

PRE 2003 Reports  
Revised  
after 2003

# **FRENCHMAN UNIT**

FRENCHMAN - CAMBRIDGE DIVISION  
Pick - Sloan Missouri Basin Program

## **NEBRASKA**

### **REHABILITATION AND BETTERMENT PROGRAM**

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CONCLUDING REPORT

JULY 1978



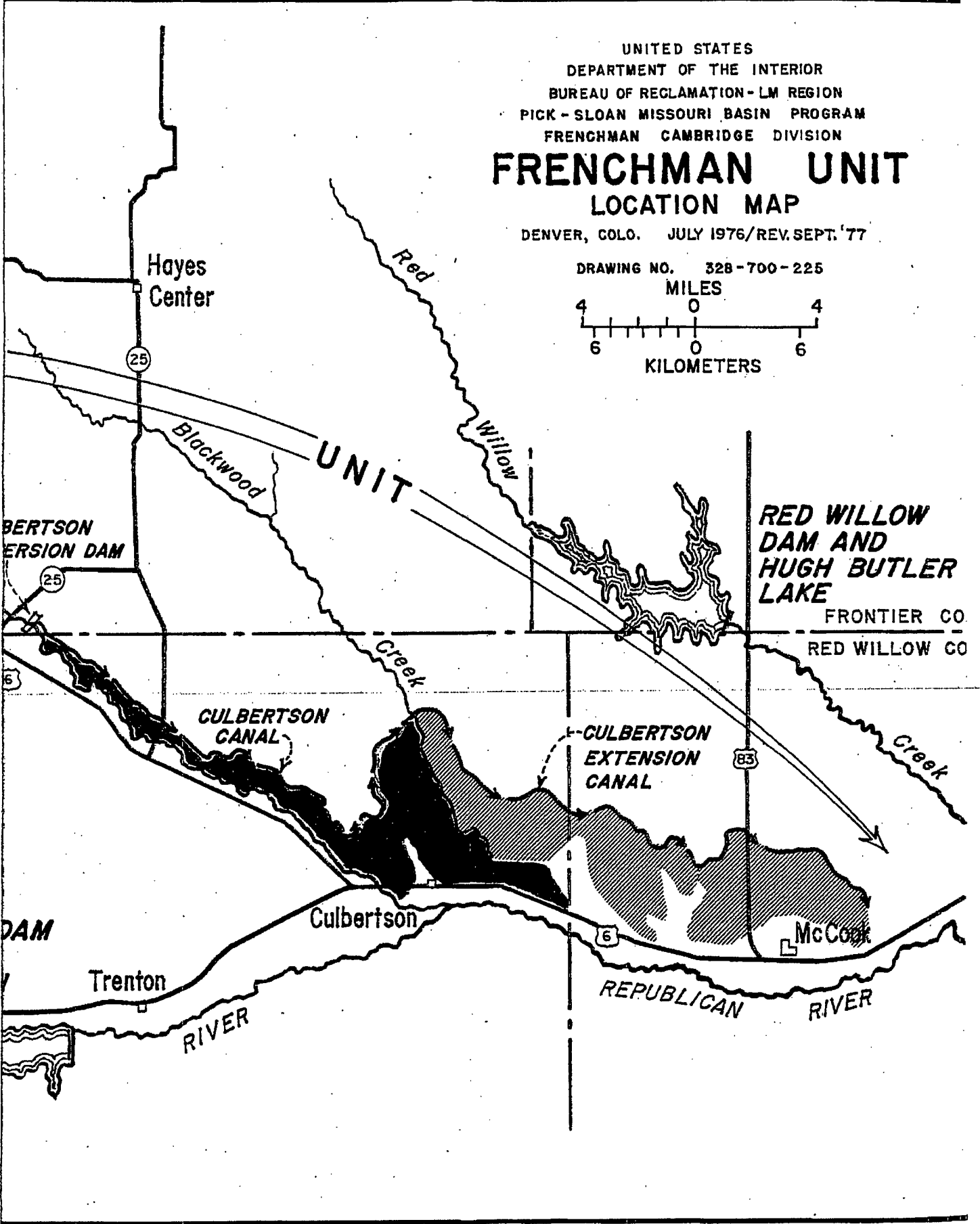
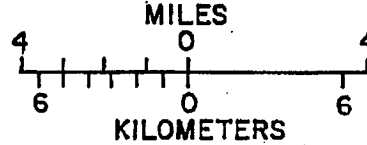
DEPARTMENT OF THE INTERIOR  
Bureau of Reclamation

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION - LM REGION  
PICK - SLOAN MISSOURI BASIN PROGRAM  
FRENCHMAN CAMBRIDGE DIVISION

