Chapter 7

Economic Valuations of a Wild Salmon Ecosystem

> *During the 2010 [salmon] season, six companies canned, 23 companies exported fresh product, 27 companies froze, and three companies cured salmon in Bristol Bay. In addition, 27 companies exported fish by air, and a total of 36 processors/buyers reported that they processed fish.*
>
> – 2010 Bristol Bay Area Annual Management Report (ADFG 2011a).

At first glance, the Pebble deposit appears vastly more valuable than the wild salmon ecosystem of Bristol Bay. Yet a deeper analysis reveals that as a renewable resource, the value of a wild salmon ecosystem in supporting recreational, commercial, and subsistence fisheries may, in fact, be greater over time than the extraction of non-renewable minerals. Recent scientific research underscores the economic importance of the Bristol Bay wild salmon ecosystem by concluding that high population diversity, which is driven by abundant complex habitats, buffers against population fluctuations, providing a reliable source of income to local communities (Schindler et al. 2010). This stands in stark contrast to the boom and bust cycles common to extractive activities such as hard-rock mining (Doukas et al. 2008).

Due to the complex interactions among salmon, people, and habitat, no one economic metric can express the wide-ranging value of the wild salmon ecosystem. Thus, a proper illustration of the wild salmon ecosystem value requires multiple frameworks (Loomis 1999, Peck 1999, Duffield et al. 2007, Helvoigt and Charlton 2009).

Following a brief summary of the Pebble Mine's value in section 7.1, this analysis presents four different frameworks for considering the value of the Bristol Bay wild salmon fishery. The first framework values the use of the ecosystem, which is measured by quantifying the annual regional expenditures and economic significance of the wild salmon ecosystem on the local economy (section 7.2). The second framework estimates the perpetual net present value (NPV) of using the ecosystem based on willingness-to-pay surveys (section 7.3), while the third framework attempts to quantify the passive use—or intrinsic—value of conserving an area, independent of human use value (section 7.4). Finally, the fourth framework compares tax revenues that will stay in Alaska to demonstrate the economic impacts derived from the respective wild salmon and mining-based industries (section 7.5).

7.1 Comparing the Economic Values of a Wild Salmon Ecosystem and the Pebble Mine

Based on the most recently available estimates, the Pebble deposit holds 80.6 billion pounds of copper, 5.6 billion pounds of molybdenum, and 107.4 million ounces of gold (NDM Ltd. 2010b, PLP 2011b). Using the U.S. Geological Survey's 2010 American market prices indexed to 2011 dollars (all mineral values herein are indexed to the PPI/Commodity Data/Metals and Metal Products through September of 2011), the deposit is worth $476.84 billion (USDL 2011a, USGS 2011a, 2011b, 2011c). However, considering the historic volatility of mineral prices, a more apt measure may be the value of the deposit based on indexed median mineral prices from 1975 to 2010 for gold and copper, and from 1991 to 2010 (the longest data set available) for molybdenum, converted to 2011 dollars (to adjust for inflation). Under this median measure, the deposit is worth $276.6 billion (USDL 2011a, USGS 2011a, 2011b, 2011c). This value is not "profit," however, because it does not account for the costs necessary to obtain it (i.e., costs to build the roads, transmission network, power plant, mine sites, milling and refining operations, wages etc.). These costs are reflected in net income estimates for the mine, which are discussed below.

It should be noted that the following discussion also does not adjust net income to account for the inevitable—and potentially substantial—costs associated with remediation and clean-up. Section 7.7 provides some historical information on these costs at other mine sites.

