Irrigation Expansion in the Pacific Northwest; Social Costs and Energy Impacts of Development

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The Pacific Northwest has built its history on successful exploitation of its water resources -- to provide cheap water for irrigation, and cheap electricity to power its irrigation pumps, factories, and homes. In the past there was water enough for all these purposes and still not threaten other instream or diversion uses of water but the era of abundance is over. The Pacific Northwest is faced with some difficult decisions over how to allocate scarce water among the competing potential uses. We must address the question whether development of additional irrigated land is a rational way to utilize our remaining unappropriated northwest water. The issue is complicated by the fact that many of the costs of development are external to the firms making the decision to expand irrigation.

The acreage under irrigation in the Pacific Northwest has continued to climb in recent years. The pressures for further growth are considerable in the Snake and Columbia River Basins of Idaho, Oregon and Washington. Much of the proposed development would utilize stream water, or well water from aquifers closely linked to streamflow. Much of the development would involve high lifts and would use sprinkler technology.

Energy Costs of Irrigation Development

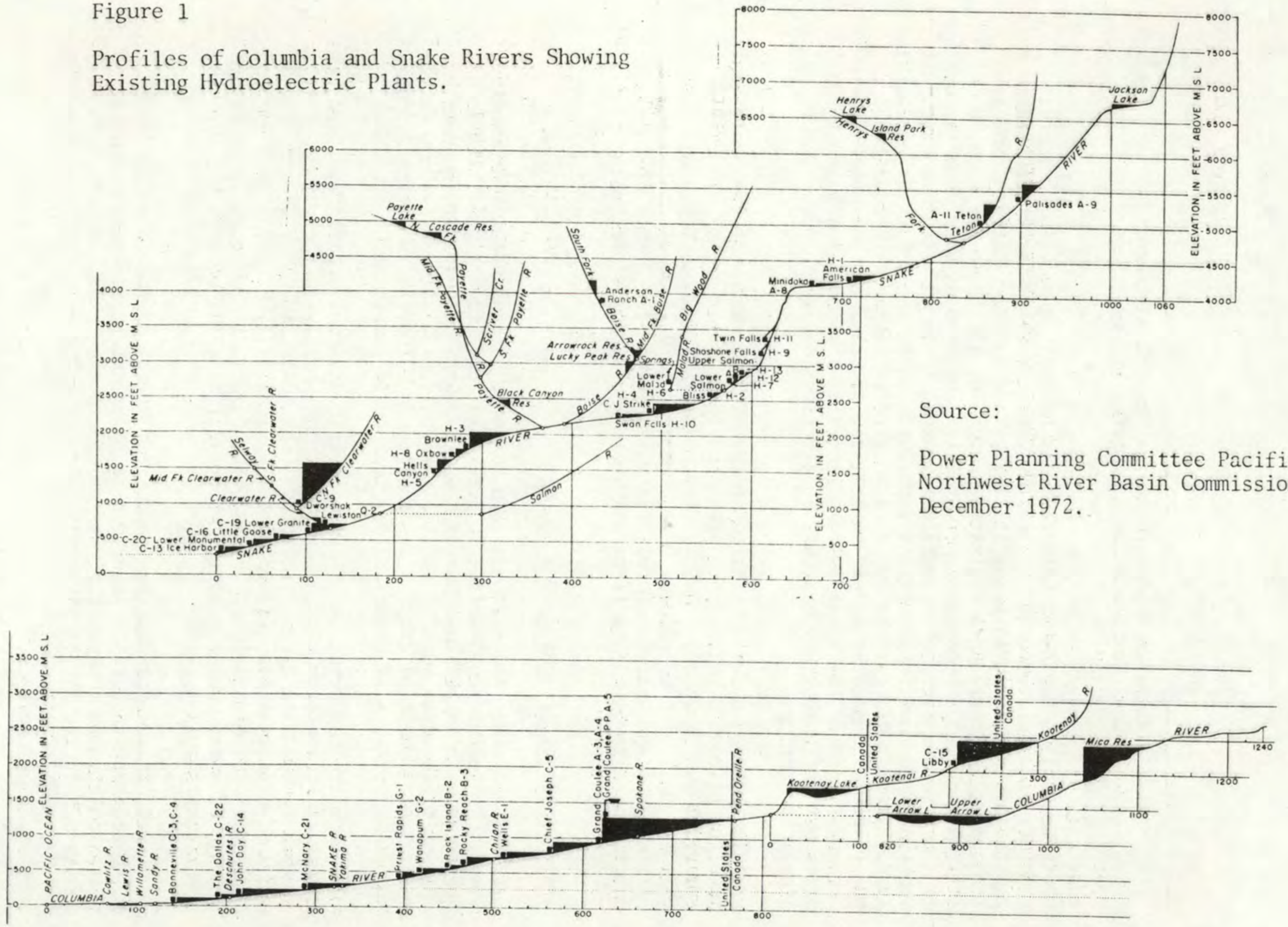
Historically, the Northwest has had access to abundant hydroelectric power. In recent years nearly 90 percent of electricity generated in the Pacific Northwest has come from water power. The future, however, will be different. Most of the best hydroelectric sites have been developed. Development at other sites has been precluded by a national decision to preserve wild rivers rather than build dams.