# FRENCHMAN UNIT LOCATION MAP

DENVER, COLO. JULY 1976/REV. SEPT. '77

DRAWING NO. 328-700-225



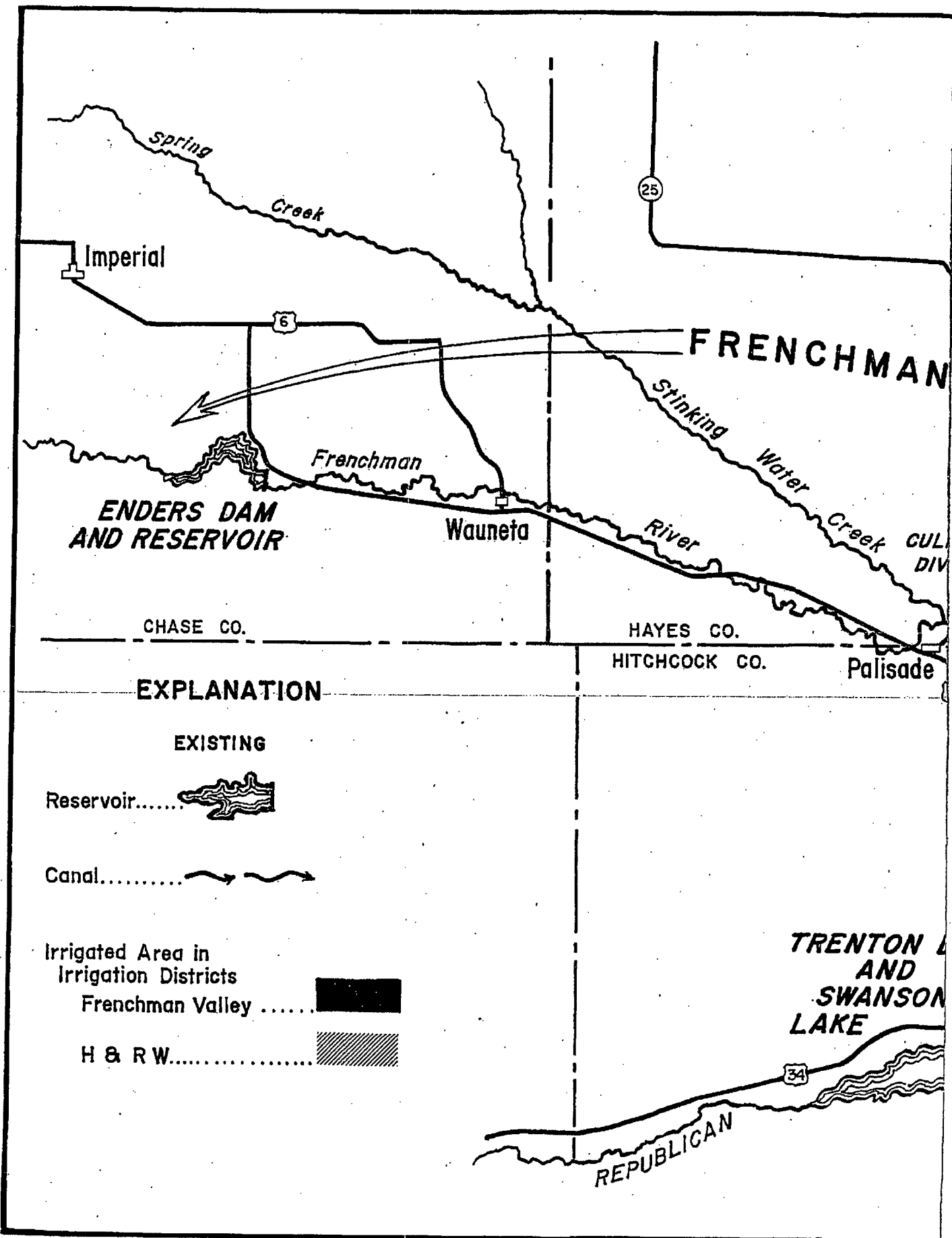


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# INTRODUCTION

## INTRODUCTION

The Frenchman Unit is located within the Frenchman-Cambridge Division in southwest Nebraska. The unit includes the H&RW and Frenchman Valley Irrigation Districts and is a multiple-purpose project of the Pick-Sloan Missouri Basin Program.

Irrigation service to the H&RW and Frenchman Valley Irrigation Districts is provided by the Culbertson Canal and the Culbertson Extension Canal. The Culbertson Canal begins at the Culbertson Diversion Dam near Palisade, Nebraska, about 84 river kilometers (52 river miles) downstream from Enders Dam. The two canals have a combined length of about 77 kilometers (48 miles) and serve up to 8550 hectares (21,100 acres) of land. Because of diminishing inflows to Enders Reservoir, due to increased pumpage of ground water above the Reservoir by private irrigators, the irrigation districts have expressed interest in the possibility of reclaiming the canal seepage by pumping ground water within the project area and returning it to the distribution system.

The Bureau of Reclamation is concerned with the depletion of the surface water supply because of the Federal Government's investment in the districts' irrigation facilities. Reclamation, with concurrence and support of the irrigation districts, initiated the Frenchman Unit Rehabilitation and Betterment Program in fiscal year 1976. This program provided Reclamation the opportunity to evaluate in more detail the hydrologic and engineering feasibility of (1) the installation of ground-water wells within the irrigation districts, and (2) the canal lining alternative which appeared viable in the January 1977 Appraisal Report for the Frenchman Unit.

