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BUREAU OF IRRIGATION  
WATER POWER AND DRAINAGE

AN ANALYSIS  
of  
THE WATER SUPPLY OF THE REPUBLICAN RIVER BASIN

Based On  
Confidential Reports of the U. S. Army Engineers  
and Bureau of Reclamation

July 12, 1940

Prepared in the Office of the Nebraska State Planning Board  
Lincoln, Nebraska

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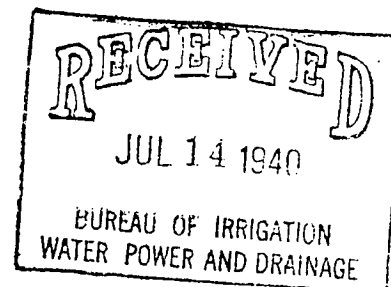
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## State of Nebraska

R. L. COCHRAN, GOVERNOR

LINCOLN

July 12, 1940



Mr. R. W. Willis, Chief  
 Bureau of Irrigation, Water Power & Drainage  
 Department of Roads & Irrigation  
 Bridgeport, Nebraska

Dear Mr. Willis:

Pursuant to your letter of June 22, 1940, we have made rather a hurried study of the water supply of the Republican River Basin. The first draft of our tentative report is enclosed for your perusal and criticism.

Data from the confidential reports of both the Army Engineers and the Bureau of Reclamation were used as a basis for the scope of new development and the principal features of the various contemplated projects. Your records of stream discharge were used in the determination of available water supply. The 10-year average (1930-1939) with flood discharges of May and June, 1935 excluded, was used, because many of the records do not extend beyond 1930, and this period tends to reduce them to more nearly a comparable basis. This period also gives a conservative estimate of the available water supply.

We have checked the reservoir capacities and cost estimates, and the findings are incorporated in our report. In determining the depletions due to the development of the most feasible storage possibilities for irrigation in combination with flood-control, together with the reclamation of the most desirable irrigable areas, we merely assumed a consumptive use of 33 per cent of the headgate diversion of 2.0 acre-feet per acre plus the reservoir losses computed from the average capacity of optimum storage for irrigation and silt accumulations. The monthly discharges were used in computing the optimum storage, or that quantity of storage which could be accumulated at a certain site and utilized economically for irrigation purposes.

Dated July 12, 1940

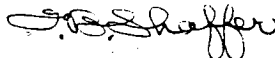
If we have adopted methods of analyzation which are inconsistent with your intended plans of making this study, please let us know and we shall proceed in accordance with your instructions.

By not knowing just when you wanted this material for the meeting of the Republican River representatives, we were anxious to get our findings submitted to you as soon as possible so that we might have an opportunity to make revisions and additions based on your suggestions before the committee convened.

Very truly yours,

NEBRASKA STATE PLANNING BOARD

W. H. Mengel  
Planning Engineer



F. B. Shaffer  
Assistant Engineer

FBS/E  
1 cc A.C. Tilley

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### North Fork of Republican River

The North Fork of the Republican River where it crosses the Colorado-Nebraska line averages 35,500 acre feet annually after having served some 3920 acres in Colorado. <sup>Pa. and Neb.?</sup> An additional 1680 acres are now irrigated in the basin below the state line in Nebraska. The greater part of the land now being served is under the Pioneer Irrigation district. Without storage facilities, the irrigation requirements under existing projects cannot be supplied. Since 1930 the monthly run-off has ranged from a minimum of 300 acre-feet in July 1934 to 6500 acre-feet in March, 1932. Thirty per cent of the run-off occurs during the May-September period.

### Arikaree River

The Arikaree River drainage area is practically all in Colorado although it traverses the extreme north western corner of Kansas and the south western corner of Nebraska. Below the Colorado-Nebraska line, at the mouth of the river near Haigler, Nebraska, the mean annual discharge is 17,400 acre-feet. The May-September discharge averages 55 per cent of the total annual. At present there are only 120 acres being irrigated along this stream, all of which are in Colorado. With the construction of a dam at the Beecher Island site in Colorado for the creation of a 28,000 acre-foot reservoir (16000 acre-feet as an optimum for irrigation and 12,900 acre-feet for silt accumulations) the irretrievable loss from reservoir evaporation would amount to 3,120 acre-feet and the consumptive use for irrigation would aggregate 4,224 acre-feet annually. This supplemental water supply would be available to serve 6400 acres along the Arikaree and Republican rivers.

Of the irrigable land susceptible of irrigation from the water supply of this stream, 4800 acres are in Colorado, 600 in Kansas and 1000 in Nebraska. The development would result in a total depletion of 7,344 acre-feet annually, thus reducing the discharge at the mouth of the stream from 17,400 to 10,056 acre-feet.