With the number of large hydroelectric dams now apparently fixed, the amount of hydroelectricity generated depends mostly on the volume of water dropped through the given structures. Obviously, if water is diverted and used consumptively for municipal, agricultural, or industrial purposes, it is not then available for hydropower production. Moreover, the removal and use of water consumes energy which must be obtained from the depleted electrical supply system.

Look, for example at the Snake River branch of the Columbia system. Water from American Falls Reservoir in Southeast Idaho could potentially be passed through the power plants of 21 existing hydroelectric structures on its way to the Pacific (Fig. 1). Of the 4,297 foot drop from the American Falls Reservoir pool to sea level, just under half (2,094) feet has been developed for power generation. An acre-foot of water dropped through one foot of head generates about .87 kilowatt-hours of electricity.

Figure 1

Profiles of Columbia and Snake Rivers Showing Existing Hydroelectric Plants.



Source:

Power Planning Committee Pacific Northwest River Basin Commission, December 1972.

Thus an acre-foot of water released from American Falls Reservoir could potentially generate 1,822 KWH of electric power if it passed through each of the 21 power plants.

If the Northwest hydroelectric system provides insufficient power to meet system loads, the only realistic way to make up the deficit is through conventional thermal and nuclear generating plants. Unfortunately it costs a great deal more to generate power this way then by traditional hydro systems. Table 1 shows the generating costs of existing and proposed hydro and thermal plants for the Idaho Power Company system. These costs are quite typical of what could be expected elsewhere in the Pacific Northwest.

Using a value of 30 mills for the replacement cost of hydropower potential lost due to irrigation diversion, the water consumptively used has a value ranging from $8.25 per acre-foot if diverted from behind McNary Dam, up to $54.65 per acre-foot if diverted from American Falls Reservoir, or $30.46 per acre-foot if diverted from behind Grand Coulee Dam.

Irrigated agriculture is itself a significant consumer of electrical energy in the Northwest. Electric power is used both to pump the water from the stream or well, and to provide the pressure needed to operate sprinklers.