7.2 Regional Economic Expenditures in Wild Salmon

Local expenditures related to the use or harvest of the wild salmon ecosystem drive the local economy in terms of job and wage creation (Duffield et al. 2007). The expenditures related to the wild salmon ecosystem that drive Bristol Bay's economy are comprised of tradable items (commercial and guided sport fishing) and items connected to the ecosystem that are not currently traded in any market (e.g., subsistence fishing, big game sport hunting, and wildlife tourism). Table 7 summarizes regional economic expenditures on services generated by Bristol Bay's wild salmon ecosystem as described by Duffield (2009). In 2008, these expenditures fell between $317.9 and $572.5 million (Duffield 2009), with an estimated direct expenditure of $392.4 million. Adjusted to the CPI-U/Anchorage/Average/All Price through September 2011 (to determine 2011 constant dollars), the Bristol Bay wild salmon ecosystem produces estimated annual regional economic expenditures of $414.7 million, which results in 4,838 annual average jobs and $206.83 million in annual gross income (Duffield 2009, USDL 2011b). Representing 73.7% of all jobs in the economy—28% of which are filled by local Bristol Bay residents—the private job sector in Bristol Bay is almost entirely dependent on the wild salmon ecosystem (Duffield 2009). Largely due to this predictable and sustainable job market, the Bristol Bay Borough has enjoyed an average annual unemployment rate that is 1.1% lower than the annual Alaska average from 1990 to 2010 (ADLWD 2010).

Table 7. Summary of regional economic expenditures based on wild salmon ecosystem services (in millions) (Duffield 2009). Note that the data presented in this table were collected in 2008. These data have been adjusted for inflation (to 2011) in the accompanying narrative.

	Regional Economic Expenditures		
Ecosystem Service	Estimated direct expenditures/ sales per year	Low estimate	High estimate
Commercial fish wholesale value	$ 280.0	$ 280.0	$ 368.5
Sport fisheries	74.6	0	166.1
Sport hunting	11.1	11.1	11.1
Wildlife viewing/ tourism	18.9	18.9	18.9
Subsistence harvest expenditures	7.9	7.9	7.9
Total direct annual economic impact	392.4	317.9	572.5

Regional Expenditures of Commercial Salmon Fishery

The Bristol Bay commercial salmon fishery is the largest sockeye salmon fishery in the world and the most valuable in Alaska (Duffield et al. 2007). From 2000 to 2008, the total salmon run averaged 36 million fish, and the catch averaged 23.11 million fish (ADFG 2011a). In 2008, the commercial fishery's wholesale value (ex vessel value plus added value of processing fish in Bristol Bay) was between $295.93 and $389.46 million (Duffield 2009), adjusted to 2011 values. In addition to this economic value, the commercial fishery mimics the natural harvest cycle while employing many of the Alaska Native residents who comprise almost 70% of Bristol Bay area communities (USBOC 2008, Duffield 2009).

Regional Expenditures of Sport Fishing

Sport fishing in Bristol Bay accounts for between $78.84 and $175.55 million (adjusted) in annual local expenditures (Duffield 2009, USDL 2011b). Based on survey data, each year, nonresident sport fishermen make an estimated 12,966 trips and spend an average of $4,344 per trip, while resident sport fishermen make an estimated 19,488 trips and spend an average of $395 per trip (Duffield et al. 2007, USDL 2011b). Among those surveyed (especially nonresident anglers, who spend much more than resident anglers), the wild, natural, isolated nature of the region was key to their decision to fish in the Bristol Bay region. Of these anglers, 76.8% disapprove of developing road access. Initiating development that affects the sport fishermen's experience risks compromising the viability of related suppliers, the service industry, and accompanying jobs (Duffield et al. 2007, Helvoigt and Charlton 2009).

Regional Expenditures of Subsistence Harvest, Big Game Sport Hunting, and Wildlife Tourism

Each year, Bristol Bay supports a large subsistence harvest (averaging 142,320 fish from 1989 to 2008) that results in $8.35 million (adjusted) in local expenditures (Duffield et al. 2007, Duffield 2009, Morstad et al. 2010, USDL 2011b). Goldsmith et al. (1998) estimated that Native family units spend an average of $3,135 per year on subsistence harvest equipment, while non-Native family units spend an average of $818 per year (adjusted) (USDL 2011b). Similar to subsistence harvesters, the Bristol Bay area big game sport hunting and wildlife tourism industries are closely tied to the health of the wild salmon ecosystem. Based on estimates, big game sport hunting annually results in $11.73 million in local expenditures, while wildlife viewing and tourism results in $19.96 million in expenditures (adjusted) (Duffield 2009, USDL 2011b).

7.3 Willingness to Pay

Instead of documenting traditional economic indicators like expenditures and related jobs and wages, the net economic value (NEV) framework monetizes the willingness to participate in the wild salmon ecosystem economy. Discounting this annual NEV "cash flow" over time yields the NPV, or "perpetual" economic value, of the wild salmon ecosystem.