#### South Fork of Republican River.

The South Fork of the Republican River rises in Colorado, crosses the northwestern corner of Kansas and joins the Republican River near Benkelman, Nebraska, where it discharges 41,500 acre-feet annually. Forty-six per cent of the annual flow occurs during the May-September period. Approximately 30,500 acre-feet of the run-off of the stream originates in Colorado and practically all of the remainder of 11,000 acre-feet is contributed by the area in Kansas. At present 6800 acres are under irrigation in Colorado and 200 acres in Kansas. With the construction of a dam at the Hale site in Colorado for the creation of a 30,900 acre-foot reservoir (17,000 acre-feet as the optimum for storage and 13,900 acre-feet for silt accumulations), the irretrievable loss from reservoir evaporation would amount to 4,692 acre-feet, and the consumption use from irrigation would aggregate 11,200 acre-feet. The supplemental water supply would be available to serve 17,000 acres all of which is of irrigable land/in Kansas. Such development would result in a total depletion of 15,912 acre-feet annually, thus reducing the discharge at the mouth of the stream from 41,500 to 25,588 acre-feet.

#### Frenchman River

It is estimated that 16,000 acre-feet are contributed annually by the upper part of the Frenchman River drainage system in Colorado.

The drainage area in Nebraska contributes about 67,100 acre-feet annually, making a total annual flow of 83,100 acre-feet at the mouth of the stream near Culbertson, Nebraska. Twenty-nine per cent of the total annual discharge occurs during the May-September period. All the potential irrigation along this stream is below the Colorado-line Nebraska/ in the latter state. All the existing irrigation of 16,680 acres is in Nebraska. Assuming a 38,100 acre-foot storage reservoir at Harvey, of which 29,000 acre-feet were optimum storage for irrigation, and 9,100 acre-feet for silt accumulations, the irretrievable loss from such a reservoir would amount to 4,325 acre-feet annually. With 42,000 acres of irrigable land along the Frenchman, Blackwood Creek and the Republican River, the consumptive use for irrigation would be 27,720 acre-feet. The storage and irrigation depletions of 32,045 acre-feet would therefore reduce the Frenchman River flow to 51,055 acre-feet.

*Power demands?*

#### Medicine Creek

Medicine Creek lies wholly within the State of Nebraska. Forty-nine per cent of the total annual discharge of 44,829 acre-feet occurs during the May-September period. There is no irrigation of any consequence along Medicine Creek at the present time, although there are 5 active appropriations totaling 173 second-feet. The operation of a reservoir on Medicine Creek (25,000 acre-feet as the optimum for irrigation and 8,400 acre-feet for silt accumulations) would result in reducing the annual flow from 44,829 to 41,327 acre-feet.

*Power Requirements?*

There are some narrow strips of irrigable land in the Medicine Creek valley, but because of the high construction costs involved, it is believed that with the exception of about 500 acres on Medicine Creek below the dam site that the water supply of this



depletions resulting from reservoir evaporation losses and the consumptive uses from irrigation would aggregate 23,256 acre-feet. The annual discharge of the river at Max would be reduced from 154,756 to 131,500 acre-feet. The total depletion above the Harlan county reservoir site would amount to 138,760 acre-feet, thus reducing the flow at this point from 409,100 to 270,340 acre-feet. Assuming a reservoir capacity of 269,000 acre-feet, of which 200,000 acre-feet would be the optimum for irrigation and 69,000 acre-feet for silting, the depletions for that part of the so-called Lower Republican River project in Nebraska embracing some 49,000 acres and the reservoir losses prorated between the two states would total 54,625 acre-feet. Therefore, the depletion in flow for all developments herein described above Hardy would total 193,385 acre-feet and the annual flow would be reduced from 463,900 to 275,515 acre-feet.

TABLE I  
 FREQUENCY OF FLOW  
 RIVER AT BLOOMINGTON, IOWA  
 AMOUNTS DESIGNATED OR MORE FOR PER CENT OF TIME INDICATED  
 SECOND-FOOT

Per Cent of Time	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Mean
Max	10,800	9,540	6,940	7,670	5,300	115,000	10,700	8,220	7,700	10,200	19,307
10	1,438	965	1,110	1,238	594	2,219	953	1,004	1,188	836	1,154
20	819	815	707	675	522	983	530	610	757	532	695
30	573	745	486	485	495	546	468	490	615	423	533
40	472	683	399	423	457	444	383	396	531	342	454
50	440	598	280	365	371	404	332	314	476	298	388
60	410	560	204	293	300	359	301	250	373	251	330
70	377	488	168	166	209	297	223	223	252	190	259
80	318	221	120	121	93	165	101	156	185	131	161
90	238	77	69	67	33	98	33	101	119	57	90
Min	126	17	32	14	10	49	7	7	39	9	31
Mean	714	675	499	579	417	1,384	525	503	613	474	638

Example: In 1930 the discharge was 1438 second-feet or more 10% of the time.

stream could be utilized more advantageously in the Republican River Valley. Part of the water supply of Red Willow Creek will also be stored for irrigation along the north side of the Republican River between Cambridge and Oxford.