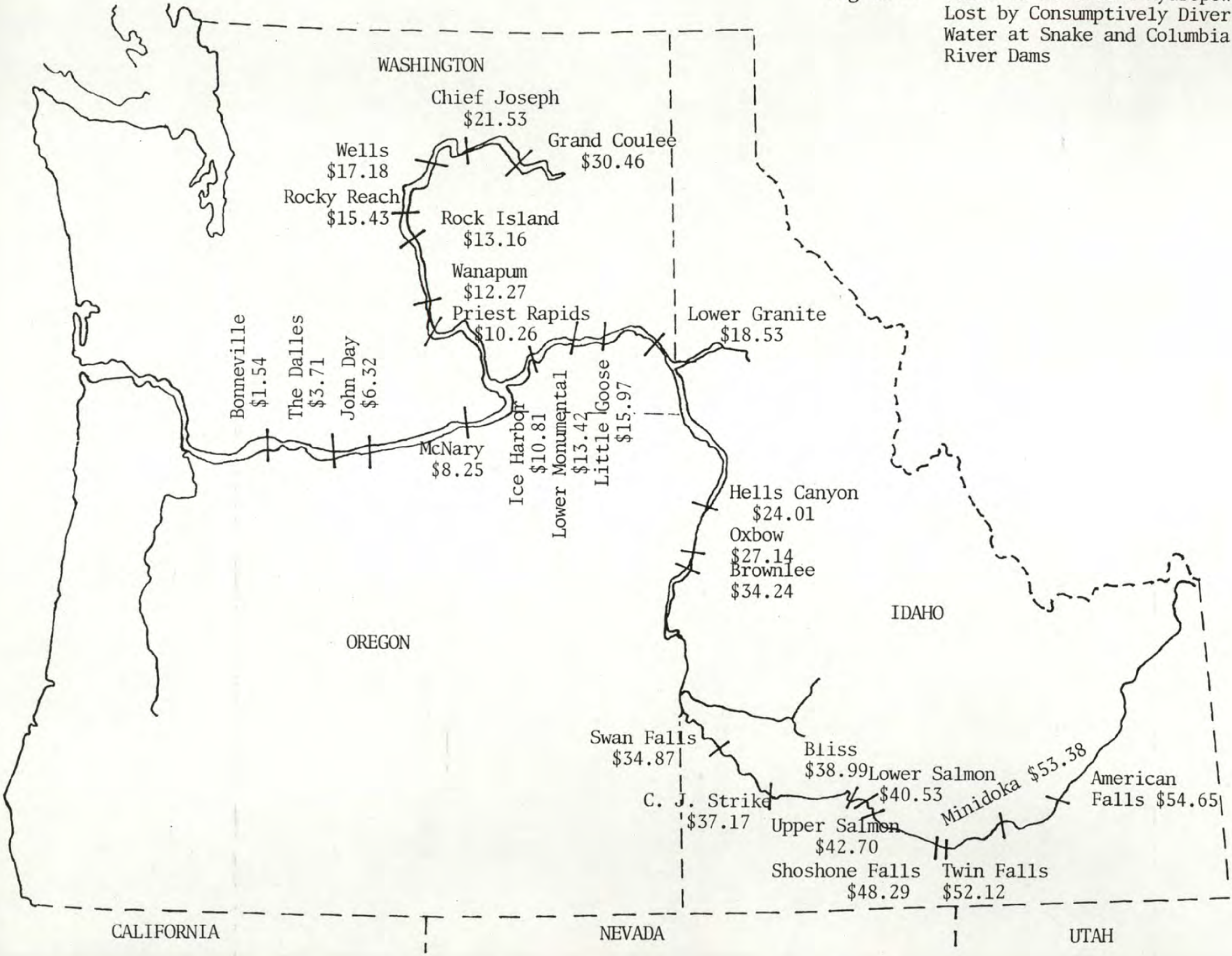
Energy requirements depend on the water use efficiency, the lift height, and the operating pressure of the respective systems. Conventional surface systems using gravity flow diversions and application require no energy for pumping but still result in lost hydropower. Unfortunately, there is very little land that can now be developed using gravity flow diversions and the new sprinkler systems, because of their high operating pressures, tend to use more electricity. As a rough rule of thumb, sprinklers require about 200 feet of head for pressurization and the power draw is about 1.25 kilowatt-hours per acre foot per foot of lift and pressurization. For example, a development involving 500 feet of lift plus 200 feet for pressurization would require 875 KWH to pump each acre-foot of water. If 3.5 acre feet were used per acre in this example, then 3063 KWH would be needed per acre, which would cost $91.88 to generate in a thermal powerplant.