Net Economic Value of the Commercial Fishery

The NEV of the commercial fishery is computed by evaluating the average adjusted prices paid for commercial fishing permits on the open market; this value represents the best metric for understanding how much commercial fishermen think it is worth to fish in Bristol Bay each year (Duffield et al. 2007). From 1999 to

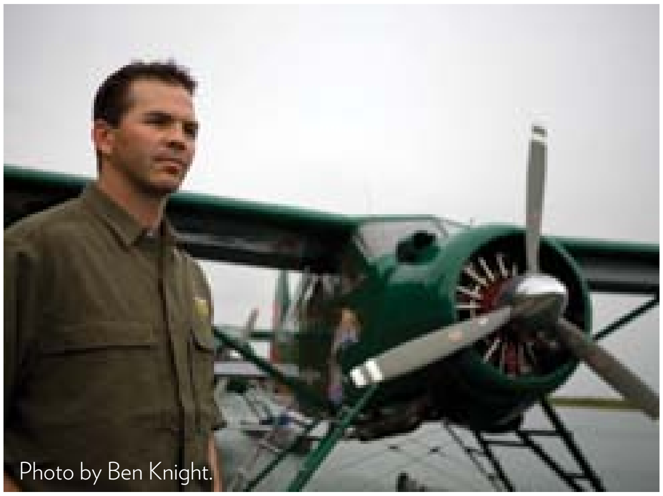


Photo by Ben Knight.

2008 in Bristol Bay, the Alaska Commercial Fisheries Entry Commission (ACFEC) issued an average of 1,874 drift-net permits (worth an adjusted average of $70,524 per permit) and 997 set-net permits (worth an adjusted average of $26,453 per permit), yielding an aggregate adjusted commercial fishery participation value of $158.52 million (ACFEC 2010, USDL 2011b). Because these permit rights are perpetual, the aggregate value must be amortized to derive an annual value. As suggested by Duffield et al. (2007), with the two types of permits fully amortized in perpetuity at 7% and 14%, the NEV for the commercial fishery is $11.1 and $22.2 million, respectively (ACFEC 2010, USDL 2011b). In assessing this valuation, it is essential to note that the current willingness to pay is depressed by a host of macroeconomic conditions, including a significant drop in demand for wild salmon in Japan, the emergence of global farmed salmon as a cheaper alternative, and the global recession's impact on consumer price points (Asche et al. 2005, Duffield et al. 2007, Duffield 2009). Yet if decreasing global fish supply and increased demand for sustainable wild products conspire to create a consumer surplus for wild Alaska salmon (meaning consumers are willing to pay more for the wild salmon than "market price"), the annual NEV of participating in the commercial fishery could rise (as open market permit values increase) and increase aggregate NPV favorably.

Net Economic Value of the Subsistence Fish Harvest, Sport Fishing and Hunting, and Wildlife Tourism

This NEV estimate is based on the willingness of subsistence fishermen to pay for the fish they harvest. It is estimated that roughly 2.1 million pounds of salmon are harvested each year in Bristol Bay for subsistence (Duffield 2009), and that each harvester would be willing to pay between $32.46/lb and $66.75/lb (note, the lower bound is set at an original estimate in Duffield et al (1997), and the upper bound is adjusted to reflect inflation adjusted estimate from 2005) (Duffield et al. 2007, USDL 2011b). This results in an annual NEV for subsistence fishing of $77.8 to 160 million. For sport fishing, Duffield et al. (2007) estimated a net willingness to pay for residents at $373 per trip and non-residents at $530 per trip (adjusted). Multiplying these amounts by the estimated number of annual trips yields a net willingness to pay for sport fishing of $15.82 million. The final components in this framework are sport hunting and wildlife tourism. The annual net willingness to pay for sport hunting and tourism is $2.06 million and $2.11 million, respectively (McCollum and Miller 1994, Duffield et al. 2007, USDL 2011b).

