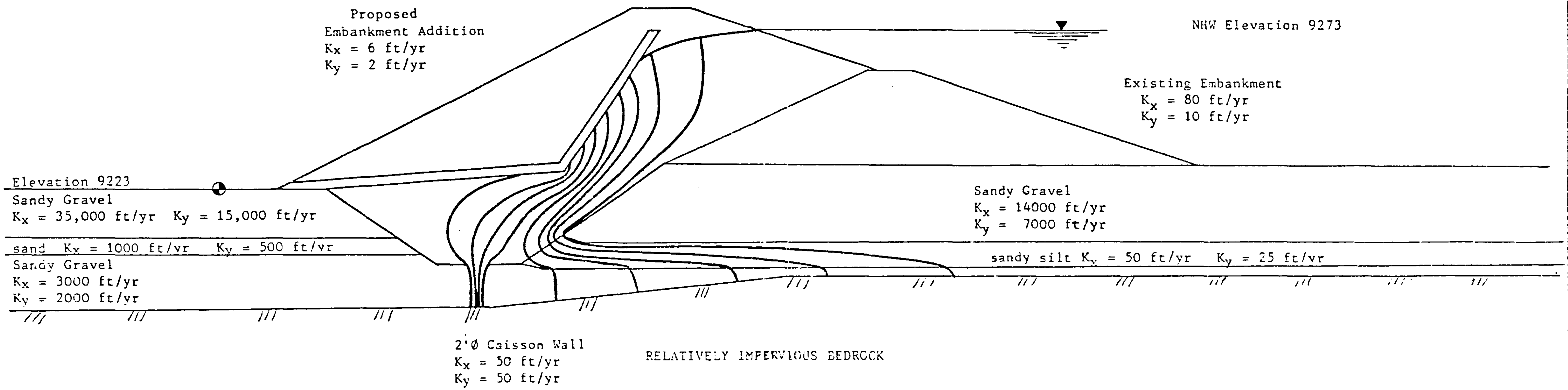
EQUIHYDRAULIC HEADLINE DISTRIBUTION
SLURRY TRENCH ALTERNATIVE
LAKE ADELAIDE DAM

SHEET NO. 7



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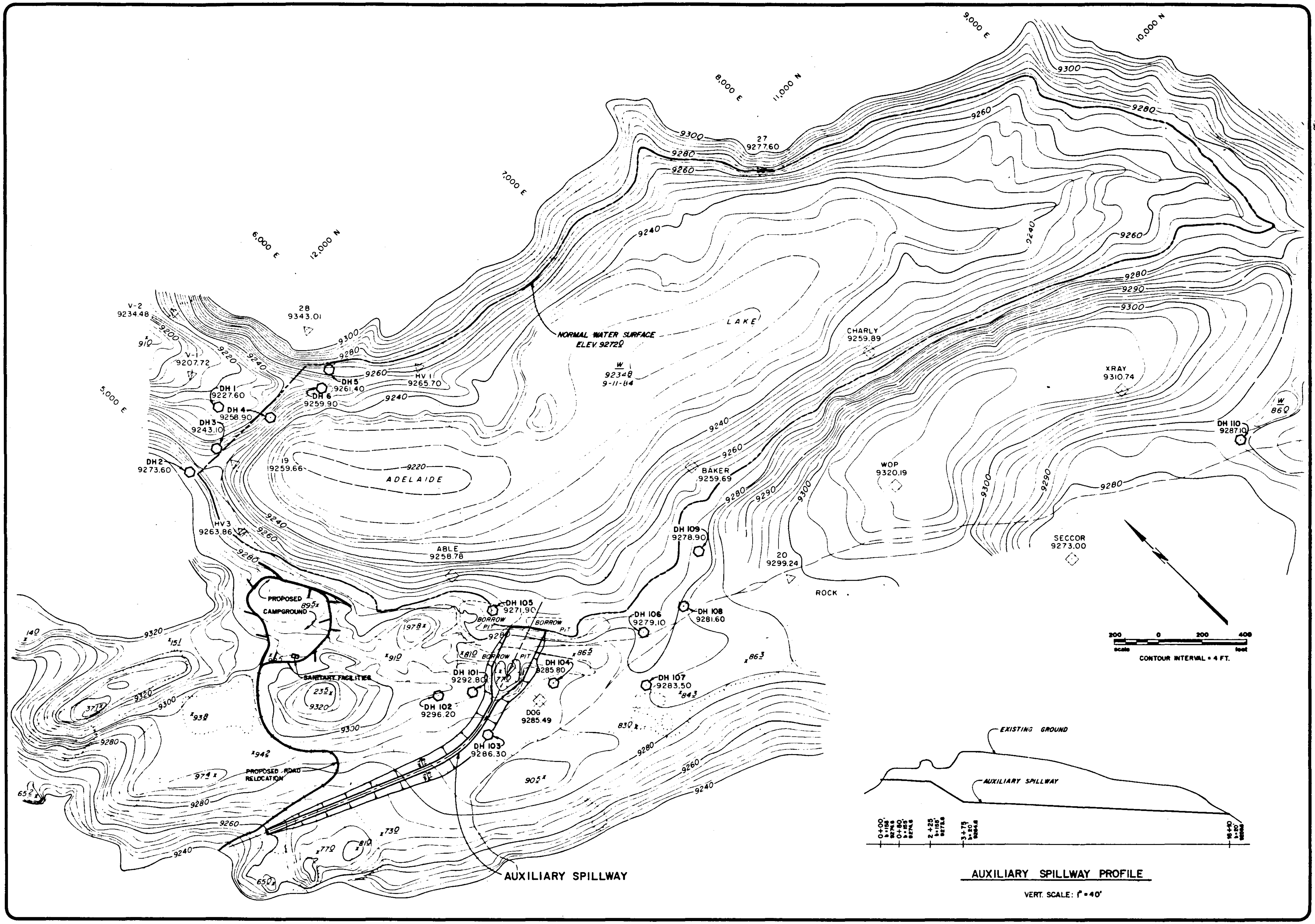
PROFESSIONAL ENGINEERS

EQUIHYDRAULIC HEADLINE DISTRIBUTION
EARTH CUTOFF ALTERNATIVE
LAKE ADELAIDE DAM

SHEET
NO. 8



Project No. 10M183.105 | ID No. | Date NOV. 1984 | Designed DP | Drawn GE/DP | Checked | Approved

No.	Revision	By	Date

LAKE ADELAIDE DAM
SHELL VALLEY WATERSHED LEVEL II STUDY

AUXILIARY SPILLWAY PLAN & PROFILE

HKM ASSOCIATES
ENGINEERS·PLANNERS

Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
• Libby, Montana
• Sheridan, Wyoming

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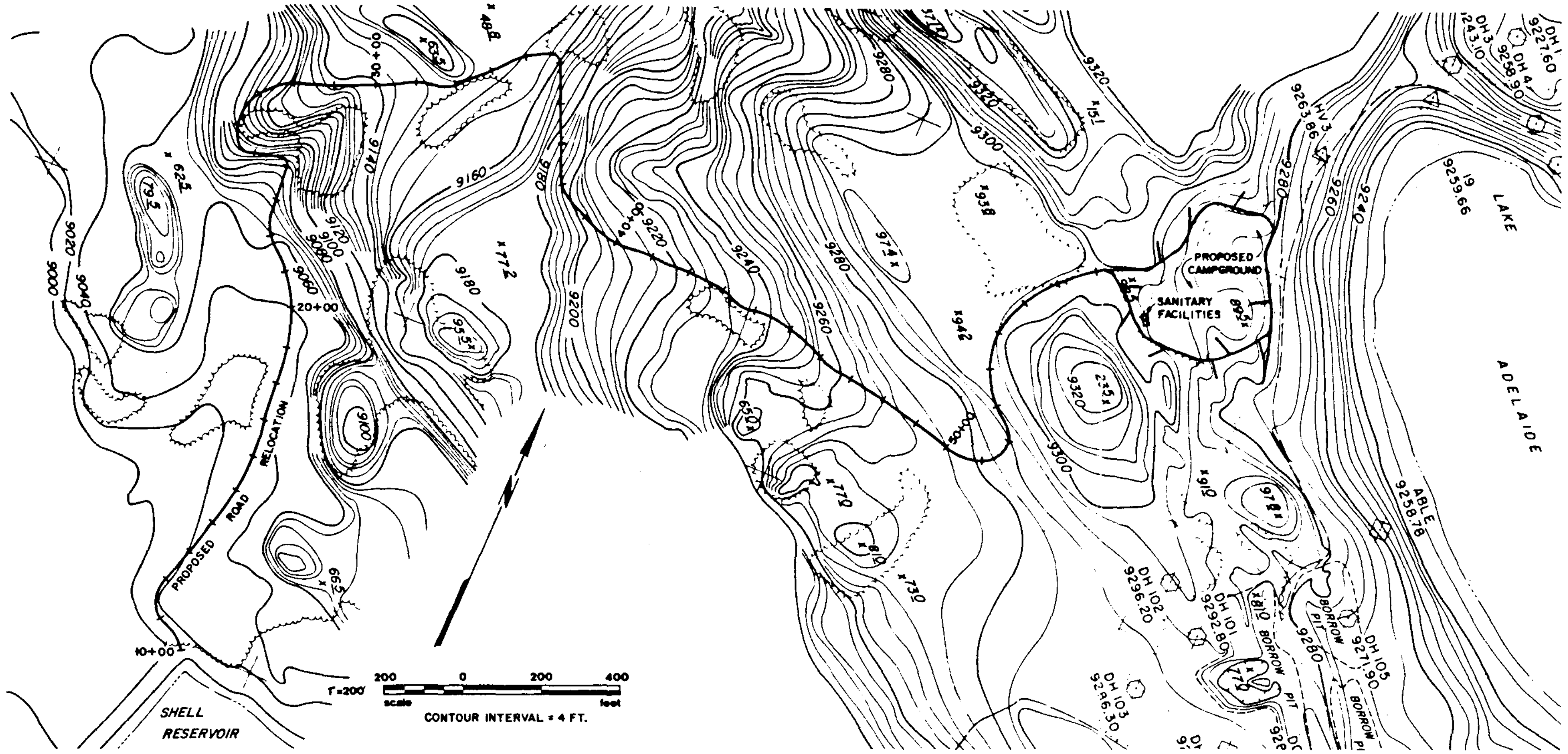
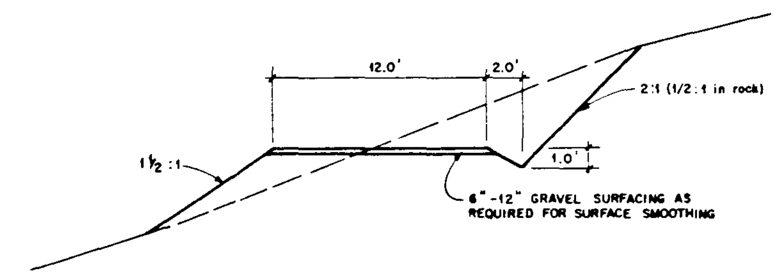
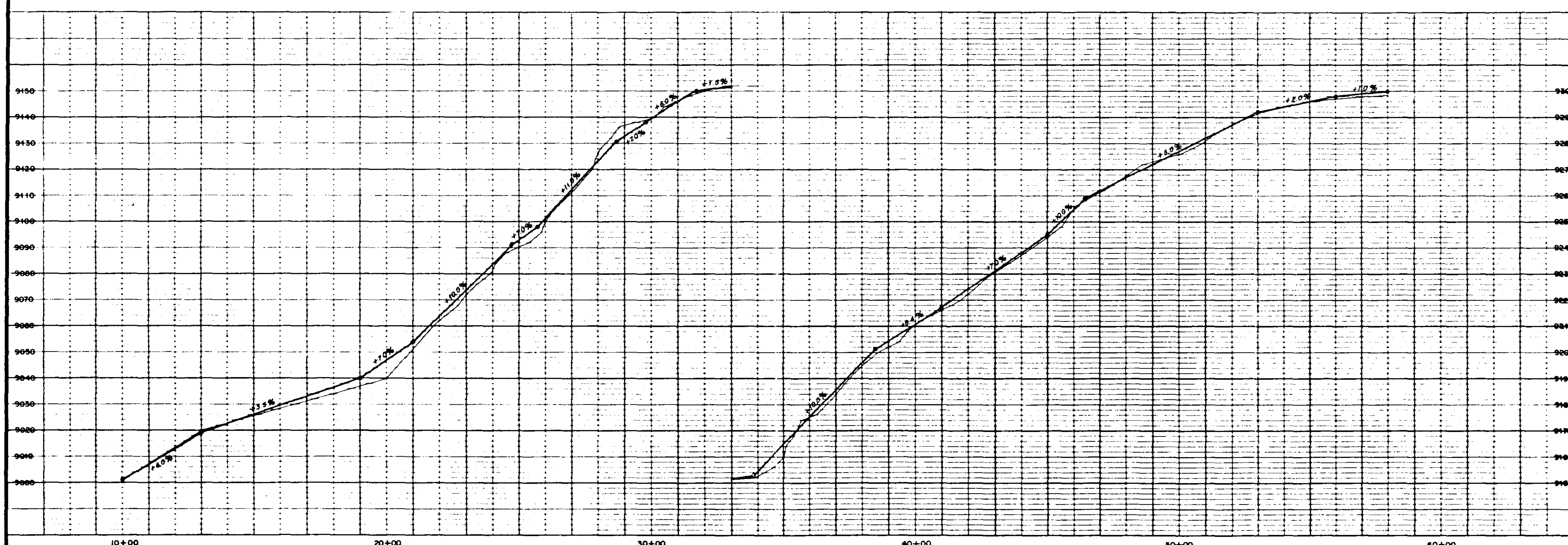
of ______





PROPOSED ROAD
TYPICAL CROSS SECTION
N.T.S.



Project No. 10M183.105 I.D. No. ___ Date NOV. 1984 Designed JT Drawn DM Checked RJP Approved

LAKE ADELAIDE DAM
SHELL VALLEY WATERSHED LEVEL II STUDY
ACCESS ROAD & CAMPGROUND FACILITIES
PLAN & PROFILE

HKM ASSOCIATES
ENGINEERS — PLANNERS

Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
• Libby, Montana
• Sheridan, Wyoming

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of ___

APPENDIX B

APPENDIX B

FARM BUDGET ANALYSIS

WORKSHEETS

NET INCOME FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

Item	Total Farm
Gross Farm Income	$118,343
Less: Total Variable Costs	$48,487
Return Over Variable Costs	$69,856
Less: Total Fixed Costs	$54,293
Return Over Variable and Fixed Costs	$15,563
Less: Opportunity Cost for Operator Labor and Management 1/	$16,403
Plus: Interest and Return to Equity on Operator's Dwelling 2/	$3,102
Net Farm Income	$2,262
Repayment Capacity Per Acre 3/	$7.54

1/ Annual earnings of production and nonsupervisory workers on payrolls in manufacturing in Wyoming for 1983, "Earnings And Employment", U. S. Department of Labor, Bureau of Labor Statistics.
2/ Considered as a farm perquisite.
3/ Net farm income of $2,262 divided by 300 acres.

CROP PRODUCTION AND TOTAL REVENUE FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

Crop	Acres	Units	Yield Per Acre 1/	Total Product	Sales Price 2/	Total Revenue
Alfalfa Hay	95	Ton	5	475.0	$67.11	$31,877
Malting Barley	115	Bu.	100	11,500.0	4.22	48,530
Corn For Grain	40	Bu.	125	5,000.0	3.65	18,250
Corn For Silage	40	Ton	22	880.0	22.37	19,686
Farmstead/Wastage	10					
TOTAL	300					$118,343

1/ Yields are from a combination of personal interviews with Shell Valley farmers and the Wyoming Agricultural Statistics. Each yield has been increased by 10% to reflect additional production due to a greater availability of water if the project is completed.

2/ Normalized prices for Wyoming as reported by the Bureau of Reclamation, Upper Missouri Region, Billings, Montana except for corn silage which was unavailable. Its price is estimated as one-third of the alfalfa hay price.

TOTAL COSTS OF PRODUCTION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

ITEM	Alfalfa Hay (95 Ac)	Malting Barley (115 Ac)	Corn for Silage (40 Ac)	Corn for Grain (40 Ac)	Total Farm Expenses (1984)
CASH COSTS					
Seed		$1,404	$622	$622	$2,648
Fertilizer	$2,961	3,494	1,691	1,691	9,837
Herbicide	33	1,462	732	732	2,959
Insecticide	544				544
Other Materials	979	87	30	30	1,126
Custom Hire	470	443	154	154	1,221
Fuel	1,745	2,273	1,463	967	6,448
Irr. Water	665	805	280	280	2,030
Mach. Var. Costs	2,658	2,425	1,328	991	7,402
Imp. Var. Costs	427	625	180	180	1,412
Taxes-Equip.	831	909	579	386	2,705
Utilities	392	475	165	165	1,197
Hired Labor	834	995	546	397	2,772
Insurance-Equip.	114	123	79	53	369
-Imp.	149	212	63	63	487
Gen. Overhead	640	787	396	336	2,159
Int. Operating	941	1,156	581	493	3,171
VARIABLE COSTS	$14,383	$17,675	$8,889	$7,540	$48,487
FIXED COSTS					
Stand Establish 1/	2,541				$2,541
Machinery Deprec.					12,284
Improv. Deprec.					187
Taxes-Land 2/					1,150
-Imp. 3/					574
Interest Improv.					1,260
Interest Land					3,658
Interest Machinery					12,341
Equity Improv.					3,482
Equity Land					10,112
Equity Machinery					6,703
TOTAL FIXED COSTS					$54,293
TOTAL COSTS					$102,780

1/ Stand establishment costs are calculated by multiplying the value of the Worland Enterprise Cost Study ($24.77) by 95 acres and by a composite update factor (1.08) which is the simple average of the fuel, machinery, seed, and fertilizer update factors.

2/ Land taxes are calculated by multiplying the assessed value per acre by the number of acres and the mill levy (.069488). The assessed values are as follows: farmstead, $120/acre (5 ac); waste, $1/acre (5 ac); Class A irrigated land, $55/acre (290 ac). This information is from the Big Horn County Assessor's Office.

3/ Building and improvement taxes are calculated by multiplying the value of the structures by 8% and the mill levy. Information is from the Big Horn County Assessor's Office.

VARIABLE CASH COSTS OF PRODUCING ALFALFA HAY IN THE SHELL VALLEY, 1984 (without beets).

ITEM	1981/1984 Price Update Factor 1/	Alfalfa Hay Costs Per Acre	Alfalfa Hay Costs Costs (95 Ac)
CASH COSTS			
Seed			
Fertilizer	1.02	$31.17	$2,961
Herbicide	1.16	0.35	33
Insecticide	1.16	5.73	544
Other Materials	1.01	10.30	979
Custom Hire	1.10	4.95	470
Fuel	0.95	18.36	1,745
Irr. Water 2/	1.00	7.00	665
Mach. Var. Costs	1.25	27.98	2,658
Imp. Var. Costs	1.02	4.50	427
Taxes-Equip. 3/	1.00	8.75	831
Utilities 4/	1.18	4.13	392
Hired Labor 5/	1.00	8.78	834
Insurance-Equip.	1.11	1.20	114
-Imp.	1.11	1.57	149
Gen. Overhead 6/	1.00	6.74	640
Interest Oper 7/	1.00	9.91	941
TOTAL		$151.41	$14,384

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.
2/ From personal interviews with Shell Valley farmers.
3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.
4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".
5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.
6/ General overhead is 5% of cash costs.
7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

VARIABLE CASH COSTS OF PRODUCING MALTING BARLEY IN THE SHELL VALLEY, 1984 (without beets).

ITEM	1981/1984 Price Update Factor 1/	Malting Barley Costs Per Acre	Malting Barley Costs (115 Ac)
CASH COSTS			
Seed	1.11	$12.21	$1,404
Fertilizer	1.02	30.39	3,494
Herbicide	1.16	12.71	1,462
Insecticide	1.16		
Other Materials	1.01	0.76	87
Custom Hire	1.10	3.85	443
Fuel	0.95	19.77	2,273
Irr. Water 2/	1.00	7.00	805
Mach. Var. Costs	1.25	21.09	2,425
Imp. Var. Costs	1.02	5.44	625
Taxes-Equip. 3/	1.00	7.90	909
Utilities 4/	1.18	4.13	475
Hired Labor 5/	1.00	8.65	995
Insurance-Equip.	1.11	1.07	123
-Imp.	1.11	1.84	212
Gen. Overhead 6/	1.00	6.84	787
Interest Oper 7/	1.00	10.05	1,156
TOTAL		$153.69	$17,675

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.

2/ From personal interviews with Shell Valley farmers.

3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.

4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".

5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.

6/ General overhead is 5% of cash costs.

7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

VARIABLE CASH COSTS OF PRODUCING CORN FOR SILAGE IN THE SHELL VALLEY, 1984 (without beets).

ITEM	1981/1984 Price Update Factor 1/	Corn for Silage Costs Per Acre	Corn for Silage Costs (40 Ac)
CASH COSTS			
Seed	1.11	$15.54	$622
Fertilizer	1.02	42.28	1,691
Herbicide	1.16	18.30	732
Insecticide	1.16		
Other Materials	1.01	0.76	30
Custom Hire	1.10	3.85	154
Fuel	0.95	36.57	1,463
Irr. Water 2/	1.00	7.00	280
Mach. Var. Costs	1.25	33.19	1,328
Imp. Var. Costs	1.02	4.50	180
Taxes-Equip. 3/	1.00	14.47	579
Utilities 4/	1.18	4.13	165
Hired Labor 5/	1.00	13.65	546
Insurance-Equip.	1.11	1.98	79
-Imp.	1.11	1.57	63
Gen. Overhead 6/	1.00	9.89	396
Interest Oper 7/	1.00	14.54	581
TOTAL		$222.20	$8,888

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.

2/ From personal interviews with Shell Valley farmers.

3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.

4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".

5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.

6/ General overhead is 5% of cash costs.

7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

VARIABLE CASH COSTS OF PRODUCING CORN FOR GRAIN IN THE SHELL VALLEY, 1984 (without beets).

ITEM	1981/1984 Price Update Factor 1/	Corn for Grain Costs Per Acre	Corn for Grain Costs (40 Ac)
CASH COSTS			
Seed	1.11	$15.54	$622
Fertilizer	1.02	42.28	1,691
Herbicide	1.16	18.30	732
Insecticide	1.16		
Other Materials	1.01	0.76	30
Custom Hire	1.10	3.85	154
Fuel	0.95	24.19	967
Irr. Water 2/	1.00	7.00	280
Mach. Var. Costs	1.25	24.76	991
Imp. Var. Costs	1.02	4.50	180
Taxes-Equip. 3/	1.00	9.64	386
Utilities 4/	1.18	4.13	165
Hired Labor 5/	1.00	9.93	397
Insurance-Equip.	1.11	1.32	53
-Imp.	1.11	1.57	63
Gen. Overhead 6/	1.00	8.39	336
Interest Oper 7/	1.00	12.33	493
TOTAL		$188.48	$7,539

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.

2/ From personal interviews with Shell Valley farmers.

3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.

4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".

5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.

6/ General overhead is 5% of cash costs.

7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

MACHINERY COMPLEMENT AND DEPRECIATION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

MACHINE/VEHICLE 1/	1984 COST	YEARS OF USEFUL LIFE 1/	SINKING FUND FACTOR 2/	ANNUAL DEPREC-IATION
Vehicles :				
Pickup - 1/2 Ton	$6,000	8	0.07339	$440
Truck - 2 Ton	15,000	16	0.01827	274
Truck - 2 Ton	6,000	16	0.01827	110
Tractors :				
125 Hp	41,000	10	0.04974	2,039
80 Hp	25,000	10	0.04974	1,243
Tillage :				
Plow - 4-16's	6,000	10	0.04974	298
Roller Harrow - 15'	7,500	8	0.07339	550
Leveler - 45' x 12'	7,500	12	0.03491	262
Tandem Disc - 15'	6,000	10	0.04974	298
Field Cultivator - 15'	3,500	12	0.03491	122
Spike Harrow - 24'	1,000	20	0.01000	10
Planting :				
Grain Drill - 14'	9,219	10	0.04974	459
Corn Planter - 4 Row	3,750	8	0.07339	275
Cultivation :				
Corn Cultivator-4 Row	5,625	10	0.04974	280
Harvest :				
Swather - 12'	15,000	10	0.04974	746
Combine	30,000	10	0.04974	1,492
Corn Head - 4 Row	6,000	10	0.04974	298
Corn Chopper - 2 Row	10,000	6	0.11482	1,148
Baler	7,485	10	0.04974	372
Miscellaneous :				
Ditcher	2,875	10	0.04974	143
Blade	3,375	12	0.03491	118
Sprayer	5,750	10	0.04974	286
Loader - Front Mount	7,875	10	0.04974	392
Auger - Gas 42'	2,250	12	0.03491	79
Fuel Tanks	1,616	15	0.02136	35
Siphon Tubes - 2,000'	4,040	10	0.04974	201
Gated Pipe - 2,000'	6,060	15	0.02136	129
Shop Equipment	10,100	25	0.00485	49
Weed Burner	3,250	12	0.03491	113
Pipe Wagon	1,000	15	0.02136	21
TOTAL	$259,770			$12,284

1/ From "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, and personal interviews.

2/ The sinking fund factor is calculated at a 14.8% interest rate which is a four year average of the Greybull, Wyoming Production Credit Association (1981-1984).

INTEREST ON MACHINERY DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

TOTAL INVESTMENT	$259,770
NON-REAL ESTATE DEBT-TO-ASSET RATIO 1/	32.10%
DEBT PORTION	$83,386
EFFECTIVE INTEREST RATE 2/	14.80%
Subtotal	$12,341
EQUITY PORTION	$176,384
RATE OF RETURN TO EQUITY 3/	3.80%
Subtotal	$6,703
TOTAL INTEREST AND RETURN TO EQUITY	$19,044

1/ A four year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.

2/ A four year simple average of the Greybull, Wyoming Production Credit Association (1981-1984) as reported by John King, Field Office Manager.

3/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

BUILDING AND IMPROVEMENTS COST AND DEPRECIATION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

BUILDING AND IMPROVEMENTS 1/	1981 COST 1/	1981/1984 PRICE UPDATE FACTOR 2/	1984 COST	YEARS OF USEFUL LIFE 1/	SINKING FUND FACTOR 3/	ANNUAL DEPREC-IATION
Machine Shop	$22,670	1.02	$23,123	30	0.00523	$121
Machine Shed	9,360	1.02	9,547	30	0.00523	50
Fences	3,000	1.02	3,060	30	0.00523	16
Dwelling	66,250	1.02	67,575			
TOTAL			$103,306			$187

1/ From "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie.

2/ Update factors are from the August issue of Agricultural Outlook ERS, USDA.

3/ The sinking fund factor is calculated at an interest rate of 10.79% which is the four year average of the Eighth Farm Credit District (1981-1984).

INTEREST ON BUILDING AND IMPROVEMENT DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

TOTAL INVESTMENT	$103,306
REAL ESTATE DEBT-TO-ASSET RATIO 1/	11.30%
DEBT PORTION	$11,674
EFFECTIVE INTEREST RATE 2/	10.79%
Subtotal	$1,260
EQUITY PORTION	$91,632
RATE OF RETURN TO EQUITY 3/	3.80%
Subtotal	$3,482
TOTAL INTEREST AND RETURN TO EQUITY	$4,742

1/ A four year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.

2/ A four year average of the Eighth Farm Credit District (1981-1984).

3/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

LONG TERM REAL ESTATE INTEREST ON DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (without beets).

TOTAL INVESTMENT 300 Acres @ $1,000 1/	$300,000
REAL ESTATE DEBT-TO-ASSET RATIO 2/	11.30%
DEBT PORTION	$33,900
EFFECTIVE INTEREST RATE 3/	10.79%
Subtotal	$3,658
EQUITY PORTION	$266,100
RATE OF RETURN TO EQUITY 4/	3.80%
Subtotal	$10,112
TOTAL INTEREST AND RETURN TO EQUITY	$13,770

1/ From Don Becker of the Federal Land Bank in Worland, Wyoming and personal interviews.
2/ A four-year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.
3/ A four year average of the Eighth Farm Credit District (1981-1984).
4/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

NET INCOME FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

Item	Total Farm
Gross Farm Income	$160,333
Less: Total Variable Costs	$76,244
Return Over Variable Costs	$84,089
Less: Total Fixed Costs	$63,175
Return Over Variable and Fixed Costs	$20,914
Less: Opportunity Cost for Operator Labor and Management 1/	$16,403
Plus: Interest and Return to Equity on Operator's Dwelling 2/	$3,102
Net Farm Income	$7,613
Repayment Capacity Per Acre 3/	$25.38

1/ Annual earnings of production and nonsupervisory workers on payrolls in manufacturing in Wyoming for 1983, "Earnings And Employment", U. S. Department of Labor, Bureau of Labor Statistics.
2/ Considered as a farm perquisite.
3/ Net farm income of $7,613 divided by 300 acres.

CROP PRODUCTION AND TOTAL REVENUE FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

Crop	Acres	Units	Yield Per Acre 1/	Total Product	Sales Price 2/	Total Revenue
Alfalfa Hay	70	Ton	5	350.0	$67.11	$23,489
Malting Barley	120	Bu.	100	12,000.0	4.22	50,640
Sugar Beets	100	Ton	23	2,300.0	37.48	86,204
Farmstead/Wastage	10					
TOTAL	300					$160,333

1/ Yields are from a combination of personal interviews with Shell Valley farmers and the Wyoming Agricultural Statistics. Each yield has been increased by 10% to reflect additional production due to a greater availability of water if the project is completed.

2/ The alfalfa hay and malting barley prices are normalized prices for Wyoming as reported by the Bureau of Reclamation, Upper Missouri Region, Billings, Montana. The price of sugar beets has been normalized by calculating a eight-year average of beet prices (1977-1984, 1983 and 1984 are preliminary and projected prices, respectively) and multiplying it by the increase in the GNP implicit price deflator (from Agricultural Outlook) from 1981 to 1984.

TOTAL COSTS OF PRODUCTION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

ITEM	Alfalfa Hay (70 Ac)	Malting Barley (120 Ac)	Sugar Beets (100 Ac)	Total Farm Expenses (1984)
CASH COSTS				
Seed		$1,465	$1,323	2,788
Fertilizer	$2,182	3,646	6,727	12,555
Herbicide	24	1,526	3,102	4,652
Insecticide	401		6,566	6,967
Other Materials	721	91	414	1,226
Custom Hire	347	462	7,370	8,179
Fuel	1,285	2,372	5,058	8,715
Irr. Water	490	840	700	2,030
Mach. Var. Costs	1,958	2,531	5,314	9,803
Imp. Var. Costs	315	652	664	1,631
Taxes-Equip.	597	924	1,919	3,440
Utilities	289	496	479	1,264
Hired Labor	615	1,038	1,943	3,596
Insurance-Equip.	84	128	270	482
-Imp.	110	221	203	534
Gen. Overhead	471	820	2,103	3,394
Int. Operating	692	1,205	3,091	4,988
VARIABLE COSTS	$10,581	$18,417	$47,246	$76,244
FIXED COSTS				
Stand Establish 1/	1,873			$1,873
Machinery Deprec.				16,195
Improv. Deprec.				232
Taxes-Land 2/				1,150
-Imp. 3/				622
Interest Improv.				1,364
Interest Land				3,658
Interest Machinery				15,681
Equity Improv.				3,771
Equity Land				10,112
Equity Machinery				8,517
TOTAL FIXED COSTS				$63,175
TOTAL COSTS				$139,419

1/ Stand establishment costs are calculated by multiplying the value of the Worland Enterprise Cost Study ($24.77) by 70 acres and by a composite update factor (1.08) which is the average of the fuel, machinery, seed, and fertilizer update factors.

2/ Land taxes are calculated by multiplying the assessed value per acre by the number of acres and the mill levy (.069488). The assessed values are as follows: farmstead, $120/acre (5 ac); waste, $1/acre (5ac); Class A irrigated land, $55/acre (290 ac). This information is from the Big Horn County Assessor's Office.

3/ Building and improvement taxes are calculated by multiplying the value of the structures by 8% and the mill levy. This information is from the Big Horn County Assessor's Office.

VARIABLE CASH COSTS OF PRODUCING ALFALFA HAY IN THE SHELL VALLEY, 1984 (with beets).

ITEM	1981/1984 Price Update Factor 1/	Alfalfa Hay Costs Per Acre	Alfalfa Hay Costs Costs (70 Ac)
CASH COSTS			
Seed			
Fertilizer	1.02	$31.17	$2,182
Herbicide	1.16	0.35	24
Insecticide	1.16	5.73	401
Other Materials	1.01	10.30	721
Custom Hire	1.10	4.95	347
Fuel	0.95	18.36	1,285
Irr. Water 2/	1.00	7.00	490
Mach. Var. Costs	1.25	27.98	1,958
Imp. Var. Costs	1.02	4.50	315
Taxes-Equip. 3/	1.00	8.53	597
Utilities 4/	1.18	4.13	289
Hired Labor 5/	1.00	8.78	615
Insurance-Equip.	1.11	1.20	84
-Imp.	1.11	1.57	110
Gen. Overhead 6/	1.00	6.73	471
Interest Oper 7/	1.00	9.89	692
TOTAL		$151.16	$10,581

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.
2/ From personal interviews with Shell Valley farmers.
3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.
4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".
5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.
6/ General overhead is 5% of cash costs.
7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

VARIABLE CASH COSTS OF PRODUCING MALTING BARLEY IN THE SHELL VALLEY, 1984 (with beets).

ITEM	1981/1984 Price Update Factor 1/	Malting Barley Costs Per Acre	Malting Barley Costs (120 Ac)
CASH COSTS			
Seed	1.11	$12.21	$1,465
Fertilizer	1.02	30.39	3,646
Herbicide	1.16	12.71	1,526
Insecticide	1.16		
Other Materials	1.01	0.76	91
Custom Hire	1.10	3.85	462
Fuel	0.95	19.77	2,372
Irr. Water 2/	1.00	7.00	840
Mach. Var. Costs	1.25	21.09	2,531
Imp. Var. Costs	1.02	5.44	652
Taxes-Equip. 3/	1.00	7.70	924
Utilities 4/	1.18	4.13	496
Hired Labor 5/	1.00	8.65	1,038
Insurance-Equip.	1.11	1.07	128
-Imp.	1.11	1.84	221
Gen. Overhead 6/	1.00	6.83	820
Interest Oper 7/	1.00	10.04	1,205
TOTAL		$153.47	$18,416

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.
2/ From personal interviews with Shell Valley farmers.
3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.
4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".
5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.
6/ General overhead is 5% of cash costs.
7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

VARIABLE CASH COSTS OF PRODUCING SUGAR BEETS IN THE SHELL VALLEY, 1984 (with beets).

ITEM	1981/1984 Price Update Factor 1/	Sugar Beet Costs Per Acre	Sugar Beet Costs (100 Ac)
CASH COSTS			
Seed	1.11	$13.23	$1,323
Fertilizer	1.02	67.27	6,727
Herbicide	1.16	31.02	3,102
Insecticide	1.16	65.66	6,566
Other Materials	1.01	4.14	414
Custom Hire	1.10	73.70	7,370
Fuel	0.95	50.58	5,058
Irr. Water 2/	1.00	7.00	700
Mach. Var. Costs	1.25	53.14	5,314
Imp. Var. Costs	1.02	6.64	664
Taxes-Equip. 3/	1.00	19.19	1,919
Utilities 4/	1.18	4.79	479
Hired Labor 5/	1.00	19.43	1,943
Insurance-Equip.	1.11	2.70	270
-Imp.	1.11	2.03	203
Gen. Overhead 6/	1.00	21.03	2,103
Interest Oper 7/	1.00	30.91	3,091
TOTAL		$472.44	$47,244

1/ Update factors are from the August issue of Agricultural Outlook. The factor updates prices from 1981 to August, 1984.
2/ From personal interviews with Shell Valley farmers.
3/ Total machinery value multiplied by 15% and by the mill levy (.069488). Information from the County Assessor's Office.
4/ The update factor for utilities is from the "Bureau of Labor Statistics, Monthly Labor Review".
5/ Labor is hired at $5.50 per hour. The values used per acre are one-third that used in "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, due to a reduced labor requirement for this smaller farm.
6/ General overhead is 5% of cash costs.
7/ Interest on operating capital is calculated by using a a 14% interest rate on all cash costs for one-half year.

