

CHAPTER III. DISCUSSION

I. NAVIGATION

1670. The Columbia is a river with steep slopes, high velocities, and numerous rapids, flowing through a tortuous channel from 2,000 to 3,000 feet below the level of the surrounding country, much of which is semiarid and comparatively unproductive without irrigation. (See pl. no. 33.) The volume of water carried by the river justifies a serious consideration of its practical use for navigation, but investigation of conditions in the Columbia above the Snake shows that the cost of improvements necessary to give a satisfactory width and depth to the channel is much greater than any possible river commerce would warrant.

1671. The river formed the main artery for transportation of goods and people to and from the interior in the early trapping and mining days, but with the advent of the railroads the river commerce above the Snake rapidly dwindled to insignificant proportions and finally disappeared.

1672. Considerable work has been done in the past to improve the river channel. As a result properly equipped boats of high power can now navigate the Columbia from its mouth to the foot of Grand Rapids at medium stages of the river, a distance of 700 miles. The work done includes removal of rock from Priest, Cabinet, and Rock Island Rapids, and of placing iron posts and ringbolts to enable boats to ascend these rapids by means of lines. Above Wenatchee, work of removing boulders and reefs was done at the mouth of Wenatchee River, at Rocky Beach, Chelan, Methow Rapids, Foster Creek Rapids, Box Canyon, Long Rapids, Whitecap Rapids, Parson Rapids, Hell Gate, Spokane Rapids, Rogers Bar, Gifford Rapids, and Three Rock Bend. A new channel was dredged at Entiat Rapids. This made the navigation of the river above Wenatchee easier and less dangerous.

1673. Complete bars to successful improvement by open-river methods occur at Priest Rapids, Rock Island Rapids, Grand Rapids, and Kettle Falls.

1674. Partial canalization of the river to Wenatchee can be secured by open-river improvement between the Snake River and Priest Rapids and by the construction of a dam and locks at Priest Rapids and locks at Rock Island. Between Snake River and Priest Rapids the controlling depth is $3\frac{1}{2}$ feet. The obstructions consist of gravel bars, and the depth could be increased to 6 feet by dredging a distance of 1 mile at Richland and for lesser distances at miles 40-46 above the Snake. The Priest Rapids Dam would provide slack water to Rock Island Dam, and the Rock Island Dam will provide slack water to Wenatchee.

1675. It is estimated that the open-river work would cost \$1,750,000, the Priest Rapids locks \$5,400,000, and the locks at Rock Island \$1,800,000, making a total charge against navigation of \$8,950,000.

1676. The high dam at Grand Coulee would create a lake reaching to the Canadian line, submerging Grand Rapids and Kettle Falls and providing slack water for local commerce.

1677. The complete canalization of the river can be accomplished by building a lock and lateral canal at Richland and at mile 40 above the Snake; dams and locks at Priest Rapids, Rock Island Rapids, Rocky Reach, Chelan, Foster Creek, Grand Coulee, a lock at Grand

Rapids, and a dam and lock at Kettle Falls. These dams would create a series of pools approximating slack water during low stages of the river, but during higher stages high velocities would be encountered at points below the dams which would make upstream navigation difficult.

1678. The cost of this work is estimated at \$165,000,000. Interest on this amount at 4 percent would be \$6,600,000 annually, which would, of course, be prohibitive if any appreciable proportion of the cost were charged against navigation.

1679. It is apparent that the fall in the Columbia, which is five times as great as the fall in the Ohio, is a serious obstacle to navigation because of the high initial cost of canalization, the high operating cost, and the delays incident to passing through the numerous locks.

1680. The test as to feasibility depends upon the per ton-mile cost as compared to cost of transportation by existing agencies.

1681. The ton-mile cost of shipping produce, such as wheat, from points above the Snake to Portland will depend upon the volume of business. The total traffic on the Ohio in 1926 amounted to nearly 20,000,000 tons. Individual companies handled from 500,000 to 2,000,000 tons annually by river transportation. Such a volume of business permits the development of facilities for handling the traffic at a very low unit cost. Sand, gravel, stone, coal, and petroleum form 90.8 percent of the traffic on the Ohio and 62.8 percent of the traffic on the Mississippi. This class of freight is particularly suited to water transportation.

1682. The Columbia River taps a sparsely settled country where the products from irrigated land form the principal articles of commerce. There are no mines or quarries of consequence adjacent to this river, nor are there any large industrial enterprises along the upper river which require fuel or raw material. The opportunity for shipping agricultural products is limited quite largely to the irrigated areas. In 1908, the year showing the greatest tonnage on Columbia River above the Snake, the local freight amounted to only 54,000 tons.

1683. The products which might be shipped by water are apples, certain vegetables, beans, dairy products, wool, hay, and grain. Some of these products would require refrigeration, while such products as hay and grain could be handled to advantage in boats or barges used for carrying wood or coal as fuel to the farming districts.

1684. Not all of the produce raised would be available for shipment by river. A large percentage of the fruits and vegetables goes east, and much of the remaining produce goes to the industrial centers around Puget Sound. Apples or other produce for export may go by water. Perishable products, such as certain vegetables, fruits, dairy and meat products require rapid transit or refrigeration and shipments may be very seasonal. Grain or beans for export would be admirably suited to water transportation, but both the seasonal character of production and the small total tonnage will not be great enough to justify the expenditure necessary to provide water transportation.

1685. Shipments by water are further restricted by the cost of delivery to the water terminals. The river forms the boundary of the project, while three transcontinental lines cross the project lands. The cost of the long haul to points on the river gives an advantage to the railway shipments over shipment by water.

1686. Upstream shipments would be limited to fuel, farm machinery which might be manufactured on the coast or shipped by water from the East, and certain package goods. The traffic would be seasonal and uncertain as no one shipper or consignee would handle enough business to justify continuous service.

1687. It is estimated that the shipments by water in and out of the territory above the Snake would not exceed 250,000 tons annually. The cost per ton of transporting goods from points between Wenatchee and Portland will be about as shown in table no. 225 on the basis of 250,000 tons annually.

TABLE NO. 225.—*Cost per ton for water transportation on the Columbia River*

[These figures refer to the improvements necessary to permit water transportation from Wenatchee to Portland when the river is fully developed for power]

Section of river	Cost of locks	Tons originating in section of river	Tons passing over section of river	Interest, 4 percent of cost of locks	Proportion of interest chargeable various sections of river	Cost of operation and maintenance of locks
Below Snake River.....	\$14,600,000	600,000	850,000	\$584,000	¹ \$664,941	\$395,630
Priest Rapids.....	1,750,000	67,500	250,000	70,000	74,806	15,000
Priest Rapids Locks.....	5,400,000	32,500	182,500	216,000	36,018	20,000
Rock Island Locks.....	1,800,000	150,000	150,000	72,000	166,235	10,000
Total.....	18,550,000	850,000		942,000	942,000	440,630

Section of river	Operation and maintenance chargeable to section	Total charges for section	Operation and maintenance charges per ton	Cost of water transportation at 8 mills per ton-mile	Total cost per ton by water
Below Snake River.....	² \$311,033	\$975,974	\$1.627	\$1.888	\$3.515
Priest Rapids.....	34,991	109,797	1.627	2.408	4.035
Priest Rapids Locks.....	16,848	52,866	1.627	2.680	4.307
Rock Island Locks.....	77,758	243,993	1.627	2.728	4.355
Total.....	440,630	1,382,630			

$$\begin{array}{r} 1\ 600,000 \\ 850,000 \end{array} \times 942,000 = 664,941.$$

$$\begin{array}{r} 2\ 600,000 \\ 850,000 \end{array} \times 440,630 = 311,033.$$

1688. The average per ton-mile rates for freight carried by the railways of Washington in 1929 was \$0.01314. Using this rate per ton-mile for the distances given the cost per ton by rail and water haul would be as follows for different assumptions as to tonnage:

Miles above Portland	Points on river	Cost of water haul per ton (estimated tonnage)		Cost of rail haul per ton
		500,000 tons	250,000 tons	
341	Wenatchee to Portland.....	\$3.26	\$4.35	\$4.48
335	Midway between Rock Island and Priest Rapids to Portland.....	3.26	4.30	4.40
300	Midway between Priest Rapids and the Snake to Portland.....	3.06	4.03	3.94

1689. From the above it appears that the improvement of the river for navigation will not result in any appreciable saving to producers or shippers above the mouth of the Snake if the tonnage does not exceed 250,000 tons annually but that if the tonnage above the Snake equals 500,000 tons there might be a saving of more than \$1 per ton.

1690. It appears, therefore, that navigation is of no present importance and that future consideration will have to depend upon conditions as they develop.

1691. Although the steep gradient of the river affects navigation adversely, it favors the development of power. Power of irrigation dams will create pools of varying lengths which may offer opportunity for local commerce. The high dam at Grand Coulee, for example, will form slack water for a distance of 152 miles. There are certain clay deposits on the upper Columbia which are used in Spokane for pottery. Some grain is produced along the upper river where the rainfall is heavier than on the Columbia Basin. Ore and timber might also form a source of revenue for local traffic on the river above Grand Coulee.

1692. It is concluded that—

1. Expenditures necessary to permit through traffic by canalization on Columbia River above the Snake are not justified by any reasonable expectation of shipments by water in or out of the territory.

2. Navigation from Portland to points below Wenatchee could be made possible by the construction of locks in all dams below Wenatchee when the river is fully developed for power.

3. The construction of any dams for the development of power would make local traffic in the pool above it possible. No special expenditure will be necessary to facilitate the development of the local commerce with the exception of the improvement of the channels at the upper end of the pool to accommodate traffic during low stages of the river.

4. Traffic on the river in and out of the territory above the Snake would represent no saving to producers, shippers, or consumers unless such traffic exceeded 250,000 tons annually.

5. The possibility of future traffic on the river above the Snake may justify Federal participation in the construction of locks when and if such are needed.

II. POWER

1693. Chapter II contains quite full information as to the power possibilities of eight sites on the Columbia above the Snake.

1694. At some of these sites—Vantage, Rocky Reach, and Chelan—the data are not so complete nor have the plans been worked out in as much detail as at the other sites, as foundation conditions were found to be not favorable to cheap development of power. Rocky Reach and Chelan sites will no doubt be developed at some future date, when the power which they can produce is required and after the more favorable sites have been placed in commission.

1695. The development of these two sites will not affect the general plan of utilization of the waters of the stream, nor will it affect the coordination of the various interests under consideration, except that that stretch of river between Wenatchee and Bridgeport cannot be canalized until dams have been constructed at Rocky Reach and Chelan. However, there is no evidence that such improvement for navigation will be required for many years.

1696. Power sites at Priest Rapids, Rock Island, Foster Creek, Grand Coulee, and Kettle Falls all permit of being developed at reasonable cost. The construction of dams and power plants at any one of these sites can be justified on economic grounds as soon as there

is a sufficient market to absorb the power generated in a reasonable length of time.

1697. Time is an important element for consideration in determining the economic feasibility of power plants on the Columbia. The plants are all large, and, except for Kettle Falls, do not readily lend themselves to stage development. It is necessary to construct the dam before any power can be generated, and it forms the major part of the cost of development. If the power cannot be sold at a rate so as to load the plant within a short time, interest on the investment increases the cost to such an extent that the development becomes uneconomical.

1698. To permit of a full development of the potential power of the river it is necessary that the backwater formed by any dam extend up to the tail water below the next higher dam. The locations of the power sites above the Snake are fixed by the topography and foundation conditions. The heights of dams to make the fullest use of the potential power are, except at Priest Rapids and Grand Coulee, also fixed within very narrow limits.

1699. The dam at Rocky Reach is located only a short distance above the backwater from the Rock Island development and backs the water to Chelan tail water. The Chelan Dam backs the water to Foster Creek Dam, which in turn backs the water to the Grand Coulee site.

1700. There remain, therefore, for comparison the relative advantages between the two heights of dam at Priest Rapids and also at the Grand Coulee.

1701. The low dam at Priest Rapids, which would back the water to the Vantage site, requires a development at Vantage to obtain full utilization of the potential power between the foot of Priest Rapids and Rock Island Rapids. The dam at Vantage would be low and not an efficient means of developing power, as the head decreases materially with the higher river stages. (See table no. 97.) Also, the foundation conditions at this site are poor. (See pl. no. 85.)²

1702. Less power could be generated with the low Priest Rapids Dam and Vantage Dam than would be available with the high dam at Priest Rapids, due, among other things, to loss of head at Vantage during high water, and also to the increased friction losses in the river by reason of the smaller cross section with corresponding increased velocities.

1703. A comparison of the two systems is as follows: First, the power lost with natural and regulated discharges for plans nos. 2-A and 4 would be as follows:

Plan of regulation	Power lost 100 percent of time, in kilowatts, if the lower Priest Rapids and Vantage Dams are built	
	With low Grand Coulee Dam	With high Grand Coulee Dam
Natural.....	1,000	1,000
Plan no. 2-A.....	8,000	14,000
Plan no. 4.....	11,000	18,000

² Not printed.

Second, the relative costs are:

Item	Low Priest Rapids Dam + Vantage	High Priest Rapids Dam
Total cost, private development (includes interest during construction at 6 percent).....		
Installed capacity..... kilowatts.....	\$76,899,896	\$60,523,811
Cost per kilowatt installed.....	690,000	648,000
Cost per kilowatt-hour (55% load factor)..... mills.....	\$111.20	\$93.50
	\$1.98	\$1.58

1704. The high dam at Priest Rapids is preferred and has been included in the plan for development of the river. However, plans for the low dam and for the Vantage development have also been given.

1705. At Grand Coulee there is a possibility of varying the height of the dam, depending on the desirability of submerging Kettle Falls. If the low dam at the Grand Coulee be constructed, the dam at Kettle Falls should back the water to the international boundary, as the only site between—the one at Little Dalles, 26 miles above Kettle Falls and 16 miles below the boundary—cannot be developed to produce cheap power. The potential power in that stretch between the boundary and Kettle Falls can best be developed by a plant at the falls designed to use the total head, or by the high dam at Grand Coulee.

1706. There remain, therefore, for comparison the relative advantages of the two dams at Grand Coulee, considered as a power development only; that is, without irrigation. For a discussion of the irrigation feature combined with power, see "Irrigation" section of this chapter.

1707. To make this comparison, consideration must be given to the two systems of developing the potential power above the Grand Coulee site—first, the high dam; second, the low dam with Kettle Falls and with the Fish Hawk site on the Spokane River, both of which would be submerged by the high Grand Coulee Dam.

1708. More potential power can be developed with the high dam than with the low dam, Kettle Falls, and Fish Hawk. The amount of this difference varies with the plan of regulation considered, being 277,000 kilowatts for plan no. 2-A, and 247,000 kilowatts for plan no. 4. The results are shown by item no. 36 of table no. 99 as a gain to the high dam.

1709. The losses under the low Grand Coulee-Kettle Falls-Fish Hawk plan would obtain forever, as it would not be possible to develop the power at some other site. The loss is due, among other things, to reduction in head at the lower-head plants by increase in tail water elevation with increased discharge, also to the greater losses in friction between plants, due to the smaller cross-section of the river and consequent higher velocities, and to the impossibility of developing all the available head all the time with the combination plan, due to changes in backwater effect. (See table no. 97.)

1710. The high dam also provides a large storage of water, over 5,000,000 acre-feet, which could be regulated so as to increase the 100-percent potential power at the Grand Coulee and at all plants below. This increase is given by item no. 37 in table no. 99 for the

downstream plants, the total difference or gain to the high dam being shown by item no. 38 in that same table.

1711. This possibility of increasing the prime potential power would also be lost forever if the low dam were built. It is probable that Chelan and Rocky Reach sites will not be improved for many years and that the Vantage site will never be used. Omitting these from consideration, by constructing the low Grand Coulee Dam, there would be lost at Foster Creek, Rock Island and at the high Priest Rapids site, 281,000 kilowatts 100 percent of the time with upstream storage regulated under plan no. 2-A. It is difficult to set a value on this. It is not developed power but is the amount of potential power that could be obtained from the additional water supplied at low-flow periods if the plants below were constructed. These losses, together with the losses given in paragraph 1708 above, are real losses of possibilities for power development, and to that extent reduce the possibilities of developing the potential power of the river.

1712. If the high Grand Coulee Dam is compared with the low Grand Coulee Dam system (low Grand Coulee Dam plus Kettle Falls plus Fish Hawk), the cost of energy is lower for the low-dam system. If credit be given the high dam for the increase in prime power at Foster Creek, Rock Island, and Priest Rapids, made possible by regulation of storage above the high Grand Coulee Dam the cost, of energy is found to be about the same as that for the low-dam system.

1713. A comparison of high dam at Grand Coulee, considered as a power project only, with low dam at Grand Coulee plus Kettle Falls plus Fish Hawk follows:

Item	High Grand Coulee Dam	Low Grand Coulee Dam plus Kettle Falls plus Fish Hawk
Potential power gained 100 percent of time at Grand Coulee:		
Natural flow..... kilowatts.....	21, 000	
Regulated for plan no. 2-A..... do.....	277, 000	
Potential power gained 100 percent of time at plants below Grand Coulee by virtue of storage above high Grand Coulee Dam:		
Foster Creek..... kilowatts.....	134, 000	
Rock Island..... do.....	40, 000	
Priest Rapids..... do.....	107, 000	
Total (plan no. 2-A regulation)..... do.....	281, 000	
Total gain (plan no. 2-A regulation)..... do.....	558, 000	
Total cost, private development (includes interest during construction at 6 percent).....	\$181, 607, 000	\$148, 574, 000
Installed capacity..... kilowatts.....	1, 575, 000	1, 697, 700
Cost per kilowatt installed.....	\$115. 31	\$75. 15
Other considerations.....	(¹)	(²)

¹ Will be more difficult to construct. Much larger energy of falling water to contend with at toe of dam. Will flood more land. Greater cost.