#### Beaver and Sappa Creeks

The headwater tributary of Beaver Creek rises in Colorado although the drainage areas for Beaver and Sappa Creeks may be considered as entirely in Kansas and Nebraska. At the Nebraska-Kansas line Beaver Creek discharges about 9,500 acre-feet annually and Sappa Creek 14,400 acre-feet. At the site of the dams near Beaver City, Nebraska, the discharges have increased to 14,400 and 17,200 acre-feet respectively. At present only 400 acres in Nebraska are being irrigated. There are some areas in Kansas along Beaver, Sappa, and Prairie Dog creeks which are susceptible of irrigation, but the water supply is too meager and uncertain to justify the expenditure involved. With the construction of dams near Beaver City on Beaver Creek (14,000 acre-feet is optimum storage for irrigation and 19,700 acre-feet for silt) and on Sappa Creek, (17,000 acre-feet as optimum storage for irrigation and 15,200 for silt), there could be served 24,000 acres of irrigable land between the dam sites and the Republican River. Such development would result in a total depletion of 26,300 acre-feet, 10,460 of which as evaporation loss from reservoirs and 15,840 as consumptive use from irrigation. The mean annual discharge of 31,600 acre-feet of the two streams would be reduced to 5,300 acre-feet.

23,700 B+S  
+ 400 x 2  
24,700

24,000 x 2 x .33  
= 15,840  
10,460 evap  
26,300

#### Prairie Dog Creek

The major part of the Prairie Dog Creek drainage basin is in

Kansas. At the Woodruff reservoir site near the Kansas-Nebraska line the run-off averages 32,700 acre-feet annually. There are only 400 acres being irrigated along the stream at the present time. All this land is in Nebraska. About 6,000 acres (1600 in Kansas and 4,400 in Nebraska) are susceptible of irrigation from the Woodruff reservoir. By assuming an optimum storage of 13,000 acre-feet for irrigation and 9,400 acre-feet for silt accumulations, the irretrievable loss from reservoir evaporation would amount to 4,290 acre-feet and the consumptive use for irrigation below the reservoir site would aggregate 3,960 acrefeet. By making further deductions of 6,600 acre-feet for the irrigable land above the Woodruff site, the ultimate depletion would total 14,850 acre-feet. Full development would result in reducing the run-off of the stream from 32,700 to 17,850 acre-feet.

#### Republican River

About 60% or 187,900 acre-feet of the tributary accretions to the Republican River in Nebraska enter the stream from the north side. Colorado contributes 99,400 acre-feet or 21% of the run-off above Hardy, Nebraska, and Kansas 67,600 acre-feet or 14 per cent. Fifty-five per cent of the total annual run-off of 468,900 acre-feet at Hardy occurs during the May-September period. The total inflow from the principal tributaries to the Republican River is 319,100 acre-feet. Above Hardy, Nebraska accretions to the main stem of the Republican and intermittent tributaries for which no records are maintained aggregate 149,800 acre-feet annually. With new developments on the Republican River and tributaries above Max, Nebraska, the

EFFICIENT UTILIZATION OF THE SURFACE WATERS OF THE REPUBLICAN RIVER BASIN

Stream	Project (Army Engr's)	Reservoir	Flood Control	Optimum Storage For Irrigation	
				Army	B of R
Arikaree	Arikaree-Republican	(a)*Beecher Is.	44,000	13,200	16,000
So. Fork	Hale-St. Francis	(a)*Hale	65,500	17,500	17,000
Buffalo		Buffalo			4,500
Frenchman	Frenchman Valley	*Enders		44,000	
		(a) Harvey	24,900		29,000
		(a) Palisade	27,600		12,000
		(a) Blackwood			No Report
Red Willow	Red Willow	(a)*Red Willow	25,000	15,500	15,500
Medicine	Medicine	(a)*Medicine	24,500	17,500	25,000
Beaver	Beaver-Sappa	(a)*Beaver City	43,000	27,000	14,000
Sappa		(a)*Sappa Cr.	32,000	24,000	17,000
Prairie Dog	Prairie Dog	(a)*Woodruff	34,000	13,000	13,000
Republican	Lower Republican	(a)*Harlan Co.	939,000	200,000	200,000
<b>Total</b>			<b>1,269,500</b>	<b>376,700</b>	<b>363,000</b>

Stream	Silt B of R	Av. Stor (1/2 Silt & Irr.)	Res. Area (Acres)	Evap. Loss From Res. (Area x 3.90)	Irrigable Land B of R		
					Colo.	Nebr.	Kan.
Arikaree	12,000	14,000	800	3,120	4,800	1,000	600
So. Fork	13,900	15,450	1,203	4,692			17,000
Buffalo		2,250	500	1,950			
Frenchman						42,000	
* Enders							
(a) Harvey	(1) 9,100	19,050	1,109	4,325			
(a) Palisade	(1) 5,600	8,800	563	2,196			
(a) Blackwood			500	1,950			
Red Willow	8,300	10,900	772	3,011			
Medicine	8,400	16,700	898	3,502			
Beaver	19,700	16,850	1,302	5,078		24,000	
Sappa	15,200	16,100	1,380	5,382			
Prairie Dog	9,400	11,200	1,100	4,290		4,400	11,600
Republican	69,000	134,500	7,326	22,285(N) 6,286(K)		45,000(U) 49,000(L)	14,000
<b>Total</b>	<b>162,800</b>	<b>265,800</b>	<b>17,453</b>	<b>68,067</b>	<b>4,800</b>	<b>165,400</b>	<b>43,200</b>