MACHINERY COMPLEMENT AND DEPRECIATION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

MACHINE/VEHICLE 1/	1984 COST	YEARS OF USEFUL LIFE 1/	SINKING FUND FACTOR 2/	ANNUAL DEPREC-IATION
Vehicles :				
Pickup - 1/2 Ton	$6,000	8	0.07339	$440
Truck - 2 Ton	15,000	16	0.01827	274
Truck - 2 Ton	6,000	16	0.01827	110
Truck - Tandem	35,179	18	0.01346	474
Tractors :				
125 Hp	41,000	10	0.04974	2,039
80 Hp	25,000	10	0.04974	1,243
Tillage :				
Plow - 4-16's	6,000	10	0.04974	298
Roller Harrow - 15'	7,500	8	0.07339	550
Leveler - 45' x 12'	7,500	12	0.03491	262
Tandem Disc - 15'	6,000	10	0.04974	298
Field Cultivator - 15'	3,500	12	0.03491	122
Spike Harrow - 24'	1,000	20	0.01000	10
Planting :				
Grain Drill - 14'	9,219	10	0.04974	459
Beet Planter - 6 Row	3,750	8	0.07339	275
Chemical Boxes - 2	3,750	8	0.07339	275
Cultivation :				
Beet Cultivator-6 Row	5,625	10	0.04974	280
Beet Roller - 6 Row	1,750	20	0.01000	17
Harvest :				
Swather - 12'	15,000	10	0.04974	746
Combine	30,000	10	0.04974	1,492
Beet Defoliater-6 Row	15,625	8	0.07339	1,147
Beet Puller - 3 Row	30,000	6	0.11482	3,444
Baler	7,485	10	0.04974	372
Miscellaneous :				
Ditcher	2,875	10	0.04974	143
Blade	3,375	12	0.03491	118
Sprayer	5,750	10	0.04974	286
Loader - Front Mount	7,875	10	0.04974	392
Auger - Gas 42'	2,250	12	0.03491	79
Fuel Tanks	1,616	15	0.02136	35
Siphon Tubes - 2,000'	4,040	10	0.04974	201
Gated Pipe - 2,000'	6,060	15	0.02136	129
Shop Equipment	10,100	25	0.00485	49
Weed Burner	3,250	12	0.03491	113
Pipe Wagon	1,000	15	0.02136	21
TOTAL	$330,074			$16,195

1/ From "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie, and personal interviews.

2/ The sinking fund factor is calculated at a 14.8% interest rate which is a four year average of the Greybull, Wyoming Production Credit Association (1981-1984).

INTEREST ON MACHINERY DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

TOTAL INVESTMENT	$330,074
NON-REAL ESTATE DEBT-TO-ASSET RATIO 1/	32.10%
DEBT PORTION	$105,954
EFFECTIVE INTEREST RATE 2/	14.80%
Subtotal	$15,681
EQUITY PORTION	$224,120
RATE OF RETURN TO EQUITY 3/	3.80%
Subtotal	$8,517
TOTAL INTEREST AND RETURN TO EQUITY	$24,198

1/ A four year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.

2/ A four year simple average of the Greybull, Wyoming Production Credit Association (1981-1984) as reported by John King, Field Office Manager.

3/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

BUILDING AND IMPROVEMENTS COST AND DEPRECIATION FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

BUILDING AND IMPROVEMENTS 1/	1981 COST 1/	1981/1984 PRICE UPDATE FACTOR 2/	1984 COST	YEARS OF USEFUL LIFE 1/	SINKING FUND FACTOR 3/	ANNUAL DEPREC-IATION
Machine Shop	$22,670	1.02	$23,123	30	0.00523	$121
Machine Shed	9,360	1.02	9,547	30	0.00523	50
Fences	3,000	1.02	3,060	30	0.00523	16
Beet Labor House	8,400	1.02	8,568	30	0.00523	45
Dwelling	66,250	1.02	67,575			
TOTAL			$111,874			$232

1/ From "Costs of Producing Crops Worland Area, Wyoming 1981-1982" Bulletin 644R, Agricultural Extension Service, University of Wyoming, Laramie.

2/ Update factors are from the August issue of Agricultural Outlook ERS, USDA.

3/ The sinking fund factor is calculated at an interest rate of 10.79% which is a four year average of the Eighth Farm Credit District (1981-1984).

INTEREST ON BUILDING AND IMPROVEMENT DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

TOTAL INVESTMENT	$111,874
REAL ESTATE DEBT-TO-ASSET RATIO 1/	11.30%
DEBT PORTION	$12,642
EFFECTIVE INTEREST RATE 2/	10.79%
Subtotal	$1,364
EQUITY PORTION	$99,232
RATE OF RETURN TO EQUITY 3/	3.80%
Subtotal	$3,771
TOTAL INTEREST AND RETURN TO EQUITY	$5,135

1/ A four year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.

2/ A four year average of the Eighth Farm Credit District (1981-1984).

3/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

LONG TERM REAL ESTATE INTEREST ON DEBT AND RETURN TO EQUITY FOR A 300 ACRE REPRESENTATIVE FARM IN THE SHELL VALLEY, 1984 (with beets).

TOTAL INVESTMENT 300 Acres @ $1,000 1/	$300,000
REAL ESTATE DEBT-TO-ASSET RATIO 2/	11.30%
DEBT PORTION	$33,900
EFFECTIVE INTEREST RATE 3/	10.79%
Subtotal	$3,658
EQUITY PORTION	$266,100
RATE OF RETURN TO EQUITY 4/	3.80%
Subtotal	$10,112
TOTAL INTEREST AND RETURN TO EQUITY	$13,770

1/ From Don Becker of the Federal Land Bank in Worland, Wyoming and personal interviews.

2/ A four year simple average (1980-1983) from "Economic Indicators of the Farm Sector, State Income and Balance Sheet Statistics, 1982" ERS, USDA, for Wyoming.

3/ A four year average of the Eighth Farm Credit District (1981-1984).

4/ From "Economic Indicators of the Farm Sector, Income and Balance Sheet Statistics, 1982". The simple average rate of return to equity for 1970 - 1982.

INCREASED NET RETURNS PER ACRE RESULTING FROM A 10 PERCENT YIELD INCREASE, SHELL VALLEY, 1984.

Item	Alfalfa Hay (tons)	Malting Barley (bushels)	Corn for Grain (bushels)	Corn for Silage (tons)	Sugar Beets
ADDED RETURNS					
Increased Yield	0.5	10	10	2	2
Sales Price Per Unit	$67.11	$4.22	$3.65	$22.37	$37.48
Added Revenue Per Acre	$33.56	$42.20	$36.50	$44.74	$74.96
ADDED COSTS					
Additional Water Costs Per Acre	$7.54	$7.54	$7.54	$7.54	$7.54
NET RETURNS PER ACRE	$26.02	$34.66	$28.96	$37.20	$67.42

DIRECT AGRICULTURAL BENEFITS TO THE SHELL VALLEY PROJECT RESULTING FROM A 10 PERCENT YIELD INCREASE, SHELL VALLEY, 1984.

Crop	Average Increased Returns Per Acre 1984	Total Non-Beet Irrigated Acres 1984	Total Sugar Beet Acres 1984	Total Increased Returns 1984
All Crops Except Beets 1/	$31.71	9401		$298,106
Sugar Beets Only	$67.42		310	$20,900
TOTAL BENEFITS				$319,006

1/ The average increased net returns per acre for alfalfa hay, malting barley, corn for grain, and corn for silage is $31.71.

DIRECT AGRICULTURAL BENEFITS TO THE SHELL VALLEY WATERSHED IMPROVEMENT DISTRICT RESULTING FROM A 10 PERCENT YIELD INCREASE, SHELL VALLEY, 1984.

Crop	Average Increased Returns Per Acre 1984	Total Non-Beet Irrigated Acres 1984	Total Sugar Beet Acres 1984	Total Increased Returns 1984
All Crops Except Beets 1/	$31.71	4,028 2/		$127,728
Sugar Beets Only	$67.42		310	$ 20,900
TOTAL BENEFITS				$148,628

1/ The average increased net returns per acre for alfalfa hay, malting barley, corn for grain, and corn for silage is $31.71.

2/ Assumes 5000 acres benefit from additional storage less 310 acres of sugar beets and 662 acres of idle lands.

DIRECT AGRICULTURAL BENEFITS TO THE SHELL VALLEY PROJECT DUE TO ADDITIONAL IRRIGABLE LAND USE, SHELL VALLEY, 1984.

Item	Alfalfa Hay (tons)	Malting Barley (bushels)	Corn for Grain (bushels)	Corn for Silage (tons)
ADDED RETURNS				
Expected Yield 1/	4	90	100	19
Sales Price Per Unit	$67.11	$4.22	$3.65	$22.37
Total Revenue Per Acre	$268.44	$379.80	$365.00	$425.03
ADDED COSTS				
Variable Cost Per Acre 2/	$151.41	$153.69	$188.48	$222.20
Additional Water Costs Per Acre 3/	$7.54	$7.54	$7.54	$7.54
Stand Establishment 4/	$8.92			
Breaking Costs Per Acre 5/	$3.40	$3.40	$3.40	$3.40
Increased Taxes Per Acre 6/	$41.25	$41.25	$41.25	$41.25
TOTAL CASH COSTS PER ACRE	$212.52	$205.88	$240.67	$274.39
Return Over Cash Costs Per Acre	$55.92	$173.92	$124.33	$150.64
Average Return Per Acre 7/	$126.20			
Total Idle Acres	662			
Direct Benefit	$83,544			

1/ The yields used are below those used in the payment capacity budgets to reflect the use of poorer land.
2/ From payment capacity budgets.
3/ Ability to pay from payment capacity budgets.
4/ The payment capacity budget figure of $26.75 for stand establishment for 1984 divided by three years.
5/ From "Custom Rates For Farm-Ranch Operations in Wyoming, Guides for 1983-1984", Bulletin 703R, Division of Agricultural Economics, University of Wyoming, Laramie. The value for custom moldboard plowing i the toughest conditions ($24/acre) is added to the custom rate for discing in toughest conditions ($10/acre) and is then spread over 10 years.
6/ It is assumed that the land would increase from Class C grazing ($3.75 per acre assessed value) to Class B irrigated ($45 per acre).
7/ The average return per acre of alfalfa hay, malting barley, corn for grain, and corn for silage on the additional irrigable land.

APPENDIX C

APPENDIX C

FIELD INSPECTION NOTES

LOW LEVEL CONDUIT

LAKE ADELAIDE DAM

FIELD INSPECTION

Low Level Conduit
Lake Adelaide Dam
By
Dan L. Dyer, Roger J. Perkins
and Ralph L. Rollins
July 12, 1984

1. The low level conduit in the existing Lake Adelaide Dam embankment is a 30 inch diameter reinforced concrete pipe. The inside surface of the conduit is in very poor condition from the outlet upstream for four sections. Each section is about 8' long. At these sections deterioration has occurred on the floor of the conduit where water has apparently frozen and spalled the concrete. The roof and sides on the conduit, in these first four sections, are not in poor condition relative to the floor.

2. Between joints 5 through 8 the conduit appears to be in relatively good condition. Near joint 5 there are roots coming into the conduit through the joint. At the 9th joint water appears to be coming into the conduit from overhead. This water likely originates from the phreatic surface intersecting the conduit.

3. Calcium deposits are observed at the 10th joint on the roof of the conduit.

4. Between joints 10 and 11 there is a crack all the way around the conduit. Water is seeping into the conduit from all sides at the rate of an estimated one gallon per minute.

5. The conduit is cracked near joint 17. This may be from settlement because it appears that the roof is in compression while the floor is in tension.

6. The conduit between joints 12 and 16 appears to be in relatively good condition.

7. At the 16th joint there is some leakage into the conduit.

8. At the 20th joint water is coming in a crack which extends all the way around the conduit. The flow in the conduit at this location appears to be slightly deeper suggesting that the conduit is slightly displaced vertically.

9. There is a pressure flow into the conduit at joint 19. The flow is into the left side, facing upstream. The hole through which the water is shooting into the conduit is approximately 1/2 inch in diameter.

10. Just upstream of joint number 20 there is a leak into the conduit. This crack is from 6 inches to a foot away from the joint itself. There are two or three places along the conduit where this type of crack occurs.

11. There appears to be a total of 22 joints in the conduit.

12. At joint 20 the pipe appears to be displaced at the roof approximately 1/2 inch.

13. At joints 21 and 22 the concrete appears very rough. There is not a smooth transition from one section to the next. The joint appears slightly displaced.

14. Water is leaking into the conduit around the gate seat on the downstream side. The gate valve does not seat properly.

15. The gate itself appears to be in fairly good condition. It is a vertical slide gate.

16. At joint number 6 there is a salt deposit on the roof of the conduit. Water is entering the conduit at this location.

In conclusion, the conduit is in need of repair. While it is operating satisfactorily presently, it could develop serious problems because of the cracks and holes in the pipe. There is a hole in the second section of the conduit from the downstream end near the first joint. The hole extends all the way through the conduit and fill soil is exposed. The entire conduit should be replaced or rehabilitated. While the existing vertical gate may be in good condition, the gate seal is in very poor condition and must be replaced. Approximately 100 gallons a minute was flowing through the conduit at the time of this investigation. The gate is completely closed, therefore, this volume is leakage through the seal of the gate. The wing walls at the outlet of the conduit appear to be fairly good condition with the exception of spalling concrete along the wing walls at various locations. At the connection between the conduit and the wing wall there is some displacement; probably the result of frost heave. There is a broad crested weir located approximately 50 feet downstream of the outlet. The weir has a staff gage located on the west bank of the channel. The gage will record a maximum of one foot of flow over the weir. Beyond that, it appears that the weir becomes inundated. On about August 6th, Ben Menzel and Dan Dyer opened the slide gate to allow an increased flow through the conduit. We opened the gate far enough to raise the flow at the staff gage to 0.85 feet.

APPPENDIX D

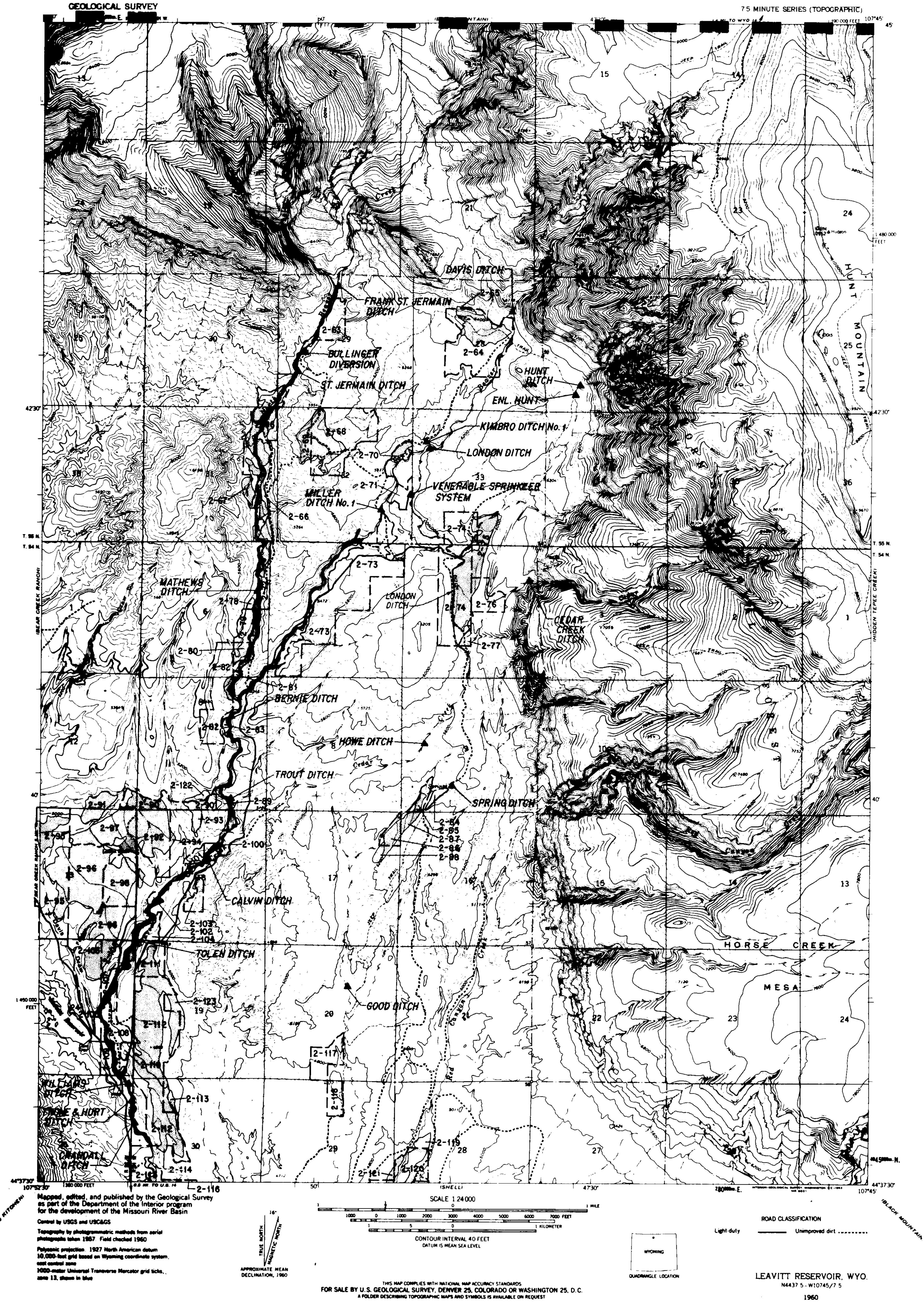
APPENDIX D

IRRIGATED LAND BASE

AND

WATER RIGHT MAPS

10M183.105/0608P



LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

1-100 — Tract Numbers

1-100 — Point of Diversion

BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
2-63 through 2-123

SHELL VALLEY WATERSHED LEVEL II STUDY

IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV., 1984

HKM ASSOCIATES
ENGINEERS·PLANNERS

Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
- Libby, Montana
- Sheridan, Wyoming

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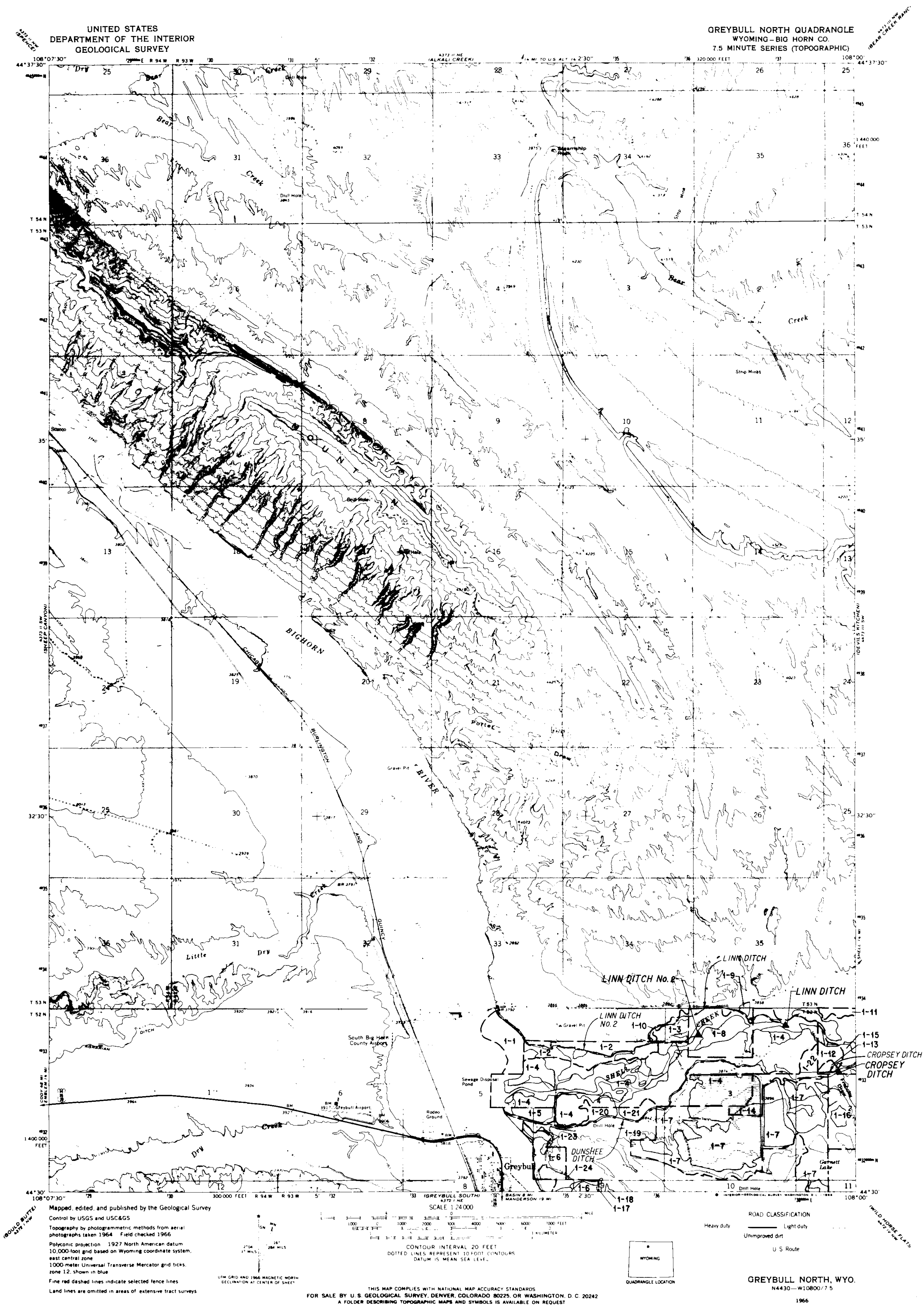

LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

- 1-100 — Tract Numbers
- 1-100 — Point of Diversion
- BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-1 through 1-24

SHELL VALLEY WATERSHED LEVEL II STUDY

IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV., 1984

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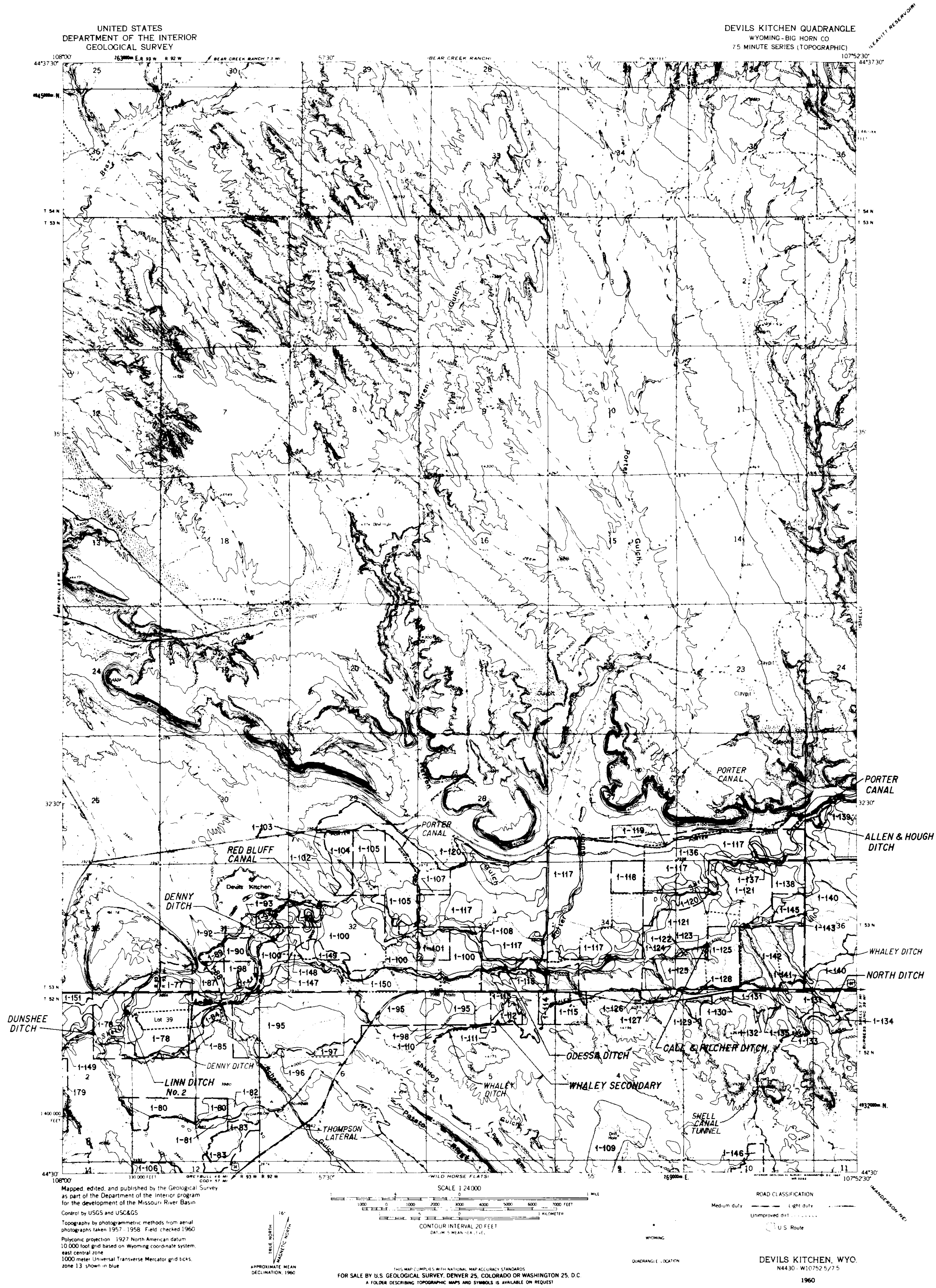

LEGEND

MAP SYMBOLS

— — — — Water Rights Boundary

—•—•— Ditches and Canals

Idle Lands

Lands in Use

Phreatophytes

REFERENCE TO TABLES

1-100 — Tract Numbers

1-100 — Point of Diversion

BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-77 through 1-151

SHELL VALLEY WATERSHED LEVEL II STUDY

IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV. 1984

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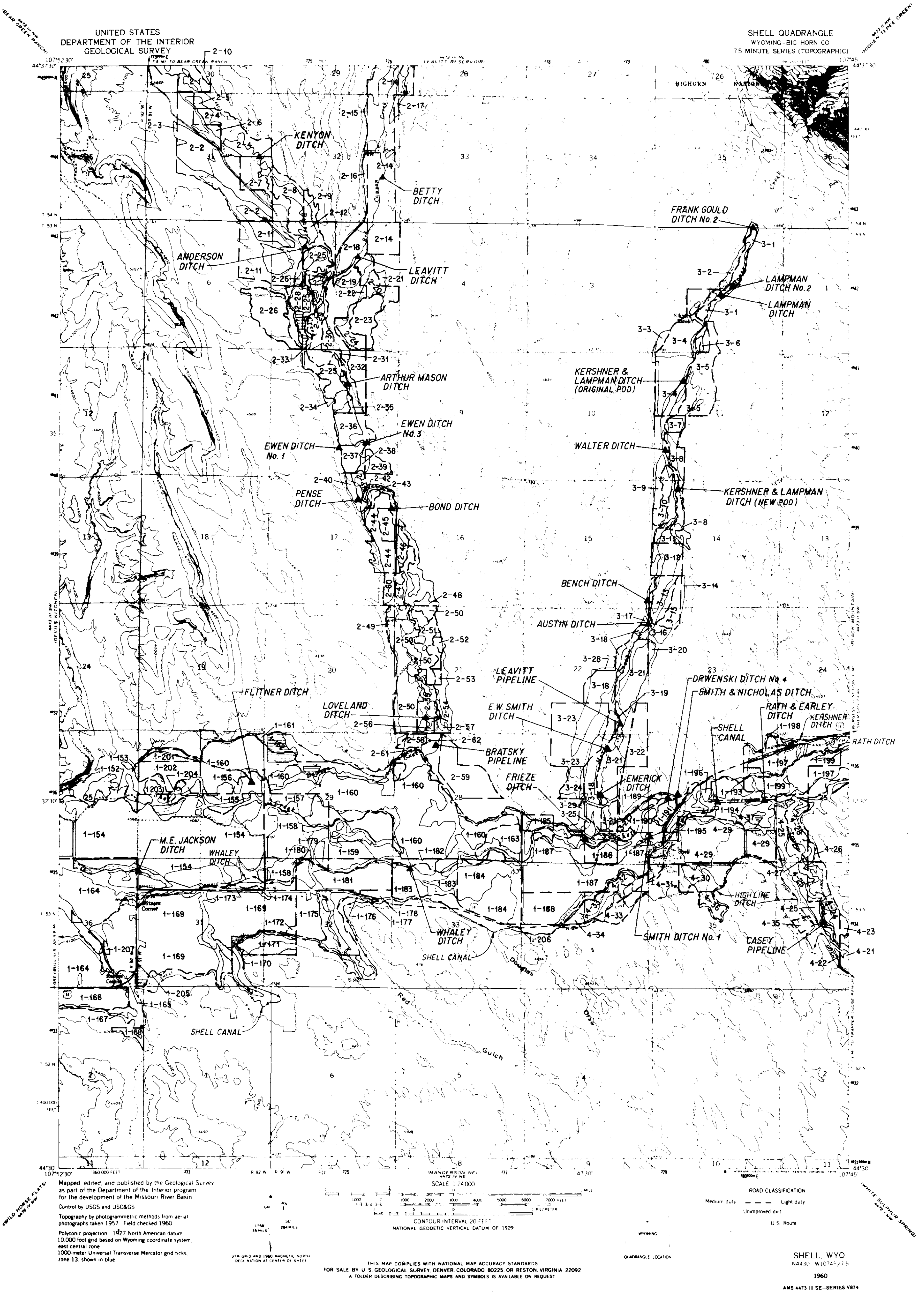

LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

- 1-100 — Tract Numbers
- 1-100 — Point of Diversion
- BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-152 through 1-201
2-1 through 2-62
3-1 through 3-29
4-21 through 4-37

SHELL VALLEY WATERSHED
LEVEL II STUDY
IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV., 1984

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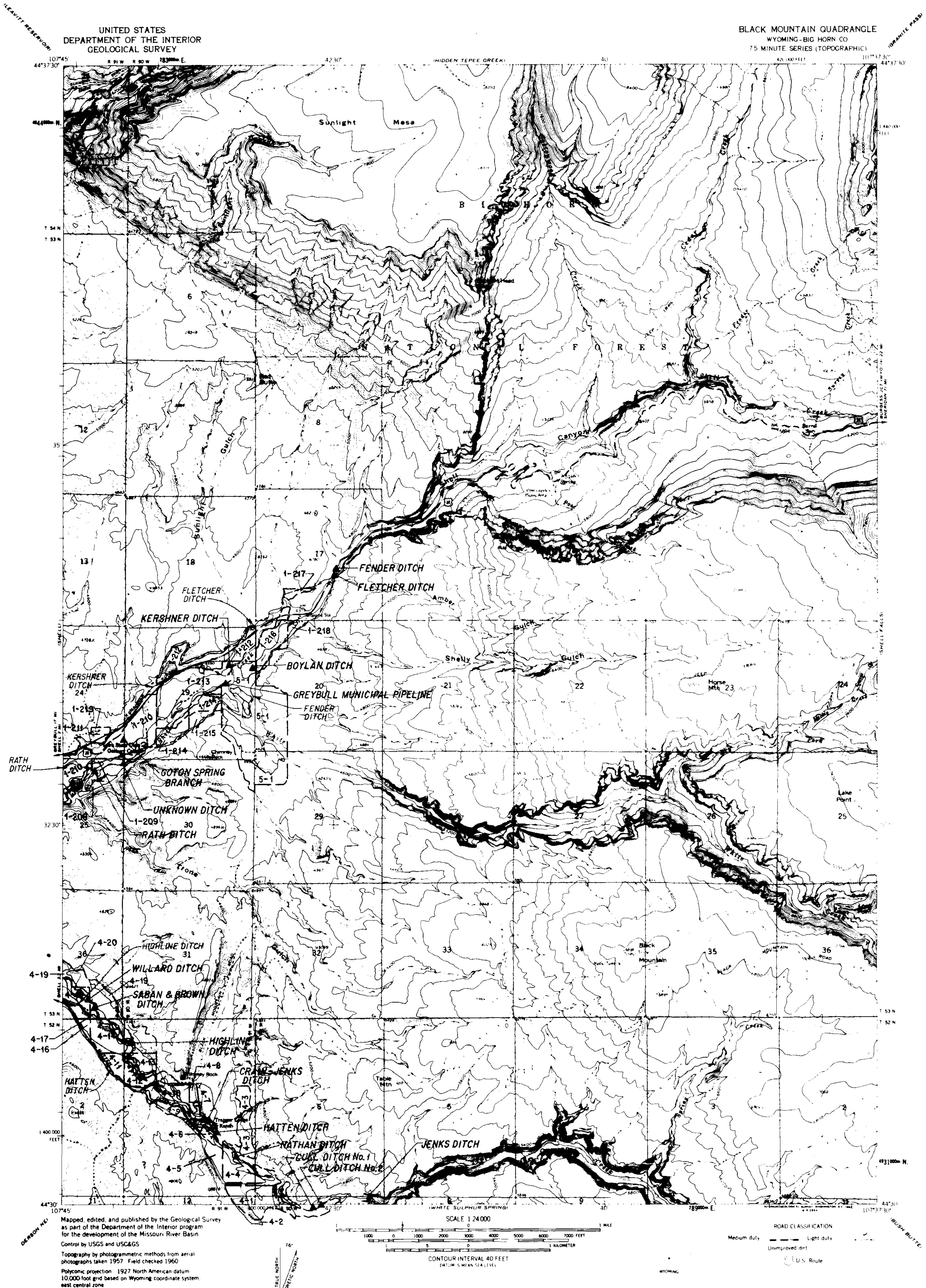

LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

- 1-100 — Tract Numbers
- Point of Diversion
- BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-208 through 1-219
4-1 through 4-20
5-1

SHELL VALLEY WATERSHED
LEVEL II STUDY
IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV., 1984

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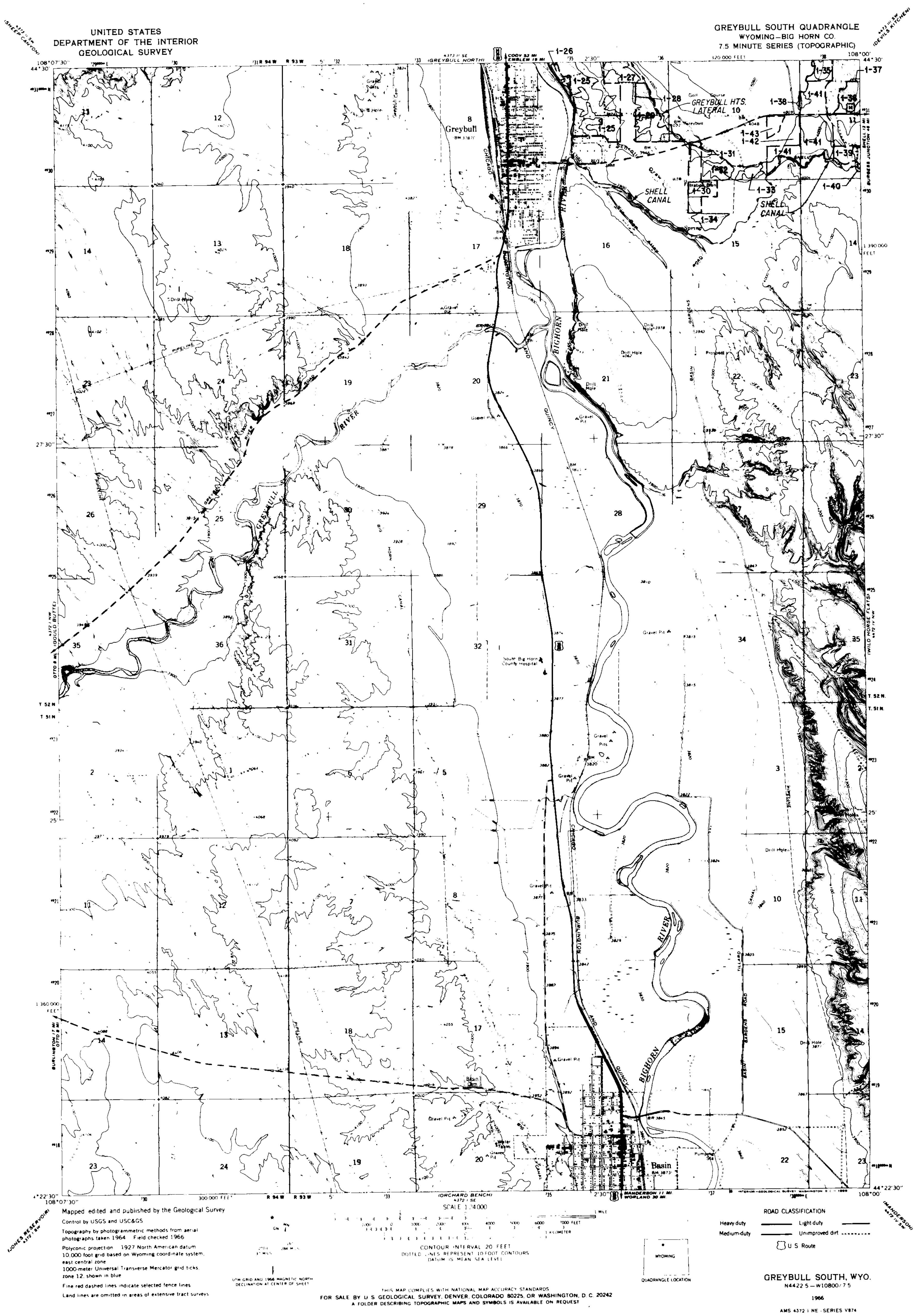

LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

1-100 — Tract Numbers
Point of Diversion
BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-25 through 1-43

SHELL VALLEY WATERSHED
LEVEL II STUDY

IRRIGATED LAND BASE
AND WATER RIGHTS

Project No. 10M183.105 Date NOV. 1984

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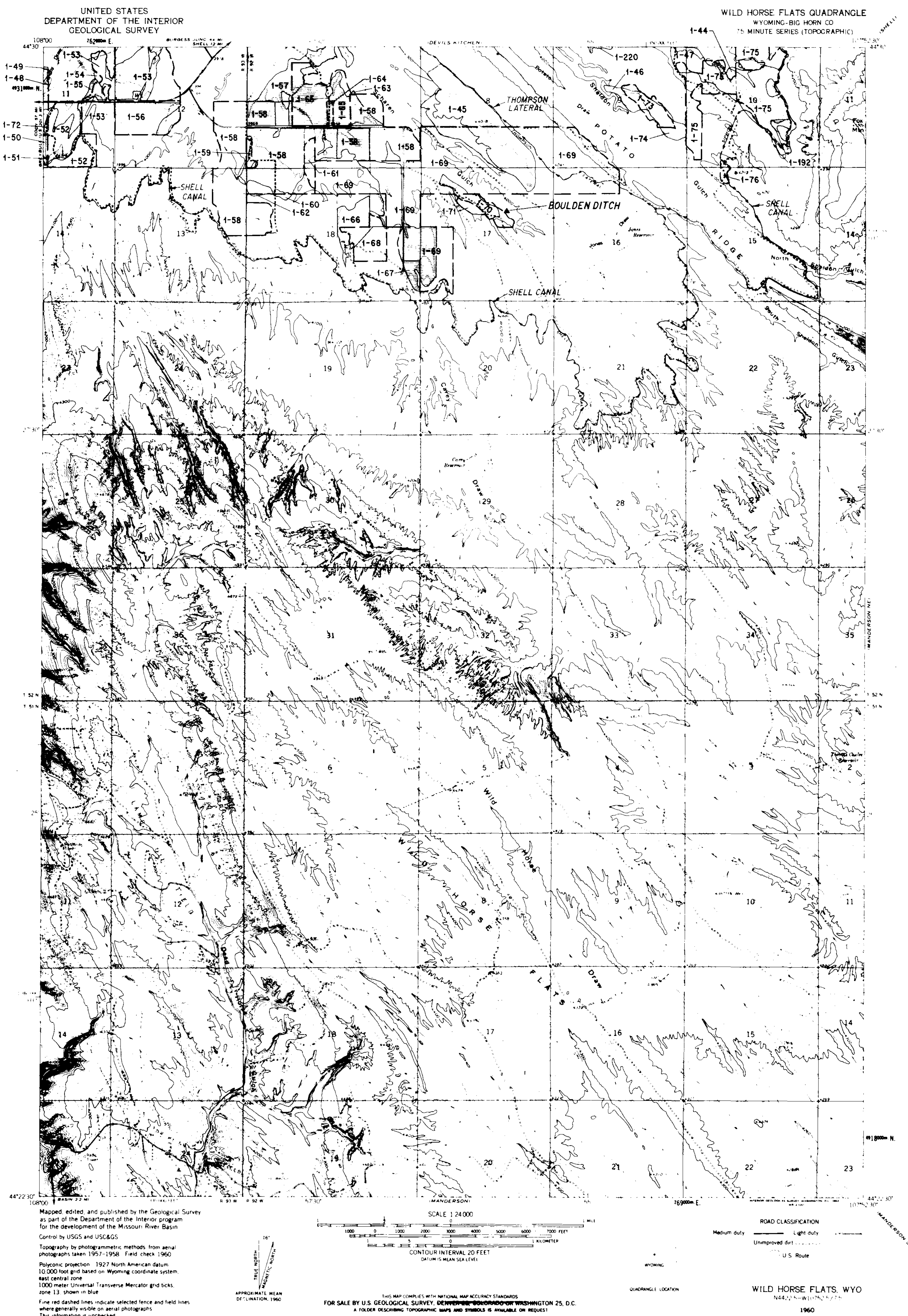

LEGEND

MAP SYMBOLS

- Water Rights Boundary
- Ditches and Canals
- Idle Lands
- Lands in Use
- Phreatophytes

REFERENCE TO TABLES

1-100 — Tract Numbers
1-100 — Point of Diversion
BOULDEN DITCH (Name of ditch or canal)

TRACTS INCLUDED ON THIS QUAD:
1-44 through 1-76, 1-192, 1-220

SHELL VALLEY WATERSHED
LEVEL II STUDY
IRRIGATED LAND BASE AND WATER RIGHTS

Project No. 10M183.105 Date NOV., 1984

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APPENDIX E

APPENDIX E

WATER RIGHT TABULATIONS

APPENDIX E

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Shell Reservoir	A	2200R	10/20/1911			1948.94 AF								
Adelaide Reservoir	P	1921R	8/8/1910			1448.6 AF								
Shell Ranger Station Pipe-line No. 1	A	19802	7/23/1943		1.0	0.015								
Shell Ranger Station P.L. No. 2	A	19803	7/23/1943			S.S.		(Sup. Supply to 1 acre under #19802)						
Shell Ranger Station Irrigation ditch	A	18893	2/26/1938		1.17	0.02								
Lockard Pipe-line	A	22667	2/8/1966			0.0228		(Domestic Use)						
Shell Ranger Station Pipe-line	A	18907	2/26/1938			0.03		(Domestic Use)						
Shell Ranger Station Rearing Pond Res.	A	5437R	7/3/1941			0.58 AF								

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Shell Rearing Pond Res. Supply Pipe-line	A	19669	7/3/1941			Supply Pipeline								
Hamilton Pipeline	A	23113	8/17/1966			0.045		(Domestic Use)						
Emmett Pipeline	A	22869	8/30/1967			0.0302		(Domestic Use)						

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Granite Creek (Trib. to Shell)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Riley Pipeline	A	22617	11/12/1963			0.0084	(Domestic Use)							
Asp & Murphy Pipeline	A	22616	11/12/1963			0.0084	(Domestic Use)							
Horn No. 1 Pipeline	A	22624	11/12/1963			0.12	(Domestic Use)							
Fun Valley Pipeline	P	26269	3/2/1978			0.014	(Miscellaneous Use)							
Meier Pipeline	A	22619	11/12/1963			0.012	(Domestic Use)							
Perkins Pipeline #2	A	22598	9/15/1965			0.0135	(Domestic Use)							
Horn No. 3 Pipeline	A	22618	11/12/1963			0.016	(Domestic Use)							
Horn No. 3 Pipeline	P	6603E	11/26/1976			0.016	(Domestic Use)							
W.C.P. Spring	A	22620	11/12/1963			0.054	(Domestic Use)							

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Fender	A	3246	6/10/1901	1-214	43.0*									Black Mtn.
				A			6							
				B			14							
				1-216	32.0									Black Mtn.
				A			13							
				1-215				8						Black Mtn.
				1-218				3						Black Mtn.
					75.0	1.05	33	11	44				44	
* Includes 5 acre overlap with #508 - Kershner Ditch. irr. lands accounted for under Kershner Ditch.														
Fletcher	A	8627	9/4/1908	1-212	53.75									Black Mtn.
				A			5							
				B			4							
				C			4							
				1-217	8.0				0					Black Mtn.
					61.75	0.87	13	0	13				13	
Kershner	A	508	6/1/1893	1-213	86.0*									Black Mtn.
				A			45							
				B			4							
				C			1							
					86.0	1.23	50		50				50	
* Includes 5 acre overlap with Fender #3246, irr. lands tabulated under this right.														

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Kershner	A	176E	12/26/1895	1-210	101.8									Black Mtn.
				A			2							
				B			56							
				1-211				12						Black Mtn.
				1-209				3						Black Mtn.
				1-197	131.3									Shell
				A			15							
				B			30							
				C			18							
				D			20							Shell
				1-198				1						Shell
					233.1	3.33	141.0	16.0	157.0				157.0	
Boylan	A	16159	5/17/1921			S.S.	(Supplemental Supply for 8 acres under Boylan #6799)							Black Mtn.
Greybull Pipeline	P	19279	9/2/1938			17.85	(Municipal Use)							Black Mtn.
Greybull Pipeline (TF-McDonald)	A	430	3/7/1893			1.326	(Municipal Use)							
Goton Spring Branch	P	23790	2/11/1972	1-219	6.3	0.09			0				0	Black Mtn.
Unknown Ditch				1-208				8	8				8	Black Mtn.

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Rath	A	1010	7/5/1895	1-199	82.0									Shell
				A			4							
				B			53							
					82.0	1.17	57		57				57	
Rath & Earley	A	8538	7/13/1908	1-193	32.0									Shell
				A			1							
				1-196				5						Shell
					32.0	0.46	1	5	6				6	
Allen No. 1 Spring	P	25707	5/18/1976			0.056	(Domestic Use)							
Shell Canal (T.F.-McDonald)	A	Terr	Spg-1886	1-187	245.0*									Shell
				A			147							
				B			4							
				1-195				2						Shell
					245.0	3.50	151	2	153				153	

* Includes 20 acre overlap with Highline #1716, irr. lands tabulated under this right.

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Shell Canal (T.F. McDonald)	A	430	3/7/1893	1-188	65.0									Shell
				A			55							
					65.0	0.93	55		55				55	
Shell Canal (T.F. McDonald)	A	271E	9/18/1897	1-169	429.0									Shell
				A						8				
				B			192							
				C			6							
				D			139							
				1-181	108.0									Shell
				A			12							
				B			11							
				C			57							
				1-205				2						Shell
					537.0	7.66	417	2	419	8		8	427	
Shell Canal (T.F. - McDonald)	A	1330E	1/6/1905	1-164	351.2*									Shell
				A			13							
				B	(Transfer to Whaley D.)									
				C			163							

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				D			93							
				1-165				5						Shell
				1-207				3						Shell
				1-140	240.0									Devils Kitchen
				A			8							
				B			7							
				C			171							
				D			2							
					591.2	8.44	457	8	465				465	

* Does not include 23.8 acres transferred to Whaley Ditch.

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Shell Canal (T.F.-North)	A	18934	3/31/1938			S.S.	(Sup.Supply to 0.62 acres under 1330E - Enl. McDonald)							
Shell Canal (T.F.-Spring Cr.)	A	17571	8/2/1922			S.S.	(Sup.Supply to 115 acres under 1330E - Enl. McDonald)							
Shell Canal (T.F. - McDonald)	A	1439E	5/22/1905	1-175	115.0									Shell
				A			41							
				B			20							
				C			1							
				1-183	75.0									Shell
				A			31							
				B			6							
				C			13							

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands			Idle Lands			Total Irr. & Idle Acres	USGS QUAD
							With Water Rights	No Water Rights	Total Irr.	With Water Rights	No Water Rights	Total Idle		
				1-176				2						Shell
				1-177							3			Shell
				1-178				9						Shell
					190.0	2.71	112	11	123		3	3	126	
Shell Canal (T.F. - McDonald)	A	1938E	4/10/1907	1-191	20.0									Shell
				A			10							
				1-194				10						Shell
					20.0	0.29	10	10	20				20	
Shell Canal (T.F. - McDonald)	A	5986E	6/23/1959	1-171	42.0									Shell
				A			33							
					42.0	0.60	33		33				33	
Shell Canal (T.F. - Allen and Hough)	A	Terr.	Spg-1887	1-121	235.0									Devils Kitchen
				A			169.0							
				1-136				2						Devils Kitchen

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-120				15						Devils Kitchen
				1-137				6						Devils Kitchen
				1-144				5						Devils Kitchen
				1-138				25						Devils Kitchen
					235	3.36	169	53	222				222	
Shell Canal (T.F.-Call & Pilcher)	P	15598	8/7/1919			S.S.	(Sup.Supply for lands under #Terr-Allen & Hough)							
Shell Canal (T.F.-Call & Pilcher)	P	15599	10/7/1919			S.S.	(Sup.Supply for lands under #Terr-Allen & Hough)							
Shell Canal	A	8290	3/20/1908	1-80	85.0									Devils Kitchen
				A			45							
				B			17							
				1-81				9						Devils Kitchen
				1-82				10						Devils Kitchen
				1-52	100.0									Wild Horse Flats
				A			63							
				1-56	75.0									Wild Horse

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
														Flats
				A			62							
				1-58	502.0									Wild Horse Flats
				A			26							
				B			12							
				C						3				
				D			150							
				E						32				
				F						21				
				G			5							
				1-61				9						Wild Horse Flats
				1-41	102.5									Greybull South
				A			4							
				B			53							
				1-43	11.5				0					Greybull South
				1-59				6						Wild Horse Flats
				1-60				2						Wild Horse Flats
				1-62				1						Wild Horse Flats
				1-63				1						Wid Horse Flats
				1-42				10						Greybull South

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-38				1						Greybull South
				1-72				3						Wild Horse Flats
					876.0	12.49	437	52	489	56		56	545	
Shell Canal	A	2084E	6/1/1909	1-6	72.44									Greybull North
				A			8							
				B			9							
				C			3							
				1-7	530.31*									Greybull North
				A			10							
				B						153				
				C			49							
				D			48							
				E			3							
				F			2							
				G			5							
				1-23				3						Greybull North
				1-24				1						Greybull North
				1-19				2						Greybull North
				1-17				1						Greybull North

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-18				2						Greybull North
				1-25	130.5									Greybull South
				A			47							
				B			8							
				C			2							
				1-29	51.0									Greybull South
				A			18							
				B			6							
				C			4							
				D			4							
				1-30	40.3									Greybull South
				A			5							
				B			6							
				C			8							
				1-26				8						Greybull South
				1-27				15						Greybull South
				1-28				3						Greybull South
				1-31				2						Greybull South
				1-32				16						Greybull South
				1-33				9						Greybull South

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-34				14						Greybull South
				1-35	15.0									Greybull South
				A			11							
				1-36	23.0									Greybull South
				A			17							
				1-39	14.0									Greybull South
				A			4							
				1-37				2						Greybull South
				1-40				2						Greybull South
				1-83	60.0									Devils Kitchen
				A			27							
				1-129	15.0									Devils Kitchen
				A						7				
				1-106	20.0				0					Devils Kitchen
				1-146	20.0				0					Devils Kitchen
				1-126				5						Devils Kitchen
				1-128				10						Devils Kitchen
				1-130				8						Devils

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
														Kitchen
				1-131	91.0									Devils Kitchen
				A			25							
				B			32							
				C			16							
				1-132				3						Devils Kitchen
				1-135				5						Devils Kitchen
				1-133				10						Devils Kitchen
				1-134				5						Devils Kitchen
				1-141				5						Wild Horse Flats
				1-48	8.0									Wild Horse Flats
				A			3							
				1-49				1						Wild Horse Flats
				1-50	4.0									Wild Horse Flats
				A			3							
				1-51				1						Wild Horse Flats
				1-54				3						Wild Horse Flats
				1-55							4			Wild Horse Flats

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-53	140.0									Wild Horse Flats
				A			62							
				B						8				
				1-65	100.0									Wild Horse Flats
				A						91				
				1-64							8			Wild Horse Flats
				1-57							52			Wild Horse Flats
				1-66				34						Wild Horse Flats
				1-67							10			Wild Horse Flats
				1-68	50.0									Wild Horse Flats
				A			20							
				1-69	701.0									Wild Horse Flats
				A			53							
				B						52				
				C			8							
				D			99							
				1-74				12						Wild Horse Flats
				1-75	207.0									Wild Horse Flats
				A			99							

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
				B						7				
				C			4							
				D						3				
				E						5				
				1-73	37.0									Wild Horse Flats
				A			24							
				1-76	5.0				0					Wild Horse Flats
				1-45				105						Wild Horse Flats
				1-46				12						Wild Horse Flats
				1-47				25						Wild Horse Flats
				1-44				3						Wild Horse Flats
				1-192				2						Wild Horse Flats
				1-220				3						Devils Kitchen
				1-109				100						Devils Kitchen
				1-116				3						Devils Kitchen
				1-166	54.0									Shell
				A			48							Shell
				1-167				8						Shell
				1-168	12.0				0					Shell
				1-170	2.0									Shell

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				A			2.0							
				1-172	2.0									Shell
				A			2.0							
					2404.55	34.29	804	443	1247	326	74	400	1647	
	* Includes 40.32 acre overlap with # Terr Dunshee, Proof 3975. Irr. lands tabulated under Dunshee.													
Shell Canal	A	5312E	5/24/1941	1-184	140.0									Shell
				A			71							
				1-206				2						Shell
					140.0	2.0	71	2	73				73	
Shell Canal	P	5445E	2/18/1947			Reservoir Supply			0				0	Shell
Shell Canal	A	6091E	1/18/1963	1-70	20.29									Wild Horse Flats
				A			16							
				1-71				7						Wild Horse Flats
					20.29	0.29	16	7	23				23	
Shell Canal	A	6374E	12/24/1970			Reservoir Supply			0				0	
Shell Canal (T.F.-Whaley)	A	462E	9/18/1899	1-95	278.0*									Devils Kitchen
				A			153							

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-97				10						Devils Kitchen
				1-96				3						Devils Kitchen
					278.0	3.97	153	13	166				166	
* Includes only that portion of Tract 1-95 transferred to Shell Canal.														
Perkins Reservoir	A	6709R	1/18/1963			95.55 AF								
Edwards Reservoir	A	7350R	12/24/1970			16.61 AF								
Smith & Nicholas	P	18665	5/23/1935	1-190	30.0									Shell
				A			2							
					30.0	0.43	2		2				2	
Drwenski No. 4 Irrigation System	P	27860	4/16/1980	1-189	2.2									Shell
				A			1						1	
					2.2	0.03	1		1				1	
Drwenski No. 3	P	27859	4/16/1980			S.S.	(Sup. Supply for lands under #18665, #27858, #27860)							

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Drwenski No. 2	P	27858	4/16/1980			S.S.	(Sup. Supply for lands under #18665, #27859, #27860)							
Drwenski No. 1	P	27857	4/16/1980			S.S.	(Sup. Supply for lands under #4715E - Enl. Bench)							
Smith No. 1	P	25722	6/1/1976	1-186	24.0									Shell
				A			13							
					24.0	0.34	13		13				13	
Frieze	A	Terr	Spg 1887	1-163	50.0									Shell
				A			26							
					50.0	0.71	26		26				26	
Frieze	A	605E	12/17/1900	1-160	608.0									Shell
				A						11				
				B			14							
				C						5				
				D			235							
				E			31							
				F			95							
				G			3							
				1-161				2						Shell
				1-162							15			Shell
				1-157				25						Shell
				1-182				7						Shell
				1-200				5						Shell
				1-155				1						Shell
				1-156				3						Shell
					608.0	8.67	378	43	421	16	15	31	452	

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands With Water Rights	Irrigated Lands No Water Rights	Irrigated Lands Total Irr.	Idle Lands With Water Rights	Idle Lands No Water Rights	Idle Lands Total Idle	Total Irr. & Idle Acres	USGS QUAD
Frieze	A	1964E	10/12/1908	1-185	18.0									Shell
				A			4							
					18.0	0.26	4		4				4	
Whaley	A	Terr	-1889	1-158	142.0									Shell
				A			79							
				B			16							
				1-180				3						Shell
				1-179				3						Shell
				1-159				26						Shell
					142.0	2.03	95	32	127				127	
Whaley	A	42E	6/17/1893	1-154	618.0									Shell
				A			21							
				B			415							
				C			9							
				D			8							
				E			15							
				1-152				12						Shell
				1-173				3						Shell
				1-174				3						Shell
				1-139	74.0									Devils Kitchen
				A			37							
					692.0	10.03	505	18	523				523	

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Whaley	A	462E	9/18/1899	1-95	156.0*									Devils Kitchen
				A		(Transfer to Shell Canal)								
				B			94							
				1-98				6						Devils Kitchen
					156.0	2.22	94	6	100				100	

* Does not include 278 acres transferred to Shell Canal)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Whaley	A	650E	4/22/1901	1-115	123.0									Devils Kitchen
				A			6							
				B			12							
				C			16							
				D			7							
				1-125	146.0									Devils Kitchen
				A			6							
				B			100							
				C			11							
				1-122				4						Devils Kitchen
				1-123				5						Devils Kitchen

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-124				2						Devils Kitchen
				1-127				7						Devils Kitchen
					269.0	3.83	158	18	176				176	
Whaley	A	1730E	12/10/1906	1-142	150.0									Devils Kitchen
				A						21				
				B			17							
				C			44							
				D						9				
				E			16							
				1-143				2						Devils Kitchen
					150.0	2.14	77	2	79	30		30	109	
Whaley (T.F.- McDonald)	A	1330E	1/6/1905	1-164	23.8*									Shell
				B			14							
					23.8	0.34	14		14				14	

* These lands transferred from McDonald #1330E to Whaley Ditch.

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Whaley	A	5420E	4/19/1945	1-112	20.0									Devils Kitchen
				A			11							
				1-113				4						Devils Kitchen
				1-114	20.0		11							Devils Kitchen
					40.0	0.57	22	4	26				26	
Whaley	A	5472E	7/26/1948	1-110	15.24									Devils Kitchen
				A			4							
				B			3							
					15.24	0.22	7		7				7	
Whaley	A	6196E	12/6/1967	1-111	2.96	0.04			0				0	Devils Kitchen
Whaley (T.F.-Whaley Secondary)	A	22810	12/6/1967			Sec. Supply (Sec. Supply to 2.96 ac under #6196E)							0	

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Flitner	A	19680	6/3/1941	1-201	25.0									Shell
				A			13							
				1-203	9.0				0					Shell
				1-204	3.0				0					Shell
					37.0	0.53	13		13				13	
Flitner (T.F. - Frieze)	A	1348E	3/11/1905	1-202	54.0									Shell
				A			43							
				1-153				3						Shell
					54.0	0.77	43	3	46				46	
Porter Canal	A	365	11/18/1892	1-117	1050*									Devils Kitchen
				A			21							
				B			32							
				C			51							
				D			80							
				E			27							
				F			49							
				G			374							
				1-107				7						Devils Kitchen

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-119				22						Devils Kitchen
				1-118				40						Devils Kitchen
					1050.0	14.99	634	69	703				703	

* 20 acres on Proof #3978 duplicated on Proof #3980. 15 acres duplicated on #Terr-Odessa, irr. lands accounted for under this right.

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Porter Canal	A	1726E	4/22/1907	1-108	43.0*									Devils Kitchen
				A			1							
					43.0	0.61	1		1				1	

* 33 acres overlap with # Terr-Odessa, irr. lands accounted for under Odessa Ditch.

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Porter Canal	A	322E	1/21/1898	1-105	146.0									Devils Kitchen
				A			42							
				B			38							
					146.0	2.09	80		80				80	
Porter Canal	A	1464E	11/3/1905	1-104	54.0									Devils Kitchen
				A			42							

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				1-103				9						Devils Kitchen
				1-102				10						Devils Kitchen
					54.0	0.77	42	19	61				61	
Odessa	A	Terr	1/10/1887	1-100	359.0*									Devils Kitchen
				A			26							
				B			5							
				C			179							
				D			4							
				1-148				4						Devils Kitchen
				1-149				13						Devils Kitchen
				1-150				8						Devils Kitchen
				1-101				32						Devils Kitchen
					359.0	5.14	214	57	271				271	

* Includes 15 acre overlap with #365 - Porter Canal, irr. lands accounted for under Porter Canal.

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
Odessa	A	2031E	3/23/1909	1-99	35.0				0					Devils Kitchen
					35.0	0.50			0			0	0	
Red Bluff Canal	A	16412	8/3/1922	1-94	12.0									Devils Kitchen
				A			6							
				1-93				3						Devils Kitchen
				1-89	10.0									Devils Kitchen
				A			8							
				B			1							
				1-91	35.0									Devils Kitchen
				A			8							
					57.0	0.81	23	3	26				26	
Red Bluff Canal (T.F. - Scharen)	A	5274	1/21/1903	1-90	20.0									Devils Kitchen
				A			20							
				1-88	15.0									Devils Kitchen

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				A			8							
				B			2							
				1-87				11						Devils Kitchen
				1-85				5						Devils Kitchen
				1-92				9						Devils Kitchen
				1-86	20.0									Devils Kitchen
				A			6							
				B			1							
				1-84				7						Devils Kitchen
					55.0	0.78	37	32	69				69	
Denny	A	Terr	5/8/1888	1-78	230.0									Devils Kitchen
				A			102							
					230.0	3.29	102		102				102	
Denny	A	609E	7/29/1901	1-77	35.0									Devils Kitchen
				A			15							
					35.0	0.50	15		15				15	

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Denny	A	1274E	4/18/1904	1-151	12.0				0					Devils Kitchen
				1-11	13.0				0					Greybull North
					25.0	0.35			0				0	
Boulden	A	22424	1/18/1963		Sec. Sup.	(Secondary Supply to 20.29 ac Under 6091E)								
Dunshee	A	Terr	4/15/1888	1-4	597.0									Greybull North
				A			16							
				B			25							
				C			38							
				D			13							
				E			5							
				F			2							
				G			5							
				H			122							
				I						67				
				1-14							20			Greybull North
				1-20				15						Greybull North
				1-21				15						Greybull North
				1-22				14						Greybull North
					597.0	8.53	226	44	270	67	20	87	357	

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Dunshee	A	1275E	4/18/1904	1-149				3.0						Devils Kitchen
				1-12	25.0									Greybull North
				A			14							
				1-15				11						Greybull North
					25.0	0.35	14	14	28				28	
Dunshee (T.F.-Linn)	A	3777E	3/10/1917	1-3	30.0									Greybull North
				A			18							
				1-10				3						Greybull North
					30.0	0.43	18	3	21				21	
Dunshee	A	3786E	4/2/1917	1-5	21.7									Greybull North
				A			19							
					21.7	0.31	19		19				19	
Dunshee	A	5859E	6/19/1956	1-16	70.81									Greybull

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
														North
				A			6							
				B			9							
				1-79	20.0				0					Devils Kitchen
					90.81	1.30	15		15				15	
Cropsey	A	20877	11/29/1951	1-13	9.0									Greybull North
				A			6							
					9.0	0.13	6		6				6	
Linn	A	3721	2/13/1902	1-8	110.0									Greybull North
				A			33							
				1-2	33.0*				0					
					143.0	2.04	33		33				33	
	* Includes only those lands not transferred to Linn No. 2. Also includes 20 acre overlap with #Terr-Dunshee, irr. lands accounted for under Dunshee Ditch.													
Unknown Ditch				1-9				4	4				4	Greybull North

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Shell Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Linn No. 2	A	3721	2/13/1902	1-2	126.0									Greybull North
				A			4							
				B			32							
					126.0	1.80	36		36				36	
Linn No. 2	A	2446E	4/6/1911	1-1	58.0	0.80			0				0	Greybull North

DRAINAGE: White Creek (Trib. to Shell Cr.)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Boylan	A	6799	7/10/1905	5-1	227.0									Black Mtn.
				A			7							
				B			8							
				C			6							
				D			52							
					227.0	3.24	73		73				73	

DRAINAGE: Cottonwood Creek (Trib. to Shell Creek)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Cottonwood S.S.	A	17878	1/12/1931			S.S.	(Supplemental Supply for 657 Ac served from Horse Creek)							

DRAINAGE: Red Gulch Creek (Trib. to Shell Creek)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
M.E. Jackson	A	3722	2/13/1902	1-145	30.0									Devils Kitchen
				A			4		4					
					30.0	0.42	4		4				4	
Sabin Spring No. 1	A	19522	2/13/1941	Not Mapped	10.0	0.14			0				0	Bush Butte

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: North Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Frank St. Jermain	A	7196	5/5/1906	2-63	36.0	0.51			0				0	Leavitt Reservoir
Bullinger Diversion	A	23032	7/14/1966			0.61	(Stock use only)						0	
St. Jermain	A	1415	1/15/1897	2-66	118.0									Leavitt Reservoir
				A			20							
				B			2							
				C			7							
				D			9							
				E			5							
				F			5							
				G			4							
				H			7							
				2-67				6						Leavitt Reservoir
					118.0	1.69	59	6	65				65	
St. Jermain	A	1496E	1/19/1906	2-72	27.0									Leavitt Reservoir
				A			6							
					27.0	0.38	6		6				6	

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: North Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Ben F. Roe No. 1 Res.	A	2454R	7/27/1912			14.35 AF								
Ben F. Roe No. 2 Res.	A	2455R	11/22/1912			18.65 AF								
Mathews	A	1341	10/15/1896	2-79	14.0									Leavitt Reservoir
				A			11							
				2-82	78.0									Leavitt Reservoir
				A			4							
				2-78				3						Leavitt Reservoir
				2-80				8						Leavitt Reservoir
				2-81				2						Leavitt Reservoir
				2-83				3						Leavitt Reservoir
					92.0	1.31	15	16	31				31	
Miller Spring Pipeline No.1	P	24942	9/4/1975			0.056	(Stock Use)							
Miller Spring Pipeline No.2	P	24943	9/4/1975			0.056	(Stock Use)							

DRAINAGE: North Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Miller Spring Pipeline No.3	P	24944	9/4/1975			0.056	(Stock Use)							
Miller Spring Pipeline No.4	P	24945	9/4/1975			0.056	(Stock Use)							
Miller Spring Pipeline No.5	P	24946	9/4/1975			0.056	(Stock Use)							
Miller Spring Pipeline No.6	P	24947	9/4/1975			0.056	(Stock Use)							

DRAINAGE: South Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Davis	A	2967	12/22/1900	2-64	114.0									Leavitt Reservoir
				A			39							
				2-65				1						Leavitt Reservoir
					114.0	1.70	39	1	40				40	
Davis	A	2747E	7/27/1912	2-68	121.0									Leavitt Reservoir
				A			40							
				2-69				15						Leavitt Reservoir
					121.0	1.72	40	15	55				55	
Kimbro No. 1	A	11335	6/21/1912	2-70	12.0									Leavitt Reservoir
				A			7							
					12.0	0.17	7		7				7	

DRAINAGE: South Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
London	A	686	9/1/1894	2-120	41.0									Leavitt Reservoir
				A			5							
				B			15							
				C			1							
				2-119				6						Leavitt Reservoir
				2-121				3						Leavitt Reservoir
				2-14	229.0									Shell
				A			10							
				B			41							
				C			4							
				D			1							
				E			31							
				2-15				3						Shell
				2-16				7						Shell
				2-17				4						Shell
					270.0	3.86	108	23	131				131	
London	A	4082E	1/5/1920	2-20	65.0									Shell
				A			6							
				B			13							
				2-21				4						Shell
				2-19				11						Shell
				2-22				3						Shell
				2-24				18						Shell
					65.0	0.93	19	36	55				55	

DRAINAGE: South Fork Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Venerable Sprinkler System	P	25276	8/24/1976	2-71	15.28	0.22			0				0	Leavitt Reservoir
Miller No. 1	P	24562	5/30/1974	2-73	199.4	2.85			0				0	Leavitt Reservoir

DRAINAGE: Hudson Falls Creek (Trib. to Cedar Creek)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Hunt	A	5363	3/17/1903	2-74	155.0									Leavitt Reservoir
				A			4							
				B			1							
				C			42							
				2-75				29						Leavitt Reservoir
					155.0	2.21	47	29	76				76	Leavitt Reservoir
Hunt	P	6542E	5/30/1974			S.S.	(Sup. Supply for lands under #24562 - Miller No. 1 and #6543E - Enl. Cedar Creek)							
Miller Spring Pipeline No.7	P	24948	9/4/1975			0.0112	(Stock Use)							
Miller Spring Pipeline No.8	P	24949	9/4/1975			0.0112	(Stock Use)							

DRAINAGE: Cedar Creek (Trib. to Beaver Creek)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Cedar Creek	A	5364	3/17/1903	2-76	30.0									Leavitt Reservoir
				A			4		4					
				2-77	5.0				0					Leavitt Reservoir
(Also Sup. Supply for 75 acres under #5363 - Hunt Ditch)														
					35.0	0.50	4		4				4	
Cedar Creek	P	6543E	5/30/1974			S.S.	(Sup. Supply for lands under #24562 - Miller No. 1 and #6542E - Enl. Hunt)							
Howe	A	12217	12/18/1912	2-85	11.0									Leavitt Reservoir
				A			5							
				2-86	15.7									Leavitt Reservoir
				A			10							
				2-87				7						Leavitt Reservoir
				2-88				6						Leavitt Reservoir
					26.7	0.38	15	13	28				28	
Good	A	14993	12/17/1917	2-117	35.0				0					Leavitt Reservoir
				2-118	20.0				0					Leavitt Reservoir
					55.0	0.78			0				0	

DRAINAGE: Red Canyon Creek (Trib. to Beaver Cr.)

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Miller No. 1 Reservoir	A	7334R	7/29/1970			23.65 AF								
Miller No. 1 Reservoir		7446R	12/17/1971			14.29 AF								
Spring Ditch	P	17468	1/21/1919	2-84	3.5	0.05			0				0	Leavitt Reservoir
Betty	A	14746	5/16/1917	2-18	40.0									Shell
				A			29							
				2-23	40.0									Shell
				A			40							
					80.0	1.14	69		69				69	
Leavitt	A	13197	12/8/1913	2-31	3.7				0					Shell
				2-32	29.0				0					Shell
					32.7	0.46			0				0	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Bernie	A	6672	5/20/1905	2-95	148.0									Leavitt Reservoir
				A			22							
				B			35							
				2-91				22						Leavitt Reservoir
					148.0	2.11	57	22	79				79	
Bernie	A	1512E	2-14-1906	2-92	66.0									Leavitt Reservoir
				A			48							
				2-94				3						Leavitt Reservoir
					66.0	0.94	48	3	51				51	
Bernie	A	1511E	3/4/1906	2-90	40.0									Leavitt Reservoir
				A			18							
				B			6							
				2-122				5						Leavitt Reservoir
				2-93				7						Leavitt Reservoir
					40.0	0.57	24	12	36				36	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Bernie	A	2204E	4/25/1910	2-89	7.0				0					Leavitt Reservoir
				2-100	8.0				0					Leavitt Reservoir
					15.0	0.21			0				0	
Trout	A	386	1/3/1893	2-98	59.0									Leavitt Reservoir
				A			43							
				2-99				3						Leavitt Reservoir
					59.0	0.84	43	3	46				46	
Trout	A	905E	8/23/1902	2-96	164.0									Leavitt Reservoir
				A			118							
				2-97				58						Leavitt Reservoir
					164.0	2.35	118	58	176				176	
Trout	A	1540E	5-3-1906	2-105	90.0									Leavitt Reservoir
				A			18							
				2-106				10						Leavitt Reservoir
					90.0	1.29	18	10	28				28	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Calvin	A	1923	8/9/1898	2-101	16.0				0					Leavitt Reservoir
				2-102	6.0				0					Leavitt Reservoir
				2-103	15.0				0					Leavitt Reservoir
				2-104	11.0				0					Leavitt Reservoir
					48.0	0.69			0				0	
Calvin	A	1438E	5/22/1905	2-111	28.0									Leavitt Reservoir
				A			15							
				(overlap w/ 2-112)	10.0*				0					Leavitt Reservoir
					38.0	0.54	15		15				15	

* Consists of lands overlapping with 10 acres under #811E - Calvin, irr. lands accounted for under #811E.