² Will permit of stage development. Will not interfere with proposed development at Kettle Falls for which application for license is now pending.

1714. The percentage of the total head developed by various plants and combinations of plants is given in table no. 97 of chapter II. This table shows that the high dam at Priest Rapids and the high dam at Grand Coulee make better use of the available fall or head than do the lower dams, the loss with natural flow by using the lower dams being 1 percent of the total head for the low-water month and 7 per-

cent for the high-water month. The table also shows that the high dam at Grand Coulee plus Foster Creek plus Rock Island plus the high dam at Priest Rapids will develop 79 percent of the total head for the low-water month, and 63 percent for the high-water month, both with natural flow—that is, omitting Rocky Reach and Chelan, where the foundation conditions are not good—causes a loss of only 17 percent of the total head for low-water month and 9 percent for the high-water month.

1715. Table no. 226 gives a summary of capital, operating and energy costs for the various plants for two rates of interest, viz, 4 percent and 6 percent. Columns (1), (2), and (3) are self-explanatory. Column (4) gives the installed capacity in kilowatts as used in the preparation of the estimates. Column (5) gives the estimated cost of a completed plant, assuming complete development at one time; i.e., without step or stage development. Column (6) gives the estimated cost per kilowatt installed and was obtained by dividing the entries in column (5) by those in column (4). Columns (7) and (8) give the estimated annual operating costs, column (7) expressing this in dollars, and column (8) in percent of the capital cost (column (5)). For public development (4-percent money), the operating costs include interest, depreciation, amortization, maintenance, and operation. For private development (6-percent money), the operating costs include interest, depreciation, taxes, maintenance, and operation.

TABLE No. 226.—Summary of costs

PUBLIC DEVELOPMENT

Item	Above Snake	Miles	Designation	Plant capacity	Cost of completed plant	Cost per kilowatt installed	Annual operating cost		Annual output, 90 per cent duration, case 6	Annual plant capacity factor, with (9)	Cost of energy per kilowatt-hour for (9)	Annual output, minimum flow, case 6	Annual plant capacity with (12)	Cost of energy per kilowatt-hour for (6)	Cost of energy per kilowatt-hour, 55 per cent plant capacity factor
							Amount	Percent of capital cost							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
				<i>Kilowatts</i>				<i>Kilowatt-years</i>	<i>Percent</i>	<i>Mills</i>	<i>Kilowatt-years</i>	<i>Percent</i>	<i>Mills</i>	<i>Mills</i>	
1	383		Kettle Falls	447,700	\$30,075,148	\$67.18	6.3	289,000	64.5	0.75	241,000	54	0.90	0.89	
2	274		Grand Coulee, low	1,230,000	107,633,003	87.51	5.76	593,545	48.3	1.19	494,864	40.2	1.43	1.03	
3	274		Grand Coulee, high	1,575,000	171,186,777	108.69	5.52	947,419	60.0	1.14	785,364	50	1.38	1.25	
4	291		Foster Creek	691,200	46,221,056	66.87	6.22	438,874	63.5	.75	366,000	53	.90	.87	
5	180		Chelan	450,000	37,645,329	83.66	6.19	257,032	57.0	1.035	216,000	48	1.23	1.07	
6	180		Rocky Reach	336,000	36,413,897	108.97	6.14	170,360	50.7	1.51	146,000	43.5	1.76	1.39	
7	128		Rocky Island	180,000											
8	98		Vantage	300,000	36,235,521	120.79	6.42	154,399	51.5	1.73	133,156	44.4	2.00	1.61	
9	73		Priest Rapids, low	390,000	37,612,651	96.44	6.14	251,254	64.5	1.05	215,000	55	1.23	1.23	
10	73		Priest Rapids, high	648,000	57,892,342	89.34	5.9	417,218	64.5	.83	395,000	55	1.09	1.09	

PRIVATE DEVELOPMENT

1	383		Kettle Falls	447,700	\$31,189,044	\$69.67	8.5	289,000	64.5	1.05	241,000	54	1.25	1.23
2	274		Grand Coulee, low	1,230,000	114,184,575	92.83	8.02	692,145	48.3	1.70	494,864	40.2	2.11	1.54
3	274		Grand Coulee, high	1,575,000	181,006,841	115.31	7.83	947,419	60.0	1.71	785,364	50	2.07	1.87
4	291		Foster Creek	691,200	48,052,013	69.91	8.42	438,874	63.5	1.06	366,000	53	1.27	1.23
5	180		Chelan	450,000	39,039,600	86.79	8.29	257,032	57.0	1.46	216,000	48	1.74	1.51
6	180		Rocky Reach	336,000	37,969,968	113.01	8.35	170,360	50.7	2.13	146,000	43.5	2.47	1.96
7	128		Rocky Island	180,000										
8	98		Vantage	300,000	37,377,378	125.26	8.37	154,399	51.5	2.38	133,156	44.4	2.70	2.22
9	73		Priest Rapids, low	390,000	39,322,318	100.83	8.04	251,254	64.5	1.50	215,000	55	1.74	1.74
10	73		Priest Rapids, high	648,000	60,523,811	93.40	8.12	417,218	64.5	1.33	366,000	55	1.58	1.58

1716. Column (9) gives the annual output in kilowatt-years, based on the energy available 90 percent of the time for case 6. As an example, refer to plate no. 41,² which gives the power durations for different conditions at Kettle Falls. The 289,000 kilowatt-years shown for Kettle Falls in column (9) of table no. 226 are shown by the shaded area on plate no. 41.² Column (10) is the annual plant capacity factor and is the ratio of column (9) to column (4).

1717. Column (11) gives the cost in mills per kilowatt-hour as obtained from the expression:

$$\text{Cost per kilowatt-hour in mills} = \frac{1000 \times \text{column (7)}}{8760 \times \text{column (9)}}$$

The cost of energy for any plant-capacity factor may be read from the curves entitled "Cost per kilowatt-hour for varying plant-capacity factors" as presented in the preceding text for any particular site. Again considering the Kettle Falls project, these curves are shown on plate no. 42.² During the first years of operation before a given plant could be fully loaded, the annual output would ordinarily be less than that shown in column (9). The carrying charges during such periods of partial productivity are included in the annual operating costs and are reflected in the higher kilowatt-hour costs with the lower plant-capacity factors. If a step or stage development could be made, the annual operating charges would be less, thus reducing the energy costs. Where the power-house would be integral with the dam the cost of the principal items can be deferred for the later stages of a step development is a small percentage of the cost of the completed plant, so that there would be but a slight difference in the cost of energy as between that for complete development in one step and that for stage development.

1718. Column (12) is the annual output in kilowatt-years based on the minimum monthly discharge for case 6. Column (13) is the annual plant capacity for minimum-flow conditions, being the ratio of column (12) to column (4). Column (14) gives the cost in mills per kilowatt-hour as obtained from the expression:

$$\text{Cost per kilowatt-hour in mills} = \frac{1000 \times \text{column (7)}}{8760 \times \text{column (12)}}$$

Column (15) gives the cost in mills per kilowatt-hour with an annual plant-capacity factor of 55 percent, this being done solely for purposes of comparison.

1719. Table no. 227 gives the "power capacity" in horsepower, as defined by the Federal Power Commission (see par. 493), of the various sites on the main river, for cases 1, 6, 7, and 8.

²Not printed.

TABLE NO. 227.—Power capacity as defined by Federal Power Commission

Power site (1)	Case no. (2)	Discharge for 90 per cent of time (3)	Average static head for 17 years (4)	Power capacity (3) by (4) by 0.08 (5)
		<i>Sec.-ft.</i>	<i>Feet</i>	<i>Horsepower</i>
Kettle Falls.....	1	23,800	114.0	217,056
	6	35,500	113.7	322,908
	7	35,500	113.7	322,908
Grand Coulee, low dam.....	1	28,400	210.4	478,029
	6	39,900	210.8	672,871
	7	42,700	205.0	700,280
Grand Coulee, high dam.....	1	28,400	340.4	773,389
	6	39,900	340.8	1,087,834
	8	53,500	319.5	1,367,460
Foster Creek.....	1	28,400	151.9	351,933
	6	39,900	155.2	495,398
	7	42,700	155.1	520,822
Chelan.....	8	53,500	154.6	661,688
	1	30,100	82.2	197,938
	6	41,800	82.6	276,214
Rocky Reach.....	7	44,700	82.5	295,020
	8	55,400	82.3	364,754
	1	31,000	51.2	126,976
Rock Island.....	6	43,800	51.1	179,054
	7	47,100	51.0	192,168
	8	57,600	50.8	234,086
Vantage.....	1	32,200	42.1	108,450
	6	46,800	42.6	159,494
	7	49,900	42.6	170,059
Priest Rapids, low dam.....	8	60,200	42.5	204,680
	1	32,200	43.0	110,768
	6	46,800	43.3	162,115
Priest Rapids, high dam.....	7	49,900	43.2	172,454
	8	60,200	43.1	207,570
	1	32,200	75.3	193,973
Total with Kettle Falls, low dam at Grand Coulee, and high dam at Priest Rapids.	6	47,200	75.5	285,088
	7	50,300	75.5	303,812
	8	61,000	75.4	367,952
Total with high dams at Grand Coulee and Priest Rapids.	1	32,200	127.3	327,925
	6	47,200	127.5	481,440
	7	50,300	127.5	513,060
	8	61,000	127.4	621,712
	1	-----	782.1	1,808,307
	6	-----	783.5	2,587,382
	7	-----	777.4	2,723,317
	1	-----	798.1	1,886,611
	6	-----	799.8	2,679,434
8	-----	777.1	3,454,380	

III. FLOOD CONTROL

1720. Reference is made to paragraphs 1039 to 1061 of chapter II for data on floods and flood control. Flood control is not a problem on the Columbia above the Snake. Floods on Flathead and Pend Oreille Lakes could be reduced by storage of water in Hungry Horse Reservoir; but the cost of creating this reservoir for flood control alone could not be justified by the savings effected.

IV. IRRIGATION

1. GENERAL

1721. In the previous chapter a discussion has been given regarding various tracts in the Columbia Basin that will eventually require water for irrigation purposes that must be provided from the Columbia River, above the mouth of Snake River, or its principal tributaries.

1722. In the discussion of the various tracts or projects the main objective of this report has been to determine the quantity of water

that will be required to meet the irrigation demand and the point on the stream where that demand will be made. Where any project considered has more than one possible source of water supply, plans have been considered and estimates prepared to determine the most desirable method of reclaiming the area and fixing the point of diversion of the water supply. For those projects having only one possible point of diversion or where the diversion points, if more than one, have a common effect on the Columbia River as far as power, navigation, and flood control are concerned, then no estimate of irrigation development has been included but the study carried only to the point where the eventual demand for irrigation requirements could be determined.

1723. Discussions in the preceding chapter lead to the following conclusions relative to the areas or project considered.

1724. *a. Rathdrum Prairie.*—This project has two possible plans of development, each requiring the same amount of water to meet the irrigation demand. Separate points of diversion are required for the two plans considered. When developed by either of the two plans proposed the same amount of water, 120,000 acre-feet will be required to meet the irrigation demand. Diversions made from either of the two sources would have the same effect on the flow of Columbia River.

1725. *b. Little Spokane Valley.*—This project has been given consideration in this report but was eliminated, as it is very questionable whether increased production, due to irrigation, would justify the cost.

1726. *c. Methow-Okanogan.*—This project has been outlined to show that its development will have no appreciable effect on the flow of the Columbia River.

1727. *d. Greater Wenatchee.*—Gravity diversion from Wenatchee River. This plan provides main canal capacity for 20,000 acres in the Wenatchee, Malaga, and Moses Coulee districts and a complete irrigation system for reclaiming 320,310 acres in the Quincy area.

Estimated cost:

Capital cost per acre.....	\$236. 22
Interest.....	60. 04
	296. 26

Annual charges:

Interest at 4 percent.....	11. 85
Operation, maintenance, and depreciation.....	1. 90
	13. 75

1728. In the above estimate no charge has been made against the 20,000 acres provided with main canal only. With that credit, the above cost per acre would be reduced to the extent of about \$10 per acre. No attempt has been made to determine the exact amount of this credit as the discussion of combined areas following demonstrates that this area can be reclaimed much more cheaply in a manner to be indicated in that discussion. It was concluded that Wenatchee River water should be used, first, for irrigation of areas within that valley; second, for power generation.

1729. *e. Quincy area.*—This plan was discussed in connection with the Greater Wenatchee project.

1730. *f. Priest Rapids.*—This project consists of 140,520 acres to be reclaimed by pumping from Columbia River at Bend. Two esti-

mates have been prepared. Both plans are identical except as to the source of power for pumping purposes. With power for pumping purposes transmitted from Grand Coulee, the estimates of cost are as follows:

Capital cost per acre.....	\$108. 50
Interest.....	14. 31
	122. 81
Annual charge:	
Interest.....	4. 91
Operation, maintenance, and depreciation.....	2. 25
Power.....	1. 83
	9. 09

1731. If the power for pumping purposes is secured from a power development at Priest Rapids, the estimated cost becomes:

Capital cost per acre.....	\$95. 30
Interest.....	12. 10
	107. 40
Annual charge:	
Interest.....	4. 30
Operation, maintenance, and depreciation.....	2. 25
Power.....	1. 59
	8. 14

1732. This area is considered later in combination with other areas constituting the Columbia Basin irrigation project, but it can best be developed as an individual project.

1733. *g. Pasco.*—Tentative estimates showed that this project could be reclaimed as an individual unit by pumping diversions from Snake River at a per-acre cost slightly less than that for plan no. 4-A. For reasons given in the discussion, it was shown why this tract was included in that plan rather than being treated as an individual project.

1734. *h. Palouse.*—The development of this area as an individual project was not favorably considered on account of lack of water supply.

1735. *j. Lind.*—This project consists of 774,260 acres developed by a gravity diversion from Clark Fork and Spokane River. Development as proposed for this area as an individual project is estimated as follows:

Capital cost per acre.....	\$227. 75
Interest.....	100. 57
	328. 32
Annual charges:	
Interest.....	13. 14
Operation, maintenance, and depreciation.....	2. 14
	15. 28

1736. This area is considered later in combination with the Columbia Basin irrigation project. The cost of the development of this area is high and it can best be developed by one of the combinations discussed later.

1737. *k. Hanford*.—The plan proposed for reclaiming this tract consists of a pumping diversion from the Columbia River near Richmond Ferry. This is the only practical way of reclaiming the area. The estimate of cost, together with annual charges based upon the availability of secondary power at low cost for pumping purposes, is as follows:

Capital cost per acre.....	\$119. 60
Interest.....	9. 80
	129. 40
Annual charges:	
Interest.....	5. 18
Operation, maintenance, and depreciation.....	1. 70
Power.....	1. 20
	8. 08

1738. *m. Marginal areas*.—No estimates have been prepared covering the reclamation of these marginal areas.

1739. *n. Combined areas*.—The Quincy (Greater Wenatchee), Priest Rapids, Pasco, Palouse, and Lind areas, while considered individually, are all located in such a manner as to permit of a combination of areas that is susceptible of cheaper development. These areas combined constitute the Columbia Basin irrigation project, for which several plans are proposed.

1740. *a'. Columbia Basin irrigation project*.—Various plans have been considered for the reclamation of the Columbia Basin irrigation project, as formed by a combination of the Lind, Palouse, Pasco, Priest Rapids, and Quincy tracts. Table no. 228, presents the estimated per-acre cost of construction for each of the plans proposed together with the annual cost of operation, maintenance, depreciation, and the purchase price of power where diversion is to be made by pumping. In order to give results that are comparable the annual cost of operation, maintenance, depreciation, and power have been capitalized at 4 percent and added to the cost of construction placing all plans considered on a common basis.

TABLE No. 228.—*Compilation of costs for plans considered for reclaiming the Columbia Basin irrigation project*

[Detail estimates not prepared for plans nos. 1 and 3]

Plan No.	Diversion	Tracts combined	Area	Cost per acre			Annual charge per acre			Operating charge capitalized at 4 percent	Cost plus capitalized operation
				Capital	Interest	Total	Interest	Operation	Total		
2	Gravity, Clark Fork	Lind, Palouse, Pasco, Priest Rapids, and Quincy.	1,519,890	\$226.05	\$167.32	\$393.37	\$16.73	\$2.05	\$17.78	\$51.25	\$444.62
2-A	Gravity, Clark Fork and Spokane River.	Same as No. 2.	1,519,890	225.62	168.01	393.63	16.74	2.05	17.79	51.25	444.88
6-A	Gravity, Clark Fork and Spokane River.	Lind, Palouse, Pasco, and Priest Rapids.	1,449,690	221.31	82.42	303.73	12.15	2.11	14.26	52.75	356.48
4	Wenatchee River.	Quincy, Lind, Palouse, Pasco, Priest Rapids, and Quincy.	1,199,430	150.76	34.10	184.76	7.39	14.00	11.39	100.00	284.76
4-A ¹	Pumping diversion from Columbia River at Grand Coulee.	Part of Lind, Palouse, Pasco, and Quincy.									
4-A ²	Pumping diversion from Columbia River at Band.	Priest Rapids	1,174,630	148.72	29.68	178.40	7.14	14.18	11.32	104.50	282.90
4-A ³	Same as 4-A above.	Same as 4-A above.	1,174,630	147.14	29.42	176.56	7.06	14.15	11.21	103.75	279.31

¹ Includes purchase price of power for pumping.

² All power for pumping purposes from Grand Coulee.

³ Power for Priest Rapids area from Priest Rapids power development, balance from Grand Coulee.

