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

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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. The question we address: Is development of additional irrigated land a rational way to utilize our remaining unappropriated northwest water?

The acreage under irrigation in the Pacific Northwest has continued to climb in recent years. The pressures for even further growth are considerable in the Snake River Basin of Oregon and Washington. Much of the proposed development would utilize stream water, or well water from an aquifer closely linked to streamflow. Much of the development would be high lift operations and would most likely use sprinkler technology.

Energy Costs of Irrigation Development

Historically, the Northwest had access to abundant hydroelectric power. In recent years nearly 90 percent of electricity generated in the Pacific Northwest has come from water power. Idaho Power generating capacity was 100% hydro based until 1974. The shape of the future, however, looks 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.

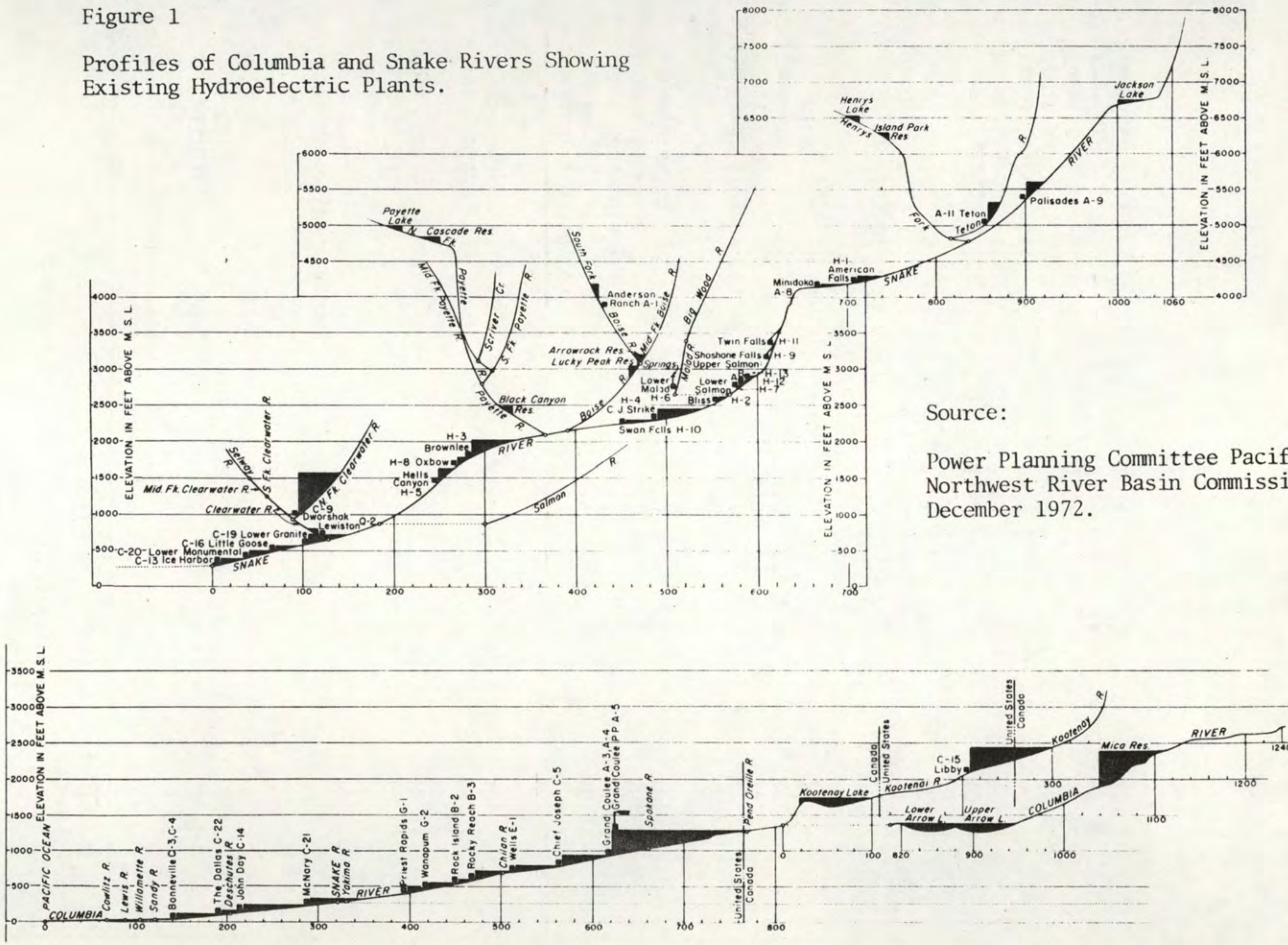
With the number of hydroelectric dams now apparently fixed, the amount of hydroelectricity generated depends mostly on the volume of water dropped through the given structures. Obviously, if water is diverted and used consumptively for municipal, agricultural, or industrial purposes, it is not then available 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 (Table 1.) An acre-foot of water dropped through one foot of head generates about .87 kilowatt-hours of electricity. 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 hydroelectic 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. When the Brownlee-Oxbow-Hells Canyon Complex was completed in the late 1960's

Figure 1

Profiles of Columbia and Snake Rivers Showing Existing Hydroelectric Plants.



Source:

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

Table 1. Potential Energy Lost by Consumptively Diverting an Acre-foot of Water from the Snake-Columbia System.