Total Net Economic Value of the Bristol Bay Wild Salmon Ecosystem

The combined annual NEV of the wild salmon ecosystem is $108.9 to $202.2 million. This estimated annual net cash flow can then be used to compute the NPV of the salmon ecosystem economy. Because this valuation spans generations, unlike typical NPV analysis, the Environmental Protection Agency (USEPA 2000) recommends using a discount rate as low as 0.5%, while Weitzman (2001) recommends a 1.75% constant rate. Based on the estimated NEV ranges, the NPV of the wild salmon ecosystem is between $6.22 and $11.56 billion (using the annual NEV range estimates, at a 1.75% constant rate over perpetuity [perpetual NPV = annual NEV/rate]). Using the annual NEV range estimates at the lower discount rate (0.5% constant rate over perpetuity), the NPV of the wild salmon ecosystem is $21.76 to $40.45 billion (Table 8).

Table 8. Net economic value and net present value of wild salmon ecosystem with NPV calculated for two discount rates.

	Net Economic Value (NEV) and Net Present Value (NPV)	
	Low-end (2009 $)	High-end (2009 $)
Annual NEV of wild salmon ecosystem	$109 million	$202 million
Net present value (1.75%, Perpetual)	$6.2 billion	$11.6 billion
Net present value (0.5%, Perpetual)	$21.8 billion	$40.5 billion

7.4 Non-market Passive Use Value

Often, nonmarket passive use values of an environmental resource—the value of saving a place for future generations (bequest value) or for the sake of its existence (existence value)—are far higher than the use values described earlier (Helvoigt and Charlton 2009). Although these valuations are controversial because of their variance from traditional legal concepts of standing and damages, Congress has legitimized passive damage valuation as an economic measure within statutes, such as the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Oil Pollution Act of 1990 (Jones 1999, Peck 1999). Willingness-to-pay passive value studies were endorsed by the National Oceanic and Atmospheric Administration, upheld in Ohio v. United States Department of Interior, and used as the basis of a $1 billion settlement between Alaska and Exxon in the wake of the Valdez spill, (D.C. Circuit 1989) (Duffield 1997, Jones 1999, Duffield et al. 2007).

Based on extrapolations of data from what citizens have been willing to pay to protect regions in other areas, Goldsmith et al. (1998) estimated that the combined bequest and existence value of Bristol Bay fish and wildlife is between $3.18 and $6.36 billion (adjusted) (USDL 2011b). When properly constructed to account for the immense size of the Bristol Bay wild salmon run, marginal willingness-to-pay models, like Loomis (1999) for the Lower Snake River on the Oregon-Idaho border and Helvoigt and Charlton (2009) for the Rogue River in southern Oregon, could provide an avenue for future economic analysis and might yield a more substantial and refined valuation of nonmarket value than Goldsmith et al. (1998).

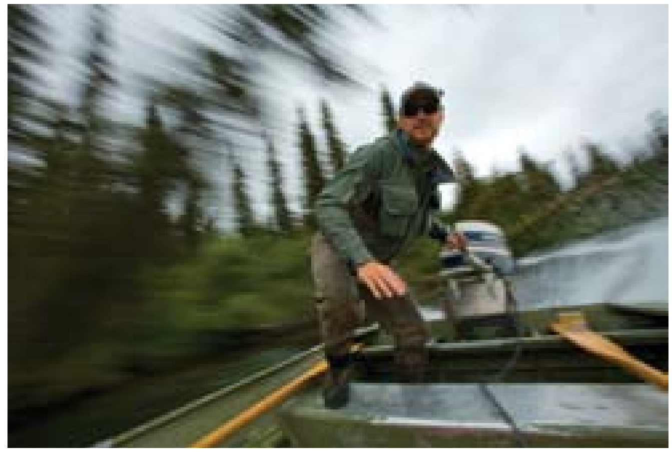
Table 9. Non-market Passive Use Value of the Bristol Bay wild salmon ecosystem in 2011 dollars.

	Non-market Passive Use Value	
	Low-end (20011 $)	High-end (20011 $)
Existence + bequest value	$3.2 billion	$6.4 billion

7.5 *Taxation and Local Revenues*

According to ADR (2010a), a Fisheries Business Tax (FBT) is levied on persons who process or export fisheries resources from Alaska. The tax is based on the price paid to commercial fishers or fair market value (when there is not an arms length transaction). A Seafood Marketing Assessment (SMA) is also levied at a rate of 0.5% of the value of seafood products processed, first landed in, or exported from Alaska. Finally, a one percent Regional Seafood Development Tax (SDT) is levied on salmon harvested by drift gillnet fishers in Bristol Bay (and these and other fishers in Prince William Sound).