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Calvin	A	811E	3/5/1902	2-112	199.0									Leavitt Reservoir
				A			131							
				B			11							
				2-10	8.0				0					Leavitt Reservoir
				2-116	2.0				0					Leavitt Reservoir
				2-123				9						Leavitt Reservoir

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				2-113				9						Leavitt Reservoir
				2-114				2						Leavitt Reservoir
					209.0	2.97	142	20	162				162	
Tolen	A	3678	1/17/1902	2-107	34.0				0					Leavitt Reservoir
				2-110	5.0				0					Leavitt Reservoir
					39.0	0.55			0				0	
Tolen	A	1546E	4/16/1906	2-108	36.0	0.51			0				0	Leavitt Reservoir
Tolen	A	1532E	3/29/1906	2-109	15.0	0.21			0				0	Leavitt Reservoir
Leavitt Reservoir	A	6220R	4/19/1954			643.45 AF								

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Williams	A	1005	7/5/1895	2-4	75.0									Shell
				A			7							
				B			15							
				2-5				4						Shell
				2-5				6						Shell
					75.0	1.05	22	10	32				32	
Trone & Hurt	A	10616	3/11/1911	2-2	193.0									Shell
				A			3							
				B			84							
				C			11							
				2-3				4						Shell
				2-7				4						Shell
					193.0	2.76	98	8	106				106	
Trone & Hurt	A	3205E	12/8/1913	2-11	136.0									Shell
				A			20							
				B			23							
				C			3							
					136.0	1.94	46	0	46				46	
Trone & Hurt	A	3558E	11/15/1915	2-27	67.0	0.96			0				0	Shell

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands With Water Rights	Irrigated Lands No Water Rights	Irrigated Lands Total Irr.	Idle Lands With Water Rights	Idle Lands No Water Rights	Idle Lands Total Idle	Total Irr. & Idle Acres	USGS QUAD
Crandall	A	691	4/19/1894	2-115	36.0									Leavitt Reservoir
				A			4							
				2-1	39.0									Shell
				A			1							
				B			6							
					75	1.07	11		11				11	
Kenyon	A	Terr	-1888	2-8	50.0									Shell
				A			15.0							
				B			5.0							
					50	0.71	20		20				20	
Kenyon	A	682	4/3/1894	2-9	15.0									Shell
				A			6.0							
				2-12				10.0						Shell
					15	0.21	6	10	16				16	
Kenyon	A	232E	1/7/1897	2-29	66.0									Shell
				A			7							
				B			24							
				2-30				10						Shell
					66	0.94	31	10	41				41	

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Kenyon (T.F. Anderson)	A	853	11/24/1894	2-25	26.0									Shell
				A			12							
					26.0	0.37	12		12				12	
Anderson	A	853	11/24/1894	2-25	67.0									Shell
				B			8							
				C						5				
				D			27							
				E			5							
				2-33							2			Shell
				2-34				7						Shell
				2-35				5						Shell
					67.0	0.96	40	12	52	5	2	7	59	
Anderson	A	3559E	11/15/1915	2-28	21.0									Shell
				A			10							
				B						6				
				2-26				4						Shell
					21.0	0.30	10	4	14	6		6	20	
Arthur Mason	A	6217	7/28/1904	2-36	41.0									Shell
				A			23							
					41.0	0.58	23		23				23	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Arthur Mason	A	5417E	10/10/1946	Supply ditch for Ewen Res.										
Ewen No. 3	A	21842	6/24/1957	2-39	15.0									Shell
				A			3							
					15.0	0.21	3		3				3	
Ewen-Pence Gulch Reservoir	A	6067R	10/15/1953			78.45 AF								
Ewen No. 1	A	13194	6/6/1913	2-37	21.8									Shell
				A			20							
				2-38				4						Shell
					21.8	0.31	20	4	24				24	
Ewen No. 2	A	13195	6/6/1913	2-41	15.6									Shell
				A			3							
				B			5							
				2-40				10						Shell
				2-42				1						Shell
					15.6	0.22	8	11	19				19	
Pense	A	Terr	-1888	2-45	20.0									Shell
				A			20							
					20.0	0.28	20		20				20	

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Pense	A	1807	3/28/1898	2-44	55.0									Shell
				A			39							
				2-43				4						Shell
					55.0	0.79	39	4	43				43	
Pense	A	1850E	3/19/1908	2-60	14.0									Shell
				A			11							
					14.0	0.20	11		11				11	
Ewen Reservoir	A	5583R	10/10/1946			132.40 AF								
Bond	A	13196	6/20/1913	2-46	17.3									Shell
				A			7							
					17.3	0.24	7		7				7	
Beaver	A	270	5/5/1892	2-50	132.0									Shell
				A			7							
				B			62							
				C			15							
				D			2							
				2-56	5.0									Shell
				A			2							
				2-48				5						Shell
					137.0	1.97	88	5	93				93	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Beaver	A	1601E	8/6/1906	2-52	5.0									Shell
				A			5							
				2-53	5.0									Shell
				A			5							
				2-54				19						Shell
				2-57	9.0									Shell
				A			2							
				B			3							
					19.0	0.27	15	19	34				34	
Beaver	A	1808E	9/16/1907	2-49	11.0									Shell
				A			4							
				B			6							
				2-51	32.0									Shell
				A			7							
				B			2							
				C			7							
				D			2							
				2-55	34.0									Shell
				A			3							
				B			2							
				C			4							
				D			5							
					77.0	1.10	42		42				42	

DRAINAGE: Mainstem - Beaver Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Beaver	A	3192E	6/20/1913	2-47	19.2	0.27			0				0	Shell
Loveland	A	Terr	6/15/1888	2-58	15.0									Shell
				A			8							
				2-62				1						Shell
				2-61				3						
					15.0	0.21	8	4	12				12	Shell
Bratsky Pipeline	P	24516	11/20/1974	2-59	76.0	1.09			0				0	Shell

DRAINAGE: Horse Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands With Water Rights	Irrigated Lands No Water Rights	Irrigated Lands Total Irr.	Idle Lands With Water Rights	Idle Lands No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
Frank Gould No. 2	A	17817	12/12/1930	3-1	30.0									Shell
				A			9							
				B			8							
				C			1							
				3-2				9						Shell
					30.0	0.43	18	9	27				27	
Lampman No. 2	A	1573	9/13/1897	3-5	80.0									Shell
				A			13							
				B			2							
					80.0	1.14	15		15				15	
Lampman No. 2	A	1871E	5/22/1905	3-12	40*									Shell
				A			21							
				3-11				7						
					40.0	0.57	21	7	28				28	

* Includes overlap of 4 acres with #510 Kershner and Lampman, proof #4022. Irr. lands accounted for under this right.

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands With Water Rights	Irrigated Lands No Water Rights	Irrigated Lands Total Irr.	Idle Lands With Water Rights	Idle Lands No Water Rights	Total Idle	Total Irr. & Idle Acres	USGS QUAD
Lampman	A	Terr.	5/1/1887	3-4	145.0									Shell
				A			83							
				B			3							
				C			6							
				3-3				8						Shell
				3-6				2						Shell
					145.0	2.07	92	10	102				102	

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Horse Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Kershner & Lampman (Original POD)	A	510	6/1/1893	3-7	12.0									Shell
				A			7.0							
			(Overlap w/3-12)		4.0*									
					16.0	0.23	7.0		7				7	
Walter	A	Terr.	4/1/1888	3-10	28.0									Shell
				A			21							
				3-9				13						Shell
					28.0	0.40	21	13	34				34	
Kershner Reservoir	A	1281R	4/30/1908			12.0 AF								
Kershner & Lampman (New POD)	A	510	6/1/1893	3-13	32.0									Shell
				A			14							
				B			9							
					32.0	0.46	23		23				23	

* Consists of 4 ac overlap of lands under #1871E - Lampman No. 2, irr. lands accounted for under Lampman No. 2.

SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: Horse Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Kershner & Lampman (new POD)	A	882E	7/14/1902	3-15	25.0									Shell
				A			21							
				3-14				5						Shell
				3-16				9						Shell
	(Also supply ditch for Lampman Reservoir)													
					25.0	0.35	21	14	35				35	
Kershner & Lampman (New POD)	A	4398E	11/14/1923	3-8	40.0									Shell
				A			10							
					40.0	0.57	10		10				10	
Lampman Reservoir	A	318R	7/14/1902			6.00 AF								
Bench	A	3648	1/9/1902	3-18	94.0									Shell
				A			3							
				B			31							
				C			31							
				D			9							
				3-17				2						Shell
				3-28				3						Shell

DRAINAGE: Horse Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
				3-19				2						Shell
				3-25				2						Shell
				3-26				1						Shell
					94.0	1.33	74	10	84				84	
Bench	A	2380E	2/11/1911	3-23	125.0									Shell
				A			23							
				B			10							
					125.0	1.78	33		33				33	
Bench	A	4715E	3/5/1931	3-24	25.0									Shell
				A			15.0							
					25.0	0.36	15		15				15	
Austin	A	Terr	4/26/1887	3-21	148.0									Shell
				A			35							
				B			39							
				C			3							
				D			6							
				3-20				4						
					148.0	2.12	83	4	87				87	

DRAINAGE: Horse Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Leavitt Pipeline	P	23409	1/16/1970	3-22	45.6	0.65			0				0	Shell
E.W. Smith	A	17840	12/12/1930	3-27	13.0									Shell
				A			3							
					13.0	0.19	3		3				3	
Emerick	A	14358	6/3/1916	3-29	10.0	0.14			0				0	Shell

DRAINAGE: Trapper Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Jenks	A	2563	4/20/1900	4-1	56.0									Black Mtn.
				A			14							
				B						5				
				C			10							
				4-2							5			
					56.0	0.80	24		24	5	5	10	34	
Cull No. 2	A	3727	2/13/1902	4-4	47.0									Black Mtn.
				A			22							
				B			4							
				4-5						13				Black Mtn.
					47.0	0.67	26		26	13		13	39	
Cull No. 1	A	3720	2/13/1902	4-3	36.0	0.51			0				0	Black Mtn.
Nathan	A	6220	6/11/1904	4-6	14.0									Black Mtn.
				A			3							
				B			5							
					14.0	0.20	8		8				8	

DRAINAGE: Trapper Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Hatten	A	1075	11/13/1895	4-14	60.0									Black Mtn.
				A			27							
				B			3							
				C			2							
				4-16				5						Black Mtn.
				4-11				15						Black Mtn.
				4-15				4						Black Mtn.
					60.0	0.86	14	24	38				38	
Hatten	A	#1262E	8/8/1904	4-18	23.0									Black Mtn.
				A			14							
				B			3							
				4-12	28.0									Black Mtn.
				A			14							
				B			2							
				4-9	18.0									Black Mtn.
				A			1							
				B			3							
				4-17				3						Black Mtn.
				4-21	12.0									Shell
				A			3							
				B			5							
				4-22				2						Shell
					81.0	1.15	45	5	50				50	

DRAINAGE: Trapper Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Crain-Jenks	A	7438	8/11/1906	4-19	42.0									Black Mtn.
				A			3							
				B			25							
				4-13	14.0									Black Mtn.
				A			9							
				4-10	35.0									Black Mtn.
				A			6							
				B			6							
				C			1							
				4-20				2						Black Mtn.
				4-7				15						Black Mtn.
				4-8				4						Black Mtn.
					91.0	1.30	50	21	71				71	
Highline	A	1716	1/21/1898	4-29	181.0*									Shell
				A			91							
				B			30							
				4-25				47						Shell
				4-37				2						Shell
					181.0	2.57	121	49	170				170	

* Includes a duplication of 20 acres under #Terr-McDonald, proof #3966. Irr. lands accounted for under McDonald Ditch.

DRAINAGE: Trapper Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Highline	A	1962E	10/9/1908	4-30	55.0									Shell
				A			23							
					55.0	0.78	23		23				23	
Highline	A	2469E	5/5/1911	4-36	14.1	0.20			0				0	Shell
Highline	A	1522E	9/7/1906	4-33	60.0									Shell
				A			2							
				B			15							
				C			4							
				4-31	5.0				0					Shell
				4-32				10						Shell
				4-34				10						Shell
					65.0	0.93	21	20	41				41	
Saban & Brown	A	3132	4/22/1901	4-24	57.0									Shell
				A			2							
				B			15							
				C			3							
				D						7				
				E			17							
				4-23				9						Shell
					57.0	0.78	37	9	46	7		7	53	

DRAINAGE: Trapper Creek

Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Saban & Brown	A	1244E	5/19/1904	4-26	9.0									Shell
				A			1							
				B			4							
					9.0	0.12	5		5				5	
Willard	A	1039	8/16/1895	4-28	40.0									Shell
				A			20							
				4-27				2						Shell
					40.0	0.57	20	2	22				22	
Casey Pipelne	P	24240	10/15/1973	4-35	9.14	0.13			0				0	Shell

APPENDIX E (continued)
SHELL VALLEY WATER RIGHTS AND IRRIGATED LANDS INVENTORY

DRAINAGE: SUMMARY

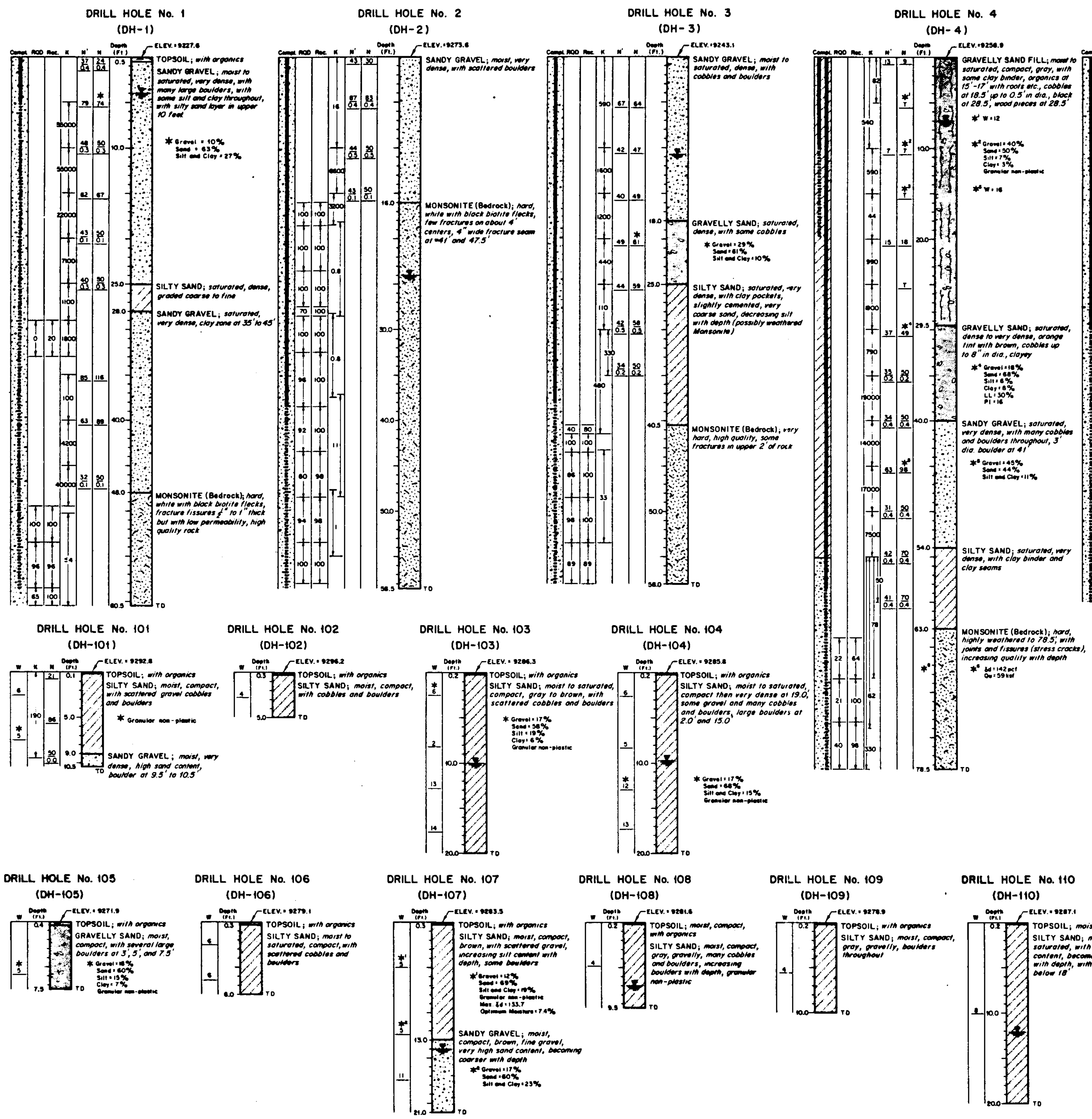
Name	Permit Status	Permit No.	Priority Date	Tract No.	Total Water Right Acres	Water Right Diversion Rate cfs/(AF)	Irrigated Lands: With Water Rights	Irrigated Lands: No Water Rights	Irrigated Lands: Total Irr.	Idle Lands: With Water Rights	Idle Lands: No Water Rights	Idle Lands: Total Idle	Total Irr. & Idle Acres	USGS QUAD
Shell Creek & Minor Tributaries					11766.07	187.359	6151	1014	7165	503	112	615	7780	
White Creek					227.0	3.24	73	0	73	0	0	0	73	
Granite Creek					0	0.2623 - all domestic use							0	
Beaver Creek & Tributaries					3758.48	54.6184	1473	368	1841	11	2	13	1854	
Horse Creek					896.6	12.79	436	67	503	0	0	0	503	
Trapper Creek					815.24	11.57	394	130	524	25	5	30	554	
TOTAL					17,463.39	269.8397*	8,527	1,579	10,106	539	119	658	10,764	

* (Includes awarded diversion rates for stock and domestic uses.)

APPENDIX F

APPENDIX F

GEOTECHNICAL DRILL LOGS AND PLATES



LEGEND

TOPSOIL	
SILTY SAND	
GRAVELLY SAND	
SANDY GRAVEL	
GRANITE	
MONSONITE	

SOLID PVC MONITORING TUBING

SAND DRILL CUTTINGS

PERFORATED PVC MONITORING TUBING

GRAVEL DRILL CUTTINGS

▽	RECORDED WATER LEVEL
TD	TOTAL DEPTH
N	NUMBER OF BLOWS REQUIRED TO DRIVE A STANDARD 2-INCH DIA. SPLIT SPOON PENETROMETER 18 INCHES INTO THE SOIL BY A 140-POUND HAMMER DROPPING FREELY A DISTANCE OF 30 INCHES
N'	STANDARD PENETRATION VALUE CORRECTED FOR OVERBURDEN STRESS AND SAMPLE DIA.
K	FIELD PERMEABILITY IN FT/YR. (U.S.B.R. DESIGNATION E-18)
Rec.	RECOVERY (PERCENT)
RQD	ROCK QUALITY DESIGNATION
Compl.	DESCRIPTION OF DRILL HOLE COMPLETION
W	WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)
LL	LIQUID LIMIT (PERCENT)
PI	PLASTIC INDEX
γd	DRY DENSITY (LB.S/CU.FT.)
Qu	UNCONFINED COMPRESSIVE STRENGTH (KIPS/SQ.FT.)
T	SHELBY TUBE SAMPLE

No.	Revision	By	Date

Designed DLD Drawn SG Checked DLD Approved

Project No. 10M183.105 I.D. No. Date OCT. 9, 1984

LAKE ADELAIDE DAM

LOGS OF EXPLORATION HOLES

HKM ASSOCIATES
ENGINEERS · PLANNERS

Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
• Libby, Montana
• Sheridan, Wyoming

Sheet No. 1 of

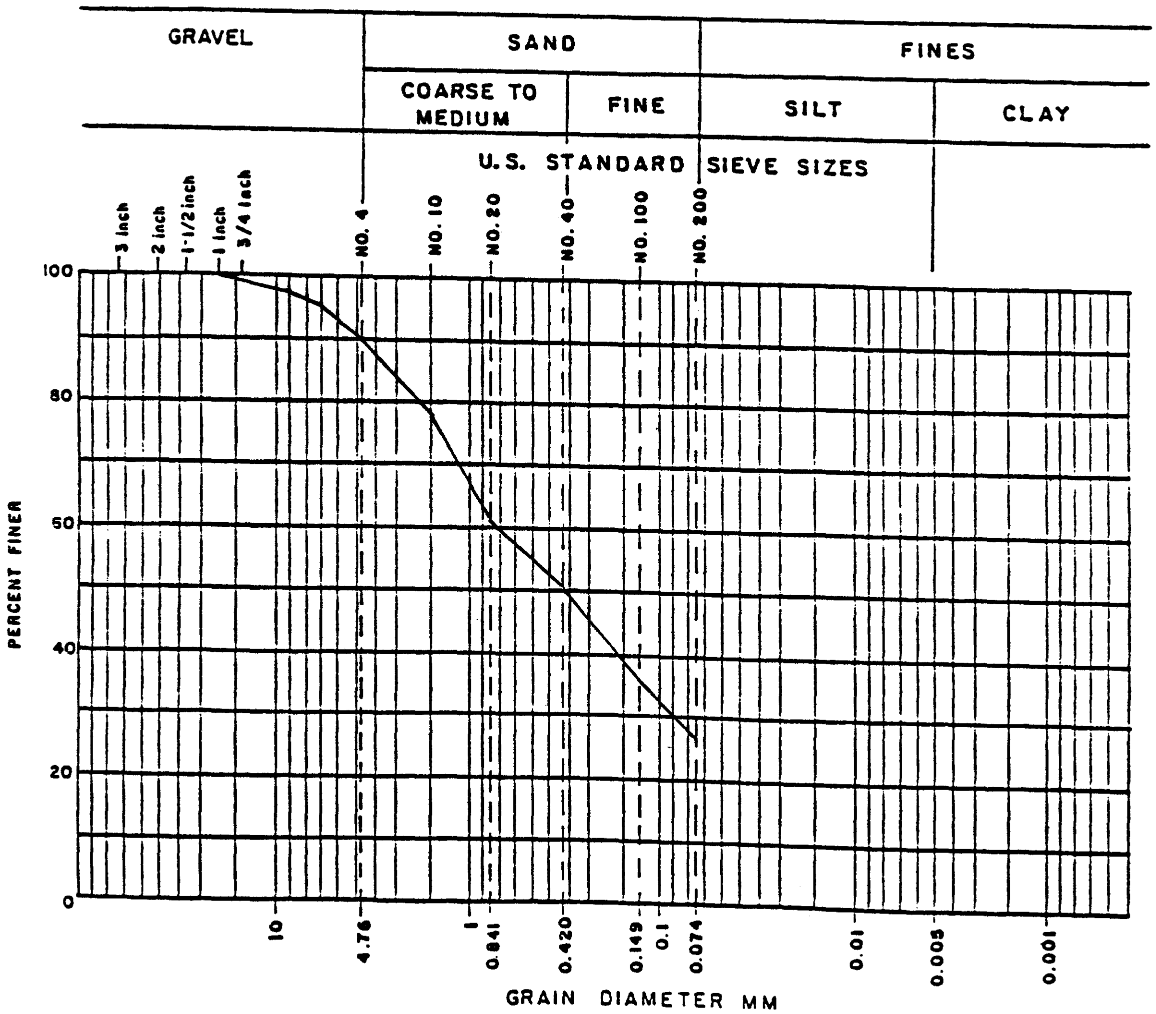
APPENDIX F

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3741
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H.1 (5'-6½')
DATE SAMPLED July, 84 DATE TESTED 8-28-84
SAMPLED BY D.L.D. TESTED BY J.R. & J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION GRAVELLY SAND



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 10 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 63 %
3)_ SILT & CLAY, Passing no. 200 sieve 27 %

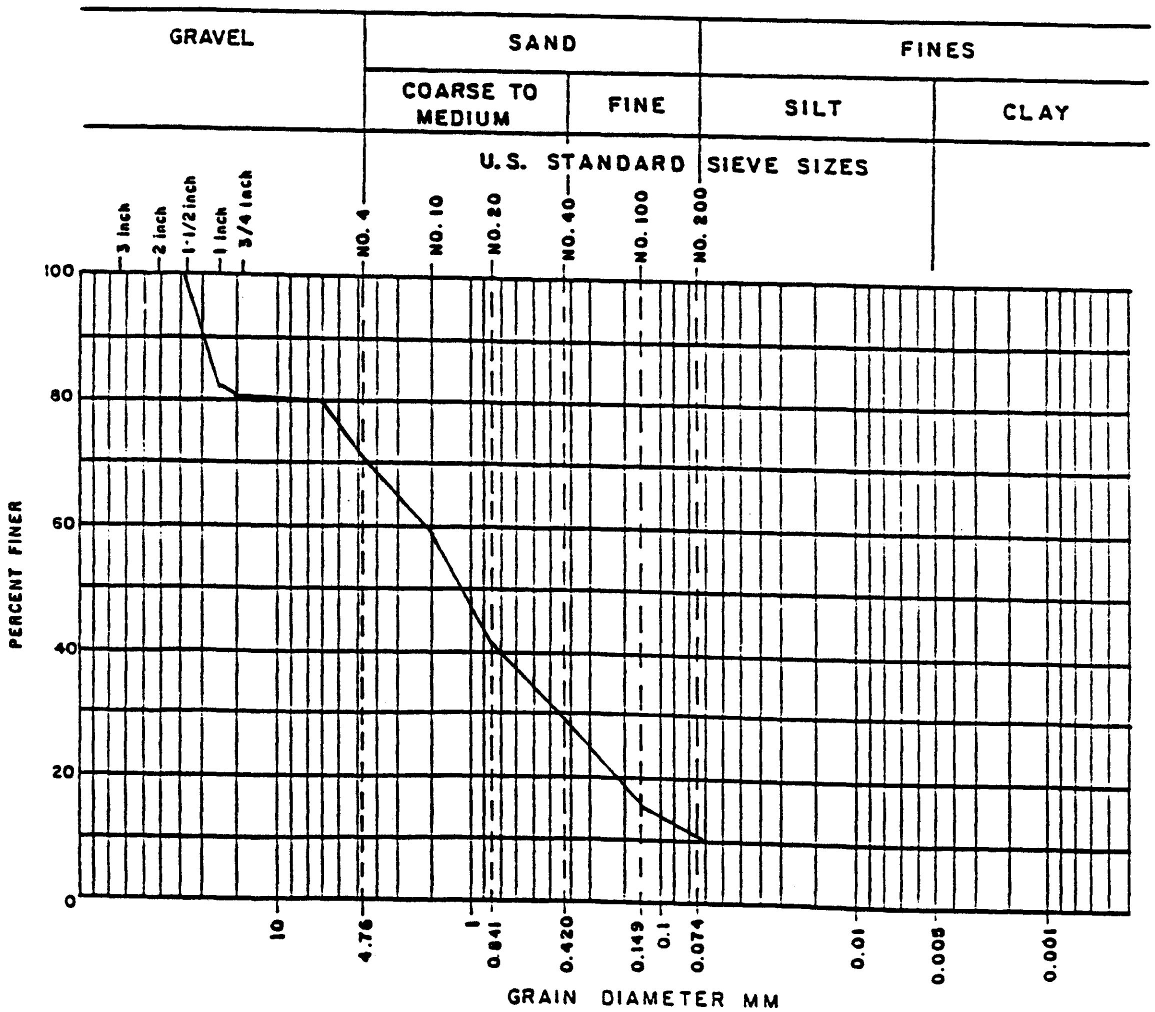
Plate No. 1

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO.	10M183.105	LAB NO.	3746
PROJECT NAME	Lake Adelaide Dam	FIELD NO.	D.H. 3 (20'-21½')
DATE SAMPLED	July 84	DATE TESTED	8-27-84
SAMPLED BY	D.L.D.	TESTED BY	J.R.& J.P.
TYPE SAMPLE	Sack	SAMPLE LOCATION	
SOIL DESCRIPTION	GRAVELLY SAND		



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve — 29 %

2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. — 61 %

3)_ SILT & CLAY, Passing no. 200 sieve — 10 %

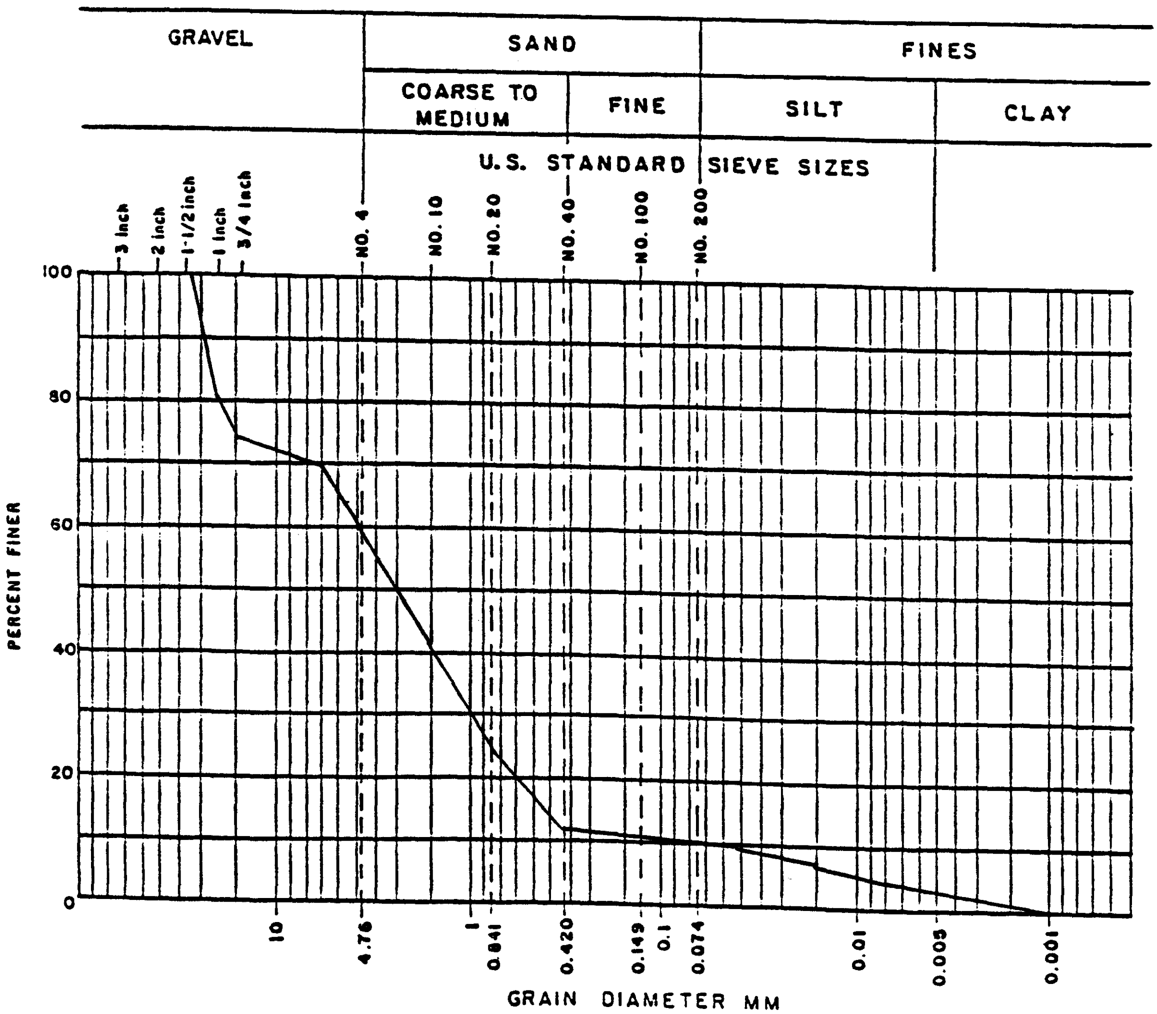
Plate No. 2

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3750
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H. 4 (10'-11.5')
DATE SAMPLED July/August, 84 DATE TESTED 8-27-84
SAMPLED BY D.L.D TESTED BY J.R. & J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION GRAVELLY SAND FILL



1) GRAVEL, Passing 3" & retained on no. 4 sieve 40 %
2) SAND, Passing no. 4 sieve & retained on no. 200 sieve. 50 %
3) SILT & CLAY, Passing no. 200 sieve 10 %

Plate No. 3

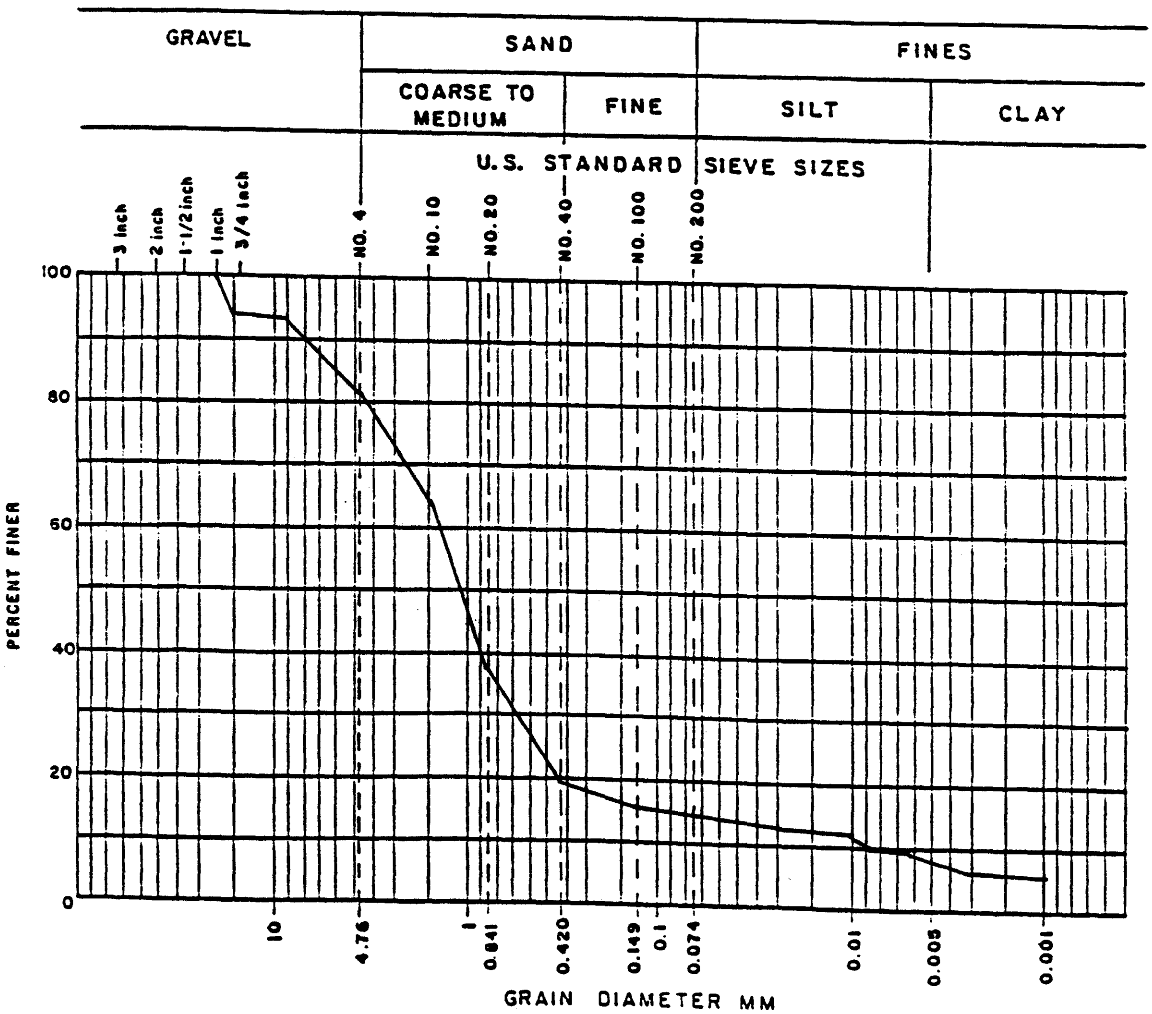
HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

FORM ST-5-80

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105
PROJECT NAME Lake Adelaide Dam
DATE SAMPLED July/August, 84
SAMPLED BY D.L.D
TYPE SAMPLE Sack
SOIL DESCRIPTION GRAVELLY SAND

LAB NO. 3752
FIELD NO. DH4 (30'-31½')
DATE TESTED 8-27-84
TESTED BY J.R.& J.P.
SAMPLE LOCATION



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve ___18___%
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. ___68___%
3)_ SILT & CLAY, Passing no. 200 sieve ___14___%