Of course, the rates paid by irrigators are not these high rates reflecting the marginal cost of new generation. The irrigation rates reflect both preference status and average cost pricing. Average costing means that rates are set based on the cost of large amounts of cheap hydropower averaged in with heretofor small amounts of more expensive thermal power. The preference status is partly unofficial (the tendency of rate setting agencies to award lower rates to agriculture) and partly official (the mandated preference which BPA must give to public power companies -- which happen to carry large amounts of the irrigation load). In Washington, a 12 mill/KWH irrigation rate would be typical, with 9 mills going to pay distribution cost and about 3 mills going to BPA as the wholesale cost of power. The Idaho situation is essentially the same, with only 4 to 5 mills of a farmers power bills actually going to pay the cost of generation. The difference between the 3 to 5 mill rates and the marginal

Table 1. Typical Costs of Electricity Generation

System	Cost of Generation (mills/KWH)
Existing Hydro:	
Brownlee/Oxbow/Hells Canyon (when completed in 1969)	4.2
Idaho Power Co. Hydroelectric System Cost in 1975	7.0
New Hydro:	
A. J. Wiley (75 MW)	36.2
Dike (60 MW)	35.7
Swan Falls/Guffey (119 MW)	38.1
Garden Valley/Scrivner Creek/ G. V. Reregulation (368 MW)	57.9
South Fork Payette River (66 MW)	67.6
Existing Thermal:	
Jim Bridger units 1-3	12.0
Jim Bridger unit 4	16.0
New Thermal:	
Pioneer I (Idaho Power Co. estimate)	28 - 30
Pioneer I (Idaho Society of Professional Engineers estimate)	32.7
Pioneer II (Idaho Power Co. estimate)	
American Falls site	37.3
Bliss site	38.2
Sid Crossing site	40.2

Figure 2 : Value of Potential Hydropower Lost by Consumptively Diverting Water at Snake and Columbia River Dams



generation cost of over 30 mills is a cost borne by all consumers of electricity in the Pacific Northwest in the form of higher rates. Table 2 shows the magnitude of these direct energy costs of development for some potential irrigation sites in Washington and Southern Idaho.

Table 3 illustrates the total power consumption directly and indirectly imposed by irrigation expansion in some development areas of Washington. After accounting for the additional power consumption necessary to support agriculture development and the transmission costs of delivering this power, the total cost to the public reaches approximately $215 per acre. Spreading these costs over all primary and secondary employment created by irrigation development results in a cost per job created of approximately $7800. This cost is in addition to that paid by the irrigators who use the electricity and must eventually be paid for through higher costs of electricity to all power consumers in the region.

Social Overhead Cost Impacts of Irrigation Expansion

As an area develops from an irrigation project, population and economic growth occurs. As production increases, commercial, processing, transportation, and related businesses are attracted. Thus, employment opportunities increase and population grows. Because of the Columbia Basin Irrigation Project in Washington the population grew from 20,730 in the project area in 1950 to nearly 60,000 in 1969. Of this increase, 36 percent was added farm population and 64 percent was added to other rural and urban populations.

Social overhead capital costs are investments in the wealth of an area. Benefits of SOC expenditures, such as for new roads or schools, accrue to all people living in an area. The average SOC per capita tends to rise with population growth, so original area residents will be paying more for public services after a population boom takes place. Because costs for such services are apportioned on an average costs basis, immigrants do not pay the full cost of required new facilities. Instead these costs are allocated to the entire population, including prior residents, in the form of higher taxes, utility rates, and costs of services. The original population must benefit from development through such things as higher wages or increased property values to avoid incurring a net loss from development.

The SOC investments actually required by the Columbia Basin Project can be used as a guide in projecting SOC capital expenditures for other new irrigation. Table 4 shows estimated per capita SOC capital expenditures for projected developments in Washington. When these SOC capital expenditures are amortized at 8.5% over 25 years the result is an annual social overhead imposed on state, county and city governments and non-electric utilities of $826 per person for the East High project, $1150 for Horse Heaven Hills, and $1040 for Eureka Flats.