The Geological Survey's report 1/, concerning ground-water availability in the H&RW and Frenchman Valley Irrigation Districts and the Meeker-Driftwood Unit, southwest Nebraska, indicates that depletion of the surface water supplies is more severe than previously anticipated in the appraisal report. Projections, furnished by the Geological Survey indicate that flows in the Frenchman River and Stinking Water Creek will be nearly depleted by 1991.2/

1/ R. E. Booker, P. F. Hemphill and E. G. Lappala, "Ground-Water availability in the Hitchcock-Red Willow, Frenchman Valley, and Meeker-Driftwood Irrigation Districts, Southwest Nebraska," Department of the Interior, Geological Survey (prepared in cooperation with the Bureau of Reclamation), Open-File Report 78-461, Lincoln, Nebraska, June 1978, pp. 1-49.

2/ Ground-Water Control Area Hearing, Upper Republican Natural Resources District, Imperial, Nebraska, March 24, 1977.

The possibility of utilizing transbasin diversions to supplement the water supply was raised, but the legal mechanisms do not exist at present in Nebraska to effect such diversions. Therefore, no hydrologic evaluations were made regarding out-of-basin supplies.

#### AUTHORITY

This survey was conducted in accordance with the Rehabilitation and Betterment Act of October 7, 1949 (63 Stat. 724, Public Law 335, 81st Congress, 1st Session), as amended March 3, 1950 (64 Stat. 11) and on October 3, 1975 (89 Stat. 485).

#### PREVIOUS INVESTIGATIONS

The plan of development for the Frenchman-Cambridge Division was presented in the Frenchman-Cambridge Division Definite Plan Report dated February 1951. The definite plan report represented the efforts of the Bureau of Reclamation in cooperation with State and other Federal agencies and local groups. In December 1956, Supplement No. 2, Frenchman Unit, Land Classification, Appendix VII--Project Lands, Volume 1, of the Definite Plan Report for the Frenchman-Cambridge Division was prepared. This report presented to Congress supporting information for the land classification certification as to the productivity of the lands prior to award of a construction contract. A study entitled "Ground-Water Geology and Pump Irrigation in Frenchman Creek Basin above Palisade, Nebraska," (Water Supply Paper No. 1577) was initiated in 1951 by the Geological Survey and published in 1963. At the request of the Bureau of Reclamation, the Geological Survey's paper included a study to determine the extent to which future pumping of ground water for irrigation might deplete the streamflow in the Frenchman River and in Stinking Water Creek.

The Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, in cooperation with the Southwest Nebraska Ground Water Conservation District, prepared a report entitled "Groundwater Geology of Southwest Nebraska Ground Water Conservation District," (Nebraska Water Survey Paper Number 37) which was published in May 1974. The purpose of that report was to provide geohydrologic data that could be used as a base for assessing the impacts of future ground-water withdrawals in the district.



The Frenchman Unit, Nebraska, Appraisal Report was published by the Bureau of Reclamation in January 1977. This study evaluated the H&RW and Frenchman Valley Irrigation Districts' water supply problems. The findings of this study indicated that intensive private well development upstream of Enders Reservoir has been a major factor in the depletion of the base flow of the Frenchman River resulting in decline in the available surface water supply. This report presented two alternatives, canal lining and ground-water development within the project area, for consideration to help stabilize the water supply for the Frenchman Unit.

#### COOPERATIVE STUDIES

On June 15, 1976, the Geological Survey's Water Resources Division, Lincoln, Nebraska, was funded by the Bureau of Reclamation in connection with this investigation to conduct a ground-water study related to the H&RW and Frenchman Valley Irrigation Districts. The Geological Survey's report was published in June 1978. This report was summarized and the objectives of that study are stated in detail in a subsequent section of this report entitled "Summary of Geological Survey's Report." Copies of the Survey's final report are on file in the Lower Missouri Regional Office, Bureau of Reclamation, Denver, Colorado, the Kansas River Projects Office, McCook, Nebraska, and at the office of the Geological Survey, Lincoln, Nebraska.

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# GENERAL DESCRIPTION

## GENERAL DESCRIPTION

The Frenchman-Cambridge Division encompasses the Frenchman-Cambridge, H&RW, and Frenchman Valley Irrigation Districts. Facilities to provide irrigation water to these three irrigation districts include four storage dams and reservoirs, four diversion dams, and the necessary distribution systems to deliver irrigation water to 26 760 hectares (66,125 acres) of land in southwest Nebraska.

## SETTING

This study is concerned only with the Frenchman Unit of the Frenchman-Cambridge Division which is located in Chase, Hitchcock, Hayes, and Red Willow Counties, as shown on the location map included as the frontispiece in this report.

Southwestern Nebraska is in a transition zone between subhumid and semi-arid climates, characterized by extreme daily and seasonal ranges of precipitation and temperature. Annual precipitation averages about 460 millimeters (18 inches) in the Frenchman River drainage area, with most of the precipitation occurring in the late spring and summer months. The average temperature for June through September is 23° C (73° F). The record high and low temperature extremes have been 46° C (115° F) and -39° C (-38° F), respectively. The average length of the frost-free season is 155 days. There is considerable wind throughout the year.

Enders Dam is an earthfill structure approximately 793.4 meters (2,603 feet) long at the crest and has a height above streambed of 31.4 meters (103 feet). Enders Reservoir provides 42 600 000 cubic meters (34,500 acre-feet) of conservation storage for the irrigation of lands in the Frenchman Unit. The water supply for both the H&RW and Frenchman Valley Irrigation Districts is provided by direct flows from the Frenchman River and Stinking Water Creek and off-season storage in Enders Reservoir on the Frenchman River. Both irrigation districts are currently receiving a limited water supply from Reclamation's Enders Reservoir. Some irrigators have supplemented their water supply received from the district by installing private ground-water wells.