Stream	Consumptive Use From Irrigation (Acreage x Div. duty 2.0 A.P. x .33% Cons.)			Total Consumptive Use Stor. (for Irr.) & Irrigation			Total
	Colo.	Nebr.	Kan.	Colo.	Nebr.	Kan.	
Arikaree	3,168	660	396	6,288	660	396	7,344
So. Fork			11,220	(2) 4,692		11,220	15,912
Buffalo					1,950		1,950
Frenchman		27,720			27,720		27,720
* Enders							
(a) Harvey					4,325		4,325
(a) Palisade					2,196		2,196
(a) Blackwood					1,950		1,950
Red Willow					3,011		3,011
Medicine					3,502		3,502
Beaver		15,840			26,300		26,300
Sappa							
Prairie Dog		2,904	7,656		7,194	7,656	14,850
Republican		62,040	9,240		84,325	15,526	99,851
<b>Total</b>	<b>3,168</b>	<b>109,164</b>	<b>28,512</b>	<b>10,980</b>	<b>163,133</b>	<b>34,798</b>	<b>208,911</b>

Sel. by Army Engr's as presenting best possibilities as multiple purpose sites.  
(a) Sel. by Bur. of Rec. as presenting best possibilities as multiple purpose sites.  
(1) Arbitrarily reduced because of Sand Hill drainage.  
(2) Res. in Colo. to serve land in Kansas.

## Irrigation

### Present

Because of the semi-arid climate in the Republican River basin in Nebraska, the requirement for supplemental irrigation water varies greatly by years. Types of soil and topographic conditions in the areas where irrigation is being considered appears conducive to successful irrigation practices. Local sentiment seems to favor changes in agricultural and farming methods which would be necessary under irrigation.

Existing developments depend almost entirely upon direct flow diversions. Of the total of 37,750 acres now being irrigated in the Republican River Basin, 28,950 acres or 77 per cent are in Nebraska. Fifty-eight per cent of all land irrigated in the Republican River Basin in Nebraska is on the Frenchman River. The South Fork and North Fork of the Republican are the tributaries next in importance with reference to amount of land irrigated.

The discharge of the Republican River at the Nebraska-Kansas line is 468,900 acre-feet. It is estimated that 301,900 acre-feet originate within the confines of Nebraska. At present 1250 second-feet have been appropriated to serve 115,500 acres under all existing projects on the Republican River and its tributaries in Nebraska, however, not all this land is capable of being served. If all the available water supply were conserved by means of storage facilities and released when needed for irrigation, the supply would greatly exceed that now needed for existing projects.

### Future

The following five applications have been submitted to the Public Works Administration as proposed Public Power and Irrigation districts, local sentiment with reference to in Nebraska and reflect the areas in which new irrigation is desired and needed.

TABLE III

SUMMARY TO SHOW COMPARISON BETWEEN PRINCIPAL FEATURES OF PROJECTS AS DESCRIBED BY PROJECT APPLICATIONS AND THOSE CONSIDERED BY THE BUREAU OF RECLAMATION

Irrigation Project Proposal	As Described in Project App.			As described by Bureau of Reclamation			Remarks
	Reservoirs	Storage Capacity Acre-Feet	Acreage	Reservoirs	Storage Capacity (Irr. & Silt) Acre-Feet	Acreage	
Benkelman-Haigler- Wapakaree	Pioneer	45,000)	28,400	Beecher Is.	28,000	6,400 Arik.	
	Benkelman	40,000)				13,000 Rep.	
	Laid	1,500)					
Imperial	Harvey	32,500	23,555 Sup. 1,000 New	(Harvey (Palisade (Blackwood	38,100 17,600	42,000 New	Below Under Rep. River Red Willow
	Medicine Red Willow	34,500 10,000	30,000	Medicine Red Willow	33,400 21,800	32,000	Rep. River Harlan 1961 site
Beaver Sappa	Beaver Sappa	40,000 40,000	49,000	Beaver Sappa	33,700 32,200	24,000	
	Harlan Co.	42,000	44,000	Harlan	*210,000	49,000	From Harlan Res. 1918 Nebr. Sappa
<b>Total</b>		285,500	152,400 (New)		414,800	166,400	

\*210,000 A.F. chargeable to Nebr. which represents 78% of land in Lower Republican Project.

An examination of the <sup>going</sup> fore summary will reveal that 8 tributary and 1 on-river reservoirs with capacities aggregating 285,500 acre-feet were proposed by the project applications, while under the plan of most efficient development for flood control and irrigation, the same number of reservoirs were considered (some different locations) with combined capacities for irrigation, excluding flood control, of 414,300 acre-feet. Under the project applications, 152,400 acres were to be irrigated, while under the second plan, the comparable areas totaled 166,400 acres.