Adding the cost of electricity to estimated costs to provide other social services brings the total public cost per acre up to approximately

Table 2. Energy lost and used plus annual energy replacement costs per acre irrigated in specific developments, assuming 3.5 acre feet of water are used for each irrigated acre.

Area	Potential Acres	Energy Foregone	Energy Used	Total Energy	Total Replacement Value[b]	Payment by Agriculture[c]
	(1000)	(KWH/A)	(KWH/A)	(KWH/A)	($/A)	($/A)
Eureka Flats[d]	109	1,620	4,073	5,693	170.79	12.22
Horse Heaven	175	777	4,847[a]	5,624	168.72	14.54
East High	385	2,965	2,443	5,408	162.24	1.22
Columbia Basin Expansion	120	2,965	1,872	4,837	145.11	1.00
Southern Idaho (300 feet)	-	4,550[e]	2,188	6,738	202.14	10.94
Southern Idaho (600 feet)	-	4,550[e]	3,500	8,050	241.50	17.50
Southern Idaho (900 feet)	-	4,550[e]	4,813	9,363	280.89	24.07

[a] Based on development of Blocks 1, 2 & 4A

[b] Based on replacement costs of 30 mills/KWH

[c] Based on payments for energy production equaling 3 mills/KWH in Washington and 5 mill/KWH in Idaho expect for the East High project and Columbia Basin project where irrigators will be charged 0.5 m/KWH

[d] Assume the diversion is behind Lower Monumental Dam

[e] Assume diversion from Bliss Pool

Source: Hamilton, J., and N. Whittlesey, "Social Costs and Energy Impacts of Irrigation Development in the Pacific Northwest," paper presented to the Pacific Northwest Conference on Nonfederal Financing of Water Resources Development, Portland, January 4, 1978.

Table 3. Total costs for supply electricity demands resulting from increased irrigation development

	Units	East High Project	Horse Heaven Hills	Eureka Flats
Irrigation pumping & lost hydropower[a]	mwh/1,000 A.	5,407	5,625	5,690
Farm and non-farm residences[b]	mwh/1,000 A.[c]	504	504	504
On-farm business	mwh/1,000 A.	141	141	141
Crop processing	mwh/1,000 A.	1,075	1,075	1,075
Commercial, industrial & public sectors	mwh/1,000 A.	216	142	142
Total added power demand per 1,000 A. irrigated	mwh/1,000 A.	7,343	7,487	7,552
Required power generation capacity[d]	kw/1,000 A.	1,120	1,120	1,130
Investment cost in transmission & distribution[g]	$/A.	165	172	174
Total investment in power supply per acre irrigated[e]	$/A.	1,386	1,392	1,405
Annual cost of electricity generation & transmission	$/A.[i] $/worker[c] $/person[h]	214 7,640 3,056	219 7,820 3.130	221 7,890 3,160

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[a] Accounting for lost hydropower production and power used to pump water to 3.5 acre feet per acre.

[b] Assuming 21,600 KWH used per household per year.

[c] Assuming 10 farm workers and 18 non-farm workers per 1,000 acres.

[d] Assuming a plant factor of 75% and a uniform distribution of power demand.

[e] Using a $1,090/kw capacity.

[f] Includes power generation and transmission costs.

[g] Based on average investment in transmission, distribution and general plant of 2.3¢/KWH sold to customers in Benton Co. PUD.

[h] Assuming 2.5 persons per worker.

[i] Present wholesale power rates are about 3 mills/KWH while replacement costs equal 30 mills/KWH, leaving a net cost of 27 mills/KWH. Transmission costs are amortized over 25 years at 8.5% interest rates, for a factor of .0977. These costs are in 1978 dollars for power to be supplied before year 2000.