The Culbertson Diversion Dam, Culbertson Canal, and Culbertson Extension Canal serve 3900 hectares (9,600 acres) of land in the Frenchman Valley Irrigation District in Hitchcock County and 4650 hectares (11,500 acres) in the H&RW Irrigation District in Hitchcock and Red Willow Counties. The Culbertson Canal and laterals, which have lengths of about

34 and 43 kilometers (21 and 27 miles), respectively, begin at the Culbertson Diversion Dam near Palisade and serve the lands in the Frenchman Valley Irrigation District. The Culbertson Extension Canal provides water to the lands in the H&RW Irrigation District and has a length of approximately 43 kilometers (27 miles) and about 68 kilometers (42 miles) of laterals. The principal crops grown in the two irrigation districts are corn, forage and grain sorghums, and alfalfa hay.

#### HISTORY OF DEVELOPMENT

Investigations of the Frenchman-Cambridge Division were initiated by the Bureau of Reclamation in 1939. Congress authorized the Frenchman-Cambridge Division by the Flood Control Act of 1944 (58 Stat. 887), and construction work was initiated in 1947.

The H&RW Irrigation District was organized in 1955. The Frenchman Valley Irrigation District organized in 1911 was incorporated into the development plan in 1956. The remainder of the division is in the Frenchman-Cambridge Irrigation District which was formed in 1946.

Enders Dam and Reservoir, the storage facility for the Frenchman Unit, was completed in 1951. The first irrigation water was delivered to irrigators in the Frenchman Valley Irrigation District in May 1958, through the enlarged Culbertson Canal and to the H&RW Irrigation District irrigators in April 1961, through the Culbertson Extension Canal.

The development period for approximately 4650 hectares (11,500 acres) of land in the H&RW Irrigation District was initiated on January 1, 1963, and ended on December 31, 1972. The original Culbertson Canal, built in 1890, was purchased from the Frenchman Valley Irrigation District in 1956 by the United States, and the enlargement of the canal was initiated in 1957 and completed in 1961. The enlargement was carried out during the nonirrigation season, thereby eliminating interruption of the district's water supply. There was no development period for the 3900 hectares (9,600 acres) of land in the Frenchman Valley Irrigation District.

Water rights involved in the Frenchman Unit are the Culbertson Canal's 1890 natural-flow right for 3.81 cubic meters/second (134.5 ft<sup>3</sup>/s), a storage right, with a priority date of May 1, 1946, for 54 371 000 cubic meters (44,079 acre-feet) in Enders Reservoir, and five natural-flow rights for the Culbertson Canal and Culbertson Extension Canal, totaling about 4.93 cubic meters/second (174 ft<sup>3</sup>/s), with priority dates of 1946, 1954, 1959, 1960, and 1974.

Table 1, Frenchman Unit, Irrigation Deliveries, shows the average project water supply delivered to the farms in both irrigation districts during the 1966 through 1976 period.

#### DISTRICT IMPROVEMENT

The H&RW and Frenchman Valley Irrigation Districts purchased and installed a pump in the Enders Dam spillway stilling basin in 1972, to pump reservoir seepage water back into the reservoir. A total of 5 202 000 cubic meters (4,217 acre-feet) of water was recovered between the 1975 and 1976 irrigation seasons in this manner.

#### REPAYMENT HISTORY

##### H&RW Irrigation District

Contract, Number 14-06-700-1242, between the United States and the H&RW Irrigation District, dated November 7, 1956, provided for the delivery of water and for the construction and operation and maintenance of the distribution and drainage works, and established \$1,320,000 as the maximum to be expended and repaid for the distribution works.

The existing contract was amended August 12, 1958. This amendatory contract provided for renewal of Part A of the contract in accordance with Public Law 643, 84th Congress, 2d Session (70 Stat. 483) which stated that long-term 9(e) water service contracts are to contain terms and conditions which provide for conversion to 9(d) contracts at the end of its term to reflect increases or decreases in construction, operation and maintenance costs, and improvement or reduction in the party's repayment capability.

Amendatory Contract, dated October 19, 1967, changed the development period from 5 years to 10 years and increased the maximum facilities expenditure and repayment for the distribution works to \$1,400,000. The contract was also amended October 13, 1970, to increase the maximum facilities expenditure and repayment to \$1,500,000.