2. CONCLUSIONS

1741. This table indicates that from an irrigation standpoint, plans nos. 2, 2-A, and 6-A, all based on gravity diversions, are eliminated because of cost. If the project is to be developed by gravity, the best plan would be plan no. 6-A, with the main body of the project securing its supply from either Clark Fork alone or Clark Fork and Spokane River and the Quincy area securing its supply from the Wenatchee River. Plans nos. 4 and 4-A both outline pumping developments of the combined areas constituting the Columbia Basin irrigation project, the cost of which is less than that for developing the Lind, Palouse, or Quincy tracts as individual projects. The Priest Rapids tract can be reclaimed at a per-acre cost less than that of plan no. 4, and as a separate project is considered one division of that plan. The Pasco tract can be developed as an individual project at a per-acre cost practically the same as that for plan no. 4-A, but is retained as a part of the area to secure a water supply from the Grand Coulee diversions for reasons which have been stated.

1742. From the standpoint of cost there is but little difference between plan no. 4 and plan no. 4-A. The difference in cost is so small that the plans may be considered the same for the present purpose. However, plan no. 4-A is more adapted to stage development than is plan no. 4. Plan no. 4-A would be developed as two separate projects, the main body of the tract referred to as division A covered by the pumping diversion from Grand Coulee and division B, the Priest Rapids area, covered by a pumping diversion at Bend.

1743. All estimates prepared of the various plans on the Columbia Basin irrigation project are predicated upon a colonization of 50,000 acres per year. Any radical decrease in this rate of colonization would increase the interest charge during the construction period and therefore the final per-acre cost.

1744. Plan no. 4-A, consisting of two separate developments, which, of course, would not be constructed concurrently, affords an opportunity to rectify, in part, any error in the assumption as to the rate of colonization. This is an important factor in favor of plan no. 4-A. In addition it is favorable to power development on the Columbia River, as the 443,000 acre-feet required to meet the irrigation demand for the Priest Rapids area would be diverted from the Columbia River at Bend instead of at Grand Coulee as in plan no. 4. The power developments at Grand Coulee, Foster Creek, Chelan, Rocky Reach, and Rock Island would be benefited by this additional flow in the river.

1745. Plan no. 4-A is, therefore, considered the least expensive and best plan of developing the various areas constituting the Columbia Basin irrigation project.

3. COST OF LAND AND LAND IMPROVEMENTS

1746. The cost of dams and canals is, of course, only a part of the capital cost involved in irrigation development. The cost of land and land improvements must be considered as these costs must be met in some way before production can be secured from the irrigable areas.

1747. *a. Productive value of land prior to irrigation development.*—The present productive value of lands of the Columbia Basin irriga-

tion project are dependent upon profits from dry farming in those areas where soil conditions and rainfall justify continued operation and upon returns from sheep pasture where the bunch grass and other native feeds have not been replaced by Russian thistle on lands which have been plowed up for dry farming but later abandoned. Present productive values, therefore, vary from nothing up to \$50 an acre.

1748. The productive value of any given area can only be determined by an appraisal. However, for the purposes of estimating the average price which would have to be paid for land included in the Columbia Basin irrigation project a figure between \$2.50 and \$7.50 an acre can be considered as a safe estimate. The average figure assumed in this report is \$5 an acre for the pumping unit and \$7.50 for the gravity system. This difference in productive value is due to the fact that the gravity plan includes a much larger percentage of land which can be successfully dry farmed. Table no. 229 gives the estimated cost of land, land leveling, buildings, and living costs during the nonproductive development period for the various sections of the pumping project area.

TABLE NO. 229.—*Cost of land and land improvements in the pumping unit of the Columbia Basin irrigation project*

10 percent of area—land value.....	\$20. 00
Land leveling.....	5. 00
Buildings and domestic water.....	50. 00
Living costs during development.....	20. 00
	95. 00
25 percent of area—land value.....	7. 50
Land leveling.....	20. 00
Buildings and domestic water.....	50. 00
Living costs during development.....	20. 00
	97. 50
40 percent of area—land value.....	2. 50
Land leveling.....	25. 00
Buildings and domestic water.....	50. 00
Living costs during development.....	20. 00
	97. 50
20 percent of area—land value.....	1. 00
Land leveling.....	40. 00
Buildings and domestic water.....	50. 00
Living costs during development.....	20. 00
	111. 00
Weighted average land value.....per acre..	5. 00
Weighted average cost of fully improved land (not including water) per acre..	100. 62

These figures are based on the assumption that rough land will not be included in the initial area to be irrigated.

1749. *b. Cost of leveling.*—The figures in table no. 229 represent the ultimate cost of putting the land into first-class shape for the intensive cultivation of any crop. In other words, when the land is finally prepared, the farmer can justly charge the amounts given in determining the investment which he has made in the purchase and preparation of his farm.

1750. In considering the problem from a practical standpoint, however, the ultimate cost is not necessarily the most important factor. Much of the land can be rough leveled cheaply. Where the grade is not too flat and with a satisfactory head of water considerable area could be put under irrigation the first year for a cost of \$5 an acre. Land so prepared can be improved from time to time by further smoothing with a heavy float or by fresno work so that ultimately it will be in proper condition for intensive use.

1751. This progressive method of preparing land has been followed satisfactorily in many of the older districts where some valuable land still remains in a rough leveled condition but returns an income as pasture or for the production of hay. Where this method is followed the smoothest land could be put in final shape by careful leveling and planted to alfalfa. The balance of the land could be rough leveled and planted to some cash crop.

1752. Where it is possible to follow this stage development in the preparation of the land, it is obvious that the burden on the purchaser is minimized as the work can be spread over a number of years and this work can be done with equipment which would otherwise be idle and at times when other work is not pressing. In such a case the actual capital outlay for the improvement would be minimized although the value attached to the land as a result of the improvement would be as great ultimately in this case as where more money was spent in putting the land in final shape in the beginning. A settler can easily save from \$10 to \$15 an acre by utilizing his time during slack periods in making these improvements.

1753. Where the grade is flat and where the surface is uneven it will require from \$25 to \$50 per acre to prepare the land for the production of any crop. On such land the initial expenditure is necessarily greater than on more level areas as it is impossible to spread the cost over a period of years as can be done on land which can be irrigated more or less successfully without putting it in final shape. Even in this case, however, the best portion of the land can be well prepared for alfalfa and a lesser amount of money spent on the balance in order to put it in shape to secure some return, the final preparation being carried out as time permits.

1754. Where the land is very uneven and the necessary equipment cost high, considerable capital would have to be spent before any returns were secured. Such areas, if included in the project at all, would remain idle in all probability until the land which can be prepared more cheaply was developed. The average cost of final leveling is estimated to be \$30 per acre.

1755. *c. Cost of buildings.*—The average cost of buildings on a fully developed 80-acre farm is estimated at \$4,000. This amount of money would provide a comfortable but modest residence and usable barns and outbuildings. On an 80-acre farm this expenditure would amount to \$50 an acre. If the same amount is spent on 160 acres the cost per acre would be reduced. In all probability during the earlier years of development the farms will be large and the expenditure per acre, even for a more or less permanent construction, will be less than the figure given in table no. 229.

1756. Settlers with insufficient capital to enable them to afford the construction of buildings which they would like to have ultimately can conserve their resources by using smaller and cheaper buildings

during the first few years, depending upon the return from the sale of crops in later years for more commodious and more permanent construction. A program of this kind calls for the sacrifices which go with all pioneering work. Those who are not willing to undergo the hardships which are incident to the reclamation of desert land should not attempt development unless they have sufficient capital to provide the comforts which they deem necessary. On the other hand the development should be so planned that those who do endure the hardships incident to pioneering or who risk their capital in pioneer development have an opportunity of reaping a reward in the ultimate increment in value of the land which they acquired.

1757. *d. Cost of domestic water supply.*—It is assumed that canal water will be used by the settlers for household purposes during the initial stages of development and that this supply will serve until such time as wells can be dug to ground water at reasonable cost. If the rate of settlement is rapid it will not require many years to raise the ground water appreciably. Using ditch water as a domestic water supply is common in irrigated sections.

1758. The cost of constructing a reservoir is included in the cost of buildings. A windmill and tank tower would provide water under pressure, but such an expenditure would not be necessary during the earlier period of settlement when money is needed for the preparation of land and the purchase of stock and equipment in order to secure an early return.

1759. *e. Total cost of land development.*—If the ultimate cost of complete development is estimated on a basis of 80-acre units as given in table no. 229, the total cost of development on 1,000,000 acres (outside of the cost for water) would range from \$75,000,000 to \$125,000,000 on the assumption that each 80-acre farm would require an expenditure of from \$6,000 to \$10,000 fully developed but not including equipment or operating capital.

1760. If the larger units prevail during the period of development, economy exercised in the construction of buildings and judgment used in the preparation of the land, the initial cost might be reduced to \$50 an acre, or a total of \$50,000,000.

4. SUMMARY OF COSTS OF CONSTRUCTION AND LAND DEVELOPMENT

1761. The total cost of development of land and water supply under the gravity and pumping plans on the basis of a charge of 4 percent compound interest on deferred payments, and on an assumed rate of settlement of 50,000 acres a year, will be as follows:

Gravity plan (plan no. 2).....	acres.....	1, 520, 000
Cost of construction.....		\$598, 469, 000. 00
Cost of land and land improvements.....		152, 000, 000. 00
Total cost.....		750, 469, 000. 00
Cost per acre.....		493. 73
Pumping plan.....	acres.....	1, 200, 000
Cost of construction.....		\$221, 712, 000. 00
Cost of land and land improvements.....		120, 000, 000. 00
Total cost.....		341, 712, 000. 00
Cost per acre.....		284. 76

5. TOTAL ANNUAL REPAYMENTS NECESSARY TO MEET COSTS

1762. The repayment of construction costs on irrigation projects has always presented a difficult problem, which is becoming constantly more serious as the larger and more expensive projects come up for consideration. The problem is complicated by the fact that the high returns per acre, resulting from the production of fruit, cannot be counted on to meet any appreciable portion of construction costs on new projects because of the fact that the market for fruit cannot be indefinitely expanded. General farming must be relied upon to meet the share of cost which the farmer is asked to pay. In Yakima, for example, where the returns from fruit predominate, the average annual return per acre in raw and manufactured produce in 1929 was \$156, while in Twin Falls, Idaho, where general farming predominates, the return per acre in raw and manufactured products in 1929 was but \$67. Future projects must face high per-acre costs and the relatively low acre yields based on returns from general agriculture. The estimated annual return per acre on the Columbia Basin irrigation project is \$61.82, which includes \$51.82⁸⁸ for farm produce and \$10 of added value due to manufacturing processes.

1763. If all of the costs of constructing the dams and ditches necessary to irrigate the lands of the Columbia Basin irrigation project were charged against the land and 4 percent interest charged on deferred payments, the annual assessment for the gravity plan would be \$19.89 per acre not including operation and maintenance costs on the basis of repayment of principal over a period of 40 years with interest at 4 percent. If operation and maintenance charges are included, the total cost will be \$23.02 per acre per year.

1764. In the case of the pumping project the annual charge per acre amounts to \$8.92 for repayment of construction costs figured on a 40-year amortized basis with interest at 4 percent not including operation and maintenance charges. If operation and maintenance charges are included the total cost will be \$13.20 per acre per year. This figure does not take into account the cost of Grand Coulee Dam which is necessary for power development and is therefore charged wholly to power. The possible contribution of power toward repayment of construction costs charged directly against irrigation is considered separately.

6. PERMISSIBLE CHARGES FOR WATER BASED ON RETURNS FROM AGRICULTURAL OPERATIONS

1765. In order to determine the economic feasibility of plans for the delivery of water to the lands of the Columbia Basin irrigation project it is necessary to determine what the landowners in the project will be able to pay toward construction costs. A satisfactory answer must be based on a consideration of the physical and economic factors which form the foundation and background for the development.

1766. *a. Influence of soil on production.*—The solvency of any irrigation project depends primarily upon the yields obtained from the lands irrigated. Low yields, whether accompanied by high or low costs per acre, will, in general result in high costs per unit of product, because the fixed costs cannot be spread over a sufficiently large

⁸⁸ The figure of \$51.82 represents the average return from the entire area. After deducting 10 percent for buildings and noncultivated farms the average production per acre is \$54.55.

number of pounds or tons. Profits and ability to pay charges for water depend upon the margin which the markets will yield above costs. The productive capacity of land, therefore, must occupy an important place in estimating the capacity of a project to pay construction costs.

1767. The history of irrigation development during the past 30 years has emphasized the importance of this fundamental consideration. As a rule, projects located on productive soil areas have prospered, if construction costs have not been excessive, while on projects including any large proportion of poor soil, both the settlers and the bondholders have lost. With the knowledge of soils gained as a result of past experience and of continued study, errors of judgment regarding the suitability of the soils of any proposed projects should be minimized in the future. No project should be undertaken before a detailed land classification has been made.

1768. It is assumed in his report that the project will not be finally approved until a land classification has been made with sufficient detail to locate the areas of first- and second-class lands based on standards of quality, fertility, depth of soil, drainage, and topography which will insure crop yields equal to the yields as set forth in this report and the costs for distribution of water over the land which will not materially increase the cost of production per unit. The final classification of land must follow a detailed topographical survey and should be preceded by studies of root behavior and of yields on various types of soil now being irrigated within the project area and in adjoining areas where the soil conditions are similar. A high standard should be set in order to avoid the inclusion of areas which will not yield a satisfactory return. This point is emphasized because of the fact that the soil studies which have been made show a large percentage of second-class land (45 percent under the gravity system and 50 percent under the pumping plan) within the limits of the project.

1769. Such a classification should be based on: First, a careful and detailed study of the adaptability of land for crops; second, upon an estimate of the permanent productive quality of the soil after water has been applied; third, upon the cost of preparing the land for irrigation; fourth, upon the cost of distributing the water over the surface after the land has been prepared. These four considerations should be the controlling factors in the classification of land prior to irrigation development, for it is upon these factors that economic feasibility depends. The benefits to the farmers, the local business interests, the railroads, and the public resulting from irrigation development all rest on the productive quality of the land and too much stress cannot be put upon the necessity for a classification of land based on the economic factors involved in its utilization.

1770. *b. Influence of population and markets on farm returns.*—It is assumed in this report that population will increase as predicted and that markets for farm products in the Northwest will increase as indicated in the market study. The feasibility of the project is so dependent upon these factors that approval of construction should be delayed until the demand for land in existing projects and in projects already approved for construction becomes great enough to justify further expansion. This matter is discussed more fully in paragraph 1858.

1771. *c. Cost of production and probable yields and prices.*—The most obvious method of arriving at a permissible charge for water is to determine the probable cost of production and the probable yields and prices on what might be considered an average farm and to determine from these figures what will remain as a fund with which to meet water charges after all other necessary operation and maintenance costs have been paid.

1772. The problem is somewhat complicated by the fact that general farming, based on the rotation of crops, is the established and desirable practice in the irrigated sections of the Northwest. If it were possible to take any one special crop and follow it through, the difficulties involved in arriving at costs and returns would be lessened. As it is, certain crops may be included in the rotation because they add fertility to the land or prepare the land for a following crop, although giving a return that might not justify their independent production.

1773. *a'. Net returns in the case of existing farms in Idaho and Washington.*—An analysis of 28 farms in Twin Falls County, Idaho, was made by Dr. Paul A. Eke of the College of Agriculture of the University of Idaho. Plate no. 140² gives a graphic presentation of the results, with individual farms arranged in order of gross returns.⁸⁹ The gross expenses, interest on investment, and labor income are shown in relation to the gross returns. The figures represent the more successful farms in the country, rather than an average, for they were selected because of their successful record. The farms range from 40 to 120 acre units with an average of 97 acres and include alfalfa, grain, potatoes, beans, and live stock in about the same proportion as adopted in the farm analysis for this report.

1774. The average gross return was \$7,346 and the average labor income was \$2,853. The average gross return per acre was \$78. Farm no. 1 of the chart had a gross income of \$12,933 and net labor income of \$5,391, while the farm to the right of the chart had a gross income of \$1,484 and a labor income of \$710. This distribution of income illustrates the position of the marginal farm. Any farm which could not produce at least as much net income as the farm on the right would be submarginal. Under a more expensive irrigation system the marginal farm would be represented by farm no. 25 as the small margin above costs as given in the analysis would be just enough to meet the larger capital cost repayments based on a 4 percent interest charge.

1775. The larger farms yielded the greatest net return. The gross return per acre was highest for the group of smaller farms, due, no doubt, to more intensive farming.

1776. Plate no. 141² gives the distribution of gross returns, gross expenses, interest on investment, and labor income for 47 farms in Kittitas County, Wash., based on a detailed analysis of farm income and expense carried out by W. O. Passmore, Kittitas County agricultural agent, and published by the State College of Washington and the United States Department of Agriculture.⁹⁰

1777. This distribution is based on gross returns but the chart does not show the uniform relationship of gross income and the various expense items that were presented in the Idaho study. The farms

² Not printed.

⁸⁹ Unpublished data.

⁹⁰ Detail secured from unpublished data in field notes. A summary is given in a bulletin entitled, "Successful Farming in Kittitas County."

represent the best in the county from the standpoint of profits, although they include farms where managerial ability has made up for poor soil, and soil conditions on some farms are somewhat inferior.

1778. The average gross return, including increased inventory, was \$6,657 or \$60 an acre. The average labor income, representing all income above total expense, decrease in inventory, and interest on investment, amounted to \$1,533 or \$13.81 per acre. Seven farms lost money, and three farms produced no labor income. In the case of one farm which showed a loss of \$4,000, much of the land was in summer fallow, while in the only other case of heavy loss (\$2,500), the labor charges were very heavy as the owner was not physically able to do much work. Water charges ranged from nothing up to \$6 per acre.