The following table summarizes the stream contributions and possible depletions by states:

TABLE IV

State & Stream	Mean Annual Discharges (1930-39 Av.) (Acre-feet)	Net Depletions (Acre-feet)	Net Contribution (Acre-feet)
<b>Colorado</b>			
Frenchman	(1) 16,000 Est.	0	16,000
No. Fork	35,500	0	35,500
Arikaree	17,400	8,288	11,112
So. Fork	30,500	0	30,500
Subtotal	99,400	8,288	93,112
<b>Kansas</b>			
Arikaree	0	396	- 396
So. Fork	(1) 11,000 (Net)	15,912	- 4,912
Beaver	(2) 9,500	0	9,500
Sappa	(3) 14,400	0	14,400
Prairie Dog	32,700	7,656	25,044
Subtotal	67,600	23,964	43,636
<b>Nebraska</b>			
Arikaree	0	660	- 660
Buffalo	8,000	1,950	6,050
Frenchman	67,100 (Net)	**36,191	= 30,909
Red Willow	24,500	3,011	21,489
Medicine	44,800	3,502	41,298

23,900

(Continued)



TABLE IV (Continued)

State & Stream	Mean Annual Discharges (1930-39 Av.) (Acre-feet)	Net Depletions (Acre-feet)	Net Contribution (Acre-feet)
Nebraska (Continued)			
Beaver-Sappa	7,700	26,300	-18,600
Prairie Dog	0	7,194	-7,194
Republican (Main stem & minor tributaries in Nebr.)	149,800	* 84,325	65,475
Sub Total	301,900	163,133	138,767
TOTAL	468,900	193,385	275,515

- Note: (a) The mean is based on the last ten years of record. This period was used because it makes practically all records comparable.
- (b) May and June flood discharges of 1935 not included in averages.
- (1) Est. from downstream records.
  - (2) Determined from Ludell and Beaver City records.
  - (3) Determined from Oberlin and Beaver City records.
- \* That part of reservoir loss for 1400 acres or 22 per cent of the Lower Republican project not included
- \*\* Includes storage in Blackwood Creek.

Irrigation Requirement

The irrigation requirement for all projects herein considered was assumed to be 2.0 acre-feet per acre at the point of diversion. With return flow amounting to 67 per cent of the diversion, the consumptive use would be 33 per cent of the total annual diversion. This consumptive use together with reservoir losses computed by multiplying the average surface area, based on irrigation storage plus silt accumulations, by 3.90 feet constitutes the total depletions from the available water supply of the basin.

Both Army Engineer and the Bureau of Reclamation reports indicate that of all the projects studied that only the Lower Republican

utilizing storage water from the Harlan County reservoir as a multiple purpose reservoir, would have a repayment ability equal to construction cost. On all tributary proposals, for irrigation and flood control either separately or together the construction costs will exceed repayment ability.

Estimates show that the additional cost of irrigation storage over that required for flood-control varies from \$63.00 to \$731.00 per acre. If the costs of storage were prorated on the basis of proportional amounts allocated to flood control and irrigation the costs vary from \$79.00 to \$575.00 per acre.

TABLE V

\*COMPARISON OF CONSTRUCTION COST (PROPORTIONAL)  
AND IRRIGATION PAYMENTS AVAILABLE FOR RETIREMENT OF  
IRRIGATION PROJECTS

Project	Annual Payment by Water User	Annual C. & M. Charge	Available for Re- tirement of Const. Cost		Const. Cost
			Annual	40 yrs.	
Frenchman Valley	\$3.00	\$4.48	\$0.00	\$0.00	\$574.73
Arikaree-Republican	3.00	3.17	0.00	0.00	400.75
Hale-St. Francis	3.00	3.11	0.00	0.00	380.66
Beaver-Sappa	3.00	2.87	0.13	5.20	372.98
Prairie Dog Cr.	3.00	2.23	0.77	30.80	255.16
Red Willow Cr.	3.00	1.87	1.13	45.20	155.60
Medicine Cr.	3.00	1.67	1.33	53.20	116.94
Lower Republican	2.60	1.49	1.11	44.40	79.08

\*From Army Engr's. report.

A cursory analysis of the discharge records for the past 10 years and the possible plans of development shows that 41 per cent of the runoff above Hardy, Nebraska would have been consumed if the most feasible irrigation possibilities had been developed to the maximum.

## Flood Control

The capacities of reservoirs were based on the economic capacities determined under 1935 flood conditions. Effectiveness of reservoirs were established by arriving at the potential economic degree of protection to be provided by each reservoir. Because of comparatively uniform width of the valleys of the main stem and tributaries, sites providing sufficient capacity for flood-control purposes are limited, and the cost per acre-foot of the capacity that would be available in reservoirs at these sites would be high. The Army Engineer's selected sites for more detailed study after a reconnaissance of the entire basin.

In every case it would be possible to obtain the greater part of the total potential flood-control benefits by utilizing a reservoir capacity substantially less than that required for complete control of the design flood discharge. A study of the most effective operating methods of tributary and on-river reservoirs was necessary to determine reservoir capacities. The economic limits for reservoir capacities on all tributaries were based on the extent of the drainage areas above the dam site, the run-off characteristics of the streams, and a possible coordinated plan of operation.

The Army Engineers selected 18 reservoir sites as a study of flood control (exclusive of irrigation) 15 of which were on tributaries and 3 on the main stem of the Republican River. Five of these sites namely, Medicine Creek, Red Willow, Harvey, Hale, and Beecher Island were selected as presenting the most favorable possibilities. These reservoirs would provide a substantial degree of protection to 287,500 acres. The total first cost is estimated at \$15,132,150 with annual costs amounting

to \$733,176. The ratio of cost to benefit is 1:0.46. The Harlan county reservoir would provide complete protection for 153,910 acres. This reservoir in combination with Tuttle Creek reservoir on the Big Blue would provide the same benefits on the Kansas and Missouri rivers as the Milford reservoir. The ratio of cost to benefit is 1:2.35.