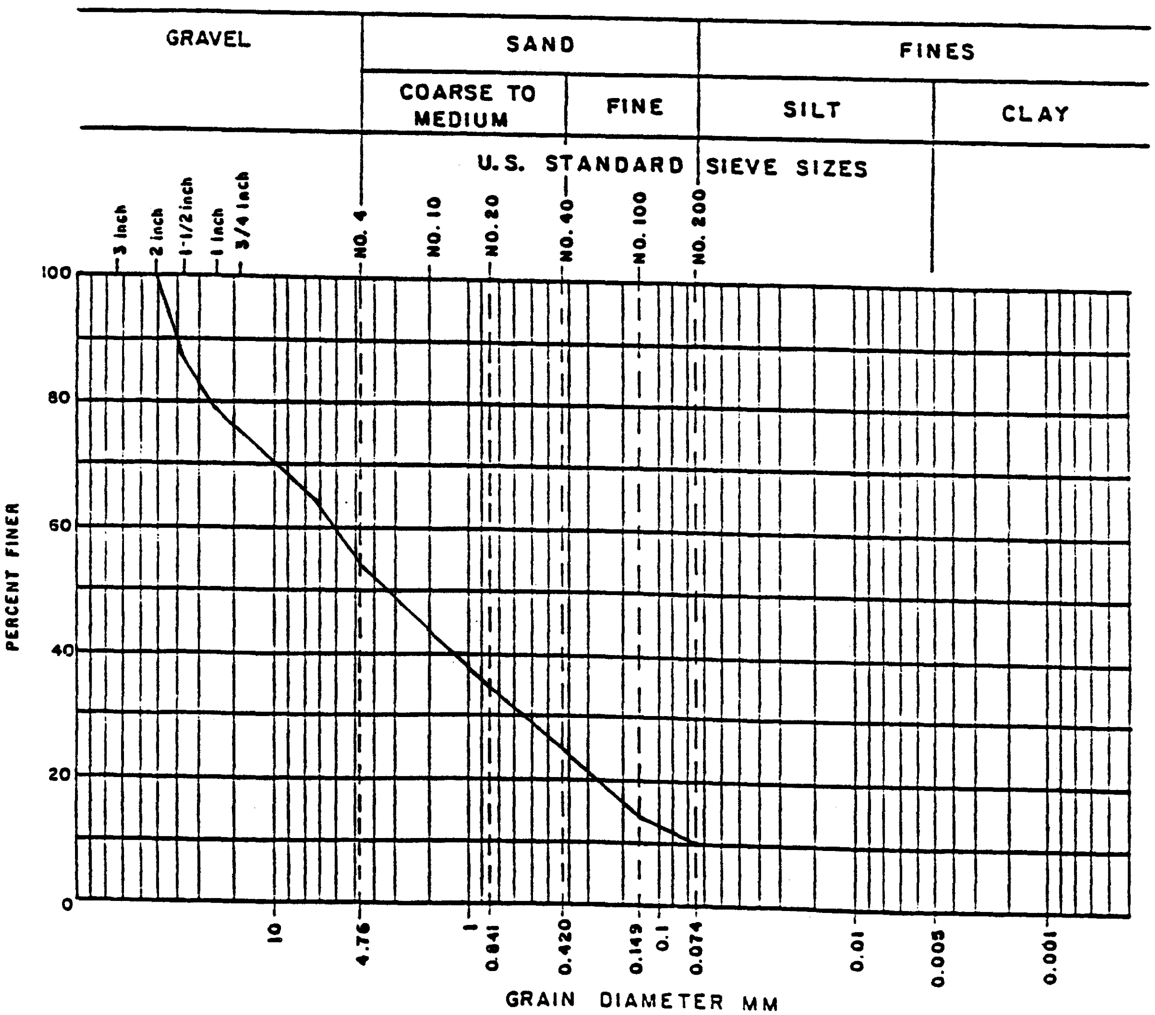
Plate No. 4

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3754
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H.4 (45'-46½)
DATE SAMPLED July/August, 84 DATE TESTED 8-27-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION SANDY GRAVEL



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 45 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 44 %
3)_ SILT & CLAY, Passing no. 200 sieve 11 %

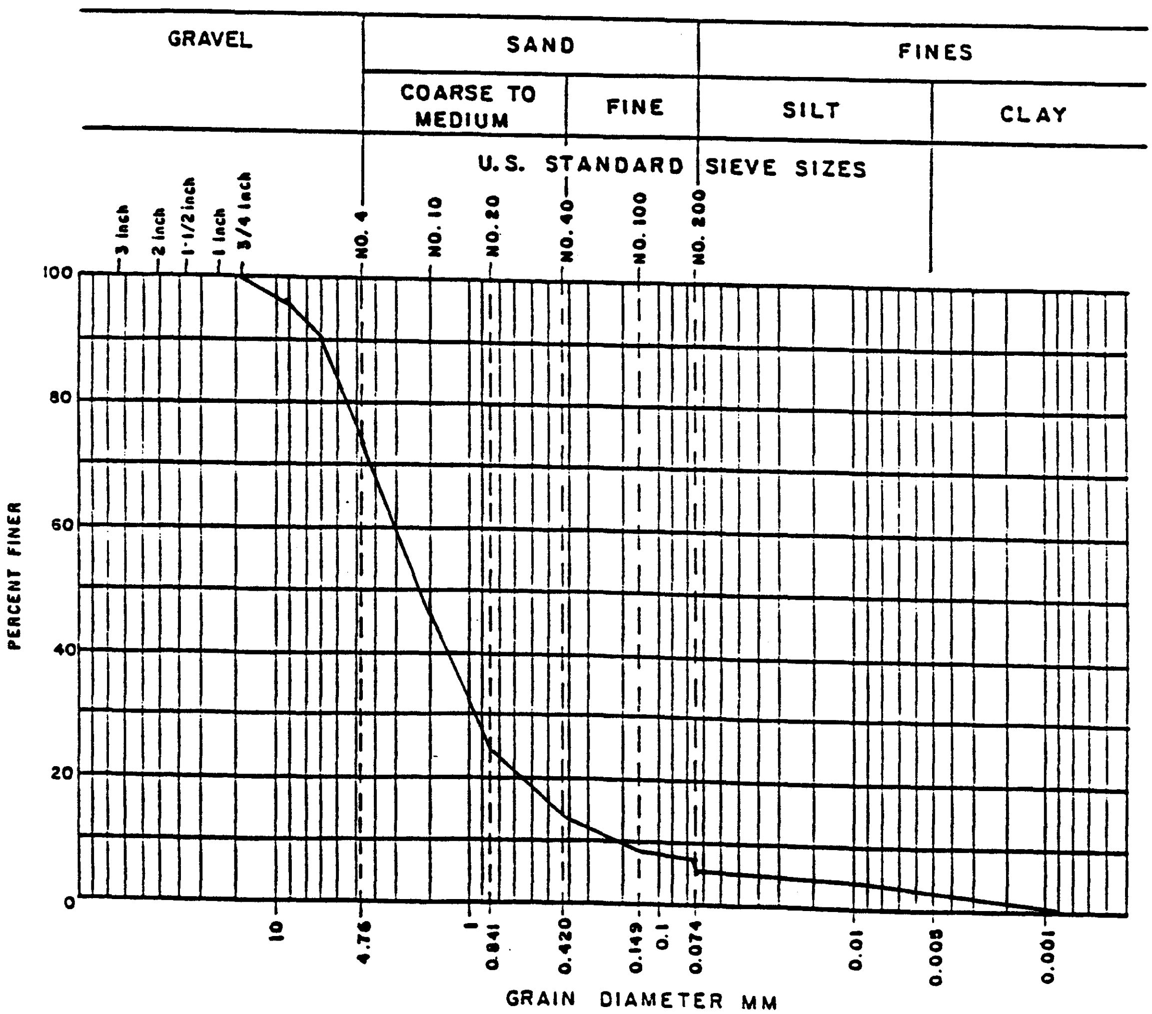
Plate No.5

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3759
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H.6 (0'-1½')
DATE SAMPLED July/August, 84 DATE TESTED 8-27-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION GRAVELLY SAND FILL



1)- GRAVEL, Passing 3" & retained on no. 4 sieve — 27 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. — 65 %
3)- SILT & CLAY, Passing no. 200 sieve — 8 %

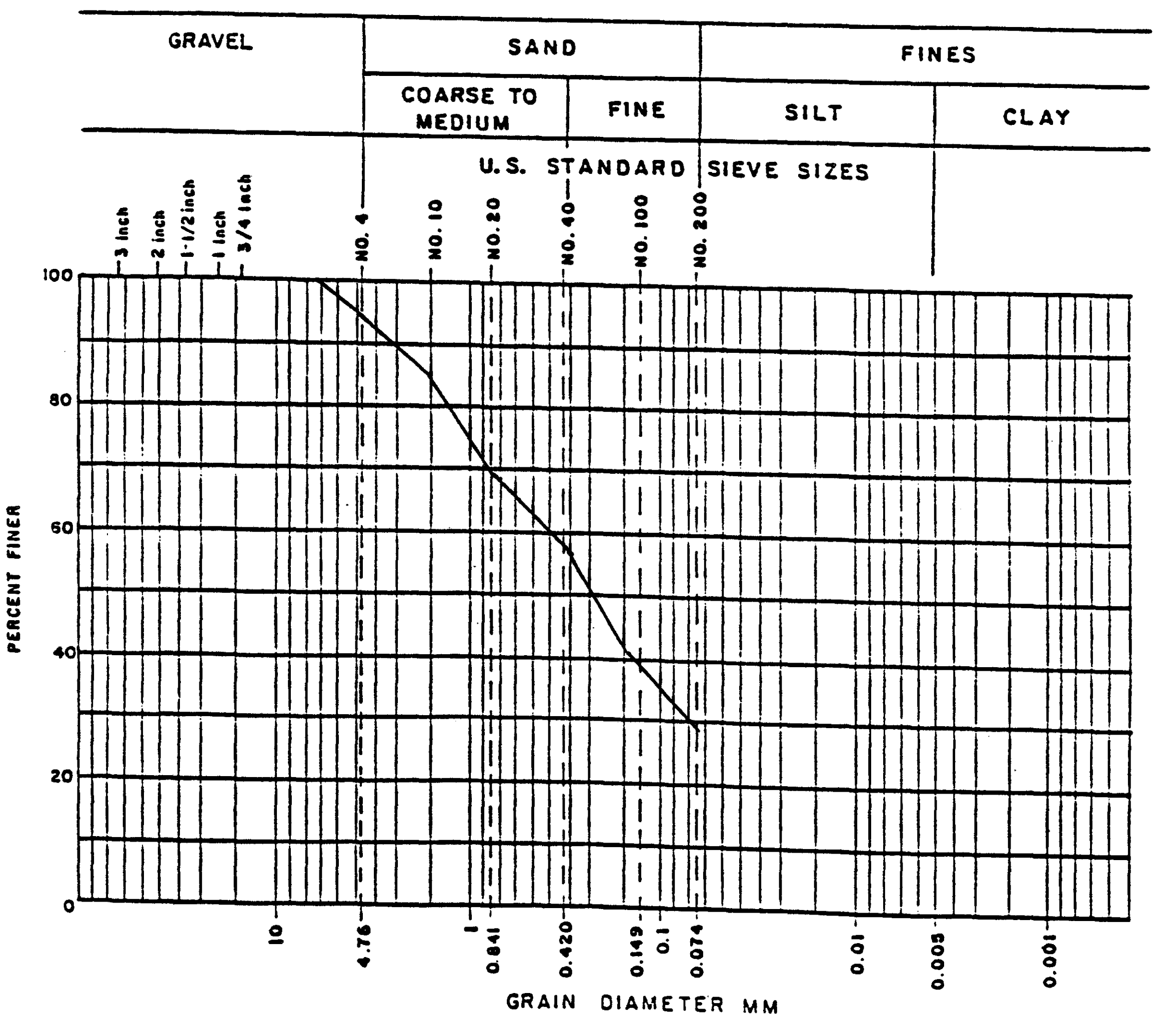
Plate No.6

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3702
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H. 101 (5-10')
DATE SAMPLED July, 84 DATE TESTED 8-28-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE SACK SAMPLE LOCATION
SOIL DESCRIPTION SILTY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 5 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 65 %
3)- SILT & CLAY, Passing no. 200 sieve 30 %

Plate No. 7

FORM ST-5-80

HKM ASSOCIATES

ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3704

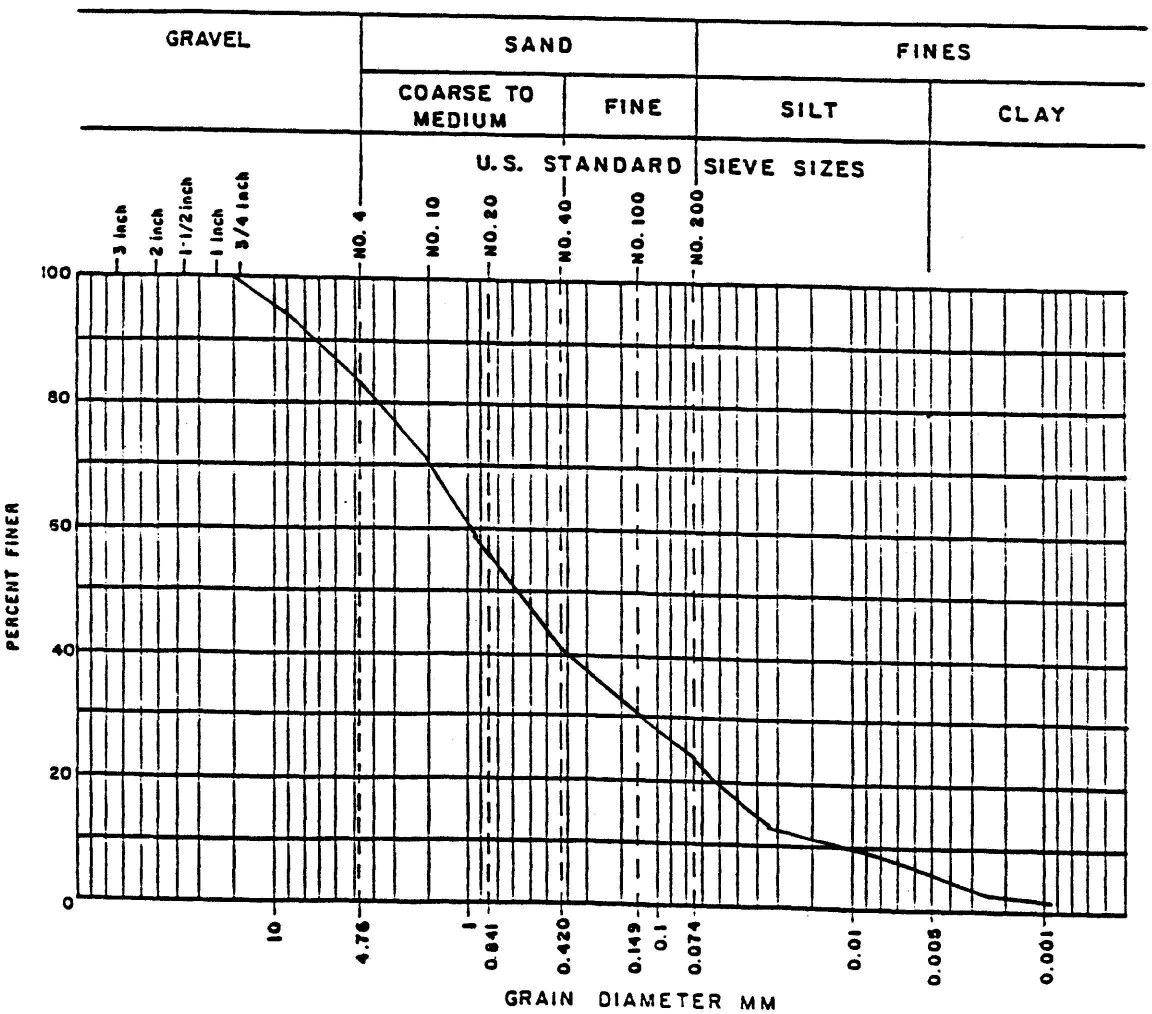
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H. 103 (1'-5')

DATE SAMPLED July/August, 84 DATE TESTED 8-27-84

SAMPLED BY D.L.D. TESTED BY J.R.& J.P.

TYPE SAMPLE Sack SAMPLE LOCATION

SOIL DESCRIPTION SILTY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 17 %

2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 58 %

3)- SILT & CLAY, Passing no. 200 sieve 25 %

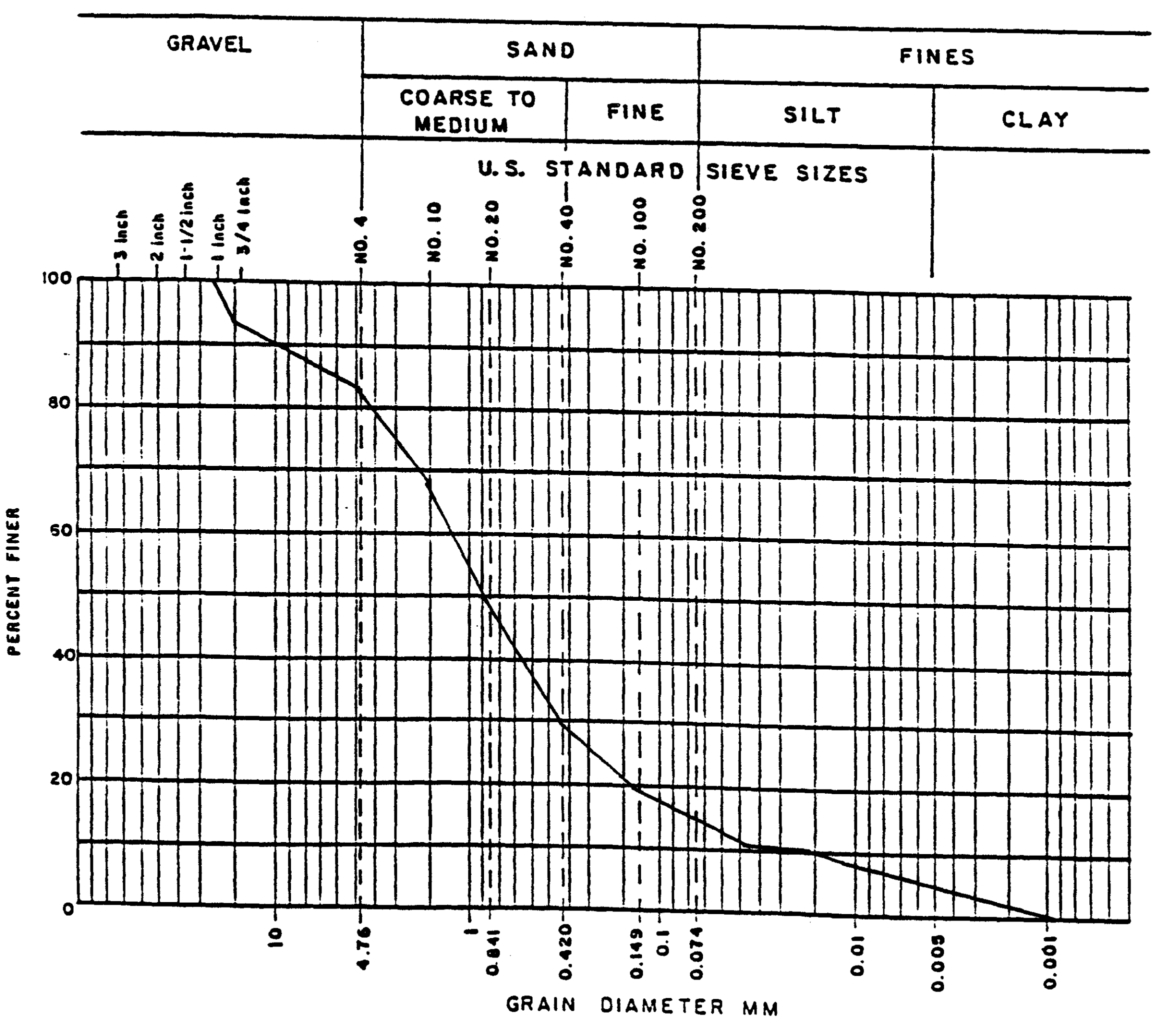
Plate No. 8

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3710
PROJECT NAME Lake Adelaide Dam FIELD NO. 104 (10'-15')
DATE SAMPLED July/August DATE TESTED 8-27-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION SILTY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 17 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 68 %
3)- SILT & CLAY, Passing no. 200 sieve 15 %

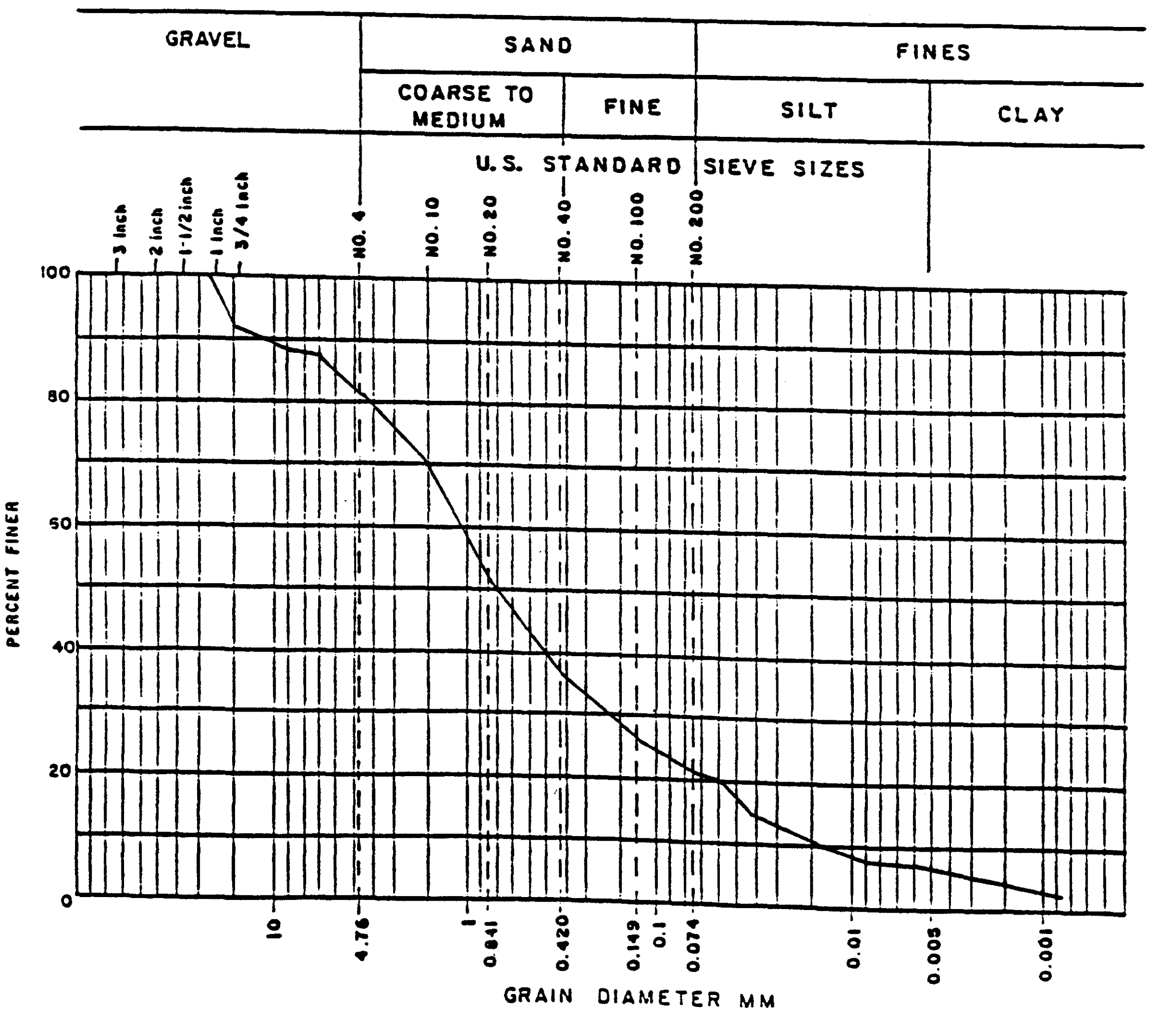
Plate No. 9

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

FORM ST-5-80

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105
LAB NO. 3712
PROJECT NAME Lake Adelaide Dam
FIELD NO. D.H. 105 (1-5')
DATE SAMPLED July/August
DATE TESTED 8-27-84
SAMPLED BY D.L.D.
TESTED BY J.R. & J.P.
TYPE SAMPLE Sack
SAMPLE LOCATION
SOIL DESCRIPTION GRAVELLY SAND



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 18 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 60 %
3)_ SILT & CLAY, Passing no. 200 sieve 22 %

Plate No. 10

FORM ST-5-80

HKM ASSOCIATES
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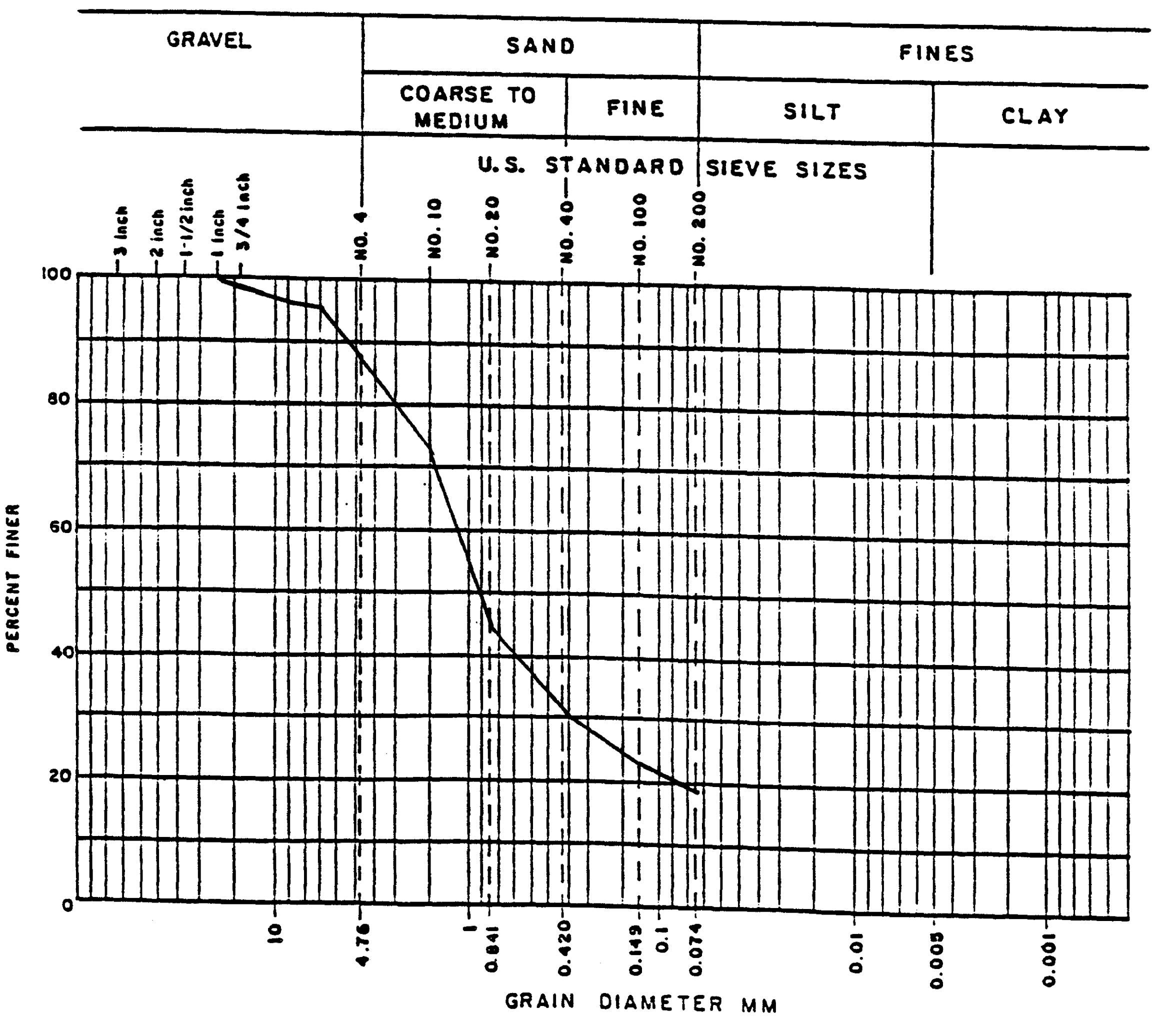
GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3716
PROJECT NAME Lake Adelaide Dam FIELD NO. D.H. 107 (0'-10')
DATE SAMPLED July/August, 84 DATE TESTED 8-27-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION SILTY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 12 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 69 %
3)- SILT & CLAY, Passing no. 200 sieve 19 %

Plate No. 11

FORM ST-5-80

HKM ASSOCIATES
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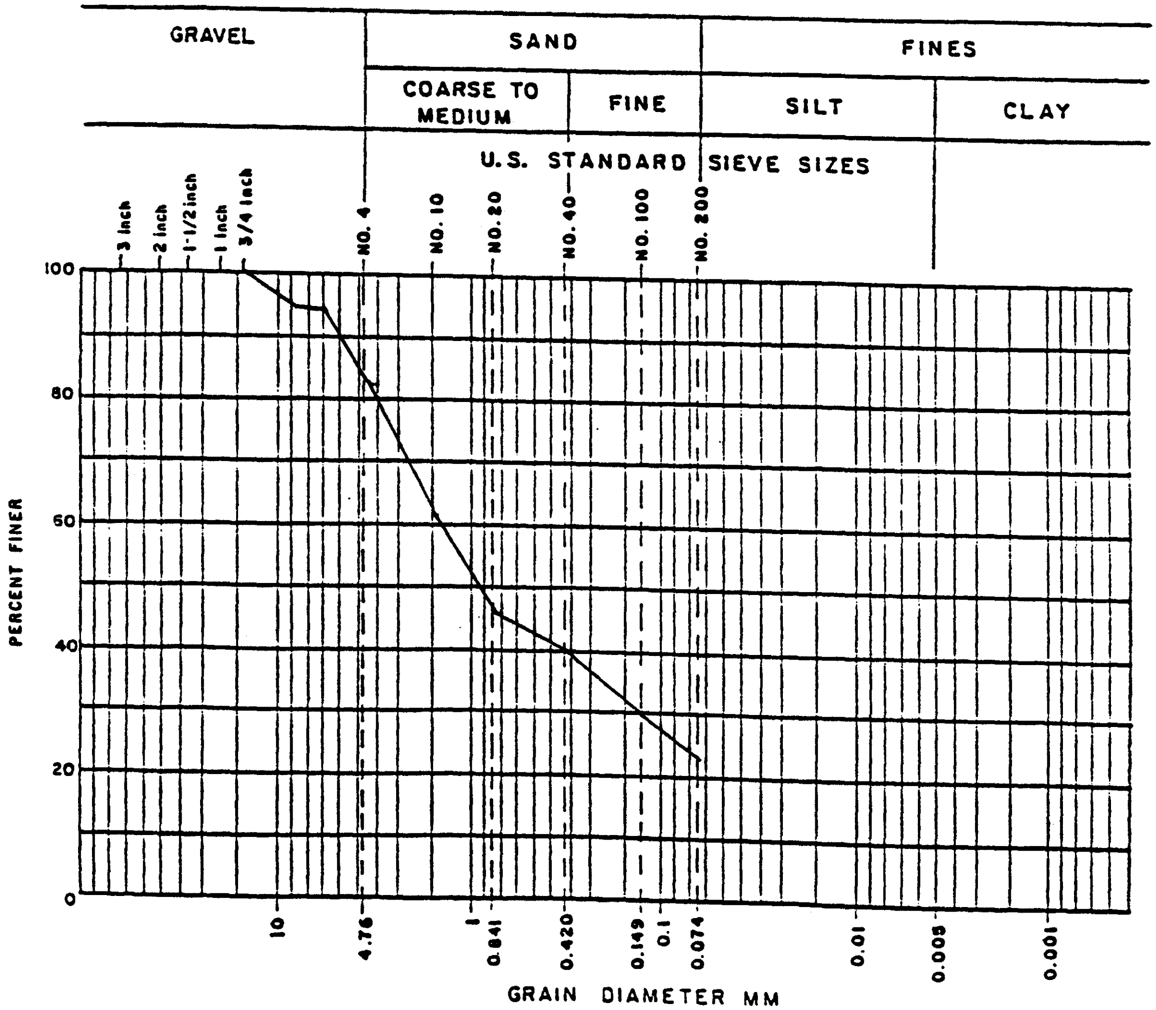
GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3717
PROJECT NAME Lake Adeliade Dam FIELD NO. D.H. 107 (10'-13')
DATE SAMPLED July 1984 DATE TESTED 8-28-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION SILTY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve — 17 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. — 60 %
3)- SILT & CLAY, Passing no. 200 sieve — 23 %

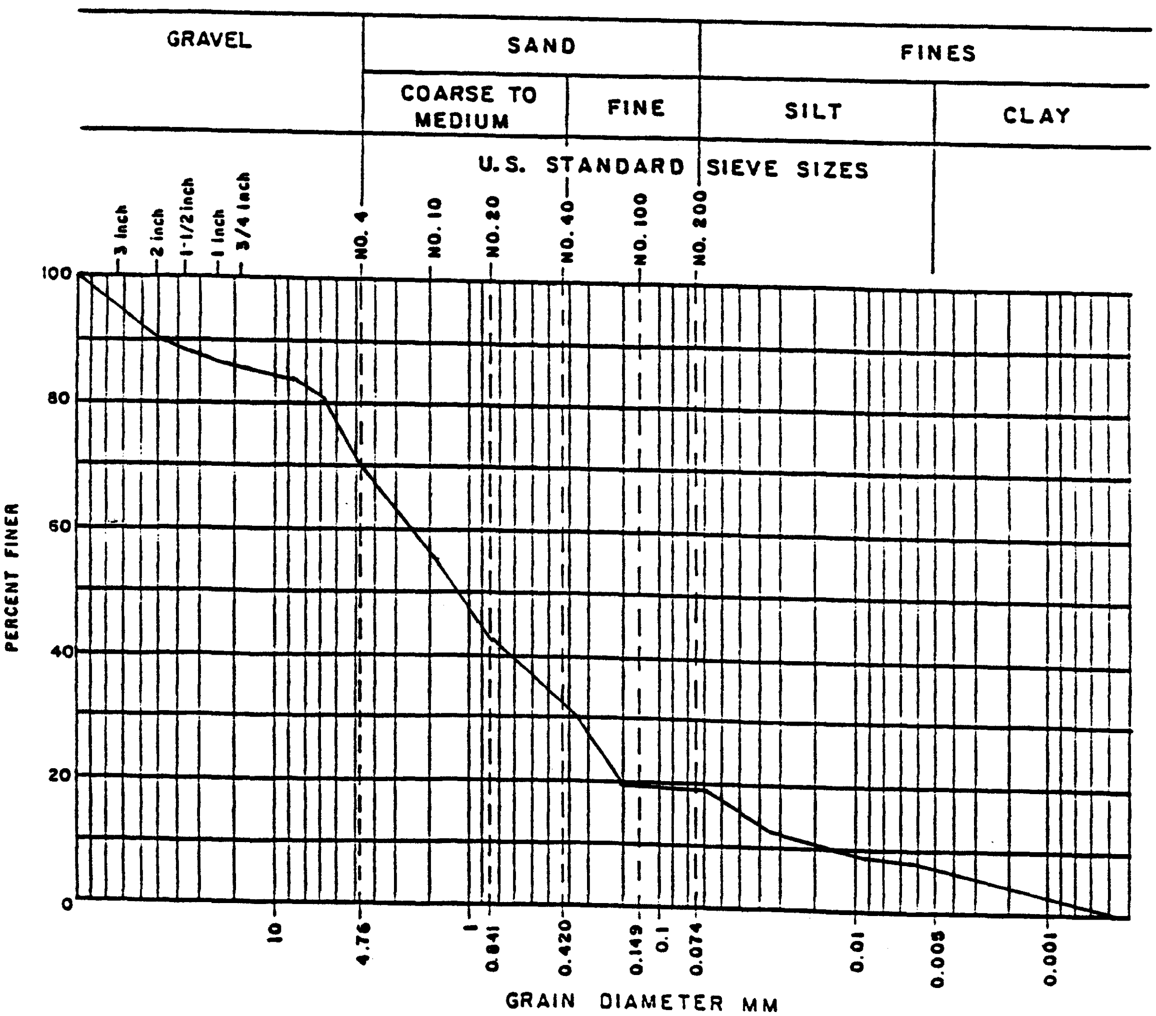
Plate No. 12

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

FORM ST-5-80

GRAIN SIZE DISTRIBUTION

PROJECT NO. 10M183.105 LAB NO. 3681
PROJECT NAME Lake Adelaide Dam FIELD NO. Dozer Excavation
DATE SAMPLED July/August, 84 DATE TESTED 8-27-84
SAMPLED BY D.L.D. TESTED BY J.R.& J.P.
TYPE SAMPLE Sack SAMPLE LOCATION
SOIL DESCRIPTION GRAVELLY SAND