1779. *b'. Estimated returns from farms of the Columbia Basin irrigation project.*—With these and other figures from Washington and Idaho as a foundation, a composite rotation of crops was prepared to represent as nearly as possible a cross section of probable production on the Columbia Basin irrigation project. Yields on existing projects were modified to meet the soil and climatic conditions of the project area as nearly as possible. In Kittitas County, for example, only two cuttings of alfalfa can be secured on account of the short growing season, while the longer growing season on the Columbia Basin irrigation project would permit at least three cuttings. Prices as given in the analysis of farm records previously referred to were lowered to meet the new price level. The composite rotation adopted includes forage crops, truck crops, and fruits in such proportion as to represent as nearly as possible the proportion which these crops will have in the total production on the project based on the market studies.

1780. In all probability no one farm would follow this composite rotation as the distribution of the labor load through the season would not prove efficient, but by taking the average yields and prices a fair estimate of returns can be secured in each case. By following through the unit costs of various items and materials used in production a fair estimate can be secured of the total costs. This is the procedure which is followed.

1781. *a''. Marginal farm.*—Table no. 230 gives the estimated income from a marginal farm, and average farm, and a better-than-average farm in the Columbia Basin irrigation project. In this table alfalfa represents any forage or hay crop; potatoes represent truck crops in general; grain includes wheat, barley, oats, and flax; while beans include field peas or any cultivated field crop other than corn.

TABLE No. 230.—Estimated income from farms of the Columbia Basin irrigation project

[In each 80-acre farm, 76 acres are cultivated]

Crop	Acres	Marginal farm			Average farm			What a good manager may expect on good land		
		Yield	Price	Gross re- turn per acre	Yield	Price	Gross re- turn per acre	Yield	Price	Gross re- turn per acre
Alfalfa.....	46.4	Tons 3.5	\$14 per ton ¹	\$49.00	Tons 3.75	\$14 per ton.....	\$52.50	Tons 5	\$14 per ton.....	\$70.00
Potatoes ²	5.0	Pounds 9,000	\$20 per ton.....	90.00	Pounds 11,500	\$20 per ton.....	115.00	Pounds 24,000	\$20 per ton.....	240.00
Grain.....	10.0	1,960	\$0.0178 per pound.....	34.88	2,240	\$0.0178 per pound.....	39.87	3,360	\$0.0178 per pound.....	59.95
Corn.....	8.0	1,960	\$0.0178 per pound.....	34.88	2,240	\$0.0178 per pound.....	39.87	3,360	\$0.0178 per pound.....	59.95
Beans and peas.....	6.0	1,000	\$0.04 per pound.....	40.00	1,200	\$0.04 per pound.....	48.00	2,000	\$0.04 per pound.....	80.00
Fruit.....	1.6	14,000	\$25 per ton.....	175.00	20,000	\$25 per ton.....	250.00	28,800	\$25 per ton.....	350.00
Total.....	76.0			3,822.44			4,364.16			6,497.10

¹ Returns from alfalfa fed to dairy cows or hogs.

² Potatoes represent various truck crops.

1782. It is assumed that marginal land will produce at least 3½ tons of alfalfa, 4½ tons of potatoes, 35 bushels of grain, 35 bushels of corn, 10 sacks of beans, and 7 tons of fruit to the acre. Land which will not yield these returns would not pay to crop, as the farm operator would not make sufficient income to maintain a satisfactory standard of living.

1783. *b''*. *Average farm*.—It is estimated that the average farm will yield 3.75 tons of alfalfa (representing all forage crops and pasture), 5.75 tons of potatoes, 40 bushels of corn, 12 sacks of beans, and 10 tons of fruit to the acre. These yields can be secured by ordinarily efficient management on reasonably productive land. The figures for the average farm represent the average returns that may be expected from the lands under cultivation, including marginal farms, average farms, and better than average farms. The figure is based on the cultivation of 76 acres out of each 80. Four acres would be utilized for farmstead, ditches, and farm roads. In estimating the gross returns on the entire project, 5 percent was deducted from the figure representing the returns from the average farm in order to allow for vacant land which may be idle because of sickness, litigation, or other factors not connected with the productive quality of the land itself.

1784. *c''*. *Better than average farm*.—Many farms will produce more than the average. Yields of 8 or 10 tons of alfalfa are not uncommon, while potatoes may yield from 10 to 15 tons; grain, from 50 to 60 bushels; beans, from 1 to 2 tons; and fruit from 12 to 15, or even 20 tons per acre. A good manager on good land can reasonably expect to secure 5 tons of alfalfa, 12 tons of potatoes, 60 bushels of corn and grain, 20 sacks of beans, and 14 tons of fruit to the acre, as indicated in table no. 230.

1785. *d''*. *Price of farm products*.—Uniform prices were used in estimating the gross return from the various types of farms in the project. In order to avoid complicating the estimate of returns from crop production by estimating the increase in returns due to the feeding of hay and grain to dairy stock, cattle, and hogs, a price was set on hay and corn which can be secured by feeding these products on the farm. With this consideration the following prices were adopted:

Alfalfa hay (price is based on returns from feeding hay to dairy cattle).....	ton.....	\$14. 00
Potatoes.....	do.....	20. 00
Fruit.....	do.....	25. 00
Grain and corn (price is based on returns from feeding grain to hogs).....	pound.....	. 0178
Beans.....	do.....	. 04

1786. *e''*. *Character of the products shipped to the consuming centers*.—In all probability the forage crops—grain, cull potatoes, corn roughage, and straw—will be fed to livestock and the products sold will be dairy products, pork, beef, mutton, wool, and eggs. Truck crops, including potatoes, and fruit, including berries, will go direct to the outside markets, except for the limited proportion which may be consumed locally or canned. The estimated income based on the sale of animal products is shown in table no. 231.

TABLE NO. 231.—*Estimated income from the sale of livestock and livestock products from the average farm on the Columbia Basin irrigation project*

Class of animals	Number of animals	Product	Quantity	Price	Total returns	Remarks
Cows	9	Butter	250 pounds per cow	\$0.320	\$720.00	
Calves and cows	8	{Cows and calves (Skimmed milk)	7,000 pounds per cow.		325.00	
Hogs	60	Fat hogs	Average weight, 212 pounds.	.055	699.60	Fed to calves, hogs, and chickens.
Cattle	9	Fat cattle	2 pounds per day gain.	1.020	144.00	Fed grain, pasture, chili potatoes, and milk.
Sheep (ewes)	10	{10 lambs (Wool)	800 pounds 120 pounds	.070 .200	56.00 24.00	Gain in price on original weight.
Chickens	150	{Eggs (Poultry)	150 eggs per hen 250 cockerels	.230 .200	287.50 50.00	Value of gain in weight.
Work stock	4					Fed bean straw, grain, pasture.
15.3 acres extra hay, grain, and winter pasture.						6 pounds per ewe and 6 pounds per lamb.
Returns from other crops, as per table no. 230.					1,263.00	1.25 pounds for cockerels.
Total					4,325.15	Work animals. Sold to dairymen on the coast.
						Fruit, vegetables, and beans.

¹ Gain on 800 pounds; \$0.08 on gain of 240 pounds.

² Per dozen.

1787. *f''*. *Estimated expense on marginal farm, average farm, and better-than-average farm.*—Table no. 232 gives the estimated expense on the marginal farm, the average farm and the better than average farm on the Columbia Basin irrigation project. The total expense equals the total income in each group.

1788. According to this analysis, the average farmer on an 80-acre farm has \$480 remaining from his estimated income after allowing 6 percent interest on the estimated cost of raw land, land improvement, equipment, and livestock, and also allowing for taxes, purchase of supplies, depreciation of equipment, employment of labor, and allowing \$75 a month for his own labor. This last item is in addition to the value of farm produce which the farmer's family consumes. This home consumption is ordinarily figured at from \$300 to \$500 per year.

1789. The \$480 which remains after allowing for all charges other than for irrigation can be considered the permissible charge for water. Dividing this sum of \$480 by the acreage of the average farm (80 acres) the permissible charge per acre is \$6.

TABLE NO. 232.—*Estimated operating expense of an 80-acre farm of the Columbia Basin irrigation project*

Item of expense	Marginal	Average farm	Better than average
Hired labor	\$800.00	\$900.00	\$1,200.00
Interest	\$700.00	\$900.00	\$1,000.00
Supplies, depreciation, replacement	\$942.44	\$944.16	\$1,557.10
Labor income	\$900.00	\$900.00	\$1,800.00
Taxes	\$160.00	\$240.00	\$300.00
Water	\$320.00	\$480.00	\$640.00
Number of acres	80	80	80
Gross return per acre	\$47.78	\$54.55	\$81.21

¹ Interest at 6 percent on a value of \$94 per acre above construction costs.

1790. *c'*. *Estimated value of developed land in the Columbia Basin irrigation project.*—The average improved property on the Columbia Basin irrigation project when fully developed will represent an investment of approximately \$140 to \$150 an acre. This figure is made up of the cost of developing land, which is approximately \$100 an acre, and the capitalized value of that portion of the estimated annual permissible charge for water which can be applied against the indebtedness (after taking care of operation and maintenance charges, \$39.58 for plan no. 4).

1791. The net ultimate value of the land to the farmer under the gravity plan would theoretically be greater than under the pumping plan because the cost of pumping represents a perpetual charge, while the bonded indebtedness against the land served by gravity will eventually be wiped out. This would give the land served by gravity the advantage of the value represented by the capitalized charge for power. The effect of this difference is so far in the future, however, that it would have little effect upon the present market value of the land.

1792. In most existing projects the market value of land does not include the bonded indebtedness. Where land is appraised on its earning power, however, it is customary to deduct the bonded indebtedness from the estimated productive value of the land in order to get the net value. This is the procedure followed in this study.

1793. In the case of the Columbia Basin irrigation project the bonded indebtedness is taken care of in the permissible water charge of \$6 per acre. According to the analysis of income and expenses, an average farm on the Columbia Basin irrigation project in the hands of an average man should yield enough to pay the permissible charge for water and interest at 6 percent on a value of \$100 per acre including improvements, not including commercial orchards. The market value of the land would, of course, vary with the location, the soil, and improvements. Better land in the district might sell for from \$200 to \$250 per acre, while the poorer land might not have a market value of more than \$75 per acre in addition to the bonded indebtedness.

1794. *a''*. *Increment in land value.*—If the estimate of cost of production and returns is correct, the increase in the productive value of land would all be absorbed in the various development costs and there would be no increment in value for the average settler except for the value which he may have created by using his own labor in the leveling of land or in the making of other improvements without the expenditure of cash. In individual cases the increment in value might be considerable, both because of economy and efficiency in development and because of judgment in the selection of better than average location or soil.

1795. The expectation of increment in land value has been a big stimulation to the development of the West. The increase in value, however, has often been taken by the promoter in the price for raw land, leaving little or no profit, or, in many cases, a direct loss for the man who spent his time, effort, and money in the development of the land. Unless the price of raw land is controlled in the interest of the development, settlers who pay the higher prices will face a serious handicap. It is highly important, therefore, that unsound speculation in land values be prevented by a wide dissemination of facts and if necessary, by contracts between the land owners and the development agency.

1796. *d'. Subdivision of land and settlement.*—The desirable size of farms depends upon the soil, the character of crops produced, the length of the growing season, the amount of capital available and the character of the individual. A farm must be large enough so that reasonable management will yield a gross return which is sufficient to meet the necessary costs of operation and maintenance and to afford a reasonable standard of living for the owner. This is important from the standpoint of the community as the farmer's buying power is a factor to be considered. The size of holdings should not be arbitrarily controlled except to prevent subdivision of land which might lead to fraud or misrepresentation by the promotion of tracts too small to afford a satisfactory return.

1797. From the standpoint of efficient production, large farms, or long-term leases of large areas for large-scale production may aid very materially in the settlement of land. The production of both truck and field crops is constantly tending toward large-scale operations where distributors enter into production, in order to secure quality and uniformity as well as a dependable supply.

1798. On the other hand, the possible necessity for absorbing a larger proportion of the population of the country on farms as an aid toward meeting the unemployment problem may make small farms desirable. This problem deserves very careful investigation from the standpoint of national policy.

1799. The size of holdings on existing projects where returns from irrigation form the principal source of income varies as shown in table no. 233.

TABLE NO. 233.—*Acres per farm, persons per farm, acres per person, value of farm produce per acre and value of farm produce per person in Yakima Valley, Wash., Twin Falls County, Idaho, and Imperial County, Calif.*

Project	Acres per farm	Persons per farm	Acres per person	Per acre value of raw and manufactured produce shipped out	Value of farm produce per person
Yakima, Wash.-----	43.0	14.4	3.30	¹ \$156.00	¹ \$528.00
Twin Falls, Idaho.-----	95.2	10.5	8.76	¹ 67.00	¹ 588.00
Columbia Basin irrigation project.-----	80.0	10.0	8.00	61.82	494.00
Imperial Valley, Calif.-----	110.5	12.8	8.60	¹ 118.00	¹ 1,030.00

¹ These figures represent the 1920 price level. The value of returns per acre would be reduced if the new price level were considered.

1800. In the Yakima Valley where the per acre value of the produce is high the acres per farm are less than one half that of Twin Falls, and a little more than a third that of Imperial Valley. The number of acres per inhabitant in Twin Falls and Imperial Valley is about the same, but the acres per individual in Yakima are less than one half that of either of the other sections.

1801. In the Columbia Basin irrigation project it is assumed that the average farm will contain 80 acres. This is based on the assumption that field crops will predominate. As population increases the demand for land may require smaller farms. However, no attempt need be made to forecast conditions affecting this problem, except by the avoidance of arbitrary ruling which might interfere with normal economic and social forces.

1802. *a''. Number of settlers needed.*—Assuming an average holding of 80 acres, the 1,000,000 acres of land under the pumping system

would require 1,250 farm families in addition to the necessary hired labor needed for the operation of these properties. If larger farms predominate during the earlier stages of the development, the number of settlers would be reduced, but as population increase becomes pronounced the demand for land will probably result in a subdivision of the larger holdings.

1803. *b''*. *Source of settlers*.—Farming areas of the West and Middle West would naturally be the main source from which experienced farmers could be secured for the settlement of land. Sons of well-to-do farmers and tenants would be desirable settlers. Many farm owners might like to sell their farms in established communities and move to a new section with the hope of improving their condition. Many of these people who would come West as a result of the advertising of the Columbia Basin project might decide to purchase going farms in Oregon, Washington, or Idaho permitting the owners, who are familiar with the country and believe in the possibilities of the Columbia Basin, to become settlers.

1804. *c''*. *Rate of settlement*.—The rate of settlement will depend upon the opportunity for profit which the development offers. If charges are so apportioned as to take away all of the speculative features which ordinarily attach to pioneering development, the rate of settlement will be much slower than if the settlers and other benefited parties are given an opportunity of making a fair profit as compensation for the hardships and risks involved in the development.

1805. In the past the policy of the Government has been to offer substantial rewards for the development of the public domain. The Homestead Act offered an opportunity for the development of farms which in the lifetime of the owners represented an increment in value of very substantial amounts. Railroads were subsidized by the granting of tremendous areas of valuable lands. People were willing to endure hardships and to risk their time and money in order to reap some of the rewards thus offered.

1806. Under present conditions, where the development of irrigated land involves more risk than was involved in the development of the homestead in the Middle West, and when luxuries of the past are considered necessities of the present, it is more difficult to secure settlers with the determination and ability to succeed even where a reasonable expectation of profit is offered. A man with money may prefer to purchase a developed ranch which would afford an immediate income rather than risk his money on the uncertainties of development of irrigated land, unless he felt that by careful management he could increase his capital by securing a reward in value as a result of the risk involved.

1807. The rate of settlement of existing irrigation enterprises varies considerably but in general is greatest during the initial period of development as shown by table no. 234.⁹¹

⁹¹ Economics of Land Reclamation. Table no. 17, p. 184, Bibliography Serial (240)

TABLE NO. 234.—*Extent to which the estimated full capacity of irrigation enterprises is utilized at various periods after construction begins*

	Percent		Percent
5 years.....	36	25 years.....	60
10 years.....	45	30 years.....	62
15 years.....	52	35 years.....	63
20 years.....	56	40 years.....	65

1808. The records of the United States Bureau of Reclamation show an increase of 880,264 acres irrigated from 1910 to 1924, or an average annual increase of 62,878 acres per year.

1809. In the Yakima Valley the record of increase in irrigated land since 1910 is as follows: 34,900 acres from 1910 to 1915, 32,100 acres from 1915 to 1920, 9,792 acres from 1920 to 1924.

1810. Table no. 235 gives a record of the increase in irrigated land by decades in Washington, Oregon, Idaho, and California since 1890.

TABLE NO. 235.—*Increase in irrigated area in Washington, Oregon, Idaho, and California for each decade since 1890 (acres)*

State	Acreage irrigated, 1890	Increase in acres irrigated			
		1900	1910	1920	1930
Washington.....	48,799	86,671	198,908	195,521	-26,441
Oregon.....				300,033	-49,094
Idaho.....	217,005	391,713	822,130	1,057,958	-336,630
California.....				1,554,936	512,592

1811. A consideration of the various figures presented does not lead to a definite answer to the problem of the probable rate of settlement of the Columbia Basin. If the land could be settled at the same rate as land was settled in Idaho between 1910-20, practically all of the irrigable land under the pumping plan could be settled in a decade. If land is settled at the average rate of settlement of other projects, 450,000 acres could be settled the first 10 years and 110,000 acres in the next 10 years. Again, if the land could be settled as rapidly as the land has been settled on the projects of the Bureau of Reclamation, 62,000 acres could be settled each year.

1812. The fact must be considered, however, that in the past project costs have been comparatively low. The relatively high annual charge of \$6 per acre on the Columbia Basin irrigation project may be a serious factor in retarding growth. The rate of settlement, however, is not governed by the capital cost or the annual payment for water except as such charges affect the opportunity offered for making a profit. If the project offered an unusually attractive opportunity for making money, there would be no serious settlement problem. On the other hand, if the opportunity for making a profit is not as great as the opportunities elsewhere, settlement will be very slow indeed.