	Cumulative Head (feet)	Cumulative Energy at .87 KWH/acre ft./ft. (KWH)	Cumulative Value at 30 mills (dollars)
Columbia River (Wash.-Oregon)			
Bonneville	59	51	1.54
The Dalles	142	124	3.71
John Day	242	211	6.32
McNary	316	275	8.25
Columbia River (Washington)			
Priest Rapids	393	342	10.26
Wanapum	470	409	12.27
Rock Island	504	439	13.16
Rocky Reach	591	514	15.43
Wells	658	573	17.18
Chief Joseph	825	718	21.53
Grand Coulee	1167	1015	30.46
Snake River (Washington)			
Ice Harbor	414	360	10.81
Lower Monumental	514	447	13.42
Little Goose	612	532	15.97
Lower Granite	710	618	18.53
Snake River (Idaho-Oregon)			
Hells Canyon	920	800	24.01
Oxbow	1040	905	27.14
Brownlee	1312	1141	34.24
Snake River (Idaho)			
Swan Falls	1336	1162	34.87
C. J. Strike	1424	1239	37.17
Bliss	1494	1300	38.99
Lower Salmon Falls	1553	1351	40.53
Upper Salmon Falls "A"	1599	1391	41.73
Upper Salmon Falls "B"	1636	1423	42.70
Shoshone Falls	1850	1610	48.29
Twin Falls	1997	1737	52.12
Minidoka	2045	1779	53.38
American Falls	2094	1821	54.65

this complex could generate power at a cost of about 4.2 mills/KWH. Idaho Power Co. estimated in 1975 that its hydro generating cost was then about 7 mills/KWH. The existing Jim Bridger coal plant runs at about 12 mills/KWH while the 4th unit of Jim Bridger will cost over 15 mills/KWH. The Idaho Society of Professional Engineers estimated that Idaho Power's proposed Pioneer II (a coal fired plant) energy would cost closer to 33 mills/KWH. Cost estimates in the 30 to 40 mill range seem to be typical for nuclear powerplants.

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 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 $101.89 to generate in a thermal power-plant.

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 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 cost 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

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 Per A	Energy Used Per A	Value of Foregone Energy Per A[b]	Value of Energy Used Per A[b]	Total Replacement Value [b]	Payment by Agriculture[c]
	(1000)	(KWH)	(KWH)	($/A)	($/A)	($/A)	($/A)
Eureka Flats[d]	109	1,620	4,073	48.60	122.19	170.79	12.22
Horse Heaven	175	777	4,847[a]	23.31	145.41	168.72	14.54
East High	385	2,965	2,443	88.95	73.29	162.24	1.22
Columbia Basin Expansion	120	2,965	1,872	88.95	56.16	145.11	1.00
Southern Idaho (300 feet)	-	4,550[e]	2,188	136.50	65.64	202.14	10.94
Southern Idaho (600 feet)	-	4,550[e]	3,500	136.50	105.00	241.50	17.50
Southern Idaho (900 feet)	-	4,550[e]	4,813	136.50	144.39	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 KWH in Washington and 5 KWH in Idaho except 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

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.

Other 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 cost 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 captial 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 $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

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]	214	219	221
	$/worker[c]	7,640	7,820	7,890
	$/person[h]	3,056	3.130	3,160

[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

[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.

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 measure 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.

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

	Employment (Thousand)	Electricity Use (Million KWH)	Electricity per job (Thousand KWH)
Manufacturing Sectors:			
Food and Kindred Products	65.0	1,172	18.0
Textiles and Apparels	12.8	29	2.3
Lumber and Wood Products	123.0	3,457	28.1
Paper and Allied Products	27.7	5,919	213.7
Printing and Publishing	19.9	117	5.9
Chemicals and Allied Products	12.1	5,157	426.2
Petroleum anc Coal Products	2.0	234	117.2
Stone, Clay, and Glass	9.7	410	42.3
Iron and Steel	6.5	850	130.8
Nonferrous Metals except Aluminum	3.7	1,582	427.6
Aluminum	10.9	20,422	1,873.6
Fabricated Metals	14.6	176	12.0
Machinery	35.4	322	9.1
Aerospace	38.9	527	13.6
Other Transportation Equipment	21.9	205	9.4
Other Selected Sectors:			
All Agriculture	171.0	3,545	20.7
Mining	5.7	234	41.1
Construction	95.0	879	9.3
Transportation Services	100.0	322	3.2
Communication	33.0	498	15.1
Trade	430.0	4,395	10.2
Finance, Ins., Real Estate	105.0	1,465	14.0
Services	570.0	2,959	5.2
Government	200.0	3,164	15.8

Source: Adapted from: Hinman, George, et.al., "Energy Consumption in the Pacific Northwest, 1971," Environmental Research Center, Washington State University, 1974.

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 thing. They are not additive as might be implied in some presentations. Borrowing from Obermiller[2], we find that 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 <u>cost</u> as virtually all of the amount is paid to factors of production within the economy. Only to the extent that such factors would otherwise be 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.

We must conclude with the belief that the public costs of irrigation development are real and very large. The costs are about the same whether imposed by small farms in a USBR development (East High Project) or by very large privatedly developed farms (Horse Heaven Hills). Assuming such costs to be at least $200 per acre per year, they would annually

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2. 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.

equal \$64,000 for a 320 acre East High project farm or \$400,000 for a 2000 acre Horse Heaven Hills farm.

This analysis does not show that irrigation development is bad or "not worth it." However, the public should be fully informed about such costs before being asked to consider the desirability of further development.

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