Silting

Silting capacity was based on a silt load of 0.20 acre-foot per square miles of active drainage area per year for a period of 50 years. Inasmuch that data on the silt load transported by the tributaries of the Republican River are meager, and the estimates used by the Army Engineers are conservative as compared with studies made on the Republican River in 1929 and 1930, it is believed that with the exception of the Frenchman River (which appears excessive in view of different soil types) the silt estimates should be accepted status quo.

Power

Existing hydroelectric power installations are low-head, direct flow developments, with practically no storage to stabilize the stream flow. The following table shows most important hydroelectric plants now in use in the Republican River Basin.

TABLE VI

Stream	Plant	Location	Installed Cap. (K.W.)
Frenchman	Krotter-Palisade	Palisade	264
"	Wauneta L. & P. Co.	Wauneta	125
"	Williams & Enders	Enders	40
"	Imperial	Imperial	245
Republican	So. Nebr. Pow. Co.	Superior	785
Total			1459

The present power market in the Republican River basin consists of rural non-farm requirements and small industrial enterprises. Existing generating and distributing facilities seem adequate to supply the immediate demands.

Power possibilities investigated by the Army Engineers at flood-control reservoir sites on tributaries to the Republican River both as individual power projects and in combination with flood control were found unjustifiable, inasmuch as the annual run-off at these various sites was insufficient to warrant large installations.

Power cost computed on the basis of charging that part of the reservoir capacity allocated to power development plus the cost of installation of power equipment assumed at \$100 per kw., showed the ratio of cost to benefits to average 1:0.23.

Other studies made on the assumption of utilizing the irrigation releases from multiple purpose reservoirs, with no storage costs allocated to power, showed the development of power to be uneconomically justified at all tributary reservoirs, except Woodruff, Red Willow, and Enders. At these sites the benefits just about equalled the costs. Studies by the Army Engineers at the Harlan County reservoir site revealed that power development, either primarily for that purpose, or for power in combination with flood control, is not economically justified, however, assuming that all storage costs be charged to flood control and irrigation, and only fixed charges for the powerhouse and equipment plus maintenance and operation charged to power, the ratio of cost to benefit would be 1:2.01.

#### Navigation

The operation of the Harlan County reservoir as a multiple purpose

development for flood control and irrigation, would result in a more uniform discharge of the Republican River below that point. The peak discharges would be leveled off, and the low water discharge during the late summer months would be increased due to accretions from the return flow.

Navigation would be benefited, inasmuch, that the stabilized flow would reduce the necessity of channel dredging, it would reduce interruptions to river traffic, and minimize damages to regulation structures. The Army Engineers estimate that the average annual benefits to navigation would be \$2,537,230.

#### Pollution Abatement

It is believed that the operation of the tributary reservoirs, either for flood control alone or for flood control and irrigation, would not increase the low-water flow in any appreciable quantity. The operation of the Harlan County reservoir for irrigation would result in an increased flow during the periods of low discharges with annual benefits amounting to \$2,920.

#### Recent Interstate Conferences

In 1939 the sub-committee of the National Resources Committee composed of representatives from Colorado, Nebraska, and Kansas found that the construction of the Imperial, United, Beaver-Sappa and Lower Republican projects embracing the reclamation of some 124,000 acres as then proposed would not cause any conflict among these three states in the equitable apportionment of the waters of the basin. Such developments would not increase the present demand of Nebraska upon Colorado for waters originating in the basin in Colorado. Conversely, contemplated projects in Colorado would not seriously affect developments

in Nebraska. The Committee further agreed that new projects on the Beaver or Sappa creeks in Kansas might cause depletion sufficient to cause later conflicts between Nebraska and Kansas.

Colorado and Nebraska are interested in the ultimate utilization of the waters of the North Fork of the Republican and all three states are concerned with the Arikaree and the South Fork of the Republican River. Kansas and Nebraska are interested in Beaver, Sappa and Prairie Dog creeks and the main stem of the Republican River.

TABLE VII (Continued)  
 SUMMARY OF IRRIGATED AND IRRIGABLE LAND IN REPUBLICAN RIVER BASIN BY STATES  
 (Continued)

Irrigated in 1939 includ-  
 ing area from wells

	Irrigated in 1939		Irrigable		Reservoir	Remarks
	Total	Area from wells	Total	Area from wells		
	Colo.	Nebr.	Colo.	Nebr.		
Republican Haigler-Republican	5,860	5,860	5,000	5,000		
Benkelman-Culbertson			8,000	8,000		Water to be supplied from Arikaree & Rep. 5,000 a.f. from Pioneer site
Red Willow-Rep. City			32,000	32,000		2,000 a.f. from Wray & Buffalo sites
Rep. City-Scandia			63,000	49,000	Harlan Co.	30,000 acres to be served from Red Willow & Medicine Creeks.
White Rock			75,000	75,000		
Below Scandia			90,000	90,000		
<b>Total</b>	<b>57,750</b>	<b>8,600</b>	<b>28,950</b>	<b>200</b>	<b>375,100</b>	<b>4,800</b>
					<b>162,100</b>	<b>208,200</b>
					<b>154,600</b>	

\*Below Idalia site.