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 31 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 55 %
3)- SILT & CLAY, Passing no. 200 sieve 14 %

Plate No. 13

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

MOISTURE DENSITY RELATIONS OF SOILS

Project No. 10M183.105

Lab No. 3716 D.H. 107 (0-10')

Project Name Lake Adelaide Dam

Test Designation ASTM D698

Date Sampled July, 1984

Date Tested 8-23-84

Soil Class. SILTY SAND

% Passing # 4Sieve 88%

Maximum Dry Density 133.7 PCF

Optimum Moisture 7.4%

MOISTURE-DENSITY GRAPH

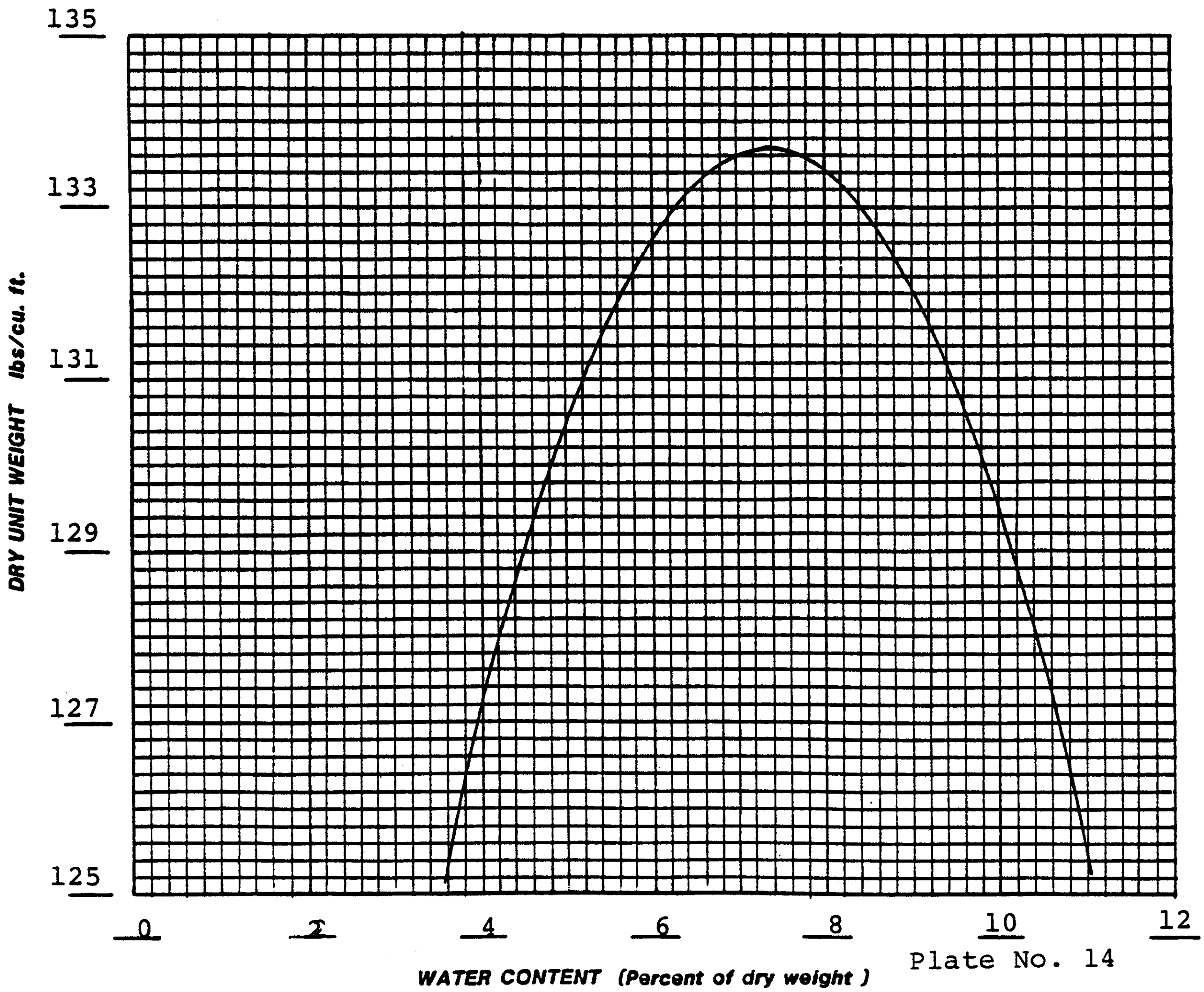


Plate No. 14

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

MOISTURE DENSITY RELATIONS OF SOILS

Project No. 10M183.105

Lab No. 3681 Dozer Excavation

Project Name Lake Adelaide Dam

Test Designation ASTM D-698

Date Sampled July, 1984

Date Tested 8-23-84

Soil Class. GRAVELLY SAND

% Passing # 4Sieve 69

Maximum Dry Density 130.1 PCF

Optimum Moisture 7.1%

MOISTURE-DENSITY GRAPH

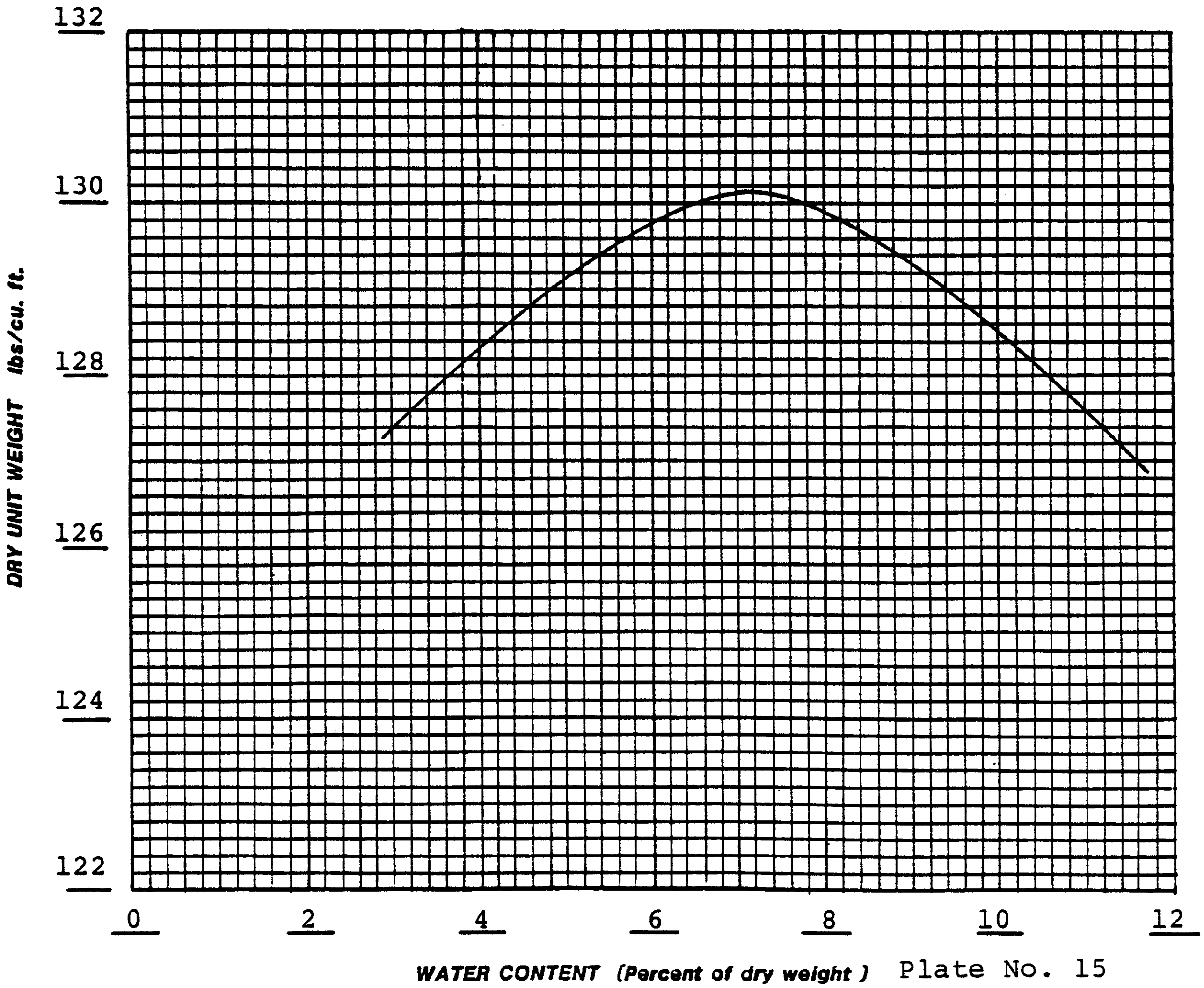


Plate No. 15

APPENDIX G

APPENDIX G

TYPICAL CONSUMPTIVE USE AND NET IRRIGATION REQUIREMENT AND MEAN MONTHLY TEMPERATURE AND PRECIPITATION FOR SHELL, WYOMING

H.K.M. ASSOCIATES

11/21/84

DATA SUMMARY
BLANEY-CRIDDLE CONSUMPTIVE USE ANALYSIS
REGION SHELL WY

MEAN MONTHLY TEMPERATURE (DEGREES F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	20.60	29.40	41.40	44.50	57.90	67.50	74.20	73.90	59.20	53.50	36.80	32.00	49.24

AVERAGE MONTHLY PRECIPITATION (INCHES)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	.90	.40	.85	3.26	.80	2.42	1.68	.28	2.98	.25	.78	.35	14.95

MONTHLY % OF DAYTIME HOURS

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	6.44	6.56	8.29	9.07	10.29	10.43	10.53	9.71	8.42	7.63	6.47	6.18	100.00

LATITUDE:- 44 DEGREES 32 MINUTES

CROP DATA

CROP	PLANTING DATE	HARVEST DATE	DEPTH (INS)
ALFALFA	APR , 29	OCT , 26	4
SUGARBEETS	APR , 14	OCT , 11	4
CORN(SILAGE)	MAY , 10	SEPT , 15	4
GRAIN(SPRING)	APR , 17	AUG , 25	4

ELEVATION :-- 4275 FEET

	FILENAME	LIBRARY	VOLUME
INPUT			
GROWING SEASON	74GROW	A12DATA	VOL555
TEMPERATURE	SHELTPE3	A12DATA	VOL555
PRECIPITATION	SHELPCE3	A12DATA	VOL555
OUTPUT			
GROWING SEASON	74CON	A12DATA	VOL555

END OF INPUT DATA FOR BLANEY-CRIDDLE FORMULA

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS
STATION:-SHELL
**** CROP **** ALFALFA
THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	OCT	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	45.55	50.87	57.90	67.50	74.20	73.90	59.20	53.25	46.38	36.80	32.00	
ADJUSTED PRECIP.	.90	.40	.85	3.15	.11	.80	2.42	1.68	.28	2.98	.21	.04	.78	.35	
ADJUSTED % DH.	6.44	6.56	8.29	8.77	.30	10.29	10.43	10.53	9.71	8.42	6.40	1.23	6.47	6.18	
ADJUSTED KT	.30	.30	.40	.47	.56	.68	.85	.96	.96	.71	.60	.48	.32	.30	
ADJUSTED KC	.40	.40	.40	.40	1.05	1.08	1.13	1.10	1.05	.98	.91	.40	.40	.40	
ADJUSTED K	.12	.12	.16	.18	.59	.74	.97	1.07	1.02	.70	.55	.19	.12	.12	
ADJUSTED F	1.32	1.92	3.43	3.99	.15	5.95	7.03	7.81	7.17	4.98	3.40	.57	2.37	1.97	
					G R O W I N G	S E A S O N									
CONSUMPTIVE USE(IN)	.16	.23	.55	.76	.09	4.46	6.84	8.41	7.33	3.50	1.88	.11	.31	.24	34.87
UPEAK								.30							
CON. USE/DAY (IN)	.00	.00	.01	.02	.09	.14	.22	.27	.23	.11	.07	.02	.01	.00	
EFFECTIVE PRECIP.	.56	.23	.54	1.84	0.00	.63	2.05	1.61	.21	2.04	.09	0.00	.49	.19	
NET IRR. REQ'D.	-.40	0.00	.01	-1.08	.09	3.83	4.79	6.80	7.12	1.46	1.79	.11	-.18	.05	24.39

GROWING SEASON CONSUMPTIVE USE = 32.51 IN.
GROWING SEASON NET IRR REQD = 25.88 IN.

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS

STATION:-SHELL

**** CROP **** SUGARBEETS

THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	OCT	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	43.63	47.60	57.90	67.50	74.20	73.90	59.20	55.37	50.27	36.80	32.00	
ADJUSTED PRECIP.	.90	.40	.85	1.52	1.74	.80	2.42	1.68	.28	2.98	.09	.16	.78	.35	
ADJUSTED % DH.	6.44	6.56	8.29	4.23	4.84	10.29	10.43	10.53	9.71	8.42	2.71	4.92	6.47	6.18	
ADJUSTED KT	.30	.30	.40	.44	.50	.68	.85	.96	.96	.71	.64	.55	.32	.30	
ADJUSTED KC	.25	.25	.25	.25	.46	.57	.86	1.11	1.24	1.17	1.07	.25	.25	.25	
ADJUSTED K	.07	.07	.10	.11	.23	.39	.73	1.08	1.20	.83	.68	.13	.08	.07	
ADJUSTED F	1.32	1.92	3.43	1.84	2.30	5.95	7.03	7.81	7.17	4.98	1.50	2.47	2.37	1.97	
					G R O W I N G S E A S O N										
CONSUMPTIVE USE(IN)	.10	.14	.35	.20	.54	2.37	5.20	8.49	8.62	4.14	1.03	.34	.19	.15	31.86
UPEAK									.31						
CON. USE/DAY (IN)	.00	.00	.01	.01	.03	.07	.17	.27	.27	.13	.09	.01	.00	.00	
EFFECTIVE PRECIP.	.56	.23	.53	.93	1.07	.56	1.87	1.61	.22	2.12	0.00	.04	.48	.19	
NET IRR. REQ'D.	-.46	-.09	-.18	-.73	-.53	1.81	3.33	6.88	8.40	2.02	1.03	.30	-.29	-.04	21.45

GROWING SEASON CONSUMPTIVE USE = 30.39 IN.

GROWING SEASON NET IRR REQD = 22.94 IN.

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS
STATION:-SHELL
**** CROP **** CORN(SILAGE)
THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	MAY	MAY	JUNE	JULY	AUG	SEPT	SEPT	OCT	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	44.50	53.29	59.37	67.50	74.20	73.90	62.81	57.80	53.50	36.80	32.00	
ADJUSTED PRECIP.	.90	.40	.85	3.26	.26	.54	2.42	1.68	.28	1.49	1.49	.25	.78	.35	
ADJUSTED % DH.	6.44	6.56	8.29	9.07	3.32	6.97	10.43	10.53	9.71	4.21	4.21	7.63	6.47	6.18	
ADJUSTED KT	.30	.30	.40	.45	.60	.71	.85	.96	.96	.77	.68	.61	.32	.30	
ADJUSTED KC	.25	.25	.25	.25	.25	.46	.63	.99	1.06	1.00	.25	.25	.25	.25	
ADJUSTED K	.07	.07	.10	.11	.15	.32	.53	.96	1.02	.77	.17	.15	.08	.07	
ADJUSTED F	1.32	1.92	3.43	4.03	1.76	4.13	7.03	7.81	7.17	2.64	2.43	4.08	2.37	1.97	
						G R O W I N G	S E A S O N								
CONSUMPTIVE USE(IN)	.10	.14	.35	.46	.27	1.36	3.80	7.54	7.38	2.04	.42	.62	.19	.15	24.82
UPEAK								.27							
CON. USE/DAY (IN)	.00	.00	.01	.01	.02	.06	.12	.24	.23	.13	.02	.02	.00	.00	
EFFECTIVE PRECIP.	.56	.23	.53	1.87	.12	.35	1.73	1.53	.21	1.01	.92	.12	.48	.19	
NET IRR. REQ'D.	-.46	-.09	-.18	-1.41	.15	1.01	2.07	6.01	7.17	1.03	-.50	.50	-.29	-.04	14.97

GROWING SEASON CONSUMPTIVE USE = 22.12 IN.
GROWING SEASON NET IRR REQD = 17.29 IN.

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS
STATION:-SHELL
**** CROP **** GRAIN(SPRING)
THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	APR	MAY	JUNE	JULY	AUG	AUG	SEPT	OCT	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	43.86	48.23	57.90	67.50	74.20	73.13	67.88	59.20	53.50	36.80	32.00	
ADJUSTED PRECIP.	.90	.40	.85	1.85	1.41	.80	2.42	1.68	.23	.05	2.98	.25	.78	.35	
ADJUSTED % DH.	6.44	6.56	8.29	5.14	3.93	10.29	10.43	10.53	7.83	1.88	8.42	7.63	6.47	6.18	
ADJUSTED KT	.30	.30	.40	.44	.52	.68	.85	.96	.95	.86	.71	.61	.32	.30	
ADJUSTED KC	.25	.25	.25	.25	.36	.76	1.26	1.06	.28	.25	.25	.25	.25	.25	
ADJUSTED K	.07	.07	.10	.11	.18	.52	1.07	1.02	.26	.21	.17	.15	.08	.07	
ADJUSTED F	1.32	1.92	3.43	2.25	1.89	5.95	7.03	7.81	5.72	1.27	4.98	4.08	2.37	1.97	
					G R O W I N G	S E A S O N									
CONSUMPTIVE USE(IN)	.10	.14	.35	.25	.36	3.12	7.58	8.05	1.52	.27	.88	.62	.19	.15	23.58
UPEAK								.29							
CON. USE/DAY (IN)	.00	.00	.01	.01	.02	.10	.25	.25	.06	.04	.02	.02	.00	.00	
EFFECTIVE PRECIP.	.56	.23	.53	1.11	.87	.58	2.14	1.57	.11	0.00	1.77	.12	.48	.19	
NET IRR. REQ'D.	-.46	-.09	-.18	-.86	-.51	2.54	5.44	6.48	1.41	.27	-.89	.50	-.29	-.04	13.32

GROWING SEASON CONSUMPTIVE USE = 20.63 IN.
GROWING SEASON NET IRR REQD = 15.36 IN.

H.K.M. ASSOCIATES

10/10/84

DATA SUMMARY
BLANEY-CRIDDLE CONSUMPTIVE USE ANALYSIS

REGION SHELL WY

MEAN MONTHLY TEMPERATURE (DEGREES F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	20.60	29.40	41.40	44.50	57.90	67.50	74.20	73.90	59.20	53.50	36.80	32.00	49.24

AVERAGE MONTHLY PRECIPITATION (INCHES)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	.90	.40	.85	3.26	.80	2.42	1.68	.28	2.98	.25	.78	.35	14.95

MONTHLY % OF DAYTIME HOURS

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	6.44	6.56	8.29	9.07	10.29	10.43	10.53	9.71	8.42	7.63	6.47	6.18	100.00

LATITUDE:- 44 DEGREES 32 MINUTES

CROP DATA

CROP	PLANTING DATE	HARVEST DATE	DEPTH (INS)
COTTONWOODS	APR , 17	NOV , 1	4
SALTGRASS 12-36	APR , 17	NOV , 1	4

ELEVATION :-- 4275 FEET

	FILENAME	LIBRARY	VOLUME
INPUT			
GROWING SEASON	GROWSP	A12DATA	VOL555
TEMPERATURE	SHELTPE3	A12DATA	VOL555
PRECIPITATION	SHELPCE3	A12DATA	VOL555
OUTPUT			
GROWING SEASON	CONUP	A12DATA	VOL555

END OF INPUT DATA FOR BLANEY-CRIDDLE FORMULA

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS
STATION:-SHELL
**** CROP **** COTTONWOODS
THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	43.86	48.23	57.90	67.50	74.20	73.90	59.20	53.50	44.74	38.09	32.00	
ADJUSTED PRECIP.	.90	.40	.85	1.85	1.41	.80	2.42	1.68	.28	2.98	.25	.03	.75	.35	
ADJUSTED % DH.	6.44	6.56	8.29	5.14	3.93	10.29	10.43	10.53	9.71	8.42	7.63	.22	6.25	6.18	
ADJUSTED KT	.30	.30	.40	.44	.52	.68	.85	.96	.96	.71	.61	.46	.34	.30	
ADJUSTED KC	.25	.25	.25	.25	1.22	1.39	1.84	1.97	1.83	1.69	1.51	1.41	.25	.25	
ADJUSTED K	.07	.07	.10	.11	.63	.95	1.57	1.91	1.76	1.20	.92	.64	.08	.07	
ADJUSTED F	1.32	1.92	3.43	2.25	1.89	5.95	7.03	7.81	7.17	4.98	4.08	.09	2.38	1.97	
							G R O W I N G		S E A S O N						
CONSUMPTIVE USE(IN)	.10	.14	.35	.25	1.20	5.69	11.08	14.98	12.68	6.00	3.79	.06	.21	.15	56.68
UPEAK								.57							
CON. USE/DAY (IN)	.00	.00	.01	.01	.09	.18	.36	.48	.40	.19	.12	.06	.00	.00	
EFFECTIVE PRECIP.	.56	.23	.53	1.11	.91	.67	2.42	1.68	.28	2.35	.14	0.00	.46	.19	
NET IRR. REQ'D.	-.46	-.09	-.18	-.86	.29	5.02	8.66	13.30	12.40	3.65	3.65	.06	-.25	-.04	45.15

GROWING SEASON CONSUMPTIVE USE = 55.48 IN.
GROWING SEASON NET IRR REQD = 47.03 IN.

% WARNING - CROP COTTONWOODS IS NOT INCLUDED IN THE STANDARD GROUP OF 9 CROPS
THIS CROP WILL NOT BE PASSED ON TO THE WEIGHTED IRRIGATION PROGRAM!

MONTHLY USAGE TABLE--BLANEY/CRIDDLE CONSUMPTIVE USE ANALYSIS
STATION:-SHELL
**** CROP **** SALTGRASS 12-36
THE YEAR BEING CONSIDERED IS:- 1973

MONTH	JAN	FEB	MAR	APR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	NOV	DEC	ANNUAL
ADJUSTED TEMP.	20.60	29.40	41.40	43.86	48.23	57.90	67.50	74.20	73.90	59.20	53.50	44.74	38.09	32.00	
ADJUSTED PRECIP.	.90	.40	.85	1.85	1.41	.80	2.42	1.68	.28	2.98	.25	.03	.75	.35	
ADJUSTED % DH.	6.44	6.56	8.29	5.14	3.93	10.29	10.43	10.53	9.71	8.42	7.63	.22	6.25	6.18	
ADJUSTED KT	.30	.30	.40	.44	.52	.68	.85	.96	.96	.71	.61	.46	.34	.30	
ADJUSTED KC	.25	.25	.25	.25	.67	.71	.83	.89	.87	.80	.63	.54	.25	.25	
ADJUSTED K	.07	.07	.10	.11	.34	.49	.70	.87	.84	.57	.39	.24	.08	.07	
ADJUSTED F	1.32	1.92	3.43	2.25	1.89	5.95	7.03	7.81	7.17	4.98	4.08	.09	2.38	1.97	
					GROWING SEASON										
CONSUMPTIVE USE(IN)	.10	.14	.35	.25	.66	2.92	5.00	6.82	6.07	2.86	1.59	.02	.21	.15	27.14
UPEAK								.24							
CON. USE/DAY (IN)	.00	.00	.01	.01	.05	.09	.16	.22	.19	.09	.05	.02	.00	.00	
EFFECTIVE PRECIP.	.56	.23	.53	1.11	.88	.58	1.85	1.47	.19	1.97	.12	0.00	.46	.19	
NET IRR. REQ'D.	-.46	-.09	-.18	-.86	-.22	2.34	3.15	5.35	5.88	.89	1.47	.02	-.25	-.04	17.00

GROWING SEASON CONSUMPTIVE USE = 25.94 IN.
GROWING SEASON NET IRR REQD = 18.88 IN.

% WARNING - CROP SALTGRASS 12-36 IS NOT INCLUDED IN THE STANDARD GROUP OF 9 CROPS
THIS CROP WILL NOT BE PASSED ON TO THE WEIGHTED IRRIGATION PROGRAM!

MEAN MONTHLY TEMP.(HISTORIC & SYNTHETIC)

FILE -- SHELTPE4
SITE -- SHELL WY
UNIT -- DEGREES F
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE   11/19/84

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL MEAN
1941	24.9	28.8	34.7	43.1	57.2	50.7	76.9	72.7	51.5	40.9	32.6	26.4	45.0
1942	18.3	21.9	33.2	48.0	51.8	62.9	77.6	73.8	58.2	45.0	32.7	24.6	45.6
1943	22.1	29.9	30.1	51.7	51.3	62.9	76.6	75.3	59.1	49.2	35.5	25.6	47.4
1944	22.8	24.1	32.8	45.5	56.7	61.1	72.4	71.5	57.2	48.0	32.6	22.6	45.6
1945	22.3	27.1	34.5	39.6	52.8	57.9	76.9	73.3	55.5	48.3	33.9	24.5	45.5
1946	24.8	27.1	38.2	53.5	52.8	63.4	81.5	73.5	59.5	44.2	32.1	28.0	48.6
1947	22.7	29.3	33.9	45.6	60.5	65.9	80.5	76.3	67.4	55.8	29.2	24.2	49.2
1948	24.4	24.4	32.4	49.0	59.9	67.0	74.7	73.6	61.6	45.5	31.9	25.1	47.4
1949	18.6	22.4	34.2	49.9	57.4	65.8	76.9	72.3	56.8	39.8	39.3	25.6	46.6
1950	22.8	29.8	33.6	42.3	48.3	63.3	70.6	67.6	56.4	49.7	32.4	25.0	45.1
1951	21.9	29.6	31.1	41.9	56.1	57.7	73.6	70.0	53.9	43.2	32.0	23.9	44.5
1952	21.5	23.3	32.3	47.6	55.7	70.2	73.0	72.8	62.8	46.3	29.7	26.5	47.2
1953	31.5	30.0	37.4	39.7	49.7	66.9	81.9	74.5	61.0	47.9	36.8	28.4	48.8
1954	25.9	35.1	31.6	44.5	54.4	63.6	81.7	73.2	60.5	43.9	37.7	27.9	48.3
1955	26.4	26.6	30.0	43.6	56.1	62.6	78.4	77.4	57.4	47.9	27.0	25.2	46.5
1956	24.6	24.2	34.8	42.4	57.7	72.1	75.0	68.3	59.4	47.7	31.8	25.9	46.9
1957	18.2	27.9	36.0	41.7	55.2	63.3	79.4	75.2	56.1	44.5	30.1	30.8	46.5
1958	28.1	29.6	34.9	43.1	62.7	64.3	67.7	75.0	60.1	45.8	31.5	25.4	47.3
1959	24.2	25.4	36.5	43.1	50.9	71.2	74.9	72.8	56.7	42.5	26.9	26.4	45.9
1960	24.9	27.5	35.8	44.9	56.0	68.4	80.0	70.6	59.3	46.5	33.2	24.6	47.6
1961	22.1	32.3	37.8	42.9	55.2	72.4	77.4	77.1	50.6	41.8	28.7	23.7	46.8
1962	18.5	25.8	33.4	46.7	53.8	66.0	72.1	69.6	57.8	48.0	35.8	28.5	46.3
1963	19.4	33.1	37.1	42.8	55.4	64.8	76.9	75.8	64.0	51.5	35.4	23.1	48.2
1964	23.1	25.8	31.3	43.9	55.3	62.3	80.5	68.6	55.4	45.4	31.5	24.7	45.6
1965	30.5	27.0	27.7	45.9	51.5	63.9	75.2	69.9	46.8	48.2	36.1	28.0	45.8
1966	25.7	28.7	36.3	41.5	57.5	63.3	81.5	70.3	62.8	43.2	32.1	27.3	47.5
1967	26.1	29.7	35.8	43.2	51.8	61.1	76.3	73.0	60.6	45.0	32.6	24.2	46.6
1968	20.9	30.1	39.6	41.1	51.3	63.2	75.0	67.4	57.2	46.3	32.4	22.9	45.6
1969	21.4	27.6	33.5	49.3	57.9	59.6	76.3	78.7	62.3	39.1	33.1	27.7	47.2
1970	24.8	32.4	33.5	39.8	55.3	68.4	77.1	76.9	52.4	40.3	33.7	24.0	46.5
1971	24.5	28.3	35.0	45.0	55.8	68.3	73.0	80.7	54.7	41.8	33.4	26.3	47.2
1972	21.9	30.2	41.4	45.3	53.2	69.3	70.0	72.4	55.7	44.1	35.8	17.3	46.3
1973	20.6	29.4	41.4	44.5	57.9	67.5	74.2	73.9	59.2	53.5	36.8	32.0	49.2
1974	20.5	36.4	40.8	52.2	55.9	70.0	73.0	70.2	50.1	52.9	37.6	27.9	49.7
1975	24.5	23.1	34.4	37.8	50.5	63.0	76.5	69.7	63.3	47.8	34.1	29.2	46.1
1976	22.9	27.7	33.3	46.7	57.7	64.1	80.4	70.3	58.4	42.6	32.0	23.2	46.6
1977	20.2	23.8	34.7	47.2	55.9	72.5	78.4	68.0	57.7	44.8	32.3	24.3	47.0
1978	19.4	15.3	32.7	46.5	50.6	62.9	72.7	68.1	56.1	43.3	24.0	13.2	42.4
1979	14.5	22.5	34.9	44.5	53.9	64.5	76.6	71.5	61.8	46.7	29.6	26.3	45.6
1980	21.1	26.5	33.3	47.0	55.0	65.8	75.0	66.9	58.3	43.7	30.3	30.9	46.1
MEAN	22.3	27.7	34.6	44.8	54.8	64.9	76.2	72.4	58.1	45.8	32.6	25.6	46.7
S.D.	3.3	3.8	3.0	3.5	3.1	4.3	3.3	3.3	3.9	3.7	3.1	2.9	1.4
COEF. VAR.	.146	.137	.086	.078	.056	.067	.044	.045	.067	.080	.096	.113	.029
PERCENT OF ANNUAL MEAN	4.1%	4.9%	6.2%	8.0%	9.3%	11.6%	13.6%	12.9%	10.4%	8.2%	5.8%	4.6%	

SUM OF MONTHLY MEANS 560.9

Shell, Wyoming Mean Monthly Temperature

MONTHLY PRECIP.(HISTORIC & SYNTHETIC)

FILE -- SHELPCE4
SITE -- SHELL WY
UNIT -- INCHES
NOTE -- ANY MONTH WITH ####.## INDICATES NO DATA AVAILABLE   11/19/84

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	.45	.26	.67	1.09	.88	1.49	.45	.60	1.89	.87	.59	.83	10.22
1942	.44	.69	.52	.75	1.45	.41	.41	.26	1.01	1.28	2.19	.63	10.04
1943	.29	.42	.82	1.03	.95	1.59	.57	.45	.38	.72	.59	.55	8.36
1944	1.01	.45	.57	2.68	1.81	1.88	1.14	.26	1.13	.39	.29	.63	12.24
1945	.48	.26	.63	.45	1.62	2.01	.85	1.17	1.42	.38	.64	.91	10.83
1946	.51	.45	.83	.62	1.37	1.56	.58	.69	2.17	1.05	.58	.81	11.22
1947	.26	.47	.29	1.49	2.08	1.83	.36	.44	1.91	1.04	1.79	.34	12.30
1948	.95	.45	.26	1.06	.84	1.01	1.02	.45	.85	.45	.50	.35	8.18
1949	.44	.42	.84	.73	.97	1.24	.71	.69	.85	1.38	.26	.26	8.78
1950	.45	.25	.35	.98	1.22	1.46	1.25	.52	1.92	.42	.65	.55	10.03
1951	.39	.29	.48	.69	1.01	1.52	1.88	.55	.53	.94	.32	.49	9.18
1952	.38	.43	.53	1.16	1.42	1.20	.96	.53	.42	.26	.45	.54	8.27
1953	.33	.65	.55	1.15	1.22	1.12	.27	.79	.73	.79	.58	.36	3.53
1954	.36	.31	.77	.93	1.91	1.07	.79	.43	.44	.48	.26	.29	3.08
1955	.41	.38	.53	.69	1.75	2.21	1.82	.32	1.15	.33	.56	.63	10.88
1956	.47	.30	.39	.57	.91	.79	.38	.50	.26	.62	.35	.45	5.39
1957	.55	.35	.51	.53	1.74	1.81	.33	.71	.67	.81	.71	.25	8.97
1958	.31	.86	.50	.54	1.02	1.55	1.29	.55	.31	.34	.78	.83	8.87
1959	.54	.93	.09	1.23	1.64	1.31	.30	.16	1.02	1.09	.81	0.00	9.11
1960	.10	.61	.16	.10	.46	1.37	0.00	.75	1.07	1.05	.69	.65	7.01
1961	0.00	.34	.62	.40	1.43	.38	.40	.04	1.97	2.13	.33	.55	8.58
1962	.45	.36	.10	.85	1.85	1.18	1.12	1.08	.47	.01	.80	.22	8.49
1963	1.63	.17	0.00	2.07	1.06	1.97	.07	0.00	1.28	.59	.41	.73	9.97
1964	.62	.26	.45	1.12	1.58	2.99	0.00	2.91	0.00	.45	.89	.51	11.78
1965	.66	.24	.88	.16	1.39	1.05	1.29	1.23	1.54	0.00	.05	.07	3.55
1966	.46	.18	.52	1.28	.12	1.06	.37	.66	.74	.10	.42	.50	6.40
1967	.81	.64	.28	1.92	.19	4.88	.28	.30	1.48	.46	.26	.84	12.34
1968	.36	.17	.44	.09	2.49	3.07	.71	2.43	1.09	.38	.26	.83	12.82
1969	.42	.10	.05	.72	.65	4.38	.10	.30	.25	1.23	.58	.14	9.11
1970	.69	.29	1.00	1.89	1.18	.81	.35	.10	1.25	.45	.58	.43	9.01
1971	.84	.96	.45	.85	2.27	.45	.33	.66	.75	3.47	.57	0.00	11.60
1972	.50	.20	.57	.68	.65	1.21	1.46	1.04	1.03	1.33	.63	1.97	11.47
1973	.90	.40	.85	3.26	.80	2.42	1.68	.23	2.98	.25	.78	.35	14.95
1974	.24	0.00	.31	.31	1.40	.36	.70	.83	1.04	1.70	.74	.77	8.39
1975	2.12	.21	.19	.84	2.20	1.73	.74	0.00	0.00	.57	.51	.09	9.19
1976	.29	.26	.38	.93	.76	1.48	.31	.81	1.55	.58	.66	.26	8.26
1977	.71	.34	1.09	1.14	.59	.73	.86	1.37	.99	.30	.29	.41	8.91
1978	.89	1.10	.31	2.17	1.00	.52	1.07	.82	1.85	.31	.58	.85	11.47
1979	.50	.39	.28	.25	2.41	.96	.34	1.55	.26	.65	.78	.33	8.70
1980	.58	.26	.35	.62	2.93	1.43	.88	1.20	1.76	1.15	.40	.30	11.36
MEAN	.58	.40	.48	1.00	1.33	1.53	.71	.71	1.06	.76	.60	.51	9.72
S.D.	.38	.23	.26	.68	.62	.95	.49	.59	.65	.63	.37	.34	1.87
COEF. VAR.	.650	.594	.539	.678	.467	.621	.693	.831	.620	.827	.622	.673	.192
PERCENT OF ANNUAL MEAN	6.0%	4.1%	5.0%	10.3%	13.8%	15.8%	7.3%	7.3%	10.9%	7.9%	6.2%	5.3%	