1813. According to the analysis of costs of developing farms and of possible and probable farm incomes, it appears that the lands of the Columbia Basin project should offer as good an opportunity for profit as is offered on the Twin Falls project in Idaho, which represents a prosperous community.

1814. This statement, however, is based on three assumptions: First, that nothing but good soil areas are included; second, the project is not constructed until the demand for land and the market for agricultural products justifies expansion; third, that the costs charged against the land are not in excess of permissible charges based on an analysis which allows a fair expectation of profit for the pioneer settler. It may prove best to charge something less than the per-

missible charge for water in order to hasten settlement and thus save on interest charges.

1815. On the basis of these assumptions, and in the light of the figures presented, it does not appear unreasonable to expect an average rate of settlement, which would result in the development of 50,000 acres a year on the average. The rate would be the greatest during the first 5 years when perhaps 35 percent of the 1,000,000 acres under the pumping project could be settled. The rate of settlement would decline as the best lands were absorbed, but in a 20-year period the entire area might be settled.

1816. It is, of course, true that areas equal to the entire pumping project have been settled in certain States during decades of great expansion. In the decade from 1910 to 1920 the area of irrigated land in California increased by over a million and a half acres and in Idaho by over 1,000,000. These record years occurred as a result of the tremendous advertising given to the benefits of irrigation through the National Irrigation Congress, by the financial interests involved in construction of private projects, by the active work of hundreds of real-estate operators, by the establishment of the United States Reclamation Service, as well as by the general interest in the development and conservation of national resources which gripped the public interest during that period.

1817. The settlement of as large an area as the Columbia Basin irrigation project will require the united support of all interests which may benefit from the development. A soundly and conservatively planned project, constructed when the demand for land and the market for agricultural products warrants, and backed by the united support of various interests in the Northwest which will benefit from such an undertaking, should not offer greater difficulties of settlement than other large projects have offered in the past. This is particularly true of plan no. 4-A which allows a stage development. The value of stage development is of tremendous importance in keeping down construction costs and interest, and every advantage should be taken of stage development where such a construction program is possible.

1818. A rate of settlement of 50,000 acres a year is recommended as a figure to use in estimating interest charges on deferred payments on construction costs. It would be unreasonable to assume a more rapid rate of settlement than this, while any delay in the development program to meet the requirement of a slower rate of settlement would not cause any difficulty, but in reality would hasten repayment as shown in the discussion of the effect of the rate of settlement on costs.

1819. *d". Effect of the rate of settlement.*—A striking fact is revealed by an analysis of the effect of the rate of settlement on the period of repayment under the combined plan where the revenue from the sale of power and water is used to repay construction costs. Where the interest is figured at 4 percent, where power is sold for 2.1 mills per kilowatt-hour, and where water is sold for \$3 per acre per year, repayment of indebtedness will require 120 years with a rate of settlement of 50,000 acres per year. Under the same conditions but with a rate of settlement of 25,000 acres per year, repayment of construction costs is accomplished in 68 years. Where power is

sold for 2 mills, construction costs will not be met in full at any time when the land is settled at a rate of 50,000 acres per year, but will be repaid in full in 78 years where the land is settled at a rate of 25,000 acres a year.

1820. This is clearly shown in plate no. 142, which presents various curves showing the results secured under different conditions for both the high and the low Coulee Dams. It is interesting to note that the revenue from the low dam would not be sufficient to successfully subsidize irrigation development, at any reasonable rate for power.

1821. The striking results shown so clearly by the curves in plate no. 142 are explained by the fact that irrigation forms a burden on power. The less the load, the quicker the repayment. Without charging any irrigation costs against power, the revenue from power sales at a rate of 2 mills per kilowatt-hour from the high dam would repay construction costs with interest at 4 percent in approximately 30 years. At the end of 40 years the accumulated net annual revenue, after full repayment of costs, with interest, would amount to \$140,000,000. This would total \$168,070,000 with interest at 4 percent compounded annually.

1822. It is not the rate of settlement itself, however, which retards repayment. It is the construction cost necessary to meet different rates of settlement which form the burden. After the construction work is complete for any particular area the more rapid the rate of settlement the more rapid the repayment. This is influenced by the fact that the cost of construction covering the development necessary to deliver water to the first unit of the project is but 20 percent of the total capital cost of the canal system. If the initial cost of the main canal, structures, and pumping plant were a large percentage of the total cost, the curves would show a different result. The interest burden in such a case would outweigh the saving due to retarded development. Under the conditions represented by plan no. 4 or plan no. 4-A, however, delaying the development does shorten the period of repayment.

1823. The fact that retarded settlement hastens repayment is an advantage in an area the size of the Columbia Basin irrigation project as it offers the essential advantages of stage development. For example, the plans for irrigating the Columbia Basin by pumping could be carried to a point where the Quincy Flats would be supplied with water as an initial unit of the larger plan. If the settlement of the first unit did not justify continuous development of other units, the construction work could be stopped entirely or postponed indefinitely without creating any special problem.

1824. Such a postponement of development would actually hasten repayment of the initial investment. For example, if one fourth of the project area, or 250,000 acres, were developed as a first unit, including the full-sized main canal and structures from the diversion point on the river to the first lateral canals and including that portion of the pumping equipment necessary to deliver water to the first unit under construction, repayment of principal with interest would be accomplished in less than 40 years whether settlement was at a rate of 25,000 or 90,000 acres per year. In other words, a unit development might result in repayment of initial investment in approximately one half the time required to meet repayment where the entire area is developed.

1825. Any postponement of development would, however, retard the flow of benefits, provided the rate of development did not exceed the demand for land under the conditions presented by the project. Under the discussion of benefits resulting from irrigation development presented hereinafter, it is clearly shown that the benefits in the case of the pumping plan considerably exceed the costs. The fact that development may be subsidized by revenue from power, thus relieving the benefited parties from direct assessment, and that the cost of irrigation forms a burden on power which retards repayment of principal, does not mean that development should be postponed or delayed provided there is a satisfactory demand for the land.

1826. The value of the benefits are sufficient to justify full development if production of crops and markets for farm produce are as predicted in the analysis of the project. This matter is discussed more fully hereinafter under the subject of benefits.

1827. *e''*. *Probable need for additional land to supply the needs of the Northwest.*—If the number of acres of cultivated land per individual is the same in 1960 as in 1930 (3.27), the predicted increase in population for Washington, Oregon, and Idaho will require an increase of 3,500,000 acres of cropped land. If the area of irrigated land per person is the same in 1960 as in 1930 (1.21), it will require the development of 1,339,000 acres of irrigated land and an increase of 2,250,000 acres of cultivated land in the areas where farming can be carried on without irrigation. Apparently the development of an area of 1,500,000 acres or an area equal to the maximum irrigable area under the Columbia Basin irrigation project would not be sufficient to maintain the present area of cultivated land per individual.

1828. The analysis of production in table no. 223 indicates that 1,000,000 acres of land under the pumping project will supply practically all of the meat products, butter and cheese, fruit and vegetables needed by the estimated increase in population in 1960. About 270,000 acres in excess of the area on the Columbia Basin available for the production of hay for sale will be needed according to that analysis to supply the whole milk market on the coast. Additional land would be necessary to meet the Northwest demand for eggs, and no provision is made for an increase in grain for direct consumption.

1829. It does not follow, however, that the need for increased production would not be met by development of other land in case of a failure to develop the Columbia Basin project. An improvement in agricultural practice through the use of better seed and better livestock, through fertilization, and by better cultural methods will undoubtedly increase yields per acre during the next 30 years. A resulting increase in production of 10 percent is not an unreasonable expectation. Such an increase would lessen the need for more land by approximately 360,000 acres, other things being equal.

1830. If the demand for farm crops requires a greater production per acre an increased expenditure per acre will be necessary, and the number of acres per man would probably have to be reduced. It is possible that the intensification of agriculture with smaller farms may prove necessary in order to keep men employed. If there is a tendency toward smaller farms, the cultivated land would support a larger population per acre, both because smaller farms usually produce more per acre than larger farms and because each farm family con-

sumes garden produce which does not form a part of the produce sold. A decrease in the size of the farms, however, would have a direct effect on the buying power of the rural population, and, insofar as that result obtained, it would represent a step backward in the economic status of the country.

1831. According to the United States census figures for 1930, 4,436,000 acres of crop land were idle in the three States of Washington, Oregon, and Idaho in 1930. A considerable portion of this is accounted for by abandoned dry farms in eastern Washington and Oregon and in Idaho. Another large portion of land is in fallow, so that most of this area does not represent potential crop land. In addition to this the number of horses and mules has been reduced by over 300,000 probably through substitution of tractors, which releases from 500,000 to 750,000 acres of pasture and crop land for other uses. The number of cattle has been reduced by 342,000 and the hogs by 400,000 during the past decade, which may have been a factor influencing the area under cultivation. This reduction will undoubtedly be replaced by a proportionate increase in cattle and hogs during the next decade, which would absorb some of the idle crop land as shown in the census report, although the increase of 273,000 milk cows during the past decade will have absorbed perhaps a major portion of the land formerly utilized in feeding cattle and hogs. An increase of 3,700,000 chickens during the past decade is another factor to balance the loss in cattle and hogs.

1832. In addition to the potential crop land, as presented above, there are 4,894,000 acres of tillable pasture, a portion of which at least might be converted into crop land in order to meet the increased demand for foodstuffs. There are also 2,600,000 acres of irrigable acreage in enterprises in Washington, Oregon, and Idaho, other than the Columbia Basin irrigation project, which were not irrigated in 1930, 825,000 acres of which were included under existing canals. The area included under projects which have recently been approved for construction by the Bureau of Reclamation in Washington, Oregon, and Idaho is shown in table no. 236.

TABLE NO. 236.—*New lands anticipated to be irrigated on projects which are now authorized and under construction or which have been approved for construction in the near future in the States of Idaho, Washington, and Oregon*

State	Project and division	Status	Area to be irrigated (acres)		
			New lands ¹	Old lands ²	Total
Idaho.....	Minidoka, gravity extension.	Under construction.....	40,000	45,000	85,000
	Owyhee.....	do.....	18,000	20,000	38,000
Oregon.....	do.....	do.....	55,000	30,000	85,000
	Vale.....	do.....	28,000	2,000	30,000
	Baker.....	Approved for construction in near future.	0	7,000	7,000
Washington.....	Yakima, Kittitas division.	Under construction.....	42,000	30,000	72,000
	Yakima, Kennewick Highlands division.	Approved for construction in near future.	1,400	2,600	4,000

¹ Lands not now irrigated.

² Lands which are now being partially or fully irrigated from other sources which will receive either a full or supplementary water supply under the project.

1833. The position which the Northwest holds in relation to natural resources per capita as compared to that of the United States, France, and Germany is shown in plate no. 143.² Apparently there is opportunity for expansion along various lines before the resources in land are entirely utilized. This points clearly to the desirability of a comparative study of the various alternative ways of providing the food and other raw material which will be required to meet the needs of a growing population.

1834. The exact way in which the increased area necessary to maintain an increased population will be provided will depend upon the comparative economic advantage of one area or method over others. If the Columbia Basin irrigation project can be developed more economically than the irrigable area now included in enterprises but not yet irrigated, or more economically than the possible conversion of tillable pasture or cut over land to crop land or possible increase in production due to better methods of agricultural practice, the development of the project would be justified if population continued to increase as predicted.

1835. *f''*. *Selection of settlers*.—A selection of settlers would be necessary in order to eliminate those who are obviously unfit to undertake the development of desert land. No definite standard can be set as a measure of a man's capacity to succeed, but men who lack experience and who lack capital should be advised against settlement. Such men might become laborers until they gain sufficient experience to justify their purchase of property. Those who have less than \$5,000, unless there are a number of workers in the family, could rent land rather than attempt the development of property of their own. Experienced men with insufficient capital to become tenants could become farm laborers until they have acquired enough capital to undertake the purchase or the lease of property.

1836. An attempt should be made to select the settler in his own community in order to save the possible loss of time, money and the disappointment in having prospective settlers visit the project who are too inexperienced or not sufficiently well financed to make it safe for them to purchase land.

1837. *g''*. *Credit*.—The total cost of buying and developing farms in the Columbia Basin project will range from \$2,500,000 to \$5,000,000 or more per year on the basis of the settlement of 50,000 acres annually.

a'''. *Sources of credit*

1838. *a''''*. *Private credit*.—Most of the money for the development of land will have to be supplied by individual settlers from their own resources unless some special provision is made for State or Government participation in development. As development progresses and the community becomes stabilized, individuals who can offer satisfactory security will be able to get credit from banks and other financial institutions or private loaning agencies. The fact that the Government or other development agency would hold a first lien upon the land as security for construction costs would limit, and perhaps prevent, the securing of loans from an institution such as the Federal land bank.

² Not printed.

1839. *b''''*. *State or Government credit*.—The State or Government could grant credit in two ways: First, by making loans to settlers; second, by developing land at Government expense so that improved farms could be offered for sale. The credit problem in any new community is a serious one, particularly where irrigation development is concerned and public funds form a convenient source of credit for those who are unable to meet the requirements for commercial credit. If money for loans is available, or if land is prepared prior to settlement, settlers would be able to secure an income more quickly and would be able to use their own resources for operation costs, rather than having their money tied up in permanent investment in land. The rate of settlement might be increased to a point which would represent a material saving in interest charges on construction, which would go toward covering losses which would inevitably occur if the Government goes beyond the financing of construction costs.

1840. The disadvantages of Government participation are obvious. Granting loans or the improvement of land would involve the Government in a very heavy indebtedness. If the Government purchased and leveled the land, \$25,000,000 to \$30,000,000 would be required for the pumping unit alone. A lesser amount would be necessary if loans were made to settlers. Interest on this indebtedness would have to be charged and would be a heavy burden on the borrowers, even though the interest rate were low. A farmer may fail to get interest on his own investment during a hard period, but interest on borrowed money continues regardless of returns from the farm and must be paid. Credit privileges beyond what can be furnished on a commercial basis would, therefore, be a handicap through a period of low production or low returns.

1841. Where a group of settlers, each interested primarily in his own success, receive aid from a more or less detached, impersonal agency such as the State or Federal Government, there is inevitably a tendency to shoulder the burden on the impersonal agency through one device or another. This is particularly true when the participation of the Government extends to the point which would be represented by the construction of canals and preparation of land or the financing of settlers. The hardships of the pioneering community exaggerate this tendency. Such a situation does not exist in community development as in the case of municipal ownership, for example, where a bond issue must be paid by the beneficiaries of the development and where there is no possibility for passing responsibility for payment to a larger and more impersonal group. For this reason a large district organization is suggested as a foundation for credit and repayment.

1842. Obviously, if no interest is charged, the land will have a greater value than other land which must carry an interest burden. In the past this saving in interest has often been capitalized in speculative values in such a way that the actual settler has had to bear as heavy a burden as though he had shouldered an interest charge in the beginning. If interest-free money is made available the increase in land value which is represented by the capitalization of the interest saving should by all means be controlled in the interest of the project if it is possible to do so.

1843. *d*. *Summary of facts covering permissible charges against farm land for construction costs*.—If the average permissible charge for

water is \$6 per acre it must cover operation and maintenance and repayment of construction costs with interest.

1844. Under the gravity system it would require approximately \$2.50 to cover operation and maintenance of the system. This would leave \$3.50 for the payment of interest and bonded indebtedness. At 4 percent interest and with amortized payment covering a period of 40 years, \$3.50 would pay out on a bonded indebtedness of \$69.28 per acre.

1845. Under the pumping plan where operation and maintenance is estimated at \$2.90 per acre and power at \$1.10 per acre there will be a remainder of \$1.90 to cover interest and repayment of bonded indebtedness at 4 percent. With interest at 4 percent and with amortized payments covering a period of 40 years, an annual payment of \$1.90 per acre will pay out on the bonded indebtedness of \$37.60 per acre.

1846. The estimated permissible charge of \$6 for the Columbia Basin irrigation project is somewhat less than the average per-acre charge by irrigation districts, public utilities and mutual water companies, as shown in table no. 237, but the charge is as high as can be paid from the returns from general agriculture and a consideration of the saving in interest due to an increased rate of settlement (after construction of canals is complete) may justify a charge for water somewhat below the permissible charge.

TABLE NO. 237.—*Cost of irrigation water under different types of enterprises*

Type of enterprise	Number of enterprises considered	Annual cost					
		Per acre			Per acre-foot		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Public utilities.....	46	\$0.56	\$32.67	\$6.10	\$0.30	\$25.14	\$4.27
Irrigation districts.....	37	.90	24.69	7.57	.37	22.19	4.80
Mutual water companies.....	111	.83	60.07	15.51	.40	50.91	10.62
Private electric pumping plants: ¹							
Sacramento Valley.....	22	3.01	45.63	19.04	2.81	55.31	7.65
Santa Clara Valley.....	24	5.34	33.08	16.24	4.04	56.34	23.73
San Joaquin Valley.....	14	6.96	48.08	22.26	1.56	18.42	7.21

¹ All of these were tested for plant efficiency.

² Average of 11 enterprises. Those enterprises for which acreage costs were not available had low acre-foot costs.

1847. *a'. Assessments for water costs.*—If land in the district is assessed on its appraised value, taking into account location and soil factors, a uniform rate of taxation would result in a justifiable variation in the annual charges per acre in different parts of the project.