\*\*Small quantities to be consumed upstream as part of water facilities program.

(1) Compiled from Bureau of Reclamation "Reconnaissance Report on Republican River Basin" March, 1940.



(1) SUMMARY OF IRRIGATED AND IRRIGABLE LAND IN REPUBLICAN RIVER BASIN BY STATES

	Irrigated in 1939 including area from wells				Irrigable			Reservoir	Remarks
	Total Colo.		Nebr.		Total		Kan.		
	Colo.	Nebr.	Colo.	Nebr.	Colo.	Nebr.			
North Fork	3,920	1,680	2,240	0	200	0	200	0	Wray Res. to supp. existing irr.--2,000 areas additional. Being investigated by Bureau of Reclamation as part of No. Rep. project.
Arkarees**	120	120	0	0	*6,400	4,800	1,000	600	Several thousand acres scattered above Idalia site--canals to serve such shoe string areas as Beecher Is. are costly and no res. site available--3,000 a. irr. Idalia--3,800 a. irr. from Beecher.
Buffalo	825	0	525	0					A few thousand acres above dam site but no up-stream stor. sites available. Water stored here can be used on stem of Rep. to obtain 1,500 acres.
So. Fork**	7,000	6,800	0	200	17,000	0	0	17,000	5,000 acres can be irr. from either res. site
Frenchman**	16,680	0	16,680	0	42,000	0	42,000	0	Irrigable land below Enders site and Rep. River to Red Willow
Red Willow									
Medicine									
Beaver--Sappa	400	0	400	0	24,000	0	24,000	0	9,000 acres can be irrigated from 2 Res.
Prairie Dog	400	0	400	0	16,000	0	4,400	11,600	Irrigable land below Clayton Res. site.
Misc. Streams	2,845	0	2,845	0					

(Continued)

TABLE VIII

RESERVOIR SITES IN REPUBLICAN RIVER BASIN

	Adopted Storage Capacity for Flood Control (Army)	Total First Cost of Flood Control	Drainage Area Above Dam Site	Flood Control and Irrigation				Reservoir Capacities		Reservoir Cost Estimates		
				Army Engineers		Bureau of Reclamation		Total	Army		B of R	
				Flood	Silt	Irr.	Total					Flood
Investigation in progress by Bureau of Reclamation												
North Fork												
North Fork												
*Wray												
Arikaree												
Arikaree	47,200	\$3,697,581	1,569	42,000	12,000	18,000	72,000	44,000	12,000	16,000	\$6,404,862	6,000,000
Idalia	54,000	3,988,387	1,740									
*Becher Is.	59,700	3,912,366	1,909									
Pioneer												
Buffalo												
*Buffalo												425,000
South Fork												
*Hale	78,900	5,139,336	2,003	65,000	15,900	17,500	96,400	65,500	13,900	17,000	7,184,000	7,000,000
St. Francis	81,800	5,641,488	2,094									
Benkelman	105,100	5,716,527	2,721									
Frenchman												
*Harvey	47,300	2,470,920	2,144	29,000	18,300	0	63,000	(2)	(2)	9,100	29,000	1,500,000
*Enders	49,200	3,800,627	2,240	50,000	19,200	44,000						
Culbertson	53,000	5,505,184	3,753									
Stinking Water												
*Palisade	30,100	1,774,621	1,113	19,000	11,100	0	34,000	(2)	(2)	5,600	12,000	1,400,000
Blackwood												
*Blackwood												
Red Willow												
Osbern												
*Red Willow	31,300	1,639,007	632	46,800	25,000	15,500	46,800	25,000	6,300	15,500	2,150,000	2,000,000
Medicine Creek												
*Medicine Cr.	40,400	1,894,500	838	57,900	32,000	8,400	57,900	24,500	8,400	25,000	2,460,500	2,500,000
Beaver Creek												
Hemdon												
*Beaver City	49,700	4,469,458	1,966	76,700	50,000	19,700	76,700	43,000	19,700	14,000	5,556,900	5,000,000

(Continued)

RESERVOIR SITES IN REPUBLICAN RIVER BASIN  
(Continued)

	Adopted		Flood Control and Irrigation											
	Storage Capacity for Flood Control (Army)	First Cost of Flood Control	Reservoir Capacities		Bureau of Reclamation		Army		Irr.		Reservoir Cost Estimates			
			Total	Silt	Total	Flood	Silt	Irr.	Army	B of R	Army	B of R		
Sappa	40,200	\$4,479,083	1,516	64,200	25,000	15,200	24,000	17,000	15,200	32,000	15,200	17,000	\$5,764,300	\$5,000,000
Oberlin														
Moroatur														
*Sappa														
Prairie Dog														
Clayton														
Almena														
*Woodruff	43,400	\$,161,730	937	56,400	34,000	9,400	13,000	9,400	34,000	34,000	9,400	13,000	3,860,200	3,500,000
Rope Creek														
Rope Cr.														
Republican River														
*Harlan	1,008,000	20,078,098	20,753	1,208,000	939,000	69,000	200,000	1208,000	839,000	69,000	200,000	200,000	21,935,000	22,000,000
Soandia	1,095,000	20,611,987	22,830											
White Rock (Feeder from Rep.)														
Milford	1,170,000		24,852											

#Extension of Gilbertson Canal from Frenchman Creek.  
 \*Tentative reservoir sites used by Bureau of Reclamation in making cost estimates in Republican River reconnaissance.  
 (2) Adjusted to correct silt estimate.