##### Frenchman Valley Irrigation District

Water service contract, Number 14-06-700-1241, between the United States and the Frenchman Valley Irrigation District, dated November 7, 1956,

Table 1.--Frenchman Unit, Irrigation deliveries

Year	Inflow		Irrigated		Net supply		Waste		Water distribution Losses		Total		Delivered to farms	
	Enders Reservoir m <sup>3</sup>	(ac-ft)	ha	(acres)	m <sup>3</sup>	(ac-ft)	m <sup>3</sup>	(ac-ft)	m <sup>3</sup>	(ac-ft)	m <sup>3</sup>	(ac-ft)	m <sup>3</sup>	(ac-ft)
1966	72 500 000	(58,800)	7 090	(17,519)	64 086 000	(51,956)	3 465 000	(2,809)	21 080 000	(17,090)	39 541 000	(32,056)	5 600	(1.83)
1967	77 800 000	(63,100)	7 955	(19,656)	59 546 000	(48,275)	3 260 000	(2,643)	22 804 000	(18,552)	33 402 000	(27,080)	4 200	(1.38)
1968	64 800 000	(52,500)	8 119	(20,063)	64 667 000	(52,426)	3 348 000	(2,714)	22 502 000	(18,243)	38 017 000	(31,469)	4 800	(1.57)
1969	63 300 000	(51,300)	8 009	(19,790)	65 711 000	(53,273)	3 007 000	(2,438)	23 590 000	(19,125)	39 114 000	(31,710)	4 900	(1.60)
1970	58 600 000	(47,500)	6 982	(17,252)	60 205 000	(48,809)	1 876 000	(1,521)	26 371 000	(21,379)	31 958 000	(25,909)	4 600	(1.50)
1971	61 400 000	(49,800)	7 359	(18,185)	64 437 000	(52,240)	3 272 000	(2,653)	20 279 000	(22,926)	32 885 000	(26,651)	4 500	(1.47)
1972	54 300 000	(44,000)	6 556	(16,200)	61 886 000	(50,172)	2 509 000	(2,034)	26 297 000	(21,319)	33 080 000	(26,819)	5 100	(1.66)
1973	53 200 000	(43,100)	7 694	(19,013)	60 034 000	(48,670)	2 233 000	(1,810)	22 631 000	(18,347)	35 170 000	(28,513)	4 600	(1.50)
1974	46 900 000	(38,000)	8 221	(20,315)	51 220 000	(41,525)	1 847 000	(1,497)	20 864 000	(16,915)	28 509 000	(23,113)	3 500	(1.14)
1975	47 200 000	(38,300)	8 168	(20,184)	54 865 000	(44,480)	2 620 000	(2,124)	22 216 000	(18,011)	30 029 000	(24,345)	3 700	(1.21)
1976	41 400 000	(33,600)	8 250	(20,386)	50 711 000	(41,112)	2 164 000	(1,754)	20 895 000	(16,940)	27,652 000	(22,418)	3 400	(1.10)

m<sup>3</sup> = cubic meters  
 ha = hectares  
 m<sup>3</sup>/ha = cubic meters per hectare

provided for the purchase of the existing Culbertson Canal and Culbertson Diversion Dam by the United States at a cost of \$247,000 and for water service and a supplemental water supply for an annual payment of \$14,880. The \$247,000 is being applied as a credit in annual amounts of \$6,180 on the district's annual fixed obligation to the United States of \$14,880. This credit applies throughout the 40-year period of the contract leaving the district an \$8,700 annual payment.

#### Repayment of Obligations

As noted in the Frenchman Unit Appraisal Report, Part V--Potential Alternative Actions, dated January 1977, the estimated costs of either the canal lining or ground-water wells as viable structural measures would exceed the financial resources of the district except as a long-term obligation.

# PROBLEMS AND NEEDS



PROBLEMS AND NEEDS

Intensive ground-water development above Enders Reservoir and the resulting depletion of the surface flows of the Frenchman River have reduced the total water supply available to irrigators in the Frenchman Unit. The use of center pivot sprinkler irrigation systems in the late 1960's and early 1970's has greatly increased the projected irrigable lands with a corresponding depletion of the spring fed streams

The Geological Survey's water supply records at Imperial, Nebraska, average 65 180 000 cubic meters (52,840 acre-feet) for 1941 through 1967. The average for 1968 through 1972 is 51 920 000 cubic meters (42,090 acre-feet). This shows an average annual reduction of 13 260 000 cubic meters (10,750 acre-feet) for this 5-year period. The 1972 flow of 48 180 000 cubic meters (39,060 acre-feet) indicates a depletion of 17 000 000 cubic meters (13,780 acre-feet) while the 1975 flow of 42 380 000 cubic meters (34,360 acre-feet) suggests a depletion of 22 794 000 cubic meters (18,480 acre-feet). The 1976 flow was 36 870 000 cubic meters (29,890 acre-feet), a depletion of 28 310 000 cubic meters (22,950 acre-feet). This 1976 flow indicates a depletion of 43.4 percent from the 1941 through the 1967 study period.

The derivation of the farm delivery requirements for the 1950-through-1972 period is shown in the following tabulation:<sup>3/</sup>

	(ac-ft/ac)	m <sup>3</sup> /ha
Consumptive use requirement	(2.36)	7200
Effective precipitation	(-1.41)	-4300
Crop irrigation requirement	(.95)	2900
Farm losses (35 percent)*	(.51)	1550
Farm delivery requirement	(1.46)	4450

\* Assumes efficiency improvements, such as irrigation management scheduling.

The tabulation indicates that the ideal farm delivery requirements would approach 4450 cubic meters per hectare (1.46 acre-feet/acre).

<sup>3/</sup> Bureau of Reclamation, "Frenchman Unit, Nebraska, Appraisal Report" Government Printing Office, Denver, 1977, p. IV-13.