1848. This policy is recognized in the State water law of Washington which authorizes taxation for water by irrigation districts on the basis of benefits. The law reads, "Assessments made in order to carry on the purposes of the act shall be made in proportion to the benefits accruing to the lands assessed." The practice is followed in the irrigation districts in California, and is followed in other States as well.⁹² Although the irrigation law of Washington provides for

⁹² Summary of Irrigation District Statutes of Western States, by Wells A. Hutchins, U.S. Department of Agriculture.

taxation on the basis of benefits, in actual practice a flat charge is usually made. If a flat rate is charged in the Columbia Basin irrigation project it might reduce the area which can be included since some lands, which might be included if water charges did not exceed \$3.50 to \$4 per acre, might not be able to pay an average charge of \$6, although such farms might pay their full share of operation and maintenance and a less than average amount for the repayment of capital expenditure.

7. POSSIBLE RETURNS FROM POWER AS A SOURCE OF REVENUE TO REPAY COSTS

1849. An important factor enters into a consideration of the pumping plan which simplifies the problem presented by the high cost projects where power can be developed in connection with the storage of water for irrigation. The profits from power development may be sufficient to pay the entire indebtedness as in the case of the Salt River project in Arizona, or it may greatly reduce the indebtedness, as for example, in the Modesto, the Turlock, and the Merced districts in California. The final approval of plans for the construction of the Boulder Canyon Dam was based on the prospect of repayment of the construction costs plus interest by the sale of power. Without this revenue the plan for delivering water from the Colorado River to Los Angeles for domestic uses and to Imperial Valley irrigation district for an extension of the irrigated area would have been financially impossible without a tremendous national subsidy.

1850. The combined revenue from payments for irrigation water and from sale of power under the pumping project may be sufficient to repay all costs plus interest over a varying period of years depending upon the rates charged. According to plate no. 142, if the farm land pays \$2.50 per acre per year toward repayment of construction costs with interest, and if the power developed can be sold at a rate of 2.1 mills per kilowatt-hour at the plant, it will require 68 years to repay the indebtedness in the case of the high dam with settlement at the rate of 25,000 acres per year and 120 years to pay out if the land is settled at the rate of 50,000 acres per year. The low dam will not carry the load.

1851. It is interesting to note that a retarding of settlement hastens repayment when the income from the sale of water and power are combined. This is due to the fact that in the combined plan irrigation is a burden on power.

8. BENEFITS FROM IRRIGATION DEVELOPMENT AGAINST WHICH CONSTRUCTION COSTS MAY BE CHARGED

1852. From a comparison of costs and permissible charges it is at once apparent that the construction costs incidental to delivering water to the lands of the Columbia Basin cannot be wholly met by any permissible charge against the farmers on the project.

1853. A study of the diagram shown in plate no. 144,² however, clearly shows that the production on the farm is but the beginning of a ramification of activity which is far reaching. That portion of the diagram to the left of the square representing the Columbia Basin irrigation project represents the flow of farm produce from the project to the ultimate consumer. A portion of this goes through manu-

² Not printed.

facturers to be put into shape for consumption and a portion goes to the consumer direct.

1854. That portion of the diagram to the right of the central square represents the flow of money which the ultimate consumer pays for the raw and manufactured produce. This fund is first divided into three parts, the first part being the total sum paid to the farmers; the second part being the value added to the farmer's price by the manufacturer, creameries, canning plants, woolen and linen mills, etc.; and the third part being the value added in payment for services performed by transportation and merchandising agencies who deliver the products to the ultimate consumer. This money is distributed to local interests, regional interests, and interests outside of Washington, Oregon, and Idaho, as shown by the diagram.

1855. If these figures accurately reflect the importance of agriculture as a factor in the economic life of a community, it is apparent that the farmer as a primary producer is not necessarily the main beneficiary of irrigation development. Local retailers of every kind, banks, public utilities (both power and railroads), labor, wholesalers, jobbers, manufacturers, and the general public are to a surprising degree dependent upon agricultural production, not only because of the food produced for direct consumption and the raw material supplied to manufacturers but because of the general business activity which is created.

1856. In order to determine the economic feasibility of plans for delivering water to the lands of the Columbia Basin irrigation project it is necessary, therefore, to determine what the total direct benefits are and how much the benefited parties can be expected to pay toward construction costs.

1857. As a starting point an analysis was made of the distribution of the estimated gross income resulting from the sale of farm products from 1,000,000 acres of land under the pumping project. This analysis is shown graphically in the diagram in plate no. 144,² and is based on records of field studies of farm production and farm expenditures made by the colleges of agriculture of Washington, Idaho, and California and upon the 1930 census record of retail trade in Yakima and wholesale trade in Spokane. Every effort has been made to confine the analysis to the practical application of known facts to the conditions.

1858. *a. Benefits to the farmer resulting from irrigation development.*— Although the farmer appears to be a direct beneficiary of irrigation development, any benefit which may result is confined to the individual who becomes a settler. Furthermore, if the analysis of costs and returns is correct, all of the increased land value above the actual cost of raw land with necessary improvement is absorbed by the permissible irrigation charge to apply on construction costs, which leaves no immediate benefit to the average settler other than the opportunity which the development offers for farm operation.

1859. The estimated permissible charge of \$6 under the pumping plan will pay out on an indebtedness of \$37.60 an acre. The estimated ultimate benefit to the farmer in increased land value is approximately the same figure. It is true, of course, that the returns from the land represent an income which meets the water cost and that eventually when the construction charges have been paid the farmer will become

² Not printed.

the owner of this equity. It is also true that land values may, and in all probability will at some future time, increase to a point much above the combined cost of raw land, improvements, and bonded indebtedness, but such an increase will probably not occur during the period covering repayment of construction costs.

1860. Assuming that the land will return interest on a value of \$140 per acre in addition to paying operation and maintenance including cost of power, and assuming further that the cost of land and land improvements averages \$100 per acre, as given in the estimate in table no. 229, the difference between these two figures would represent the increase in value of land due to irrigation development. This difference amounts to \$40 per acre, which is a measure of the farmer's ultimate money benefit. On a basis of 1,000,000 acres of irrigated land the farmer would receive a total of \$40,000,000 in increased land value, as shown in column 15, plate no. 144.²

1861. Farmers as a class receive no direct benefit. They are, in fact, damaged by the increased competition, particularly if the increased production of new land is sufficient to reduce prices. This fact forms the basis for opposition to any plan for increasing production. In the analysis of the economic feasibility of the Columbia Basin irrigation project, however, it is assumed that the project will not be approved for construction until the demand for land and the market for agricultural products warrant development of new land.

1862. The relative income per person engaged in agricultural and nonagricultural industries in the United States from 1909 to 1928 is shown in plate no. 145.² This comparison emphasizes the fact that the farmer is not necessarily the benefited party against whom the main cost of irrigation construction should rest.

1863. In a general way, however, an expansion of the cultivated area offers an opportunity for settlement to any farmer in the country and to that extent the development may be considered a benefit to the agricultural interests. The son of a farmer in Ohio or Iowa who may not have the opportunity to establish himself in a settled community has just as much of an opportunity to profit by the development of land in the Columbia Basin as a resident of Grant County.

1864. The wealth of the United States and the opportunity which it has offered to millions of families in the past has been due to continued expansion of the cultivated area. If expansion is to stop, the opportunity which has been the stimulating force in the conquest of the West will also stop. It is not unreasonable, therefore, to consider the development of new land a benefit to the general farming interests of the country, provided the rate of expansion is not too rapid, although it is evident that this benefit carries with it a direct damage in competition which does not attach to the benefits received by other benefited parties, including the general public. The activities which are built up around agriculture as a primary industry afford too great a benefit to society to permit a limitation of expansion in the interest of a group which might profit by a monopoly interest, provided the legitimate interests of that group are not damaged by such expansion.

1865. Expansion in the past has been subsidized through the Homestead Act and other related measures and by great grants of land to railroads. The problem which is presented by high-cost irrigation projects is not different in principle from the problem presented

² Not printed.

throughout the history of the westward movement of population. The problem, however, requires a careful analysis in order to insure the expenditure of money and man power to the best advantage. Since the farmer cannot pay all of the costs it is important to determine whether or not the combined specific and assessable benefits resulting from agricultural development, and taking into account all possible damage to existing interests, are sufficient to meet the costs. Furthermore, if the benefited parties apply for a subsidy represented by a loaning of Government credit with or without interest, it is important to know in a general way whether or not there is some other and better use which should be made of the resources at hand.

1866. *b. Benefits to local business interests as a result of irrigation development.*—The fund resulting from the sale of farm crops forms the nucleus of a wide circle of business activity which embraces every kind of human effort. The first distribution of the money paid to the farmer from the sale of crops is shown in column 9 of plate 144.² The fund is divided as follows:

Land.....	\$12, 500, 000
Hired labor.....	10, 687, 500
Farmers' labor and management.....	10, 111, 900
Capital goods.....	15, 525, 000
Taxes.....	3, 000, 000
Total.....	51, 824, 400

1867. This represents the major grouping of the debit items in the farmer's balance sheet. Hired laborers' wages are spent for food, clothing, automobiles, furniture, rent, drugs, amusements, and various personal services. The farmer spends his income for prepared foods, clothing and dry goods, furniture, supplies, investments (of surplus), interest on borrowed money, automobiles, amusements, and various personal services. This second and further distribution of the fund as shown in column 10 of plate no. 144² is as follows:

Hardware and machinery.....	\$1, 465, 344
Lumber and building material.....	2, 412, 641
Automobiles and tractors.....	10, 932, 932
Furniture and supplies.....	2, 482, 465
Dry goods, drugs, jewelry, coal, ice, etc.....	11, 791, 320
Food and eating places.....	5, 960, 998
Personal services, amusements, etc.....	3, 716, 020
Interest on borrowed money.....	3, 571, 080
Livestock, work stock, and feeders.....	490, 600
Taxes (county).....	3, 000, 000
Water (irrigation district).....	6, 000, 000

1868. This distribution of the farm income is based on the analyses of farm accounts made by the colleges of agriculture of Washington, Idaho, and California.

1869. For convenience in analysis these items are grouped under two headings—retail trade and expenditures not included in retail trade. In this case the retail trade amounted to \$35,046,700 and the other expenditures to \$16,777,700.

1870. The farmer's buying power, as represented by the money received from the sale of crops, is the primary source of community credit, but it is not the only source. The money received by store-keepers, school teachers, clerks, bankers, railroad employees, judges, and all the other persons who perform a service, augments the money

² Not printed.

spent by the farmer and the two together form the total buying power of the community. Taxes go largely toward the payment of wages and salaries for school teachers, county officials, and other public employees. This money is largely spent for consumable goods. The water assessments also go largely toward payment of salaries, although insofar as the irrigation bonds are held by outsiders, the money used for payment of interest and principal goes outside of the community and does not add to local buying power.

1871. There are two sources of added wealth other than agriculture which create a part of the community buying power. According to the analysis shown in the diagram (plate no. 144),³ \$10,000,000 is added to the value of the raw farm produce through local manufacturing activities, including creameries, canneries, and meat packers principally. This fund is spent for capital goods, land, labor, and taxes just as the farmer's fund is spent.

1872. The other added value results from the services performed in transporting and in handling the raw and manufactured produce. Most of this added value is distributed in regional centers or in more distant consuming areas, but a portion represented by the local expenditure of the railroads and by the services of local buyers and warehouse interests forms a part of the local community fund. In addition, the railroads spend some money locally in the handling of incoming freight, which money is not included in the retailer's 25 percent but which is a part of the total freight charge which is included in the net cost of merchandise.

1873. The extent to which the fund spent by the farmer is augmented by the money spent by the urban population which is occupied in supplying goods and services to themselves and to the farmers is shown in column 11 of plate no. 144.² The items are as follows:

Hardware and machinery.....	\$990, 173
Lumber and building material.....	1, 557, 615
Automotive equipment.....	4, 679, 907
Furniture and supplies.....	1, 228, 959
Dry goods, drugs, jewelry, coal, ice, etc.....	5, 035, 930
Food and eating places.....	2, 460, 716
Total.....	15, 953, 300

1874. This retail trade when added to the retail trade of the farmer makes a total retail business for the community of \$51,000,000. This figure represents an average retail business of \$400 per capita for the estimated population of 125,000 people. This is based on the figures secured by the analysis of the retail trade in Yakima County, Wash.; Imperial County, Calif.; and Twin Falls County, Idaho, as shown by the retail trade census made by the United States Department of Commerce. Due allowance was made for the new price level in setting the figure for the Columbia Basin irrigation project.

1875. In order to make this point clear it can be said that the money used by the urban population comes from four sources: First, from the distribution of that portion of the total value of the retail business which the local retailer keeps to meet rent, wages, salaries, interest, taxes, profits, cost of supplies, and other items of expense. (This usually equals about 25 percent of the total value of the retail trade.)⁴³ Second, from the money spent by the farmer for interest,

³ Not printed.

⁴³ Reports on analysis of retail business—Harvard School of Business Administration.

taxes, personal services, or, in general, the items which are included under the grouping of expenditures other than retail trade. Third, by the money spent by railroads and trucking agencies who handle outgoing and incoming produce. Fourth, by money spent by local manufacturing concerns. This total sum is shown in column 13 of plate no. 144² and is called the total local income. The balance left over after meeting all local retail accounts represents money sent out of the community for direct wholesale trade, for interest and principal payments on bonds, for profits to chain stores, branch banks, etc., and by personal expenditures for traveling, insurance, and the like. This amounts to \$62,000,000 according to the analysis in plate no. 144.²

1876. The important point in a consideration of the money which leaves the community is that it does not add to local buying power. As the community is able to pay off indebtedness and as local residents are able, through their savings, to buy bonds, the local buying power will increase, which will result in a greater consumption of luxuries. This will show up in an increased retail trade.

1877. The proportional distribution of the total retail business as between the various retail activities as given in the diagram is the same as given in the census analysis of the retail trade of Yakima County prepared by the United States Department of Commerce, but the grouping of the various retail activities was changed, as for example, by combining dry goods, drugs, jewelry, coal, and ice into one group.

1878. *a'. Summary.*—The benefits to local business interests are of precisely the same character as the benefits to the farmer. The development offers the usual business opportunities as indicated in the analysis of retail trade in plate no. 144, which shows a total volume of business valued at \$51,000,000. The business transacted does not compete with similar lines of business elsewhere and there is, therefore, no opposition to the development of the project from either local or regional business interests.

1879. The increase in land value which represents the net money gain above ordinary business profits which the owner of city property enjoys is equal to approximately one third of the increase in farmland value. This is shown in column 17 of plate no. 144.² In Yakima County, for example, the assessed value of city land is 29.8 percent of the assessed value of farm land, exclusive of improvements in both cases. In the Modesto irrigation district in California the assessed value of city property is 36.6 percent of the assessed value of farm land, exclusive of improvements in both cases. In the latter case irrigation district taxes to cover construction charges as well as operation and maintenance are levied at the same rate per hundred dollar value against city property as against country property.

1880. On the basis of the proportion existing between the direct money benefits to city interests on the Columbia Basin irrigation project and the direct money benefits to country interests, the city interests should pay \$25,000,000 toward construction costs. The interests which are affected by this direct money benefit are shown in column 14 on plate no. 144.²

1881. *c. Benefits to regional business interests as a result of irrigation development.*—Regional centers are benefited in two ways. The first and perhaps the most direct benefit results from local production. In

² Not printed.

an isolated community this may be very great indeed, while in a community which is surrounded by producing land an increase in production might mean simply a substitute of one product for another.

1882. It is impossible to appraise the exact direct benefit which the regional center might secure from the saving in price due to increased local production. The annual saving might easily reach into the millions if western Washington and western Oregon become highly industrialized, since any saving in price does not apply to the products from the project alone but to all products which compete on the market.

1883. For example, 85 percent of the hogs slaughtered under Government inspection in the State of Washington are imported from other States. The receipts of hogs at the Seattle Union Stock Yards for 1930 totaled 165,736. The points of origin were as follows:

Oregon.....	795
Portland Union Stock Yards (mostly Idaho).....	20,592
Idaho.....	28,904
Montana.....	65,367
North Dakota.....	12,958
South Dakota.....	33,504
Wyoming.....	2,928
Iowa.....	688
Total.....	165,736

1884. The price for hogs in Washington is governed largely by the cost of the marginal supply which in this case would probably be represented by the large shipments from the Dakotas. Local producers enjoy a price based on Dakota cost of production plus freight, and as a result Seattle is the highest-priced hog market in the United States. If the Columbia Basin project produced enough hogs to meet this marginal supply (without reducing shipments from Idaho or Montana, which can be considered as back country for the industrial section on the west), the consumers of the Northwest would have the benefit of a reduction in price of all hogs based on the elimination of the extra cost of freight on the present marginal supply. A reduction of 1 cent a pound (Seattle prices are from 0.01 to 1.05 above Chicago), the consumers in Washington would save \$650,000 a year, which if capitalized at 4 percent represents interest on a sum of \$16,250,000, which is a rough measure of the possible benefit which regional centers might enjoy as a result in the saving in this one item.

1885. It is true, of course, that some of this saving comes out of the producer's pockets in Washington, Oregon, Idaho, and Montana, since their price is set by the high cost of the marginal supply. A small portion of this reduction is carried by the railroads who would not have the long haul on the marginal supply from the Dakotas.

1886. A similar saving would result in beef which is now largely imported. The project should aid in maintaining the per capita production of dairy products, fruits, and vegetables, in order to meet the increased demand which will result from an increase in population, especially in the industrial centers. The total saving to consumers as a result of production on the Columbia Basin project would be very appreciable if the population increases as predicted.

1887. It is frequently claimed that new production in any specific area is but a substitute for present production elsewhere. The illus-

tration given above, as affecting the market for hogs in the Dakotas, is a case in point. This argument is not valid when considered from the standpoint of a growing country, however. If the population of the United States increases as predicted the normal market for hogs produced in the Dakotas will sufficiently increase to absorb much more than the reduction which a loss of present shipments to Washington represent.