SUM OF MONTHLY MEANS 9.7

Shell, Wyoming Mean Monthly Precipitation

APPENDIX H

APPENDIX H

RIVER BASIN MODEL DIVERSION

Node 1 Diversions

DIVERSIONS

FILE -- GE136
SITE -- WHALEY+SHELL+MAINSTEM
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	12.8	11.5	12.8	15.9	967.8	463.6	1436.9	1047.4	413.1	12.8	12.3	12.8	4419.9
1942	12.8	11.5	12.8	39.0	654.1	1143.1	1363.8	1059.5	723.0	12.8	12.3	12.8	5057.8
1943	12.8	11.5	12.8	106.5	759.7	913.2	1236.8	1046.6	980.7	252.4	12.3	12.8	5358.4
1944	12.8	11.5	12.8	19.6	761.0	807.2	1120.6	1019.2	730.7	140.9	12.3	12.8	4661.8
1945	12.8	11.5	12.8	15.3	385.1	568.5	1425.7	1090.4	610.3	12.8	12.3	12.8	4170.5
1946	12.8	11.5	14.3	205.5	812.9	1144.5	1302.1	925.8	625.5	135.0	12.3	12.8	5215.2
1947	12.8	11.5	12.8	33.6	909.5	1029.8	1459.3	1142.0	992.7	431.1	12.4	12.8	6060.6
1948	12.8	11.5	12.8	85.1	1313.5	1250.6	1157.1	1004.2	1002.2	126.7	12.3	12.8	6002.9
1949	12.8	11.5	12.8	120.7	1143.7	1144.1	1249.6	908.2	777.0	74.7	12.3	12.8	5480.6
1950	12.8	11.5	12.8	12.3	258.0	837.1	1091.7	1025.8	583.0	12.8	12.3	12.8	3883.1
1951	12.8	11.5	12.8	21.8	779.9	694.7	1153.1	991.0	503.8	12.8	12.3	12.8	4219.6
1952	12.8	11.5	12.8	47.4	857.1	1355.1	1131.7	964.6	897.5	131.5	12.3	12.8	5447.5
1953	12.8	11.5	12.8	12.3	342.4	1030.1	1430.3	1282.2	957.5	82.6	12.3	12.8	5249.8
1954	12.8	11.5	12.8	18.4	570.2	1019.1	1458.2	1087.9	1191.9	93.5	12.3	12.8	5506.6
1955	12.8	11.5	12.8	23.7	675.0	793.4	1309.4	1263.6	636.4	12.8	12.3	12.8	4776.7
1956	12.8	11.5	12.8	26.2	998.3	1380.4	1422.2	925.3	1000.3	237.8	12.3	12.8	6053.0
1957	12.8	11.5	12.8	23.7	571.1	857.6	1471.0	1160.9	749.0	80.3	12.3	12.8	4976.0
1958	12.8	11.5	12.8	46.6	1265.9	982.6	958.7	1121.8	1092.0	197.1	12.3	12.8	5727.3
1959	12.8	11.5	12.8	12.4	413.6	1270.8	1420.9	1192.0	806.0	12.8	12.3	12.8	5191.0
1960	12.8	11.5	12.8	40.4	1088.0	1196.7	1467.9	916.9	965.3	198.2	12.3	12.8	5936.0
1961	12.8	11.5	12.8	27.5	710.2	1398.9	1449.9	1307.6	308.1	12.8	12.3	12.8	5277.4
1962	12.8	11.5	12.8	23.2	634.7	1154.4	1095.1	723.8	610.5	12.8	12.3	12.8	4322.1
1963	12.8	11.5	12.8	12.4	782.5	394.8	1446.8	1277.0	1151.6	440.7	26.3	12.8	6082.3
1964	12.8	11.5	12.8	15.2	676.4	656.1	1473.0	543.8	896.3	12.8	12.3	12.8	4336.0
1965	12.8	11.5	12.8	45.7	570.1	1068.2	1213.5	730.9	134.3	12.8	12.3	12.8	3839.0
1966	12.8	11.5	12.8	13.0	1125.5	979.0	1475.1	991.6	1171.8	12.8	12.3	12.8	5831.4
1967	12.8	11.5	12.8	12.3	723.0	338.9	1426.3	1148.1	928.8	125.4	12.3	12.8	4765.3
1968	12.8	11.5	12.8	15.3	199.4	601.3	1388.6	666.9	732.9	157.4	12.3	12.8	3824.4
1969	12.8	11.5	12.8	108.6	1138.8	395.7	1367.9	1203.7	1237.9	80.5	12.3	12.8	5646.7
1970	12.8	11.5	12.8	12.3	683.8	1252.5	1459.4	1374.0	349.8	12.8	12.3	12.8	5207.1
1971	12.8	11.5	12.8	24.0	606.4	1365.1	1308.1	1268.3	464.0	12.8	12.3	12.8	5111.3
1972	12.8	11.5	12.8	29.8	874.2	1282.6	960.9	903.8	633.1	12.8	12.3	12.8	4759.5
1973	12.8	11.5	12.8	17.7	1092.4	989.9	1138.9	1117.0	457.9	409.5	12.3	12.8	5286.0
1974	12.8	11.5	16.6	228.8	571.3	1148.1	1174.4	1000.0	657.5	176.1	12.3	12.8	5022.5
1975	12.8	11.5	12.8	12.3	499.6	1012.3	1121.8	1151.2	915.9	279.1	12.3	12.8	5054.7
1976	12.8	11.5	12.8	53.6	1146.8	1030.1	1460.4	865.2	468.7	84.7	12.3	12.8	5173.0
1977	12.8	11.5	12.8	44.5	1072.5	1397.8	1324.5	696.1	912.0	309.6	13.7	12.8	5320.9
1978	12.8	11.5	12.8	12.3	578.5	1110.2	1102.0	794.7	355.5	12.8	12.3	12.8	4023.4
1979	12.8	11.5	12.8	34.3	439.8	1089.9	1433.9	822.3	890.2	82.4	12.3	12.8	4355.4
1980	12.8	11.5	12.8	55.0	450.0	1083.3	1217.6	701.5	639.1	113.5	12.3	12.8	4332.5
MEAN	12.7	11.5	12.9	43.3	753.8	1003.4	1303.9	1011.6	753.8	116.4	12.7	12.7	5049.2
S.D.	.0	.0	.6	48.9	284.5	276.1	157.1	197.9	268.4	122.6	2.2	.0	658.6
COEF. VAR.	.000	.000	.049	1.130	.377	.275	.120	.195	.356	1.053	.174	.000	.130
PERCENT OF ANNUAL MEAN	.3%	.2%	.3%	.9%	14.9%	19.9%	25.8%	20.0%	14.9%	2.3%	.3%	.3%	

SUM OF MONTHLY MEANS 5,049.3

Node 4 Diversions

DIVERSIONS

FILE -- GE141
SITE -- ALL DOWNSTREAM DIVERSIONS
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	15.6	14.2	15.6	19.9	1000.7	480.8	1475.2	1081.9	429.1	15.6	15.2	15.6	4579.2
1942	15.6	14.2	15.6	42.7	677.9	1180.0	1402.2	1094.3	749.2	15.6	15.2	15.6	5238.6
1943	15.6	14.2	15.6	112.4	786.9	944.0	1275.2	1081.0	1014.0	263.2	15.2	15.6	5553.6
1944	15.6	14.2	15.6	22.7	788.3	835.3	1156.6	1052.9	757.2	148.0	15.2	15.6	4337.3
1945	15.6	14.2	15.6	18.3	400.1	589.1	1464.0	1126.0	632.8	15.6	15.2	15.6	4322.3
1946	15.6	14.2	17.2	214.5	841.7	1181.3	1340.4	957.1	648.5	141.9	15.2	15.6	5403.8
1947	15.6	14.2	15.6	37.1	940.9	1063.7	1497.7	1179.0	1026.3	447.8	15.3	15.6	6269.4
1948	15.6	14.2	15.6	91.4	1351.9	1287.9	1194.0	1037.5	1036.1	133.3	15.2	15.6	6208.8
1949	15.6	14.2	15.6	127.0	1181.4	1181.0	1288.0	939.1	804.9	79.7	15.2	15.6	5677.7
1950	15.6	14.2	15.6	15.2	268.9	866.0	1126.9	1059.7	604.6	15.6	15.2	15.6	4033.6
1951	15.6	14.2	15.6	25.0	807.8	719.4	1189.9	1024.0	522.8	15.6	15.2	15.6	4381.3
1952	15.6	14.2	15.6	51.4	887.1	1392.4	1167.9	996.9	928.6	133.3	15.2	15.6	5639.5
1953	15.6	14.2	15.6	15.2	356.0	1064.0	1518.7	1320.6	990.2	87.3	15.2	15.6	5429.1
1954	15.6	14.2	15.6	21.4	591.3	1052.7	1496.6	1123.4	1229.2	104.2	15.2	15.6	5695.5
1955	15.6	14.2	15.6	26.9	699.5	821.1	1347.7	1302.0	659.7	15.6	15.2	15.6	4949.4
1956	15.6	14.2	15.6	29.5	1032.1	1417.7	1460.6	956.6	1034.1	248.1	15.2	15.6	6255.5
1957	15.6	14.2	15.6	26.9	592.2	887.0	1509.4	1198.3	776.1	85.4	15.2	15.6	5152.0
1958	15.6	14.2	15.6	50.6	1304.3	1015.3	990.5	1158.2	1128.3	206.1	15.2	15.6	5930.0
1959	15.6	14.2	15.6	15.3	429.6	1308.0	1459.3	1230.2	834.7	15.6	15.2	15.6	5369.5
1960	15.6	14.2	15.6	44.2	1124.2	1234.0	1506.3	948.0	938.2	207.2	15.2	15.6	6133.3
1961	15.6	14.2	15.6	30.3	735.8	1436.2	1488.2	1346.0	320.7	15.6	15.2	15.6	5450.2
1962	15.6	14.2	15.6	31.6	657.8	1191.6	1130.4	749.4	633.0	15.6	15.2	15.6	4486.2
1963	15.6	14.2	15.6	15.3	810.5	925.2	1485.2	1315.4	1188.8	457.7	29.6	15.6	6289.3
1964	15.6	14.2	15.6	18.1	700.9	679.5	1511.4	563.6	927.3	15.6	15.2	15.6	4493.3
1965	15.6	14.2	15.6	49.7	591.2	1103.1	1251.8	756.7	141.1	15.6	15.2	15.6	3986.0
1966	15.6	14.2	15.6	15.9	1162.7	1011.6	1513.5	1024.6	1209.1	15.6	15.2	15.6	6029.3
1967	15.6	14.2	15.6	15.2	749.0	352.2	1464.6	1185.2	960.8	132.0	15.2	15.6	4935.8
1968	15.6	14.2	15.6	13.3	208.3	623.0	1426.9	690.7	759.5	165.0	15.2	15.6	3963.5
1969	15.6	14.2	15.6	114.6	1227.1	411.8	1406.3	1242.3	1275.2	85.6	15.2	15.6	5339.7
1970	15.6	14.2	15.6	15.2	708.6	1289.7	1497.8	1412.4	363.8	15.6	15.2	15.6	5379.9
1971	15.6	14.2	15.6	27.2	628.7	1402.4	1346.4	1306.7	431.7	15.6	15.2	15.6	5285.6
1972	15.6	14.2	15.6	33.2	904.7	1319.9	992.7	934.6	656.3	15.6	15.2	15.6	4933.3
1973	15.6	14.2	15.6	20.3	1128.7	1022.7	1175.3	1153.3	475.4	425.6	15.2	15.6	5473.6
1974	15.6	14.2	19.6	238.5	538.2	1179.2	1206.2	1028.9	677.4	183.6	15.2	15.6	5182.7
1975	15.6	14.2	15.6	15.2	515.0	1040.0	1151.2	1182.4	942.1	283.9	15.2	15.6	5211.5
1976	15.6	14.2	15.6	57.8	1184.6	1064.0	1498.8	895.9	486.5	89.9	15.2	15.6	5354.3
1977	15.6	14.2	15.6	48.4	1108.2	1435.1	1362.9	720.3	943.5	322.3	16.6	15.6	6019.4
1978	15.6	14.2	15.6	15.2	599.8	1146.1	1137.5	822.5	369.6	15.6	15.2	15.6	4183.1
1979	15.6	14.2	15.6	37.9	456.6	1125.4	1472.2	850.9	921.2	87.6	15.2	15.6	5023.6
1980	15.6	14.2	15.6	59.3	467.1	1123.7	1256.0	726.3	662.5	124.8	15.2	15.6	4496.6
MEAN	15.6	14.2	15.8	47.1	779.9	1035.1	1341.1	1044.4	780.0	122.6	15.5	15.6	5227.5
S.D.	.0	.0	.6	50.4	292.8	282.5	158.9	202.5	276.2	126.6	2.2	.0	675.3
COEF. VAR.	.000	.000	.041	1.070	.375	.272	.118	.193	.354	1.032	.146	.000	.129
PERCENT OF ANNUAL MEAN	.3%	.3%	.3%	.9%	14.9%	19.8%	25.7%	20.0%	14.9%	2.3%	.3%	.3%	

SUM OF MONTHLY MEANS 5,227.5

Node 8 Diversions

DIVERSIONS

FILE -- GE134
SITE -- WHALEY+SHELL+MAINSTEM
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	22.9	5968.9	2820.6	8900.6	6466.7	2504.9	0.0	0.0	0.0	26684.9
1942	0.0	0.0	0.0	166.7	4008.2	7067.9	8443.9	6542.3	4442.1	0.0	0.0	0.0	30671.4
1943	0.0	0.0	0.0	589.1	4668.3	5630.6	7650.5	6461.5	6052.6	1497.6	0.0	0.0	32550.6
1944	0.0	0.0	0.0	45.6	4676.8	4968.3	6924.3	6290.2	4490.3	800.8	0.0	0.0	28196.4
1945	0.0	0.0	0.0	19.0	2327.1	3476.5	8830.7	6735.2	3737.4	0.0	0.0	0.0	25126.0
1946	0.0	0.0	9.5	1207.7	5000.6	7076.3	8058.2	5706.3	3832.8	763.8	0.0	0.0	31655.4
1947	0.0	0.0	0.0	133.0	5604.5	6359.4	9041.1	7057.9	6127.4	2614.8	.7	0.0	36939.2
1948	0.0	0.0	0.0	461.6	8129.5	7739.5	7152.0	6196.4	6187.0	712.0	0.0	0.0	36578.4
1949	0.0	0.0	0.0	677.8	7068.5	7073.9	7730.1	5596.6	4779.3	387.4	0.0	0.0	33314.0
1950	0.0	0.0	0.0	0.0	1532.8	5155.1	6743.1	6331.3	3567.1	0.0	0.0	0.0	23329.6
1951	0.0	0.0	0.0	59.5	4794.9	4265.4	7127.0	6113.9	3072.0	0.0	0.0	0.0	25432.9
1952	0.0	0.0	0.0	219.6	5277.3	8392.5	6993.4	5949.3	5532.6	742.0	0.0	0.0	33107.0
1953	0.0	0.0	0.0	0.0	2060.2	6361.2	9171.9	7934.1	5907.5	436.3	0.0	0.0	31871.6
1954	0.0	0.0	0.0	38.0	3483.9	6292.6	9033.9	6719.4	7372.6	535.7	0.0	0.0	33476.4
1955	0.0	0.0	0.0	71.2	4139.0	4882.1	8103.8	7817.7	3900.5	0.0	0.0	0.0	28914.6
1956	0.0	0.0	0.0	86.8	6159.8	8550.7	8808.8	5703.7	6174.9	1406.4	0.0	0.0	36891.4
1957	0.0	0.0	0.0	71.2	3489.5	5283.4	9113.8	7175.7	4604.5	421.9	0.0	0.0	30160.3
1958	0.0	0.0	0.0	214.7	7832.4	6064.8	5911.9	6931.7	6748.1	1152.1	0.0	0.0	34855.9
1959	0.0	0.0	0.0	1.0	2505.3	7865.5	8800.9	7370.2	4960.9	0.0	0.0	0.0	31504.1
1960	0.0	0.0	0.0	175.7	6720.3	7402.5	9094.8	5651.1	5956.1	1159.0	0.0	0.0	36160.0
1961	0.0	0.0	0.0	95.0	4358.8	8666.5	8981.9	8093.0	1848.8	0.0	0.0	0.0	32044.1
1962	0.0	0.0	0.0	99.7	3886.9	7138.6	6764.7	4444.3	3738.8	0.0	0.0	0.0	26073.2
1963	0.0	0.0	0.0	1.0	4811.0	5516.0	8962.7	7901.3	7120.5	2674.4	87.4	0.0	37074.6
1964	0.0	0.0	0.0	18.1	4147.7	4023.7	9126.5	3319.1	5524.8	0.0	0.0	0.0	26160.3
1965	0.0	0.0	0.0	209.0	3483.7	6599.5	7504.5	4488.7	762.5	0.0	0.0	0.0	23048.0
1966	0.0	0.0	0.0	4.7	6954.9	6042.1	9139.6	6117.8	7247.1	0.0	0.0	0.0	35506.4
1967	0.0	0.0	0.0	0.0	4438.7	2041.6	8834.4	7095.8	5728.4	704.2	0.0	0.0	28843.3
1968	0.0	0.0	0.0	19.0	1166.3	3681.7	8598.8	4088.4	4504.1	903.9	0.0	0.0	22962.5
1969	0.0	0.0	0.0	602.2	7350.0	2402.7	8469.9	7443.5	7650.3	423.2	0.0	0.0	34351.9
1970	0.0	0.0	0.0	0.0	4194.1	7751.1	9041.6	8507.8	2109.8	0.0	0.0	0.0	31604.6
1971	0.0	0.0	0.0	73.2	3710.3	8455.4	8095.6	7847.4	2823.4	0.0	0.0	0.0	31005.7
1972	0.0	0.0	0.0	109.2	5384.0	7939.5	5925.8	5569.2	3879.9	0.0	0.0	0.0	28307.9
1973	0.0	0.0	0.0	34.2	6747.6	6109.8	7038.4	6901.7	2735.1	2480.4	0.0	0.0	32097.5
1974	0.0	0.0	23.7	1353.1	3490.7	7099.1	7260.1	6170.0	4032.8	1021.0	0.0	0.0	30450.8
1975	0.0	0.0	0.0	0.0	3042.7	6250.0	5931.4	7115.1	5647.5	1664.9	0.0	0.0	30652.0
1976	0.0	0.0	0.0	258.4	7087.8	6361.5	9048.0	5333.8	2852.5	449.5	0.0	0.0	31391.8
1977	0.0	0.0	0.0	201.4	6623.2	8659.5	8198.3	4271.0	5623.4	1855.1	8.6	0.0	35440.9
1978	0.0	0.0	0.0	0.0	3535.8	6861.9	6807.9	4886.9	2144.9	0.0	0.0	0.0	24237.7
1979	0.0	0.0	0.0	137.7	2669.2	6735.3	8881.9	5059.9	5487.2	435.1	0.0	0.0	29405.7
1980	0.0	0.0	0.0	267.2	2732.7	6725.0	7530.2	4304.6	3917.5	560.5	0.0	0.0	26138.3
MEAN	0.0	0.0	.8	193.6	4631.6	6194.7	8069.4	6242.8	4634.8	647.5	2.4	0.0	30613.0
S.D.	0.0	0.0	4.0	305.8	1778.4	1726.0	982.4	1236.8	1677.8	766.6	13.8	0.0	4116.2
COEF. VAR.	+###.###	+###.###	4.822	1.579	.383	.278	.121	.198	.362	1.183	5.723	+###.###	.134
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.6%	15.1%	20.2%	26.4%	20.4%	15.1%	2.1%	0.0%	0.0%	

SUM OF MONTHLY MEANS 30,618.0

Node 11 Diversions

DIVERSIONS

FILE -- DPH233A
SITE -- SHELL
UNIT -- AF
NOTE -- ANY MONTH WITH ****.** INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.00	0.00	0.00	9.61	67.95	55.53	221.83	164.65	34.85	5.43	0.00	0.00	559.38
1942	0.00	0.00	0.00	21.26	42.91	125.23	227.46	177.37	67.18	13.98	0.00	0.00	675.41
1943	0.00	0.00	0.00	24.65	48.25	104.65	217.37	182.22	80.48	29.31	0.00	0.00	686.96
1944	0.00	0.00	0.00	4.95	53.10	91.93	179.12	164.55	62.13	27.96	0.00	0.00	583.76
1945	0.00	0.00	0.00	2.52	43.59	76.30	214.07	157.56	52.81	28.93	0.00	0.00	575.80
1946	0.00	0.00	.77	43.20	46.98	133.78	251.73	167.37	55.33	14.17	0.00	0.00	713.37
1947	0.00	0.00	0.00	12.81	62.03	115.91	248.92	188.34	86.59	38.73	0.00	0.00	753.46
1948	0.00	0.00	0.00	22.52	77.86	135.62	196.20	172.51	81.45	22.81	0.00	0.00	709.00
1949	0.00	0.00	0.00	28.15	67.18	125.33	216.78	160.67	64.94	5.72	0.00	0.00	668.81
1950	0.00	0.00	0.00	0.00	36.11	108.83	165.91	138.73	48.83	31.94	0.00	0.00	530.37
1951	0.00	0.00	0.00	8.64	62.32	82.52	173.68	150.77	59.22	10.48	0.00	0.00	547.65
1952	0.00	0.00	0.00	17.57	55.24	149.89	186.30	166.49	93.00	26.60	0.00	0.00	695.12
1953	0.00	0.00	0.00	0.00	41.55	133.19	261.05	171.25	81.16	26.21	0.00	0.00	714.44
1954	0.00	0.00	0.00	11.55	44.65	116.98	249.11	170.57	84.36	17.65	0.00	0.00	694.92
1955	0.00	0.00	0.00	12.42	52.03	93.49	206.59	197.27	62.52	27.66	0.00	0.00	652.01
1956	0.00	0.00	0.00	11.26	69.12	168.05	210.28	142.71	83.68	25.72	0.00	0.00	710.34
1957	0.00	0.00	0.00	8.93	49.31	103.00	241.73	176.69	65.53	15.04	0.00	0.00	660.26
1958	0.00	0.00	0.00	14.56	85.23	112.42	147.85	178.63	85.14	23.59	0.00	0.00	647.45
1959	0.00	0.00	0.00	5.82	37.36	153.68	211.25	174.55	62.23	9.99	0.00	0.00	655.41
1960	0.00	0.00	0.00	19.02	70.48	136.93	251.93	150.33	69.90	19.22	0.00	0.00	717.93
1961	0.00	0.00	0.00	11.74	53.49	177.46	226.20	200.86	31.35	2.52	0.00	0.00	703.56
1962	0.00	0.00	0.00	17.86	43.59	127.37	177.56	139.12	74.36	33.20	0.00	0.00	613.08
1963	0.00	0.00	0.00	4.46	59.41	107.86	229.99	193.10	83.29	37.75	0.00	0.00	715.39
1964	0.00	0.00	0.00	10.09	51.74	81.06	255.42	103.39	73.00	19.99	0.00	0.00	594.73
1965	0.00	0.00	0.00	20.67	42.81	118.73	194.65	138.15	26.89	31.35	0.00	0.00	573.28
1966	0.00	0.00	0.00	6.50	82.03	115.62	256.01	150.38	87.47	19.70	0.00	0.00	717.74
1967	0.00	0.00	0.00	4.07	61.64	50.87	221.15	172.03	68.44	21.05	0.00	0.00	599.30
1968	0.00	0.00	0.00	2.52	28.54	83.63	203.87	105.23	62.71	23.88	0.00	0.00	510.46
1969	0.00	0.00	0.00	26.01	70.67	51.45	225.91	205.52	94.36	8.05	0.00	0.00	682.01
1970	0.00	0.00	0.00	2.81	57.27	146.79	225.13	199.70	45.72	6.11	0.00	0.00	683.56
1971	0.00	0.00	0.00	14.46	44.46	152.71	198.24	210.76	59.90	1.45	0.00	0.00	682.01
1972	0.00	0.00	0.00	16.60	58.44	144.75	158.63	154.94	58.83	10.87	0.00	0.00	603.08
1973	0.00	0.00	0.00	2.81	71.45	114.65	181.06	177.46	44.07	49.70	.77	0.00	642.01
1974	0.00	0.00	3.20	45.04	56.21	163.87	191.06	146.79	73.20	27.85	.77	0.00	708.03
1975	0.00	0.00	0.00	0.00	28.93	102.90	213.39	158.82	101.16	28.34	0.00	0.00	633.57
1976	0.00	0.00	0.00	18.34	71.45	112.52	249.31	150.38	60.09	14.07	0.00	0.00	676.19
1977	0.00	0.00	0.00	17.47	66.50	171.45	224.26	125.82	65.82	20.67	0.00	0.00	692.01
1978	0.00	0.00	0.00	6.69	45.43	123.00	182.32	135.82	48.93	15.63	0.00	0.00	557.84
1979	0.00	0.00	0.00	15.82	36.89	123.29	221.93	141.05	92.22	23.68	0.00	0.00	654.92
1980	0.00	0.00	0.00	20.67	33.83	122.13	200.67	123.19	56.89	12.42	0.00	0.00	569.38
MEAN	0.00	0.00	.09	13.60	54.46	117.89	212.90	162.14	67.25	20.74	.03	0.00	649.15
S.D.	0.00	0.00	.51	10.42	14.35	31.22	28.96	25.58	17.71	10.67	.17	0.00	62.14
COEF. VAR.	****.***	****.***	5.207	.766	.263	.264	.136	.157	.263	.514	4.414	****.***	.095
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	2.1%	8.4%	18.2%	32.8%	25.0%	10.4%	3.2%	0.0%	0.0%	

SUM OF MONTHLY MEANS 649.2

Node 12 Diversions

DIVERSIONS

FILE -- DMS774
SITE -- SHELL CREEK MAINSTEM
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	1.2	145.4	128.9	548.3	295.3	45.5	0.0	0.0	0.0	1164.6
1942	0.0	0.0	0.0	9.0	97.6	322.7	501.1	298.7	80.7	0.0	0.0	0.0	1310.2
1943	0.0	0.0	0.0	31.9	113.7	257.1	454.0	295.1	110.0	23.5	0.0	0.0	1285.5
1944	0.0	0.0	0.0	2.4	113.9	226.9	410.9	287.2	81.6	12.5	0.0	0.0	1135.3
1945	0.0	0.0	0.0	1.0	56.6	158.7	530.7	307.6	67.9	0.0	0.0	0.0	1122.8
1946	0.0	0.0	.5	65.5	121.8	323.1	478.2	260.6	69.7	11.9	0.0	0.0	1331.6
1947	0.0	0.0	0.0	7.2	136.5	290.4	583.4	322.3	111.4	41.0	.0	0.0	1492.5
1948	0.0	0.0	0.0	25.0	198.0	353.4	424.5	282.9	112.5	11.1	0.0	0.0	1407.7
1949	0.0	0.0	0.0	36.8	172.1	323.0	458.8	255.6	86.9	6.0	0.0	0.0	1339.4
1950	0.0	0.0	0.0	0.0	37.3	235.4	400.2	289.1	64.8	0.0	0.0	0.0	1027.0
1951	0.0	0.0	0.0	3.2	116.8	194.3	423.0	279.2	55.8	0.0	0.0	0.0	1072.9
1952	0.0	0.0	0.0	11.9	128.5	384.3	415.0	271.7	100.6	11.6	0.0	0.0	1323.8
1953	0.0	0.0	0.0	0.0	50.1	290.5	671.9	362.3	107.4	6.8	0.0	0.0	1489.3
1954	0.0	0.0	0.0	2.0	84.8	287.3	581.6	306.8	134.0	3.4	0.0	0.0	1405.3
1955	0.0	0.0	0.0	3.8	100.8	222.9	480.9	357.0	70.9	0.0	0.0	0.0	1236.6
1956	0.0	0.0	0.0	4.7	150.0	416.2	525.3	260.4	112.3	22.0	0.0	0.0	1491.2
1957	0.0	0.0	0.0	3.8	85.0	241.2	613.8	327.7	83.7	6.6	0.0	0.0	1362.1
1958	0.0	0.0	0.0	11.6	190.7	276.9	350.8	316.5	122.7	19.0	0.0	0.0	1287.7
1959	0.0	0.0	0.0	.0	61.0	359.2	523.3	336.5	90.2	0.0	0.0	0.0	1370.4
1960	0.0	0.0	0.0	9.5	163.7	338.0	596.9	258.0	108.3	18.1	0.0	0.0	1492.8
1961	0.0	0.0	0.0	5.1	106.1	445.5	568.6	369.6	33.6	0.0	0.0	0.0	1529.7
1962	0.0	0.0	0.0	5.4	94.6	326.0	401.5	202.9	67.9	0.0	0.0	0.0	1093.6
1963	0.0	0.0	0.0	.0	117.1	251.9	563.8	360.8	129.4	41.9	4.7	0.0	1470.1
1964	0.0	0.0	0.0	.9	101.0	183.7	626.5	151.5	100.4	0.0	0.0	0.0	1164.3
1965	0.0	0.0	0.0	11.3	84.8	301.4	445.4	205.0	13.8	0.0	0.0	0.0	1061.9
1966	0.0	0.0	0.0	.2	169.4	275.9	639.6	279.4	131.7	0.0	0.0	0.0	1496.5
1967	0.0	0.0	0.0	0.0	108.1	93.2	531.7	324.0	104.1	11.0	0.0	0.0	1172.3
1968	0.0	0.0	0.0	1.0	28.4	168.1	510.3	186.7	81.9	14.1	0.0	0.0	990.7
1969	0.0	0.0	0.0	32.7	179.0	109.7	502.7	339.9	139.3	6.6	0.0	0.0	1310.1
1970	0.0	0.0	0.0	0.0	102.1	353.9	583.5	383.5	38.3	0.0	0.0	0.0	1466.6
1971	0.0	0.0	0.0	3.9	90.3	397.0	480.5	358.3	51.3	0.0	0.0	0.0	1381.6
1972	0.0	0.0	0.0	5.9	131.1	362.5	351.7	254.3	70.5	0.0	0.0	0.0	1176.3
1973	0.0	0.0	0.0	1.8	164.3	279.0	417.7	315.2	50.6	33.9	0.0	0.0	1267.8
1974	0.0	0.0	1.2	73.4	153.7	425.1	363.1	223.0	38.8	0.0	0.0	0.0	1278.7
1975	0.0	0.0	0.0	0.0	25.7	214.0	532.4	352.1	153.5	27.9	0.0	0.0	1306.0
1976	0.0	0.0	0.0	14.0	172.6	290.5	585.1	243.5	51.8	7.0	0.0	0.0	1364.9
1977	0.0	0.0	0.0	10.9	161.3	439.5	486.6	195.0	102.2	29.1	.4	0.0	1425.3
1978	0.0	0.0	0.0	0.0	86.1	313.3	404.0	223.1	39.0	0.0	0.0	0.0	1065.7
1979	0.0	0.0	0.0	7.4	65.0	307.6	543.6	231.0	99.7	6.8	0.0	0.0	1261.4
1980	0.0	0.0	0.0	14.5	66.5	307.1	446.9	196.5	71.2	10.3	0.0	0.0	1113.3
MEAN	0.0	0.0	.0	10.5	113.3	286.9	498.9	284.3	84.7	9.3	.1	0.0	1288.8
S.D.	0.0	0.0	.2	16.6	45.3	87.6	83.0	57.9	33.0	12.1	.7	0.0	151.3
COEF. VAR.	+###.###	+###.###	4.822	1.579	.400	.305	.166	.203	.390	1.240	5.723	+###.###	.117
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.8%	8.8%	22.3%	38.7%	22.1%	6.6%	.8%	0.0%	0.0%	

SUM OF MONTHLY MEANS 1,288.8

Node 16 Diversions

DIVERSIONS

FILE -- DSC3826A
SITE -- SHELL CANAL
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	17.5	4722.7	2182.9	6710.0	5004.7	1994.5	0.0	0.0	0.0	20632.6
1942	0.0	0.0	0.0	127.9	3171.4	5470.0	5441.5	5063.2	3537.0	0.0	0.0	0.0	23811.1
1943	0.0	0.0	0.0	451.8	3693.6	4357.6	5836.3	5000.6	4819.4	1195.5	0.0	0.0	25355.2
1944	0.0	0.0	0.0	34.9	3700.3	3345.0	5282.3	4868.1	3575.4	639.2	0.0	0.0	21945.6
1945	0.0	0.0	0.0	14.5	1841.2	2690.5	6710.0	5212.5	2975.9	0.0	0.0	0.0	19444.8
1946	0.0	0.0	7.2	926.3	3956.6	5476.4	6147.2	4416.2	3051.8	609.7	0.0	0.0	24591.3
1947	0.0	0.0	0.0	102.0	4434.4	4921.6	6710.0	5462.2	4879.0	2087.3	.5	0.0	28597.4
1948	0.0	0.0	0.0	354.1	6432.2	5989.8	5455.9	4795.5	4926.4	568.4	0.0	0.0	28522.6
1949	0.0	0.0	0.0	519.9	5592.8	5474.6	5897.0	4331.3	3805.6	309.3	0.0	0.0	25930.6
1950	0.0	0.0	0.0	0.0	1212.7	3989.6	5144.1	4899.9	2840.3	0.0	0.0	0.0	18085.8
1951	0.0	0.0	0.0	45.6	3793.8	3301.0	5436.9	4731.7	2446.1	0.0	0.0	0.0	19755.3
1952	0.0	0.0	0.0	168.4	4175.5	6490.0	5335.0	4604.2	4405.4	592.3	0.0	0.0	25771.0
1953	0.0	0.0	0.0	0.0	1630.1	4923.0	6710.0	6140.3	4703.9	348.3	0.0	0.0	24455.8
1954	0.0	0.0	0.0	29.1	2756.6	4369.9	6710.0	5200.2	5870.5	427.7	0.0	0.0	25864.2
1955	0.0	0.0	0.0	54.6	3274.9	3778.3	6132.1	6050.3	3105.8	0.0	0.0	0.0	22446.1
1956	0.0	0.0	0.0	66.5	4873.8	6490.0	6710.0	4414.1	4916.8	1122.7	0.0	0.0	28594.2
1957	0.0	0.0	0.0	54.6	2761.0	4088.9	6710.0	5553.4	3666.3	336.8	0.0	0.0	23171.2
1958	0.0	0.0	0.0	164.7	6197.2	4693.6	4510.0	5364.5	5373.2	919.7	0.0	0.0	27223.0
1959	0.0	0.0	0.0	.3	1932.2	6087.2	6710.0	5703.9	3950.2	0.0	0.0	0.0	24434.4
1960	0.0	0.0	0.0	134.8	5317.3	5723.9	6710.0	4373.5	4742.6	925.2	0.0	0.0	27932.5
1961	0.0	0.0	0.0	72.8	3448.7	6490.0	6710.0	6263.3	1472.1	0.0	0.0	0.0	24457.1
1962	0.0	0.0	0.0	76.5	3075.4	5524.6	5160.5	3439.5	2977.0	0.0	0.0	0.0	20253.3
1963	0.0	0.0	0.0	.8	3806.6	4263.9	6710.0	6115.0	5669.7	2134.9	57.0	0.0	28773.1
1964	0.0	0.0	0.0	13.9	3281.8	3114.0	6710.0	2568.7	4399.2	0.0	0.0	0.0	20087.3
1965	0.0	0.0	0.0	160.3	2756.3	5107.4	5724.9	3473.3	607.1	0.0	0.0	0.0	17330.1
1966	0.0	0.0	0.0	3.6	5502.9	4676.0	6710.0	4734.6	5770.5	0.0	0.0	0.0	27397.8
1967	0.0	0.0	0.0	0.0	3512.0	1580.0	6710.0	5491.5	4561.3	562.1	0.0	0.0	22417.1
1968	0.0	0.0	0.0	14.5	922.8	2849.3	6559.7	3164.1	3586.4	721.5	0.0	0.0	17813.6
1969	0.0	0.0	0.0	461.8	5815.5	1359.5	6461.3	5760.6	6099.5	337.8	0.0	0.0	26796.3
1970	0.0	0.0	0.0	0.0	3318.4	5998.7	6710.0	6584.3	1679.9	0.0	0.0	0.0	24291.5
1971	0.0	0.0	0.0	56.2	2935.7	6490.0	6175.8	6073.2	2248.1	0.0	0.0	0.0	23979.2
1972	0.0	0.0	0.0	83.8	4259.9	6144.5	4520.6	4310.1	3089.4	0.0	0.0	0.0	22403.5
1973	0.0	0.0	0.0	26.2	5338.8	4728.5	5369.3	5341.3	2217.6	1980.1	0.0	0.0	25002.2
1974	0.0	0.0	18.2	1037.8	2673.0	5346.0	5524.0	5278.0	3305.0	977.0	0.0	0.0	24159.0
1975	0.0	0.0	0.0	0.0	2293.0	4585.0	4961.0	5336.0	4471.0	1322.0	0.0	0.0	22969.0
1976	0.0	0.0	0.0	198.2	5608.1	4923.3	6710.0	4127.9	2271.3	358.8	0.0	0.0	24197.7
1977	0.0	0.0	0.0	154.5	5240.4	6490.0	6254.2	3305.4	4477.7	1480.9	6.6	0.0	27409.9
1978	0.0	0.0	0.0	0.0	2797.6	5310.5	5193.5	3782.1	1707.9	0.0	0.0	0.0	18791.3
1979	0.0	0.0	0.0	105.6	2111.9	5212.6	6710.0	3916.0	4369.2	347.3	0.0	0.0	22772.9
1980	0.0	0.0	0.0	204.9	2162.2	5204.6	5744.5	3331.4	3119.3	527.4	0.0	0.0	20294.7
MEAN	0.0	0.0	.6	148.5	3559.5	4768.8	6084.7	4839.7	3692.1	520.3	1.8	0.0	23716.9
S.D.	0.0	0.0	3.0	234.5	1411.3	1312.9	699.8	957.1	1334.8	614.3	10.6	0.0	3202.2
COEF. VAR.	****.***	****.***	4.822	1.579	.385	.275	.115	.197	.361	1.179	5.723	****.***	.135
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.6%	15.4%	20.1%	25.7%	20.4%	15.6%	2.2%	0.0%	0.0%	