Reclamation's Frenchman Unit Appraisal Report<sup>4/</sup> points out, that with continued unregulated ground-water pumping of the base flows of the Frenchman River and with further depletions resulting from the expanding private well development, there would only be an adequate water supply available to irrigate approximately 4150 of the 8550 hectares (10,250 of the 21,100 acres) presently included in the project by the year 2000.

Subsequent investigations by the Geological Survey indicate that the surface flows in the Frenchman River and Stinking Water Creek will be essentially depleted by 1991 even without further development of the upstream ground-water resources.<sup>5/</sup>

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<sup>4/</sup> Ibid, p. I-4

<sup>5/</sup> Ground-Water Control Area Hearing, Upper Republican Natural Resources District, Imperial, Nebraska, March 24, 1977.

# FINDINGS OF INVESTIGATIONS

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These investigations were carried out in two parts: (1) the studies reported in the Frenchman Unit Appraisal Report, dated January 1977, and (2) the current studies performed in connection with the Frenchman Unit Rehabilitation and Betterment Program.

### FRENCHMAN UNIT APPRAISAL REPORT

Two structural measures, (1) development of ground water, and (2) canal lining were identified as alternative actions for further study to conserve the surface water supplies of the unit. The description of these two measures was presented in detail in the Frenchman Unit Appraisal Report for consideration by local, State, and Federal interests. Brief descriptions of these measures are included in this section of the report.

Monthly data were used for the Enders Reservoir Operation Studies, which reflected an unimproved canal and lateral system for the critical 8-year period, 1950 through 1957. Historical runoff from the Frenchman River and Stinking Water Creek was modified to reflect the estimated year 2000 depletions due to projected ground-water depletions. This study demonstrated that the depletion to streamflow expected to result from irrigation well development upstream from the Culbertson Diversion Dam would reduce the acreage to 4150 hectares (10,250 acres) that could be provided an adequate project water supply.

#### Ground-Water Development

The wells that affect the inflow to Enders Reservoir are located on both sides of the Frenchman River upstream of Enders Reservoir and extend onto the upland area. Irrigation wells below Enders Reservoir and in the Spring Creek and Stinking Water Creek drainage areas are now concentrated in the alluvium along the stream valleys with considerable development extending to the uplands between these valleys. Streamflows that originate from Spring Creek and Stinking Water Creek are diverted during the irrigation season. Development of ground water in this area is also depleting the districts' surface water supplies. This depletion of natural streamflows will continue to increase even without further upstream development of the ground water, as the current use of the water already exceeds the natural recharge in the area.

The potential for the H&RW and Frenchman Valley Irrigation Districts or individual landowners to develop the ground-water aquifer in or adjacent to the districts was investigated. Development by the districts would have consisted of installing wells throughout the two districts that would pump into the canal and lateral system.

Based on the estimated pumping rate of existing wells in the area, it was assumed that the project wells could develop a continuous pumping rate of 32 liters per second (500 gallons per minute) during the irrigation season. However, the Frenchman Unit Appraisal Report indicated that before any development by the districts could take place under this assumption, additional studies would be required to determine the potential of the aquifer. Approximately 10 850 000 cubic meters (8,800 acre-feet) of water could be theoretically provided annually to the distribution facilities by a system of 43 wells pumping at a rate of 32 liters per second (500 gallons per minute) during 3 months of the irrigation season. The maximum power demand would be 1100 kilowatts and the average power used would be 2333 MWh per year.

#### Canal Lining

The 34-kilometer- (21-mile) long Culbertson Canal includes 2.6 kilometers (1.6 miles) of earth-lined canal. The Culbertson Extension Canal is 43-kilometers- (27-miles) long and includes 1.9 kilometers (1.2 miles) of earth-lined canal. A program to earth-line both canals completely could result in a reduction of about 10 000 000 cubic meters (8,100 acre-feet) of seepage losses annually.

#### Costs

The total estimated construction costs, presented in the Frenchman Unit, Nebraska, Appraisal Report, dated January 1977, which are based on January 1976 prices for the ground-water development and canal lining alternatives, are \$860,000 and \$4,778,000, respectively, exclusive of investigation costs.

## Environmental Compliance

Implementation studies for either the aforementioned ground-water development or canal lining alternatives would require compliance with NEPA regulations. An environmental assessment of the impacts of the proposed action would be made to determine whether an environmental statement or a negative determination would be required.

## FRENCHMAN UNIT R&B PROGRAM

The hydrologic and geohydrologic analyses, utilized in the current rehabilitation and betterment program studies, were developed through a cooperative agreement with the Geological Survey. Reclamation used the information from the Survey's studies to develop the findings presented in the subsequent sections of this report.

## Surface Water

The 1976 inflow to Enders Reservoir, the storage facility for the Frenchman Unit, was reduced about 43 percent from the flows previous to 1967 due to upstream ground-water withdrawals. <sup>6/</sup> These reduced inflows to the reservoir have resulted in insufficient water supplies to provide the full irrigation requirements to the two irrigation districts.

Projections, made by the Geological Survey at a public hearing in Imperial, Nebraska, in connection with the establishment of a ground-water control area, indicated that perennial flows in the Frenchman River and in Stinking Water Creek will be essentially depleted by 1991 even without further upstream ground-water development. <sup>7/</sup>

## Ground Water

Originally the results of the Geological Survey's report were to be used to indicate to what degree the ground-water resource in the study area could be used to augment the surface water supply. However, this study indicates that the water supplies have been depleted more rapidly

<sup>6/</sup> Depletion data presented by the Bureau of Reclamation at a Ground-Water Control Area Hearing, Upper Republican Natural Resources District, Imperial, Nebraska, March 24, 1977.