Table 4. Annual social costs imposed by irrigation development in specific areas of Washington State

	Units	East High Project	Horse Heaven Hills	Columbia Basin Project
Annual amortized investment costs for:				
State, county & city Governments plus utilities[a]	$/person	826	1150	1040
Electricity[b]	$/person	3056	3130	3160
Total Annual Costs	$/person	3882	4280	4200
	$/worker[c]	9700	10,700	10,500
	$/acre[d]	272	300	294

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[a] Source: Benefits and Costs of Irrigation Development in Washington. Department of Agricultural Economic, Washington State University. 1976. Capital investment cost amortized over 25 years at 8.5% interest rate.

[b] Taken from Table 3.

[c] An alternative calculation of total SOC investment assuming 2.5 persons per worker.

[d] An alternative calculation of total SOC investment assuming 10 farm workers and 18 non-farm workers per 1,000 acres irrigated.

$290. Spreading these costs over all employment created by agricultural development brings the total to approximately $10,000 per job.

The question remains as to whether more development is good or bad, or is it some of each.

The significance of these costs cannot be ignored, however, It is obvious that the cost for energy accounts for about three quarters of the total imposed costs. Since these energy costs result from the rather new phenomenon of exhausted hydropower production capacity and the rapidly escalating costs of alternate energy forms, most residents of the region neither understand nor believe that such costs do exist and are very real.

A Brief Look at Benefits

So far, this analysis has made no attempt to develop comparative benefits of irrigation development. Certainly, there are some obvious beneficiaries of such activity. Land owners, farm operators, food processors are examples of those who benefit. But what measures of benefit are relevant for comparison?

Employment created by economic development is probably the most obvious and desirable form of benefit. It is estimated that one on-farm job and 1.8 off-farm jobs are created by each 100 acres of new irrigation. We have already shown that the annual social costs of each new job may reach $10,000. Assuming that the average wage of each new job is $12,000, the contribution of taxes and payment for services to offset the estimated costs are in the neighborhood of $1200 per year. (Whittlesey, etal., Benefits and Costs of Irrigation in Washington, 1976). This still leaves a net cost to people in the region of $8800 for each job.

If cheap electricity is considered a scarce resource, then economic development would be most efficient if it avoids electricity intensive industries. Table 5 shows the electricity required per direct job in the major economic sectors of the Pacific Northwest. The most energy intensive sectors are chemicals (426,200 kilowatt hours per job), aluminum (1,873,600 kilowatt hours per job), and other nonferrous metals (427,600 kilowatt hours per job). Using the examples from Table 3, high lift irrigation requires about 600,000 kilowatt hours per direct job; making it second only to the aluminum industry as an electricity intensive activity. Shifting emphasis from irrigation development to other kinds of growth may be a more efficient way to create jobs in the Pacific Northwest.

Another measure of benefits is that of income or economic activity generated through the multiplier effect of new irrigation. One must be careful to describe employment and dollar measures of economic activity as alternative measures of the same things. There are not additive as might be implied in some presentations. Borrowing from Obermiller*, we find that

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*Obermiller, Frederick W. "To Grow or Not to Grow is Not a Relevant Question." Paper presented to the Umatilla Kiwanis and Hermiston Rotary Club., Nov. 1977.

Table 5. Electricity Use Per Direct Job in Selected Economic Sectors in the Pacific Northwest in 1971.

Rank	Sector	Employment (Thousand)	Electricity Use (Million KWH)	Electricity per job (Thousand KWH)
1	Aluminum	10.9	20,422	1,873.6
2	High Lift Irrigation[1/]	-	-	600.0
3	Nonferrous Metals except Aluminum	3.7	1,582	427.6
4	Chemical Products	12.1	5,157	426.2
5	Paper Products	27.7	5,919	213.7
6	Iron and Steel	6.5	850	130.8
7	Petroleum and Coal Produts	2.0	234	117.2
8	Mining	5.7	234	41.1
9	Wood Products	123.0	3,457	28.1
10	All Agriculture	171.0	3,545	20.7
11	Food Products	65.0	1,172	18.0
12	Aerospace	38.9	527	13.6

[1/] Using 100 acres per job and electricity use such as that shown in Table 2, the consumption ranges from 483,700 to 936,000 KWH per job.