Between 1985 and 2005, total production value for processors averaged about $288 million, or $335.74 million in 2011 dollars (Duffield 2009, USDL 2011b). Thus, based on this twenty year average, the Bristol Bay fishing economy may generate up to $11.75 to $16.79 million/year in tax revenue for the state of Alaska



In 2008, sport hunting and wildlife tourism in the Bristol Bay basin accounted for an estimated $33 million in local expenditures (Duffield 2009) (photo by Ben Knight).

from the FBT and SMA taxes. In addition, using 1975-2009 data, adjusted to 2011, Bristol Bay's wild salmon economy generates an average of $158.6 million in gross income from drift gillnet usage (ACFEC 2011, USDL 2011b). Based on this average, the SDT generates up to $1.6 million per year in additional tax revenue for Alaska. In total, the Bristol Bay fishery economy may raise up to $13.37 to 18.37 million per year in state tax revenue. To put the value of Bristol Bay in context, in 2010 Alaska as a whole raised $22.4 million in fisheries related taxes (ADR 2010a).

In comparison, based on 2000 to 2009 industry financials for Anglo-American (50% share in the Pebble Mine) and Rio Tinto (9.9% share, at the time), the estimated aggregate net income from the mine's 2011 median value—(2000–2009 net income/gross revenues %) x (estimated median gross value of mine)—would be $43.81 billion (AA 2009b, Rio Tinto 2009, NDM Ltd. 2010a, USDL 2011b). Yet most of this value will be realized by shareholders and the international market. In terms of revenues that will stay in Alaska, the primary source will be the Mining License Tax, levied on the net income of mining operations (annual revenues = $4,000 + 7% over $100,000 in net income [$43.81 billion]), which will total $3.07 billion overall or $39.36 million per year over 78 years (Table 10) Stickel 2007, ADR 2009, ADR 2010b).

Table 10. Estimated tax revenues for wild salmon ecosystem and the Pebble Mine.

	Estimated Annual Local Revenues from Taxes	
	Wild Salmon Ecosystem*	Pebble Mine**
Annual tax revenue	$13.4–$18.4 million	$39.4 million

*Revenue stream available in perpetuity (assuming sustained health of ecosystem)
**Based on 78 years mine life scenario (see chapter 2)

7.6 Local Employment and Native Communities

The economic frameworks described thus far in this chapter portray the value of the wild salmon ecosystem from four different perspectives. If the mine were to damage the Bristol Bay wild salmon ecosystem, there would be large and enduring economic consequences to the region. The present economic engine of the region (the annual regional economic expenditures of $414.72 million, 4,837 annual jobs, and $206.83 million in annual gross income) would likely be derailed, while the long-term use ($6.2 to $11.5 billion), extrinsic passive use value ($3.2 to $6.4 billion, possibly more using marginal valuation methods), and tax revenue potential of the Bristol Bay wild salmon ecosystem could potentially be lost forever (Goldsmith et al. 1998, Loomis 1999, Duffield et al. 2007, Helvoigt and Charlton 2009). Therefore, the true economic value (market value plus extrinsic passive use value) of the wild salmon ecosystem should be considered before proceeding with mine development.

In addition to considering economic values through the lenses described above, policy makers and the public should also consider the application of a market economy on the subsistence-based cultures that comprise the majority of the population in the Bristol Bay region. Although worth billions of dollars to shareholders, most extractive activities undertaken in "remote rural Alaska" only result in modest economic benefits for people living in the region (Goldsmith 2007). Most of the long-term jobs are held by nonresident "commuters" with the education and technical skills required of a major industrial development (Goldsmith 2007, Haley et al. 2008). Similarly, the majority of service contracts are provided to nonresident suppliers because most remote rural communities have not developed a service sector sufficiently advanced to meet highly technical needs (Goldsmith 2007). A cross-sectional survey of Bristol Bay residents conducted by Craciun Research (2009) reinforced these findings among Bristol Bay residents, reporting that 71% of residents agree that most of the jobs created by the Pebble Mine would be taken by people from outside the area.