<sup>7/</sup> Ground-Water Control Area Hearing, Upper Republican Natural Resources District, Imperial, Nebraska, March 24, 1977.

than anticipated in Reclamation's appraisal report for the Frenchman Unit, dated January 1977. The Survey's report, which is summarized in the following section, covered the Frenchman and Meeker-Driftwood Units and developed the more critical depletion criteria and data used in this report.

### Summary of Geological Survey's Report

The following is a summary of the Geological Survey's report <sup>8/</sup> prepared in cooperation with the Bureau of Reclamation and published in June 1978. Copies of the Survey's final report are on file at the locations shown in the "Introduction" in the front of this report.

### Preface

The H&RW and Frenchman Valley Irrigation Districts' surface water supplies have been significantly reduced since 1967. The water supply for these two irrigation districts, located north of the Republican River in southwest Nebraska, is stored in Enders Reservoir. The 1976 inflow to Enders Reservoir on the Frenchman River was reduced due to upstream ground-water development. This reduction in reservoir inflow has made it impossible to provide a full supply of irrigation water to the two irrigation districts.

One alternative considered was to pump ground water directly into the canal system during the irrigation season to augment the surface water supplies. The purpose of this alternative was to capture the canal and lateral losses and the deep percolation of excess irrigation water.

<sup>8/</sup> Booker, Hemphill, and Lappala, op. cit., pp. 1-49.

The objectives of this study were to obtain hydrologic data and develop analyses to help the Bureau of Reclamation and the H&RW and Frenchman Valley Irrigation Districts in assessing: (1) the geohydrologic system including the aquifer boundaries, hydraulic properties and inflow-outflow functions, (2) the changes in the geohydrologic system resulting from district operations and private irrigation well development prior to 1976, (3) the availability of ground water to supplement surface water irrigation systems, and (4) the future effect on water levels and streamflow caused by continued district operations, existing private irrigation well development, and supplemental well fields.

The geohydrologic system was delineated by examination of data from test holes, observation wells, registered irrigation wells, geologic maps, streamflow and climatic records, district operating summaries, and aerial photography. Digital models of the hydrologic system were also used to analyze the effect of developing surface and ground-water irrigation and to determine the future effect existing developments would have upon water levels and streamflow.

#### Description of the Ground-Water Resources

The most productive aquifers are composed of the sands and gravels of the Ogallala Formation of late Tertiary age and alluvial deposits of Pleistocene and Holocene age. These aquifers are being used for irrigation, municipal, and domestic supplies. The alluvial deposits along the Republican and Frenchman River Valleys are the most potentially productive aquifers in the area. The second most productive aquifer is composed of local saturated sand and gravel deposits in the Ogallala Formation. These deposits are located parallel to and north of the Republican River Valley between McCook and Culbertson. The remainder of the study area is underlain by deposits of the Ogallala Formation which have a saturated thickness generally less than 30 meters (100 feet).

#### Analyses of Well Configurations

The Geological Survey analyzed the ability of ground-water systems to augment the declining surface water supplies. A digital model of the stream aquifer system was used to analyze the following well configurations:

In the January 1977 Frenchman Unit Appraisal Report, it was assumed that 43 wells capable of pumping 32 liters per second (500 gallons/minute) throughout the irrigation season could be installed along



the Culbertson Canal to recover approximately 10 850 000 cubic meters (8,800 acre-feet) of water from the ground-water system and return it to the distribution system. In making the necessary calculations for well spacing and well locations to serve as input to the model study that the Geological Survey was going to perform for Reclamation, it appeared that the aquifer characteristics along the canal were marginal for the installation of 32 liters per second (500 gallons/minute) wells. Subsequently, the number of wells was reduced from 43 to 30.

In the first supply well configuration, the Bureau of Reclamation furnished the Geological Survey the location of 30 wells. Seventeen of the wells were located along the old Culbertson Canal parallel to the Frenchman River, eight wells were located along the canal in the vicinity of Blackwood Creek, and five wells were located along the canal extension north of McCook. Each of the wells was simulated as pumping 32 liters per second (500 gallons/minute) during the irrigation season (90-day period) for a total withdrawal of 7 360 000 cubic meters per year (5,970 acre-feet/year). At the end of the hypothetical 2-year study period, the analyses showed that with pumping rates of 32 liters per second (500 gallons/minute), 19 of the 30 wells would have drawdowns causing production to cease before the end of the 90-day period. In order to alleviate the severity of the drawdowns, the number of the wells was increased to 60 and the pumping rates reduced to 16 liters per second (250 gallons/minute). This analysis showed excessive drawdowns caused production to cease in 10 wells.

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The analysis shows that with 30 wells pumping at the rate of 32 liters per second (500 gallons/minute), only 37 percent of the total well field capacity of 7 360 000 cubic meters per year (5,970 acre-feet/year) could be supplied and with 60 wells pumping 16 liters per second (250 gallons/minute), 84 percent of the total capacity could be supplied. Since the drawdown appears to be excessive in wells located along the canal, the simulation for this well configuration was run for only 2 years.