1888. The business represented by the transportation and merchandising activities in regional centers due to the handling of produce being shipped out of the project cannot be considered as new business except for that portion of the produce which is shipped out of the Northwest. Produce consumed locally is simply a substitute for a similar quantity of produce which would be secured from other sources if the project were not developed. The produce shipped east or to foreign countries, however, does add to the business of the railroads, the jobbers, the wholesalers, and the shippers.

1889. In general, it can be said that the benefits resulting from increased production are confined quite largely to general or public benefits, realized through a reduction in prices. This general benefit may be very great indeed and may justify a public subsidy. This would depend, however, upon the cost per unit of product to the consumer. If the quantity produced is not sufficient to eliminate the marginal supply, the public would not be benefited and any assessment would properly rest on those who are enjoying the monopoly price because of the opportunity which the project offers to producers. Other farmers who would also receive monopoly prices would not be benefited by the construction of the Columbia Basin irrigation project and should not be assessed, particularly since their profit would be endangered by the increased production.

1890. *a'. Benefits to regional centers resulting from the creation of local buying power.*—The second type of benefit results from the buying power of the local community, both rural and urban. A new community represents an entirely new market for manufactured products. The increased consumption is not confined to the local buying power for those who are engaged in supplying the raw material which goes into both the capital and consumable goods used by the local people, those who manufacture the products, and those who are engaged in merchandising and transportation of the goods are also new consumers who constitute a new market. Regional wholesalers and retailers and transportation agencies are affected by the shipments of raw products out of the project and of manufactured products into the project. The distribution of benefits is shown graphically in column 20 in plate no. 144.²

1891. According to the analysis given in plate no. 144,² the regional manufacturers of goods consumed locally receive \$12,050,100 from the business transacted on the Columbia Basin irrigation project. This fund is distributed to wages, salaries, and charges for transportation, raw material, interest on capital, and other items entering into costs. This does not include added value of manufactured goods consumed in regional centers by those engaged in transporting, wholesaling, and manufacturing the products consumed on the project, nor does it take into account the transportation, wholesaling, retailing, and manufacturing created by the shipment of produce out of the project.

² Not printed.

1892. The value of this volume of business is shown in a general way by an analysis of the wholesale trade in Spokane for 1929, which totaled \$52,091,186, according to the preliminary report made by the United States Department of Commerce in the 1930 Census of Distribution. The increased buying power in regional centers is indicated by the \$3,501,000 paid in salaries and wages paid by the wholesalers of Spokane. This is but 6 percent greater than the estimated wholesale trade resulting from the sale of goods to the consuming population of the Columbia Basin irrigation project. The total wholesale trade resulting from the total business created by the Columbia Basin irrigation project is about twice this figure as it includes the handling of produce which goes out of the community as well as that which is sent into the community to be consumed by the local population. In other words, the wholesaler receives two profits, one from outgoing raw material and the other from incoming manufactured goods. The distribution of the money handled by the wholesale trade of Spokane is given in table no. 238.

TABLE NO. 238.—Wholesalers by kind of business, Spokane, Wash.

[Source: 1930 Census of Distribution, U.S. Department of Commerce]

Kind of business	Number of establishments	Number of employees	Net sales, 1929	Salaries and wages, total	Stocks on hand, end of year, at cost
Total.....	159	2,049	\$52,091,186	\$3,501,892	\$8,375,336
Automotive group, total.....	15	225	4,732,032	481,774	927,645
Automotive equipment and parts.....	9	118	1,846,532	241,952	468,465
All other.....	6	107	2,885,480	239,822	459,180
Farm products (except dairy and poultry), total.....	6	41	2,473,399	77,697	63,235
Flowers and nursery stock.....	1				
Grain.....	2				
Hides and skins.....	2	41	2,473,399	77,697	63,235
Livestock.....	1				
Food and tobacco products, total.....	44	591	18,123,569	921,760	1,856,519
Poultry and poultry products.....	3	9	154,421	9,432	3,167
Groceries.....	11	273	11,849,618	492,131	1,620,152
Confectionery and soft drinks.....	4				
Dairy products.....	3				
Fish and sea foods.....	1				
Fruits and vegetables.....	14	309	6,119,530	420,197	233,200
Meats and meat products.....	6				
Tobacco products.....	2				
Hardware, electrical, plumbing, and sporting goods, total.....	20	540	9,205,027	953,970	2,122,633
Plumbing and heating equipment and supplies.....	3	59	1,402,067	121,187	289,840
Radios and radio equipment.....	5	28	569,684	55,726	35,233
Electrical goods (except radios).....	7	453	7,233,276	777,057	1,797,560
Hardware.....	6				
Lumber and building materials (except metal), total.....	15	132	4,455,312	180,439	624,421
Construction and building materials (other than metal and wood).....	1				
Lumber and millwork.....	14	132	4,455,312	180,439	624,421

1893. The benefits to regional centers as a result of increased local buying power can be grouped under two headings—increase in land value and increase in profits.

1894. The increase in land value is exactly similar in nature to the increase in local land values and is in proportion to the buying power of the community as affected by project business.

¹ Not printed.

1895. *b'. Summary of regional benefits.*—Regional benefits are of two kinds: First, the general benefit to the public in reduced prices (if the increased supply eliminates the marginal supply shipped in from distant points); second, the specific benefits which are enjoyed by project settlers, local business interests, regional business interests, and the utilities resulting from the buying power of the community.

1896. These two classes of benefits are very distant. A public subsidy through general taxation might be justified by the first class of benefits, while the second class is enjoyed by certain groups of individuals who are benefited directly and who should bear some share of the cost.

1897. *d. Benefits to transportation interests.*—The transportation interests are benefited more directly than any other single interest. With comparatively little additional investment the railroads will carry \$53,000,000 worth of consumable goods annually into the irrigated area and \$62,000,000 worth of raw farm produce and manufactured goods (such as butter, canned goods, and meat products) out of the irrigated district to consuming centers.

1898. According to records of shipments from the Yakima Valley, 68 percent of the farm produce is shipped west and 32 percent east. Assuming that all wool, meat products, and dairy products are shipped west and that such portion of the total tonnage of fruit and vegetables is shipped west as to make the total western shipments equal to 68 percent of the total shipments out of the project, the freight on outgoing traffic would be approximately \$7,750,000.

1899. This checks rather closely with the amount of freight secured by the railroads handling produce from the Yakima Valley. In a detailed market analysis in 1928, published by the Yakima daily Republic, it is stated that the freight on apples alone amounted to \$5,184,200 in that year. The \$7,750,000 on outgoing freight equaled \$624 per farm family. This is somewhat less than the estimate of the freight returns from an average farm family made by the railroads, but it is a conservative figure and within a reasonable range of other estimates.

1900. The incoming freight, according to records of outgoing and incoming freight in Yakima, amounts to approximately seven ninths of the outgoing freight. Using this proportion, the outgoing freight would bring \$6,066,000 to the railroads annually. The figure secured in the analysis of freight on incoming produce is \$5,875,000.

1901. The combined outgoing and incoming freight, according to this estimate, would total \$13,625,000 annually. This equals approximately \$1,110 in freight annually per farm family on the Columbia Basin irrigation project. This figure is approximately the same as the estimate of the total value of freight per farm family made by the railroads.

1902. The total freight received by railroads in Washington in 1929 amounted to \$54,582,733.75. The estimated freight income to the railroads from the new business developed as a result of the Columbia Basin irrigation project is approximately 25 percent of the total freight received in the state and approximately 4 percent of all of the freight received from the entire system of roads operating in Washington. This new business would represent a greater increase in profit than indicated by the percentage which the value of the new business

holds to the value of present business, because no new expenditure in trackage would be necessary.

1903. No attempt has been made to evaluate the increase in passenger traffic or the indirect increase in freight due to the increased business in regional centers as a result of the development of the Columbia Basin irrigation project.

1904. The benefits to the railroads cannot be measured in the same way that benefits to farmers and local business interests are evaluated. The railroads receive three distinct types of benefits: First, increase in land value; second, increase in profits; third, increase in franchise value. The increase in county assessments of the physical property would be a measure of the increase in land value, and it is assumed that this value is included in the estimated increase in land values locally and in regional centers. An increase in the net return to stockholders would represent the increase in profits. The increase in the market value of the stock would be a measure of the increased franchise value. If this increase in returns should cause the profit to exceed the legal limit, then the public would benefit in decreased rates. Plate no. 144² shows the relation of these benefits graphically.

1905. The railroads are not benefited to the same degree by outgoing freight as by incoming freight except for that portion of the produce which goes East or to foreign markets, since the railroads would have to haul farm produce to regional consuming centers from other areas if the Columbia Basin irrigation project was not developed. This is not true of the incoming freight to meet the demands created by the project itself. It is also true that long hauls on marginal supplies (such as hogs from the Dakotas) would be eliminated by production on the project. Because of this, no account is taken of the benefits resulting from outgoing freight in estimating the direct benefit to the railroads.

1906. Assuming that the new investment necessary to carry the increased traffic will not represent more than 10 percent of the increased revenue and using a ratio of 25 percent of the balance as net gain to apply to income, the railroads will receive the amount shown in the following tabulation from incoming freight. (This figure of 25 percent is considered conservative since affected by the law of increasing returns).

Total freight.....	\$5, 875, 000
10 percent for increased capital cost.....	587, 500
Balance.....	5, 287, 500
25 percent of balance as net benefit to railroads.....	1, 327, 500

1907. This figure capitalized at 4 percent will total \$33,187,500 as a measure of the total increase in franchise value to transportation interests.

1908. *e. Benefits to power.*—The Grand Coulee Dam will develop a large block of power which must be sold in the power markets of the Northwest. The Columbia Basin irrigation project will create a demand for power in the local community, in regional centers, and in the transportation of produce in and out by the producing center. In general the local community will consume \$5,000,000 in power. The manufacturers, wholesalers, retailers, and the population employed in these activities in regional centers will all use power. The regional use of power is estimated to be \$2,000,000, including the power

² Not printed.

used by the railroads. The local and regional power consumption equals \$7,000,000 not including income resulting from goods going out of the community.

1909. The benefit to power resulting from this increased consumption of electrical energy is realized in three ways: First, by an increase in profit; second, by the increase in franchise value represented by the capitalized return on stock; third, by an increase in the value of land owned by the power interests.

1910. The increase in land value is included in the general estimate of local and regional increases in land value.

1911. The profit from a gross annual income of \$7,000,000 from the sale of power is approximately 55 percent or \$3,850,000. From this must be deducted a sum equal to interest on the cost of new transmission lines necessary to deliver the power. This will require approximately 15 percent of the net operating profit. The balance, or \$3,272,500, represents the net benefit which the power interests secure in profits. A portion of this represents the profit from the sale of secondary power to lift the irrigation water to the project lands. An allowance of \$1,100,000 annually is made to cover this item.

1912. By capitalizing this net return a rough measure of the increased franchise value is secured. Capitalizing this return on the basis of 4 percent interest, the franchise value would equal \$81,837,500.

1913. *f. Benefits to the public.*—The public is benefited in two distinct ways by irrigation development.

1914. In the first place, if the increased production is on a sufficiently large scale to eliminate the marginal supply shipped in from distant points, the public will enjoy lower prices. If the increased supply cannot be provided more cheaply by some other method, then a general tax, possibly in the form of a sales tax, might be justified as a subsidy.

1915. The second form of benefit results from the opportunity which is offered through an expansion of a primary industry. The ramification of influence is widespread and any citizen may profit by the opportunity offered. Expansion of territory is a distinct benefit to the Nation because of the opportunity which is offered.

1916. It is interesting to note in this connection that the 1,000,000 acres of land would feed about 500,000 people and that the activities created as a result of the creation of increased local buying power will permanently occupy about 400,000 people. The people who are fed but not permanently occupied will be employed during the development period in construction of dams and canals, in leveling land, building buildings on farms, in local towns and in regional centers and in supplying the capital goods required for production, transportation, and merchandising of the products sold. The opportunity for expansion is fundamental.

1917. *g. Summary of benefits.*—The benefits resulting from irrigation development are of three kinds: First, direct benefits which result in profits to farmers and to local and regional business interests; second, indirect benefits which result in an increase in value of farm land and of land in local and regional centers and also increases in franchise values; third, general benefits to the public in increased supply of produce for direct consumption and to supply manufacturers and in reduced prices to consumers.

1918. In the analysis it is contended that the first and third class of benefits may form a justification for Federal aid while the second class of benefits forms an assessable asset upon which an estimate of the economic feasibility of the project may depend.

1919. The value of the second class of benefits follows:

Farm land increase.....	\$37, 600, 000
Local increase in land value.....	25, 000, 000
Regional increase in land value.....	40, 000, 000
Increase in franchise value:	
Railroads.....	33, 046, 875
Power.....	81, 837, 500
Total benefits.....	217, 483, 875

1920. This total is \$33,000,000 more than the total cost of construction under the pumping plan. This does not include any possible benefit to regional interests because of activities incident to the handling of outgoing produce, nor does it include any benefit to the public in reduction of prices to the consumer.

1921. Since the cost of the pumping plans for irrigating the Columbia Basin irrigation project are considerably less than the value of the assessable benefits it is assumed that the pumping project is economically feasible. It logically follows that since the cost of the gravity plans for irrigation are considerably more than the value of the assessable benefits, the gravity plans for irrigation development are not economically feasible.

9. POSSIBILITY AND DESIRABILITY OF ASSESSING BENEFITS

1922. The Columbia Basin irrigation project presents a situation which must be met if irrigation development is to continue.

1923. The cost of irrigation projects which remain to be developed is reaching a point which is beyond the ability of the farmer to pay, even after easing his burden as far as possible by spreading construction cost over a long period of years or by granting a subsidy represented by interest-free money.

1924. This fact indicates the desirability of determining first, whether or not the total direct assessable benefits of any project equals the cost, which would be a measure of economic feasibility; second, whether or not the benefits can be secured in a better way, which would be a measure of the desirability of any project; third, whether or not a revenue can be developed as a subsidy to meet irrigation cost by use of power in case the project proved to be both economically feasible and desirable; fourth, whether or not such a use of power revenue is justified by the benefits secured; and, fifth, whether or not a uniting of power revenue and assessment of all specific and direct benefits should be made in order to afford satisfactory security for either State or Federal aid in financing construction and to hasten repayment.

1925. In the past every attempt has been made to justify development by spreading repayment charges over a constantly lengthening period of years. In some States the benefit from irrigation development to town interests within the irrigated areas has been recognized by permitting the organization of irrigation districts with the power to tax both farm land and city land within the districts. The direct benefit to other than local producers has been considered in the various

plans which have been suggested for the organization of a super-district to include local and regional business interests in order to spread the risk and thereby gain security of repayment of costs. The public benefit was recognized by the organization of the United States Reclamation Service which has provided a subsidy for over 10 percent of the irrigated area of the West in the form of interest-free money with long periods for repayment of the principle.

1926. The possibility and the desirability of assessing benefits present many problems which cannot be fully answered in this report.

1927. A land tax could, of course, be used to reach all land values within the State or within a large district including the portion of Washington and Oregon.

1928. The farmer's increase in value is covered by the water charge.

1929. There is ample precedent for assessing urban property at the same rate per hundred-dollar value as used in assessing farm land. The increase in value in both cases is due to exactly the same cause and an assessment in one case is as just as an assessment in the other.

1930. The regional land values would be harder to assess without affecting parties not directly benefited, although the values are no less real on account of the difficulties involved.

1931. The question as to whether or not regional centers should be assessed for benefits resulting from the sale of produce raised locally depends in part upon the per-unit cost of produce from some other area of agricultural land which might be developed at less cost. The substitution of raw produce from other sources outside of the territory involved would reduce the benefit to the regional centers even if the substitutes could be secured at the same price per unit, since in such a way the buying power of the community would not be available to the regional centers. The benefits to business interests result from the buying power created rather than from the production of produce.

1932. Assessments against profits is possible but a decision as to whether or not a profit tax is desirable is a matter of policy which need not be discussed here.

1933. The franchise tax on railroad earnings is essentially the same as a land tax in its effect, as neither would affect costs, rates, or privately owned values unless the increment in value was paid for prior to the tax on the increase. In such a case any assessment would not represent the return from an unearned increment. The question is extremely complicated and involves policy which need not enter into this discussion.

1934. The possibility of assessing increased land and franchise values in the case of power presents a problem which is similar in principle to the problem of assessing railroads. Power and irrigation are as interdependent as railroads and agriculture. There is one fundamental distinction, however. Power is generated by the flow of water which is a national asset. It is possible, therefore, to consider the franchise value of a power site as a national asset, the returns from which can be used in promoting development in the same manner as the returns from public lands or oil reserves are now used.

1935. Applying the five points outlined above to the figures developed in the study of the Columbia Basin irrigation project, it would appear that the following facts appear to stand out as important:

First. The assessable benefits in increased values total \$217 per acre. The cost of the pumping project is \$184 per acre, or \$33 per acre less than the benefits. The per-acre cost of the gravity plan is \$393 per acre or \$176 per acre more than the assessable benefits. It appears, therefore, that the pumping project can be considered economically feasible, and that the gravity plan cannot be considered economically feasible.

Second. No answer can be given as to whether or not the benefits can be secured in some better way as no study has been made of any specific methods of increasing production other than by the development of the Columbia Basin irrigation project.

Third. A revenue can be secured to cover the irrigation construction costs under the pumping plan by the development of power. This revenue would not meet the cost under the gravity plan.

Fourth. The ramification of benefits resulting from the development of a primary industry would justify the use of power revenue as a subsidy. (This is discussed in paragraphs which follow.)

Fifth. The time required to meet all costs when returns from the sale of water and power are the only sources of revenue is so long as to warrant the assessment of benefits representing increased values for a portion of the cost. Reasonable assessments would be sufficient to cut the period of repayment in half. By spreading the liability, the security to the State or Government would be greatly increased. This subject is discussed more fully in following paragraphs.