Source: Adapted from: Hinman, George, et.cal., "Energy Consumption in the Pacific Northwest, 1971," Environmental Research Center, WSU, 1974.

secondary activity in the economy may reach an equivalent of $1800 per acre irrigated. Some people have used such figures as the implied benefits of irrigation. However, it is very important to note that the same figure should also be called a cost as virtually all of the amount is paid to factors of production within the economy. Only to the extent that such factors would otherwise by unemployed or their value raised above that in alternate forms of employment can such economic activity be called a net benefit. Probably the best measure of the net benefit from this activity, other than increased employment, is also provided by Obermiller. He shows that agricultural sales generate approximately $40 per acre for local government revenues. These revenues would partially offset the overhead costs of providing the state, county, and city government costs shown in Table 4 (about $70/acre) but would pay nothing for the remaining costs of energy also shown in that table. The costs of energy per job shown in Table 3, therefore, become a net cost that must be paid by residents of the region.

The Problem of Utility Rate Structures

It has been noted that a key part of the problem is the average cost pricing methods used by public utilities. Average cost pricing, along with preferential rates being received by irrigation both result in the new developments paying power rates far below the generation costs imposed on the utilities by the development. Several objectives might be expected of a utilities rate structure:

> Among these objectives, three may be called primary, not only because of their widespread acceptance but also because most of the more detailed criteria were ancillary thereto. They are (a) the revenue-requirements or financial-need objective, which takes the form of a fair-return standard with respect to private utility companies; (b) the fair-cost-apportionment objective, which invokes the principle that the burden of meeting total revenue requirements must be distributed fairly among the beneficiaries of the service; and (c) the optimum-use or consumer-rationing objective, under which the rates are designed to discourage the wasteful use of public utility services while promoting all use that is economically justified in view of the relationships between costs incurred and benefits received. J. Bonbright, Principles of Public Utility Rates at 292 (1961).

If one took the third objective seriously it would serve as a rational for not only eliminating declining block rate structures, but replacing them with a marginal cost pricing structure.

The preference rates available to BPA public utility customers are a contributing factor. By keeping rates to these customers artificially low, irrigation is encouraged to expand, the cheap power is used for a less optimal purpose, and nonpreference customers are being forced to rely on expensive new thermal generation. The current attacks on the preference structure verify the growing resentment against the economic misallocation it represents. Preference can perhaps be justified for existing customers but not as a subsidy for further irrigation expansion.

The comparison between Southern Idaho and the Columbia Basin is perhaps instructive. In Southern Idaho, where Idaho Power Company is faced with massive expenditures for thermal generation, there is a growing awareness by existing irrigators that new irrigation development may severely impact their own power rates. The general alarm seems to be fostering some coalitions between farmers and environmentalists urging a reexamination of the situation. In the Columbia Basin, where many irrigators are preference customers who would not feel such a rate impact, there is not such political coalition. The political issue in the Basin is how to maintain the preference structure.

One can only speculate as to the effects of a marginal cost pricing system. Assuming it were possible to charge new irrigators a 30 to 40 mill rate for the power they use, one assumes it would dampen their enthusiasm to expand. Pricing mechanisms that would recognize the hydropower opportunity cost of water diverted for irrigation would further rationalize the system.

Conclusion

We must conclude with the belief that the public costs of irrigation development are real and very large. Assuming such costs to be at least $200 per acre per year, they would annually equal $64,000 for a 320 acre farm that is typical under existing federal water project guidelines, or as much as $400,000 for a 2000 acre privately developed farm of the kind proposed in the Horse Heaven Hills area of Washington.

This analysis does not show that irrigation development is bad or "not worth it". Rather, we are arguing that we need to look with great care at proposals for such development, try to understand all of the consequences involved, and only then decide whether the benefits justify the costs.

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