Upon examining the results of the first supply well configuration, it was determined that the aquifers were not capable of readily supplying the desired amount of water with the previously discussed pumping rates without producing excessively high drawdowns and resulting low well efficiencies. Reclamation then developed a second well configuration comprised of 22 wells which were located farther from the canal alignments to take advantage of these areas' more productive aquifers. Six of these wells were located in an area north and east of the confluence of the Republican and Frenchman Rivers and generally parallel to the

Republican River. These six wells were simulated as pumping 32 liters per second (500 gallons/ minute). The other 16 wells were located along selected laterals where the transmissivity looked the best and were simulated as pumping 16 liters per second (250 gallons/minute) for a total pumpage of 3 430 000 cubic meters (2,780 acre-feet) for a 90-day period. These wells were capable of sustaining the required pumping rates in all but four wells during the first year and in all but five wells at the end of the 19-year study period (1977 through 1995). This simulated well configuration was able to supply 79 percent of the total well field capacity of 3 430 000 cubic meters per year (2,780 acre-feet/year) during the study period.

A third analysis was made at the request of Reclamation to determine whether the private irrigation wells located on project lands could supply the total irrigation requirements from ground water. In 1976, there were 156 private irrigation wells within the project area. A total of 4950 hectares (12,230 acres) of project lands were irrigated in part by these wells. The wells were simulated as supplying 3750 cubic meters per hectare (1.23 acre-feet/acre) during the irrigation season (90-day period). No recharge was applied from surface water supplies, thus simulating the conditions of not receiving any surface irrigation water supplies. This simulation showed that the existing private irrigation wells could sustain the water required to irrigate the 4950 hectares (12,230 acres) of project lands for at least the 19-year study period.

The fourth and final analysis was made to determine whether the total demand for the 8550 hectares (21,100 acres) of project lands in the H&RW and Frenchman Valley Irrigation Districts could be supplied with ground water. This analysis was based on a consumptive irrigation requirement of 200 millimeters (8 inches) per year in the study area to determine whether the project lands could be supplied with ground water under steady-state conditions. The results of this study were generally inconclusive as no convergence to steady-state could be obtained. Therefore, this analysis indicated that the ground-water resources could not meet the total irrigation demands.

#### Analyses of Alternatives

Based on information developed by the Geological Survey in their study, Reclamation reexamined the two alternatives, canal lining and ground-water development, which were identified in the January 1977 Frenchman Unit Appraisal Report as having potential for further study.

### Canal Lining

Projections by the Geological Survey indicate that flows in the Frenchman River and Stinking Water Creek will be essentially depleted by 1991. In view of these streamflow depletions, this alternative was not examined in detail during the rehabilitation and betterment studies since the projected absence of surface water flows precludes implementation of this alternative.

### Ground-Water Development

The Geological Survey's study indicates that ground-water resources are not available to the H&RW and Frenchman Valley Irrigation Districts for a long-term water supply. Well yields obtainable along the canal and lateral systems are lower than anticipated and drawdowns appear to be excessive with resultant low pumping efficiencies. With the resulting low well yields and low well efficiencies, it would be difficult to recover the seepage losses that are expected to occur during the irrigation season without resorting to numerous low capacity wells. In addition, other studies performed by the Geological Survey indicate that the canal and lateral seepage, which was to be reclaimed by the wells, will probably not be available by 1991. The yields from the various well layouts are optimistic at best.

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### Findings

Consequently, neither the canal lining alternative nor development of the ground-water resources on a district-wide basis was considered by Reclamation to provide a long-term hydrologic solution to the irrigation districts' water supply problems.

The recreation and fish and wildlife components were not investigated under this rehabilitation and betterment program, due to the conclusionary nature of this study.

# CONCLUSIONS

## CONCLUSIONS

The findings and conclusions resulting from studying the Frenchman Unit, Nebraska, are:

1. That ground-water development above Enders Reservoir has caused depletions of surface water supplies to the H&RW Irrigation District, Frenchman Valley Irrigation District, and the United States. The lack of legislative or judicial definition of the relationship between ground and surface water in Nebraska has permitted this development to occur without restraint.
2. That projections, presented by the Geological Survey at a ground-water control area hearing in Imperial, Nebraska, in March 1977, indicate that the perennial flows in the Frenchman River and Stinking Water Creek would be essentially reduced to zero by 1991 without further development of the ground-water resources.
3. That the Geological Survey's report, published in June 1978, states that the ground-water resources in the project area are insufficient to meet consumptive irrigation requirements for the developed project lands.
4. That neither the ground-water development nor the canal lining alternatives, presented in the Frenchman Unit, Nebraska, Appraisal Report as the most favorable measures to supplement the districts' depleting surface water supplies can be hydrologically justified as a long-term solution.
5. That as a result of ground-water development which has depleted surface water supplies and in view of the depletions expected to occur in the future, Reclamation's studies have not resulted in identification of any physical solution to the H&RW and Frenchman Valley Irrigation Districts' water supply problems.
6. That there is evidence the water shortages within the Frenchman Unit are going to become progressively worse; therefore, the water users should take every possible step to conserve the available water supply.