SUM OF MONTHLY MEANS 23,716.9

Node 18 Diversions

DIVERSIONS

FILE -- DSC129A
SITE -- SHELL CANAL
UNIT -- AF
NOTE -- ANY MONTH WITH #####.# INDICATES NO DATA AVAILABLE 01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	.5	159.1	73.4	193.0	168.5	67.2	0.0	0.0	0.0	661.9
1942	0.0	0.0	0.0	4.3	106.8	184.1	193.0	170.4	119.2	0.0	0.0	0.0	778.0
1943	0.0	0.0	0.0	15.2	124.4	146.7	193.0	168.3	162.4	40.4	0.0	0.0	850.7
1944	0.0	0.0	0.0	1.1	124.7	129.4	177.7	163.9	120.5	21.6	0.0	0.0	739.1
1945	0.0	0.0	0.0	.4	62.0	90.5	193.0	175.4	100.3	0.0	0.0	0.0	621.9
1946	0.0	0.0	.2	31.2	133.3	184.3	193.0	148.6	102.8	20.6	0.0	0.0	814.3
1947	0.0	0.0	0.0	3.4	149.4	165.7	193.0	183.9	164.4	70.6	.0	0.0	930.6
1948	0.0	0.0	0.0	11.9	193.0	187.0	183.6	161.4	166.0	19.2	0.0	0.0	922.3
1949	0.0	0.0	0.0	17.5	188.4	184.3	193.0	145.8	128.2	10.4	0.0	0.0	867.9
1950	0.0	0.0	0.0	0.0	40.8	134.3	173.1	164.9	95.7	0.0	0.0	0.0	609.0
1951	0.0	0.0	0.0	1.5	127.8	111.1	182.9	159.3	82.4	0.0	0.0	0.0	665.2
1952	0.0	0.0	0.0	5.6	140.7	187.0	179.5	155.0	148.5	20.0	0.0	0.0	836.5
1953	0.0	0.0	0.0	0.0	54.9	165.7	193.0	193.0	158.5	11.7	0.0	0.0	777.0
1954	0.0	0.0	0.0	.9	92.8	163.9	193.0	175.0	137.0	14.4	0.0	0.0	827.4
1955	0.0	0.0	0.0	1.8	110.3	127.2	193.0	193.0	104.7	0.0	0.0	0.0	730.1
1956	0.0	0.0	0.0	2.2	164.2	187.0	193.0	148.6	165.7	37.9	0.0	0.0	898.8
1957	0.0	0.0	0.0	1.8	93.0	137.6	193.0	186.9	123.5	11.3	0.0	0.0	747.5
1958	0.0	0.0	0.0	5.5	193.0	158.0	151.7	180.6	131.1	31.1	0.0	0.0	901.2
1959	0.0	0.0	0.0	.0	56.8	187.0	193.0	192.0	133.1	0.0	0.0	0.0	772.0
1960	0.0	0.0	0.0	4.5	179.1	187.0	193.0	147.2	159.8	31.3	0.0	0.0	902.1
1961	0.0	0.0	0.0	2.4	116.2	187.0	193.0	193.0	49.6	0.0	0.0	0.0	741.3
1962	0.0	0.0	0.0	2.5	103.6	186.0	173.6	115.8	100.3	0.0	0.0	0.0	682.0
1963	0.0	0.0	0.0	.0	128.2	143.7	193.0	193.0	137.0	72.2	2.2	0.0	919.5
1964	0.0	0.0	0.0	.4	110.5	104.8	193.0	85.4	148.3	0.0	0.0	0.0	643.7
1965	0.0	0.0	0.0	5.4	92.8	171.9	192.6	116.9	20.4	0.0	0.0	0.0	600.3
1966	0.0	0.0	0.0	.1	185.4	157.4	193.0	159.4	187.0	0.0	0.0	0.0	882.4
1967	0.0	0.0	0.0	0.0	118.3	53.1	193.0	184.8	153.7	19.0	0.0	0.0	722.2
1968	0.0	0.0	0.0	.4	31.0	95.9	193.0	106.5	120.9	24.6	0.0	0.0	572.3
1969	0.0	0.0	0.0	15.5	193.0	62.6	193.0	193.9	187.0	11.4	0.0	0.0	856.5
1970	0.0	0.0	0.0	0.0	111.8	187.0	193.0	193.0	56.6	0.0	0.0	0.0	741.4
1971	0.0	0.0	0.0	1.8	98.9	187.0	193.0	193.0	75.7	0.0	0.0	0.0	749.6
1972	0.0	0.0	0.0	2.8	143.5	187.0	152.1	145.1	104.1	0.0	0.0	0.0	734.7
1973	0.0	0.0	0.0	.8	179.9	159.2	180.7	179.3	74.7	67.0	0.0	0.0	842.3
1974	0.0	0.0	.6	34.9	77.0	154.0	159.0	152.0	95.0	28.0	0.0	0.0	700.5
1975	0.0	0.0	0.0	0.0	66.0	132.0	143.0	154.0	129.0	38.0	0.0	0.0	662.0
1976	0.0	0.0	0.0	6.6	188.9	165.7	193.0	138.9	76.5	12.1	0.0	0.0	782.1
1977	0.0	0.0	0.0	5.2	176.5	187.0	193.0	111.2	150.9	50.1	.2	0.0	874.3
1978	0.0	0.0	0.0	0.0	94.2	178.3	174.7	127.3	57.5	0.0	0.0	0.0	632.7
1979	0.0	0.0	0.0	3.5	71.1	175.5	193.0	131.8	147.2	11.7	0.0	0.0	734.1
1980	0.0	0.0	0.0	6.9	72.8	175.2	193.0	112.1	105.1	17.3	0.0	0.0	683.1
MEAN	0.0	0.0	.0	5.0	121.6	153.5	185.8	159.2	122.4	17.3	.0	0.0	765.3
S.D.	0.0	0.0	.1	7.9	46.2	38.0	13.2	23.7	43.3	20.5	.3	0.0	101.1
COEF. VAR.	####.###	####.###	4.822	1.579	.380	.247	.071	.180	.353	1.183	5.723	####.###	.132
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.7%	15.9%	20.1%	24.3%	20.8%	16.0%	2.3%	0.0%	0.0%	

SUM OF MONTHLY MEANS 765.3

Node 20 Diversions

DIVERSIONS

FILE -- DWD1019A
SITE -- WHALEY DITCH
UNIT -- AF
NOTE -- ANY MONTH WITH #####.* INDICATES NO DATA AVAILABLE 01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	4.0	1100.7	508.8	1642.3	1166.7	464.8	0.0	0.0	0.0	4887.6
1942	0.0	0.0	0.0	29.8	739.1	1275.1	1501.2	1180.3	824.2	0.0	0.0	0.0	5549.9
1943	0.0	0.0	0.0	105.3	860.9	1015.8	1360.1	1165.7	1123.1	278.5	0.0	0.0	5909.7
1944	0.0	0.0	0.0	8.1	862.4	895.3	1231.0	1134.8	833.2	148.9	0.0	0.0	5115.0
1945	0.0	0.0	0.0	3.3	429.1	627.2	1589.9	1215.1	693.5	0.0	0.0	0.0	4558.3
1946	0.0	0.0	1.6	215.8	922.2	1276.6	1432.6	1029.5	711.2	142.0	0.0	0.0	5731.3
1947	0.0	0.0	0.0	23.7	1033.5	1147.3	1747.6	1273.3	1136.9	486.4	.1	0.0	6849.2
1948	0.0	0.0	0.0	82.5	1499.2	1396.3	1271.5	1117.9	1148.0	132.4	0.0	0.0	6648.0
1949	0.0	0.0	0.0	121.1	1303.5	1276.2	1374.3	1009.7	886.8	72.0	0.0	0.0	6043.9
1950	0.0	0.0	0.0	0.0	282.6	930.0	1198.8	1142.2	661.9	0.0	0.0	0.0	4215.7
1951	0.0	0.0	0.0	10.6	884.2	769.5	1267.0	1103.0	570.0	0.0	0.0	0.0	4604.6
1952	0.0	0.0	0.0	39.2	973.2	1518.2	1243.3	1073.3	1026.6	138.0	0.0	0.0	6012.0
1953	0.0	0.0	0.0	0.0	379.9	1147.6	1790.0	1431.4	1096.1	81.1	0.0	0.0	5926.4
1954	0.0	0.0	0.0	6.7	642.5	1135.2	1742.2	1212.2	1368.0	99.6	0.0	0.0	6206.8
1955	0.0	0.0	0.0	12.7	763.3	880.8	1440.7	1410.4	723.7	0.0	0.0	0.0	5231.3
1956	0.0	0.0	0.0	15.5	1135.9	1644.4	1573.5	1029.0	1145.8	261.5	0.0	0.0	6805.9
1957	0.0	0.0	0.0	12.7	643.5	953.2	1790.0	1294.6	854.4	78.4	0.0	0.0	5626.9
1958	0.0	0.0	0.0	38.3	1444.4	1094.1	1051.0	1250.5	1252.1	214.3	0.0	0.0	6345.1
1959	0.0	0.0	0.0	.1	462.0	1419.0	1567.6	1329.6	920.5	0.0	0.0	0.0	5699.1
1960	0.0	0.0	0.0	31.4	1239.3	1335.5	1787.9	1019.5	1105.2	215.6	0.0	0.0	6734.6
1961	0.0	0.0	0.0	16.9	803.8	1730.0	1703.3	1460.1	343.0	0.0	0.0	0.0	6057.3
1962	0.0	0.0	0.0	17.8	716.8	1287.9	1202.6	801.8	693.7	0.0	0.0	0.0	4720.8
1963	0.0	0.0	0.0	.1	887.2	995.1	1688.9	1425.5	1321.2	497.4	15.6	0.0	6831.4
1964	0.0	0.0	0.0	3.2	764.9	725.9	1790.0	598.8	1025.1	0.0	0.0	0.0	4908.1
1965	0.0	0.0	0.0	37.3	642.4	1190.6	1334.2	809.8	141.4	0.0	0.0	0.0	4155.9
1966	0.0	0.0	0.0	.8	1282.6	1090.0	1790.0	1103.7	1344.7	0.0	0.0	0.0	6612.0
1967	0.0	0.0	0.0	0.0	818.5	368.3	1592.6	1280.1	1062.9	131.0	0.0	0.0	5253.7
1968	0.0	0.0	0.0	3.3	215.0	664.2	1528.7	737.6	835.7	163.1	0.0	0.0	4153.0
1969	0.0	0.0	0.0	107.6	1355.4	433.4	1505.8	1342.9	1421.4	78.7	0.0	0.0	6245.5
1970	0.0	0.0	0.0	0.0	773.4	1398.4	1748.0	1534.9	391.5	0.0	0.0	0.0	5846.4
1971	0.0	0.0	0.0	13.0	684.2	1568.4	1439.3	1415.7	523.9	0.0	0.0	0.0	5644.8
1972	0.0	0.0	0.0	19.5	992.9	1432.4	1053.5	1004.7	719.9	0.0	0.0	0.0	5223.1
1973	0.0	0.0	0.0	6.1	1244.3	1102.3	1251.3	1245.1	516.8	461.4	0.0	0.0	5827.5
1974	0.0	0.0	4.2	241.8	664.0	1323.0	1373.0	569.0	639.0	44.0	0.0	0.0	5013.0
1975	0.0	0.0	0.0	0.0	724.0	1450.0	1438.0	1427.0	1023.0	315.0	0.0	0.0	6377.0
1976	0.0	0.0	0.0	46.1	1307.1	1147.7	1752.8	962.3	529.3	83.6	0.0	0.0	5829.1
1977	0.0	0.0	0.0	36.0	1221.4	1730.0	1457.5	770.5	1043.4	345.0	1.5	0.0	6605.6
1978	0.0	0.0	0.0	0.0	652.0	1237.9	1210.3	881.6	398.0	0.0	0.0	0.0	4380.1
1979	0.0	0.0	0.0	24.6	492.2	1215.1	1628.3	912.8	1018.2	80.9	0.0	0.0	5372.4
1980	0.0	0.0	0.0	47.7	503.9	1213.3	1338.7	776.6	726.9	122.8	0.0	0.0	4730.2
MEAN	0.0	0.0	.1	34.6	858.7	1138.9	1485.7	1113.7	857.9	116.9	.4	0.0	5612.2
S.D.	0.0	0.0	.7	54.6	324.9	335.2	220.1	238.2	311.6	142.8	2.4	0.0	801.7
COEF. VAR.	****.***	****.***	4.822	1.579	.378	.294	.148	.212	.363	1.221	5.723	****.***	.142
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.6%	15.3%	20.3%	26.5%	19.9%	15.3%	2.1%	0.0%	0.0%	

SUM OF MONTHLY MEANS 5,612.3

Node 21 Diversions

DIVERSIONS

FILE -- DWD33A
SITE -- WHALEY DITCH
UNIT -- AF
NOTE -- ANY MONTH WITH *****.* INDICATES NO DATA AVAILABLE

01/23/85

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1941	0.0	0.0	0.0	.1	28.9	16.4	28.9	28.9	15.0	0.0	0.0	0.0	118.2
1942	0.0	0.0	0.0	.9	23.9	28.0	28.9	28.9	26.6	0.0	0.0	0.0	137.2
1943	0.0	0.0	0.0	3.4	27.8	28.0	28.9	28.9	28.0	9.0	0.0	0.0	154.1
1944	0.0	0.0	0.0	.2	27.9	28.0	28.9	28.9	26.9	4.8	0.0	0.0	145.7
1945	0.0	0.0	0.0	.1	13.8	20.3	28.9	28.9	22.4	0.0	0.0	0.0	114.4
1946	0.0	0.0	.0	6.9	28.9	28.0	28.9	28.9	23.0	4.6	0.0	0.0	149.3
1947	0.0	0.0	0.0	.7	28.9	28.0	28.9	28.9	28.0	15.7	.0	0.0	159.2
1948	0.0	0.0	0.0	2.6	28.9	28.0	28.9	28.9	26.0	4.2	0.0	0.0	147.6
1949	0.0	0.0	0.0	3.9	28.9	28.0	28.9	28.9	28.0	2.3	0.0	0.0	148.9
1950	0.0	0.0	0.0	0.0	9.1	28.0	28.9	28.9	21.4	0.0	0.0	0.0	116.3
1951	0.0	0.0	0.0	.3	28.6	24.9	28.9	28.9	18.4	0.0	0.0	0.0	130.0
1952	0.0	0.0	0.0	1.2	28.9	28.0	28.9	28.9	28.0	4.4	0.0	0.0	148.4
1953	0.0	0.0	0.0	0.0	12.2	28.0	28.9	28.9	28.0	2.6	0.0	0.0	128.7
1954	0.0	0.0	0.0	.2	20.7	28.0	28.9	28.9	28.0	3.2	0.0	0.0	138.0
1955	0.0	0.0	0.0	.4	24.6	28.0	28.9	28.9	23.4	0.0	0.0	0.0	134.3
1956	0.0	0.0	0.0	.5	28.9	28.0	28.9	28.9	28.0	8.4	0.0	0.0	151.6
1957	0.0	0.0	0.0	.4	20.8	28.0	28.9	28.9	27.6	2.5	0.0	0.0	137.1
1958	0.0	0.0	0.0	1.2	28.9	28.0	28.9	28.9	28.0	6.9	0.0	0.0	150.8
1959	0.0	0.0	0.0	.0	14.9	28.0	28.9	28.9	28.0	0.0	0.0	0.0	128.7
1960	0.0	0.0	0.0	1.0	28.9	28.0	28.9	28.9	28.0	6.9	0.0	0.0	150.7
1961	0.0	0.0	0.0	.5	26.0	28.0	28.9	28.9	11.1	0.0	0.0	0.0	123.4
1962	0.0	0.0	0.0	.5	23.1	28.0	28.9	25.9	22.4	0.0	0.0	0.0	128.9
1963	0.0	0.0	0.0	.0	28.7	28.0	28.9	28.9	28.0	16.1	.5	0.0	159.1
1964	0.0	0.0	0.0	.1	24.7	23.5	28.9	19.4	28.0	0.0	0.0	0.0	124.6
1965	0.0	0.0	0.0	1.2	20.7	28.0	28.9	26.2	4.5	0.0	0.0	0.0	109.5
1966	0.0	0.0	0.0	.0	28.9	28.0	28.9	28.9	28.0	0.0	0.0	0.0	142.7
1967	0.0	0.0	0.0	0.0	26.4	11.9	28.9	28.9	28.0	4.2	0.0	0.0	128.4
1968	0.0	0.0	0.0	.1	6.9	21.5	28.9	23.9	27.0	5.4	0.0	0.0	113.8
1969	0.0	0.0	0.0	3.4	28.9	14.0	28.9	28.9	28.0	2.5	0.0	0.0	134.7
1970	0.0	0.0	0.0	0.0	25.0	28.0	28.9	28.9	12.6	0.0	0.0	0.0	123.4
1971	0.0	0.0	0.0	.4	22.1	28.0	28.9	28.9	16.9	0.0	0.0	0.0	125.2
1972	0.0	0.0	0.0	.6	28.9	28.0	28.9	28.9	23.3	0.0	0.0	0.0	138.6
1973	0.0	0.0	0.0	.1	28.9	28.0	28.9	28.9	16.7	14.9	0.0	0.0	146.5
1974	0.0	0.0	.1	7.8	11.0	22.0	22.0	11.0	11.0	1.0	0.0	0.0	85.9
1975	0.0	0.0	0.0	0.0	12.0	23.0	23.0	23.0	17.0	5.0	0.0	0.0	103.0
1976	0.0	0.0	0.0	1.4	28.9	28.0	28.9	28.9	17.1	2.7	0.0	0.0	136.0
1977	0.0	0.0	0.0	1.1	28.9	28.0	28.9	24.9	28.0	11.1	.0	0.0	151.1
1978	0.0	0.0	0.0	0.0	21.0	28.0	28.9	28.5	12.8	0.0	0.0	0.0	119.2
1979	0.0	0.0	0.0	.7	15.9	28.0	28.9	28.9	28.0	2.6	0.0	0.0	133.1
1980	0.0	0.0	0.0	1.5	16.3	28.0	28.9	25.1	23.5	3.9	0.0	0.0	127.3
MEAN	0.0	0.0	.0	1.1	23.4	26.1	28.5	27.5	23.1	3.6	.0	0.0	133.6
S.D.	0.0	0.0	.0	1.7	6.5	4.0	1.4	3.3	6.3	4.5	.0	0.0	16.1
COEF. VAR.	****.***	****.***	4.822	1.579	.235	.155	.049	.122	.276	1.239	5.723	****.***	.120
PERCENT OF ANNUAL MEAN	0.0%	0.0%	0.0%	.8%	17.6%	19.6%	21.4%	20.6%	17.3%	2.7%	0.0%	0.0%	

SUM OF MONTHLY MEANS 133.7

APPENDIX I

APPENDIX I

SAMPLE HEC-3 OUTPUT

UNREG	76.	32.	33.	29.	42.	182.	279.	81.	77.	48.	47.	34.	32.
INFLOW	35.	30.	31.	27.	36.	65.	142.	0.	0.	-0.	25.	32.	30.
REQ DIV	-9.3	0.0	0.0	0.0	-0.5	-20.2	-22.4	-29.1	-16.6	-18.6	-3.5	0.0	0.0
DIVERSN	-3.9	0.0	0.0	0.0	-0.5	-20.2	-22.4	0.0	0.0	0.0	-3.5	0.0	0.0
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	39.	30.	31.	27.	37.	85.	164.	0.	0.	-0.	29.	32.	30.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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20 WHALEY DITCH PRE1910 LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11 12 16 17 18 19 20

YR 1960	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	70.	31.	33.	28.	41.	162.	242.	76.	75.	47.	46.	33.	32.
UNREG	76.	32.	33.	29.	42.	182.	279.	81.	77.	48.	47.	34.	32.
INFLOW	39.	30.	31.	27.	37.	85.	164.	0.	0.	-0.	29.	32.	30.
REQ DIV	9.3	0.0	0.0	0.0	0.5	20.2	22.4	29.1	16.6	18.6	3.5	0.0	0.0
DIVERSN	3.9	0.0	0.0	0.0	0.5	20.2	22.4	0.0	0.0	-0.0	3.5	0.0	0.0
SHORTG1	5.4	0.0	0.0	0.0	0.0	0.0	0.0	29.1	16.6	18.6	0.0	0.0	0.0
RIV FLW	35.	30.	31.	27.	36.	65.	142.	0.	0.	0.	25.	32.	30.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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21 WHALEY DITCH POST1910 LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11 12 16 17 18 19 20 21

YR 1960	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	70.	31.	33.	28.	41.	162.	242.	76.	75.	47.	46.	33.	32.
UNREG	76.	32.	33.	29.	42.	182.	279.	81.	77.	48.	47.	34.	32.
INFLOW	35.	30.	31.	27.	36.	65.	142.	0.	0.	0.	25.	32.	30.
REQ DIV	0.2	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.1	0.0	0.0
DIVERSN	0.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.1	0.0	0.0
SHORTG1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.0	0.0	0.0
RIV FLW	35.	30.	31.	27.	36.	64.	142.	0.	0.	0.	25.	32.	30.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

1ANNUAL INPUT DATA FOR 1961

**INFLOWS

STA	1	102.	84.	70.	114.	8800.	6500.	718.	251.	500.	1080.	666.	341.
STA	7	1770.	1490.	1590.	1720.	18120.	15520.	4250.	4160.	2390.	3250.	2900.	2480.

**DIVERSION REQUIREMENTS

STA	1	12.	11.	12.	27.	710.	1393.	1449.	1307.	308.	12.	12.	12.
STA	4	15.	14.	15.	30.	735.	1436.	1483.	1346.	320.	15.	15.	15.
STA	8	0.	0.	0.	95.	4358.	8665.	8981.	8093.	1843.	0.	0.	0.
STA	11	0.	0.	0.	11.	53.	177.	226.	200.	31.	2.	0.	0.
STA	12	0.	0.	0.	5.	106.	446.	568.	369.	33.	0.	0.	0.
STA	13	0.	0.	0.	89.	4252.	8220.	8413.	7723.	1815.	0.	0.	0.

STA 16	0.	0.	0.	72.	3443.	6490.	6710.	6263.	1472.	0.	0.	0.
STA 17	0.	0.	0.	16.	803.	1730.	1703.	1460.	343.	0.	0.	0.
STA 18	0.	0.	0.	2.	116.	187.	193.	193.	49.	0.	0.	0.
STA 20	0.	0.	0.	16.	803.	1730.	1703.	1460.	343.	0.	0.	0.
STA 21	0.	0.	0.	0.	26.	28.	28.	28.	11.	0.	0.	0.

ALL FLOWS IN CFS, STORAGES AND EVAP IN ACFT, AND POWER IN THOUSAND KWH

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1 PASS GREY,MAIN,SHEL,WHAL PRE1910 LEAKAGE
LOCAL DIVERSIONS 1

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
UNREG	5.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
REQ DIV	7.3	0.2	0.2	0.2	0.5	11.5	23.5	23.6	21.3	5.2	0.2	0.2	0.2
DIVERSN	3.5	0.2	0.2	0.2	0.4	11.5	23.5	2.7	0.9	1.9	0.2	0.2	0.2
SHORT31	3.8	0.0	0.0	0.0	0.0	0.0	0.0	20.9	20.3	3.2	0.0	0.0	0.0
RIV FLW	3.	0.	0.	0.	0.	21.	2.	0.	0.	0.	4.	2.	1.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORT33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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2 ADELAIDE RESERVOIR LEAKAGE 0. SERVED BY 2
SERVING 2 3 -4 5 6 -7 -8 -9 10 -11 -12 16 -17 18 19 -20 -21
LOCAL DIVERSIONS 1

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
UNREG	5.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	3.	0.	0.	0.	0.	21.	2.	-0.	-0.	0.	4.	2.	1.
EOP STR		219	219	223	223	1537	1634	219	219	219	219	219	219
EOP EL		9233.00	9233.00	9233.09	9233.09	9253.11	9254.21	9233.00	9233.00	9233.00	9233.00	9233.00	9233.00
EVAPO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CASE		501	501	201	201	201	201	1601	201	201	501	501	501
LEVL2		1.00	1.00	3.00	3.00	3.84	3.90	1.00	1.00	1.00	1.00	1.00	1.00
CSV REL	3.	0.	0.	0.	0.	0.	0.	23.	0.	0.	4.	2.	1.
RIV FLW	3.	0.	0.	0.	0.	0.	0.	23.	0.	0.	4.	2.	1.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORT33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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3 RETURN DIVERSION FROM CP1 LEAKAGE 0. SERVED BY 2
LOCAL DIVERSIONS 3

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UNREG	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	3.	0.	0.	0.	0.	0.	0.	23.	0.	0.	4.	2.	1.
REQ DIV	-7.3	-0.2	-0.2	-0.2	-0.5	-11.5	-23.5	-23.6	-21.3	-5.2	-0.2	-0.2	-0.2
DIVERSN	-3.5	-0.2	-0.2	-0.2	-0.4	-11.5	-23.5	-2.7	-0.9	-1.9	-0.2	-0.2	-0.2
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	5.	0.	0.	0.	0.	12.	23.	26.	1.	2.	4.	3.	1.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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4 PASS ALL PRE1984 DEMANDS LEAKAGE 0. SERVED BY -2
LOCAL DIVERSIONS 3 4

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UNREG	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	6.	0.	0.	0.	0.	12.	23.	26.	1.	2.	4.	3.	1.
REQ DIV	7.5	0.2	0.3	0.2	0.5	12.0	24.1	24.2	21.9	5.4	0.2	0.3	0.2
DIVERSN	3.5	0.2	0.2	0.2	0.4	11.5	23.5	2.7	0.9	1.9	0.2	0.2	0.2
SHORTG1	4.0	0.0	0.1	0.0	0.1	0.4	0.6	21.5	21.0	3.4	0.0	0.1	0.0
RIV FLW	3.	0.	0.	0.	0.	0.	0.	23.	0.	0.	4.	2.	1.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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5 ADELAIDE RESERVOIR 1984 LEAKAGE 0. SERVED BY 2 5
SERVING 5 6 -7 -8 -9 10 -11 -12 16 -17 18 19 -20 -21
LOCAL DIVERSIONS 3 4

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UNREG	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	3.	0.	0.	0.	0.	0.	0.	23.	0.	0.	4.	2.	1.
EOP STR		1876	1885	1852	1819	1819	1819	1790	1790	1790	2026	2168	2234
EOP EL		9255.88	9255.96	9256.63	9256.29	9256.29	9256.29	9256.00	9256.00	9256.00	9258.42	9259.87	9260.52
EVAPO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CASE		501	501	2103	2103	501	501	1601	501	501	501	501	501
LEVEL		2.07	2.08	2.05	2.02	2.02	2.02	1.00	1.00	1.00	2.19	2.31	2.36
CSV REL	2.	0.	0.	0.	0.	0.	0.	23.	0.	0.	0.	0.	0.
RIV FLW	2.	0.	0.	1.	1.	0.	0.	23.	0.	0.	0.	0.	0.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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6 RETURN DIVERSION FROM CP4 LEAKAGE 0. SERVED BY 2 5
LOCAL DIVERSIONS 6

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UNREG	6.	0.	0.	0.	0.	33.	25.	3.	1.	2.	4.	3.	1.
INFLOW	2.	0.	0.	1.	1.	0.	0.	23.	0.	0.	0.	0.	0.
REQ DIV	-7.5	-0.2	-0.3	-0.2	-0.5	-12.0	-24.1	-24.2	-21.9	-5.4	-0.2	-0.3	-0.2
DIVERSN	-3.5	-0.2	-0.2	-0.2	-0.4	-11.5	-23.5	-2.7	-0.9	-1.9	-0.2	-0.2	-0.2
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	5.	0.	0.	1.	1.	12.	23.	26.	1.	2.	0.	0.	0.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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7 SHEL-ADEL CONFL,GREYBULL PRE1910 LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	25.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	83.	29.	27.	26.	29.	273.	259.	93.	68.	50.	49.	46.	39.
REQ DIV	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
DIVERSN	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	81.	27.	25.	25.	28.	272.	258.	91.	66.	49.	48.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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8 PASS MAINSTEM,SHEL,WHALEYPRE1910 LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	25.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	81.	27.	25.	25.	28.	272.	258.	91.	66.	49.	48.	45.	38.
REQ DIV	44.3	0.0	0.0	0.0	1.6	70.9	145.6	146.1	131.6	31.1	0.0	0.0	0.0
DIVERSN	32.1	0.0	0.0	0.0	1.6	70.9	145.6	67.8	66.4	31.1	0.0	0.0	0.0
SHORTG1	12.2	0.0	0.0	0.0	0.0	0.0	0.0	78.2	65.3	0.0	0.0	0.0	0.0
RIV FLW	49.	27.	25.	25.	27.	201.	112.	23.	0.	18.	48.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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9 CITY OF GREYBULL POST 1910 LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	49.	27.	25.	25.	27.	201.	112.	23.	0.	18.	48.	45.	38.
REQ DIV	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DIVERSN	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.3	0.3	0.3	0.3
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
RIV FLW	49.	27.	25.	25.	26.	201.	112.	23.	0.	18.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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10 RETURN DIVERSION FROM CP8   LEAKAGE   0. SERVED BY 2 5
LOCAL DIVERSIONS 6 7 8 9 10

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	49.	27.	25.	25.	26.	201.	112.	23.	0.	18.	47.	45.	38.
REQ DIV	-44.3	0.0	0.0	0.0	-1.6	-70.9	-145.6	-146.1	-131.6	-31.1	0.0	0.0	0.0
DIVERSN	-32.1	0.0	0.0	0.0	-1.6	-70.9	-145.6	-67.8	-66.4	-31.1	0.0	0.0	0.0
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	81.	27.	25.	26.	28.	272.	258.	91.	66.	49.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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11 PHRYEATOPHYTE LOSSES   LEAKAGE   0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	81.	27.	25.	25.	28.	272.	253.	91.	66.	49.	47.	45.	38.
REQ DIV	1.0	0.0	0.0	0.0	0.2	0.9	3.0	3.7	3.3	0.5	0.0	0.0	0.0
DIVERSN	1.0	0.0	0.0	0.0	0.2	0.9	3.0	3.7	3.3	0.5	0.0	0.0	0.0
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	80.	27.	25.	25.	28.	271.	255.	88.	63.	49.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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12 MAINSTEM PRE1910   LEAKAGE   0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11 12

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	25.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	80.	27.	25.	25.	23.	271.	255.	88.	63.	48.	47.	45.	38.
REQ DIV	2.1	0.0	0.0	0.0	0.1	1.7	7.5	9.2	6.0	0.6	0.0	0.0	0.0

DIVERSN	2.1	0.0	0.0	0.0	0.1	1.7	7.5	9.2	6.0	0.6	0.0	0.0	0.0
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	73.	27.	25.	25.	28.	269.	247.	78.	57.	48.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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16 SHELL CANAL PRE1910　　LEAKAGE　0. SERVED BY　2　5
LOCAL DIVERSIONS　6　7　8　9　10　11　12　16

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	73.	27.	25.	25.	28.	269.	247.	78.	57.	48.	47.	45.	38.
REQ DIV	33.8	0.0	0.0	0.0	1.2	56.1	109.1	109.1	101.9	24.7	0.0	0.0	0.0
DIVERSN	27.4	0.0	0.0	0.0	1.2	56.1	109.1	78.4	57.1	24.7	0.0	0.0	0.0
SHORTG1	6.4	0.0	0.0	0.0	0.0	0.0	0.0	30.7	44.8	0.0	0.0	0.0	0.0
RIV FLW	51.	27.	25.	25.	26.	213.	138.	0.	0.	23.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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17 PASS WHALEY DITCH PRE1910　　LEAKAGE　0. SERVED BY　-2　-5
LOCAL DIVERSIONS　6　7　8　9　10　11　12　16　17

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	51.	27.	25.	25.	26.	213.	138.	0.	0.	23.	47.	45.	38.
REQ DIV	8.4	0.0	0.0	0.0	0.3	13.1	29.1	27.7	23.7	5.8	0.0	0.0	0.0
DIVERSN	4.0	0.0	0.0	0.0	0.3	13.1	29.1	0.0	0.0	5.8	0.0	0.0	0.0
SHORTG1	4.4	0.0	0.0	0.0	0.0	0.0	0.0	27.7	23.7	0.0	0.0	0.0	0.0
RIV FLW	47.	27.	25.	25.	26.	200.	109.	0.	0.	17.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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18 SHELL CANAL POST1910　　LEAKAGE　0. SERVED BY　2　5
LOCAL DIVERSIONS　6　7　8　9　10　11　12　16　17　18

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	47.	27.	25.	25.	26.	200.	109.	0.	0.	17.	47.	45.	38.
REQ DIV	1.0	0.0	0.0	0.0	0.0	1.9	3.1	3.1	3.1	0.8	0.0	0.0	0.0
DIVERSN	0.5	0.0	0.0	0.0	0.0	1.9	3.1	0.0	0.0	0.8	0.0	0.0	0.0
SHORTG1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.1	0.0	0.0	0.0	0.0
RIV FLW	46.	27.	25.	25.	26.	198.	106.	0.	0.	16.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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19 RETURN DIVERSIONS FROM CP17   LEAKAGE 0. SERVED BY 2 5
LOCAL DIVERSIONS 6 7 8 9 10 11 12 16 17 18 19

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	46.	27.	25.	25.	26.	198.	106.	0.	-0.	16.	47.	45.	38.
REQ DIV	-8.4	0.0	0.0	0.0	-0.3	-13.1	-29.1	-27.7	-23.7	-5.8	0.0	0.0	0.0
DIVERSN	-4.0	0.0	0.0	0.0	-0.3	-13.1	-29.1	0.0	0.0	-5.8	0.0	0.0	0.0
SHORTG1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIV FLW	50.	27.	25.	25.	26.	211.	135.	0.	-0.	22.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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20 WHALEY DITCH PRE1910   LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11 12 16 17 18 19 20

YR 1951	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	26.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	68.	50.	53.	49.	40.
INFLOW	50.	27.	25.	25.	26.	211.	135.	0.	-0.	22.	47.	45.	38.
REQ DIV	8.4	0.0	0.0	0.0	0.3	13.1	29.1	27.7	23.7	5.8	0.0	0.0	0.0
DIVERSN	4.0	0.0	0.0	0.0	0.3	13.1	29.1	0.0	-0.0	5.8	0.0	0.0	0.0
SHORTG1	4.4	0.0	0.0	0.0	0.0	0.0	0.0	27.7	23.7	0.0	0.0	0.0	0.0
RIV FLW	46.	27.	25.	25.	26.	198.	106.	0.	0.	16.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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21 WHALEY DITCH POST1910   LEAKAGE 0. SERVED BY -2 -5
LOCAL DIVERSIONS 6 7 8 9 10 11 12 16 17 18 19 20 21

YR 1961	AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LOC FLW	77.	28.	26.	26.	28.	262.	236.	66.	67.	48.	49.	46.	39.
UNREG	83.	29.	27.	26.	29.	295.	261.	69.	63.	50.	53.	49.	40.
INFLOW	46.	27.	25.	25.	26.	198.	106.	0.	0.	16.	47.	45.	38.
REQ DIV	0.2	0.0	0.0	0.0	0.0	0.4	0.5	0.5	0.5	0.2	0.0	0.0	0.0
DIVERSN	0.1	0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.0	0.2	0.0	0.0	0.0
SHORTG1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
RIV FLW	46.	27.	25.	25.	26.	198.	105.	0.	0.	16.	47.	45.	38.
DES FLW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORTG3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

1ANNUAL INPUT DATA FOR 1962
**INFLOWS