Although better road access, more settlement (and property taxes), and higher median income levels would result from construction of the Pebble Mine, the development will also impose a market economy model onto a sensitive, subsistence-based culture that has existed for thousands of years (Wolfe and Walker 1987). Huskey (1992) found that certain types of economic development promoted to stimulate local economies can inadvertently alter and diminish the subsistence lifestyle. Likewise, increased employment has actually been

Pebble Mine drill rig (photo by Steve Baird).

observed to have a negative relationship to well-being in some Native Alaskan communities (Martin 2004, Haley et al. 2008). This is likely because typical Anglo-American jobs take time away from participation in the familial, social, and subsistence activities that are vital to the well-being of these communities (Martin 2004, Haley et al. 2008). The threat posed by the Pebble Mine to the region's Native subsistence culture is substantial. Wolfe and Walker (1987) observed that there was 69% less subsistence activity in communities with road networks versus those communities without them.

These threats to Native subsistence lifestyles are further reflected in the polling undertaken by Craciun Research (2009), which found that 73% of residents agreed that any local jobs provided by the mine would not be worth the damage that 78% anticipate will occur to commercial and subsistence fishing. Further, 94% of residents considered it very important that there are plenty of subsistence resources such as fish for future generations, while 91% of residents considered it very important to maintain the subsistence lifestyle (Craciun Research 2009).

Despite the fact that Bristol Bay communities will likely derive only modest benefits from the extractive activities, these communities historically bear the brunt of cycles of "boom" (growth during extractive operations) and "bust" (decline in population, income levels, employment, and ecological integrity after the resource has been successfully mined or collected) (Leask et al. 2001, SEACC 2007, Doukas et al. 2008). During the boom, local communities must typically expand their infrastructure and service capacities to provide the necessary housing, health, and transportation services for

On Nushagak Point, preparing the annual salmon harvest (photo by Wild Salmon Center).

new residents (Doukas et al. 2008). Not only will these services likely be expanded, but 60% of residents agree that the substantial projected influx of residents related to the mine would compete for subsistence resources (Craciun Research 2009). As a result, during and following the extraction period, local businesses and wage earners that have become tied to the mine will likely struggle to recover from both the economic and subsistence impacts of population fluctuations (Doukas et al. 2008, Haley et al. 2008). These impacts are especially acute in predominantly native communities that are not as well prepared to weather the entry and exodus of industry, which have the potential to alter traditional lifestyles and economic models.

7.7 Potential Treatment Costs and Liabilities

In evaluating the economic benefits of the Bristol Bay fishery and the economic opportunities presented by exploitation of the Pebble deposit, it should be noted that the ecological risk posed by the mine comes with substantial economic costs as well. Uncertainties surrounding mine reclamation and treatment methods create cost uncertainties, which increase with mining area size and environmental complexity (NRC 2005). Although lacking consistent estimates of treatment costs, the Environmental Protection Agency (USEPA 2004) identified 156 mine sites with $24 billion of potential cleanup costs, including 19 sites with liabilities exceeding $50 million each. Thirty percent of the 159 lacked a viable payer, and acid mine drainage is expected to multiply costs by at least 1,000%. In addition, 59% of the total sites will require over 40 years of treatment, and 20% will require perpetual treatment. Unfortunately, few companies will endure long enough to compensate taxpayers for reclamation costs. When mines are abandoned and included in the Superfund program, federal taxpayers are responsible for the first 10 years of treatment costs, after which those costs fall to state taxpayers (USEPA 2004, Woody et al. 2010).