10. FORMATION OF A LARGE DISTRICT TO EMBRACE THE AREAS BENEFITED

1936. One method of gaining stability for a development of the magnitude of the Columbia Basin irrigation project which might be followed would be through the formation of a large district with taxing power and embracing the States of Washington and Oregon or parts thereof. The Federal Government, through the Bureau of Reclamation, could hold the district responsible for repayment of construction costs. Such a plan would permit of assessments of direct benefits to interests other than agriculture, which would insure the repayment of indebtedness, with interest, in a much shorter time than where revenue from the farmer and from the sale of power are depended upon alone. In addition to affording value securities as a guarantee of repayment of construction costs, such a plan would insure a direct and widespread interest in securing a sound plan of development.

11. DESIRABLE TIME TO START DEVELOPMENT

1937. The present depression in agriculture presents the strongest argument against any immediate effort looking toward increased production. This fact, therefore, has an important bearing upon any consideration of the Columbia Basin irrigation project.

1938. The study of markets in relation to production on the Columbia Basin irrigation project indicates that the normal demand of the estimated increase in population by 1960 will be sufficient to absorb the increased production of staples on 1,000,000 acres of irrigated land. If the project is developed in stages and only one fourth of the area developed, it would require 17 years to settle the area at a rate of settlement of 25,000 acres a year and some years more to get the land in shape for full production. If the estimate of

markets is correct, the increased population in 1950 would absorb all of the production from much more than a fourth of the area under the pumping plan.

1939. It would appear, therefore, that so far as normal demand for agricultural products is concerned, construction could safely start as soon as the topographic and soil surveys have determined the exact area to be irrigated. This situation is based on the fact that stage development of the pumping area is both possible and desirable and that the delayed development possible in a stage development will hasten repayment.

1940. Overproduction, however, is not the only factor affecting the situation. The buying power of the Nation must be sustained in order to permit the absorption of raw and manufactured products. The problem of consumption is, therefore, as important in relation to the development of the Columbia Basin as is the problem of production. This condition is influenced by two facts which fundamentally affect the problem: First, the passing of the geographic frontier, and, second, the primary saturation of markets for goods which require employment of large numbers of laborers.

1941. The situation facing the country is unprecedented in our history, since much of the work of expansion involved in the conquering of a vast domain has been accomplished. Those who have been employed in these expansion activities, in the construction of railroads and highways, and in the building of cities will have to find a place in the operation and maintenance activities of the more static society in the future. Furthermore, that portion of the growing population which, in the past, has been absorbed in the rapid extension of the agricultural area, now embracing nearly 400,000,000 acres of cultivated land, will have to be taken care of in some other way.

1942. In view of these facts developments such as outlined in the comprehensive plan for the utilization of the water of Columbia River are important since they may serve to permit a gradual transition from a long-continued period of expansion to a period when expansion activities will be of relatively little importance. In other words, the days of the pioneer have passed.

1943. In like manner the unsupplied market for automotive equipment, farm machinery, and other articles, which have formed so important a part in the expansion of domestic trade during the past 2 or 3 decades, is more or less saturated and the activity which this tremendous market for new products has supported in the past will not continue to offer the same degree of employment in the future. Replacements, repairs, and improvements will be of relatively greater importance in the employment of labor than supplying a new demand. The general economic conditions, therefore, have a very direct bearing upon the whole question of development.

1944. If a program of construction is to be adopted as one means of stimulating employment and increasing buying power, work could begin on the Columbia Basin irrigation project as soon as the exact area to be included is determined by topographical and soil surveys. If, on the other hand, development is to be delayed pending a decided improvement in the market conditions, construction need not start for many years. The time element, therefore, depends in part at least upon future policies which cannot be predicted and which are not a province of this report.

12. POSSIBILITY OF COMBINING RETURNS FROM POWER DEVELOPMENT AND IRRIGATION TO MEET CONSTRUCTION COSTS

1945. The construction costs for irrigation are so much above any possible permissible charge for water that any plan submitted for the delivery of water to the lands of the Columbia Basin would have to be declared infeasible if no other source of revenue were available than that afforded by a charge for water to the farmer.

1946. The estimated revenue from the sale of power developed at Grand Coulee is sufficient to subsidize the development of the Columbia Basin irrigation project and when that is paid for to subsidize other irrigation development along the Columbia River as demand for land warrants expansion.

1947. The studies in this report show clearly that the permissible charge for water will not meet the cost of construction of the irrigation system for the Columbia Basin irrigation project even when the Grand Coulee Dam is charged wholly against power. The studies also indicate that the benefits from irrigation development are widespread and much in excess of the cost of construction with interest. If these benefits are to be secured, construction costs will have to be met by direct assessment against benefits or by a subsidy. Since power can be developed in connection with irrigation and since the combined revenue will meet the total costs with interest without assessing benefits outside of the local area, it is reasonable to assume that such a use of the power revenue is justified in the light of the analysis of benefits already given.

13. POSSIBLE ALTERNATIVE USES OF THE REVENUE FROM POWER

1948. A granting of the principle involved in the use of power revenue for subsidizing irrigation development opens up the question as to whether or not there may not be other possible uses of the money and man power which may be of greater value.

1949. An answer to that question would involve a wide range of study but the claim which agriculture may have as against other interests is shown by a study of the fundamental position which agriculture occupies.

1950. There are but five primary industries—farming, mining, hunting, fishing, and lumbering. All consumable goods originate from some one of these industries, and the importance of their development to any community is apparent. The development of irrigation means the creation of a primary industry in a country where agriculture is limited by a scarcity of rainfall. The growth of the West depends in large part upon an extension of the irrigated area.

1951. The various benefits, a portion of which has been credited to local and regional areas and to utilities, can perhaps be better understood when summarized as follows:

By increasing land values.

By providing business opportunities.

By providing homes for an expanding population.

By producing food and raw materials for consumption.

By increasing the consuming power of the country for manufactured goods.

By providing an opportunity for the profitable investment of money and the employment of labor.

By increasing the taxable wealth of the State and Nation.

1952. A money value can be placed on many of these benefits, while others are a part of what may be called the national dividend.

1953. The question as to whether or not society, through government, should subsidize irrigation development by lending its credit or by granting interest-free money depends upon an analysis and a measure of the general benefits which may result. After all, governments are but congregations of people and public money spent on consumption, represented by the absorption of interest charges, as in the case of the United States Bureau of Reclamation, or by the expenditure of principle as in the case of general governmental functions, may be necessary to support national growth, just as an individual has to consume a part of his income in order to live and grow. The national policy, covering the conservation of natural resources, recognized the public benefits resulting from the irrigation development which involves the combined use of natural resources of land and water. The Bureau of Reclamation is one of the important outgrowths of that policy, and under its direction one tenth of the irrigated land in the West has been developed. The decision as to expansion of this development must rest with those who formulate the public policy.

1954. It has been concluded that—

First. Plans nos. 4 and 4-A for delivering water to the Columbia Basin by pumping show the lowest construction costs per acre of any of the plans considered. The actual difference in the cost between these two plans is slight, but the stage development, which plan no. 4-A permits, represents a sufficiently important advantage to justify its recommendation as the best plan.

Second. The permissible charge for water will not be sufficient to meet operation and maintenance costs plus full repayment of principle with interest at 4 percent under any of the plans proposed.

Third. An analysis of the influence of agricultural production on local and regional centers indicates that the assessable benefits to the various interests affected by irrigation development are greater than the cost in the case of plans nos. 4 and 4-A, while the cost of construction under any of the gravity plans is greater than the assessable benefits. For this reason plans nos. 4 and 4-A are considered economically feasible, while the gravity plans are considered economically infeasible.

Fourth. The development of power in connection with irrigation and the use of power revenue as a subsidy for irrigation development are considered to be fully justified where an economic analysis shows that the assessable benefits from irrigation development are appreciably greater than the cost.

V. COMBINED FEATURES

1955. What can be done in the way of improving the Columbia in the interest of navigation, power development, and irrigation alone, has been discussed in the foregoing sections of this chapter. It is the purpose of the present section to indicate how these various interests can be combined to the best advantage.

1956. The navigation section of this chapter shows that to be successful, improvements for navigation must be combined with power development by constructing the navigation locks through the dams

built for power. To develop the potential power of the river, each dam should back the water to the next dam upstream, so that there will be no loss of head between. This is also necessary for full canalization of the river in the interest of navigation. The high dams desirable in power development to minimize drowning out during high-water stages are not, however, ideal for navigation improvement, as the high lifts are difficult to overcome. Furthermore, the draw-down of pondage desirable to care for changes in load makes improvements for navigation more difficult to construct. The lowering of the water would also expose shoals, rocks, and reefs in the upper reaches of the pools, thereby obstructing navigation.

1957. At Priest Rapids, Rock Island, Rocky Reach, Chelan, and Foster Creek Rapids the difficulty is not great, as the storage or rather pondage above these dams is limited.

1958. At Grand Coulee, however, with either dam the storage is large and could be used to the advantage of power at Grand Coulee and all plants downstream. It could be used to increase the prime power and would involve changes in pool level extending over several months' time. The dam is of such height and the drawdown so great that locks would be very difficult and costly to construct. The amount of traffic past this dam, if locks were provided, would be quite limited.

1959. It is believed that the Columbia Basin irrigation project will furnish the greater portion of the traffic to be carried on the upper river. This area and the rich Wenatchee Valley can both be served by improving the river no farther upstream than through Rock Island Rapids. A limited amount of channel work would permit boats to reach the Okanogan River. Power sites at Rocky beach and Chelan do not have good foundations, and these sites will probably be developed only after the power plants at the other sites have been placed in commission. While the construction of locks through power dams at points above Rock Island Rapids may not be warranted for many years, the right to construct such locks should be reserved to the United States, and the power plants built should be so planned that the navigation structures could be constructed at a minimum expense.

1960. The dam at Foster Creek Rapids will create a pool extending to Grand Coulee and the high Coulee Dam will provide a pool extending to the boundary. There is now rail connection at Marcus, near Kettle Falls, and when the Coulee Dam is constructed there will be rail connection at that point. These pools would be easily navigated, except in high water, and would aid local navigation, which would connect with the railway at the Coulee and at Marcus.

1961. In the power section of this chapter it is shown that power developments at Priest Rapids, Foster Creek Rapids, and Kettle Falls are economically feasible; that power can be generated at a cost which will be sufficiently low to permit of the transmission of the energy to tidewater and compete with power generated by steam; and that construction would be justified as soon as there is a market for the disposal of the power. The site at Grand Coulee can also be developed so as to produce power at low cost.

1962. The total prime potential power on the stream can be greatly increased by regulation of storage. Flathead, Pend Oreille, Priest, and Coeur d'Alene Lakes, together with the Hungry Horse Reservoir, offer the principal means of obtaining such regulation. Regulation

of storage impounded by the higher Grand Coulee Dam will also increase prime potential power at that plant and at all plants below.

1963. Regulating storage to increase prime power will also aid navigation by increasing the low-water flow and the navigable depths and by reducing the discharge at the higher stages and thus lessening the current velocities. Regulation of Hungry Horse Reservoir in the interest of power will also reduce flood heights on Flathead and Pend Oreille Lakes. By constructing that dam to a greater height and reserving a part of the storage for flood control, these flood heights could be further reduced.

1964. There is on the Columbia, therefore, no great conflict between navigation and power interests. Navigation is dependent on power development to aid in paying the cost of canalization and on irrigation to furnish the freight to be transported.

1965. The coordination of the interests of power and irrigation is a problem that demands an important place in any study of the uses of the waters of the Columbia River.

1966. Irrigation of isolated areas within reach of the river will be aided by power development, as pumping lifts will be reduced and it will be possible to irrigate some areas by gravity from the pools above power dams. The total aggregate area of land to be thus irrigated is not sufficiently large to materially affect power development, especially as the withdrawals of water will occur during times of high flow. This is not true, however, of the Columbia Basin irrigation project, which has been studied in detail, the results of this study forming an important part of this report, as the irrigation of this large area of a million or more acres, requiring the diversion of about 12,000 second-feet of water, does affect power on the river.

1967. Irrigation of this area by gravity through diversion of water from Clark Fork and by pumping from the Columbia has been studied, and the costs, economic feasibility, effect on navigation and power, and all related problems were given due consideration with a view of determining the best solution of the problem for all interests involved.

1968. In previous studies of projects made for the Government it has been the custom to consider general benefits that would be created as a result of the construction of the project as a basis for determining the extent of Federal participation. These benefits have been stated in broad, general terms without attempt to evaluate them. The cost of projects has so greatly increased in recent years that it is now necessary to exercise greater care in estimating their value and to determine their economic feasibility with greater accuracy. Therefore, in the economic studies made for this report the specific and general benefits have been evaluated, and the result gives a more definite measure of the effect of the improvement and a better indication of the extent of Federal interest.

1969. A word of explanation as to what is meant by economic feasibility seems in order. If the specific assessable benefits to the farmer, the community, transportation systems, power interests, and other participants—benefits which can be determined with a fair degree of accuracy and would be assessable if suitable laws existed—are greater than the cost of the work, the net result is a gain, and the project is considered to have economic feasibility. If, on the other

hand, the sum of these benefits is not as great as the cost, there is a net loss, and the project is considered to be not economically feasible.

1970. The economic studies indicate that none of the plans considered for gravity irrigation of the Columbia Basin irrigation project are economically feasible. Even taking credit for the general benefits that would result due to the irrigation of this area, the work cannot be justified. It would cost more than the total resulting benefits are worth. The pumping plans, nos. 4 or 4-A, however, can be justified by inclusion of only those general benefits which would be assessable under suitable laws. That is, the benefits are greater than the cost.

1971. The returns to the farmer alone are not of sufficient value to meet the cost of improvement under either plan of irrigation, and some other aid must be found to make up the difference. The proper and logical method would be to assess those benefited in proportion to the benefits received, but under existing law this cannot be done except to a limited extent.

1972. The Grand Coulee Dam site on the Columbia, which site is the point of diversion for the greater part of the pumping plan, Priest Rapids being the other, provides a choice in height of dam. Regarded as a power project, and neglecting the downstream effect of regulation of storage above the high dam, the lower dam, together with Kettle Falls and Fish Hawk sites, can generate power at less cost than is possible with the higher dam at Grand Coulee. If the effect of storage be included, the cost of energy in the river system is about the same.

1973. The cost of power generated at the Coulee with 6-percent money is not low in comparison to some other sites on the river, even under the most favorable assumptions as to quick loading of the plant. With 4 percent or Government money, however, the cost is low. This offers a means of obtaining the necessary aid for irrigation. The project could be financed by means of Government credit, with apparent injury to no one.

1974. The factors which affect the financial success of this combined project are: First, the rate of settlement of the land (see par. 1818); second, the growth of the power market (see par. 1026 et seq.); third, the permissible charge for water (see par. 1789); fourth, the sale value of electric energy.

1975. Each of the above in turn depends upon other factors or conditions, which are more fully discussed in the paragraphs indicated.

1976. A comparison of the two dams as elements of a combined irrigation and power developments shows that the high dam is much more desirable; that it is not possible with the low dam to generate and sell sufficient power at a cost that will return the total investment, with interest, whereas with the high dam the project is feasible, and the money, with interest, could probably be returned to the Government.

1977. That irrigation is a burden on power when combined with it is clearly shown by the curves on plate no. 142. These show that the faster the land is settled the longer time it will take to return the money invested, with interest; that with power separated from irrigation the power project would return the money, with interest, in a comparatively short time.

1978. Under the pumping plan of irrigation there will be eliminated from the irrigable area some 320,000 acres of good land lying on the eastern border of the area. This is to be regretted, as the land would, if it could be irrigated economically, form an asset to the State. But it is an integral part of the gravity plan, which is infeasible, and only a small part of it can be included in the pumping plan at any reasonable cost per acre.

1979. The pumping plan, with the high dam at the Coulee, is the system which permits of the maximum amount of potential and commercial power being developed on the river and its tributaries, and has that further advantage over the gravity plan as an offset to the reduction in area.

1980. Comparisons of the potential power available under various schemes of regulation and of irrigation have been made earlier in the report. Under the pumping plan of irrigating the Columbia Basin irrigation project from the high Grand Coulee Dam there would be 323,000 kilowatts (case 8) less commercial power available 100 percent of the time at that dam than would be available under the gravity plan (case 4). However, if Z Canyon and all the sites on the main river above the Snake be considered, plan 4 (pumping) would still show an excess of 103,000 kilowatts in commercial power available 100 percent of the time over plan 2-A (gravity). With Columbia River Reservoir regulated to produce the maximum commercial power in the river system, and considering the tributaries in the United States and the main stream above the Snake, plan 4 (pumping) would produce 295,000 kilowatts more than would plan 2-A (gravity).

1981. While the foregoing discussion shows that the high dam is to be preferred in the combined irrigation and power development, when interest on the cost is considered, it should be stated that if the irrigation of the Columbia Basin irrigation project is to be effected under a plan whereby no interest is charged, the low dam might be preferred. Under such a plan, if the land were settled at the rate of 50,000 acres per year, and if \$2.50 per acre were repaid on the principal each year, the subsidy to irrigation at the end of the settlement period would be many millions of dollars.

IV. COMPREHENSIVE PLAN

A. ELEMENTS OF THE PLAN

(Pls. nos. 146 and 147)

1982. A general plan for the most effective improvement of Columbia River above the Snake for the purposes of navigation, and the prosecution of such improvement in combination with the most efficient development of the potential water power, the control of floods, and the needs of irrigation, is as follows:

1983. This plan is set up as a guide to future operations on Columbia River above the Snake. It is not contemplated that any of the elements are for immediate construction or that any will necessarily be undertaken by the United States. It is believed that if the plan be followed that the best use of the waters of the river will result and that the natural resources will be conserved to the fullest possible extent.