TABLE IX

IRRIGATION PROJECTS SELECTED FOR STUDY BY ARMY ENGINEERS

Project	Cost Estimates			Reservoir	Add. Stor. for Irr.	Irrigable Acreage			
	Total Charge-able to Irr.	Stor. & Control	Div. & Dist.			Per A.F. of Proj. Area	Total	Colo. Nebr. Kans.	
Arkaree-Repub.	\$2,609,808	\$2,416,475	\$193,333	Beecher Is.	18,200	4,900	2,870	450	1,580
Hale-St. Francis	2,164,180	2,059,640	104,540	Hale	17,500	4,000	0	0	4,000
Frenchman	4,504,792	4,208,282	10,280 286,230	Enders	44,000	*14,550 6,150 F. & R.	0	0	0
Red Willow	686,947	522,836	164,111	Red Willow	15,500	(2,200 Red W. (4,050 Rep.	0	6,250	0
Medicine	859,632	594,700	264,932	Medicine	17,500	( 600 Med. (9,150 Rep.	0	9,750	0
Beaver-Seppa	2,707,662	2,372,638	335,024	Beaver Seppa	27,000 24,000	(4,740 Bea. (5,360 Sap. (2,400 Bel. Junc.	0	12,500	0
Prairie Dog	797,046	698,491	98,555	Prairie Dog	13,000	4,200	0	4,200	0
Lower Repub.	6,900,339	1,856,903	5,043,436	Harlan Co.	200,000	109,700	0	44,000	65,700
Soandia	8,206,428	2,690,028	5,516,400	Soandia	200,000	120,000	0	0	120,000
Total	29,436,834	17,419,993	12,016,841		576,700	277,450 100%	2,870 1%	83,300 30%	191,280 69%

\*Existing Irr. to receive supplemental water.

TABLE X

SUMMARY OF RUN-OFF RECORDS AND IRRIGABLE AREAS  
FOR REPUBLICAN RIVER AND TRIBUTARIES

Station & Station	Drainage Area Sq. Miles	Mean Annual Run-off Acre-Feet		Inches Army Engr's	Bureau of Reclamation Irrigable Acreage	Acreage Considered by A. Engr's	Cost Est. Per Acre, A. Engr. (Based on Irr. Stor. & add. to contract)
		Army Engr's	B of Irr. Engr's				
MF Republican Reber Line	1870 1998	36,300 38,000	35,500	.36 .36	(1) 200		
AX Republican	1918	22,500	17,400	.22	6400	4,900	\$532.61
SF Republican	2726	40,200	41,500	.28	17,000	4,000	541.05
Free Republican River	2386 3765	71,600 88,300	83,100	.56 .44	42,000	*20,700 (6150 New)	730.81 (6150 A. New)
Stinger Water Cr.	1200	26,020		.41			
RW Republican	742	24,520		.62		6,250	109.91
Red Republican	864	58,800	44,800	1.28		9,750	88.17

(Continued)

TABLE X (Continued)

SUMMARY OF RUN-OFF RECORDS AND IRRIGABLE AREAS  
FOR REPUBLICAN RIVER AND TRIBUTARIES  
(Continued)

Stream & Station	Drainage Area Sq. Miles	Mean Annual Run-off Acre-feet		Inches Army Engr's	Bureau of Reclamation Irrigable Acreage	Acreage Considered by A. Engr's	Cost Est. per Acre, A. Engr's (Based on Irr. Stor. in addition to flood control)
		Army	B of Irr.				
Beaver Creek Ludell, Kan.	1,391	4,570		.06)			
Beaver City	1,964	16,320	14,400	.16)	24,000	12,500	\$216.61
Sappa Creek Oberlin, Kan.	1,073	11,650		.20)			
Beaver City	1,492	19,250	17,200	.24)			
Prairie Dog Cr. Woodruff, Kan.	921	32,700		.67	16,000	4,200	189.77
Republican River Benkelman, Nebr.	4,416	60,000		.25	5,000		
" "	7,188	154,756		.39			
" "	7,897	194,600	124,900	.46	8,000		
" "	12,558				32,000		
" "	21,037	477,700	409,100	.43	49,000)		
" "	22,410	534,100	468,900	.45	**14,000)	109,700	62.90
" "				.45	**75,000)		
Scandia, Kan.	22,930	552,000					
Concordia, "	23,538						
Junction City, Kan.	24,948	1,058,000		.80	**90,000	120,000	68.39

\*Including 14,550 acres under existing projects. \*\*Acreage in Kansas. (1) AP report of July 8, 1940 indicates that 5,400 acres in Colo. and Nebr. are to be served under a project proposal now being studied by Bureau of Reclamation.