The following case studies from Idaho's Coeur d'Alene region and Montana's Clark Fork Basin provide two examples of "megamine" sites that illustrate some of the treatment and payment inefficiencies associated with hard rock mining

Coeur d'Alene Basin Superfund Complex

According to a report produced by the National Research Council (NRC 2005), the Coeur d'Alene Basin Superfund Complex (CBSC) is a rural region of Idaho outside of the city of Coeur d'Alene, which was mined for lead, zinc, gold, and silver by companies that included the American Smelting and Refining Company (ASARCO), then a subsidiary of ASARCO Incorporated (which was a subsidiary of Americas Mining Corporation, itself a subsidiary of Grupo Mexico). The CBSC covers three units, one of which, the Bunker Hill complex, encompassed 21 square miles. Contamination from the Bunker Hill unit entered a second unit, the 50-square-mile Coeur d'Alene Lake area, which now contains an estimated 75 million tons of sediment contaminated by metals. The CBSC was listed as a Superfund site in 1983 and included the Bunker Hill complex, most of the South Fork Coeur d'Alene River and its tributaries, the Coeur d'Alene River and chain lakes, Coeur d'Alene Lake, and anywhere mining wastes were deposited, including Washington's Spokane River. Following designation, a series of legal proceedings ensued, with the EPA seeking $2.3 billion for cleanup costs. The suit culminated in a $436 million bankruptcy settlement for the Bunker Hill unit in 2009.

Partly because of the funding shortfall, the NRC (2005) reported that up to that time (2005), the EPA cleanup:

- Failed to adequately address metal contamination of groundwater, despite its being the major source of surface water contamination;
- Failed to rehabilitate physical habitat structure, which also precludes fish and wildlife recovery throughout the basin;
- Failed to locate adequate repositories for contaminated sediments and soil;
- Developed treatment models based on mean flows despite flood frequencies that periodically contaminated reclaimed areas with metals, thereby further limiting the long-term effectiveness of reclamation measures; and
- Inadequately assessed rehabilitation effectiveness on fish and macroinvertebrate assemblage structure.

The NRC (2005) concluded that it was unrealistic to a priori develop and assess comprehensive rehabilitation measures because of environmental and reclamation uncertainties. Thus, despite EPA estimates of $440 million and 30 years to reduce ecological and related human health risks, such an amount will fall short of what is needed. This is due in large part to over 100 million cubic yards of contaminated wastes, which are spread across heterogeneous aquatic and terrestrial environments (NRC 2005). This broad dispersal of wastes precludes full removal and capping of contaminated soil and treatment of contaminated water. Given the lack of ecological engineering solutions for the CBSC, rehabilitation effectiveness, duration, and costs are only crude estimates. But the preponderance of the costs will be incurred by taxpayers—not the bankrupt ASARCO. As of 2001, costs to taxpayers of the partial cleanup totaled $212 million (Woody et al. 2010).

Sampling a Clark Fork tributary (photo by U.S. Geological Survey).

Clark Fork Basin

Mining and smelting in Montana's Clark Fork Basin have impaired 119 miles of the Clark Fork River and produced the largest Superfund site in the United States (Woody et al. 2010). The contaminated area includes nearly 5 million cubic yards of contaminated tailings in the Clark Fork floodplain, a tailings pile 800 feet high over a two-square-mile area, and 1.2 million cubic yards of contaminated tailings and smelter dusts (Moran 2001). Silver Bow Creek, draining Butte, is nearly devoid of aquatic life (Hughes 1985). It has been found impossible to treat all of the contaminated groundwater in the area, and it is contaminating surface water in places. The copper mine pit (542 feet deep, 4,000 feet wide) contains about 250 million gallons of acidic (pH 2.7–3.4) water and metals (aluminum, arsenic, cadmium, copper, zinc) and continues filling with ground and surface water seepage, requiring perpetual water treatment via an 8-million-gallon-per-day plant that cost $75 million to build and costs $10 million per year to maintain and operate. Treatment of the groundwater at the city of Butte requires a $20 million plant and annual operating and maintenance costs of $500,000. Capping the tailings pile and transporting the dusts are additional costs.

The EPA sued the mining company, the Atlantic Richfield Company (ARCO), a subsidiary of British Petroleum, for $680 million for water treatment, culminating after five years of litigation in a $187 million settlement for Clark Fork River cleanup. Fixed and perpetual costs are certain to far exceed that amount. Most costs will be incurred by taxpayers (USEPA 2011b).

CASE STUDY: THE TRUE COST OF MINING

Zortman and Landusky Mines (Montana)

In 1979, Zortman Mining Company, a subsidiary of Pegasus Gold Corporation, reopened two historic gold mines named after the original miners' claims—Zortman and Landusky. The mines are located side by side in the Little Rocky Mountains of north central Montana within one quarter mile of the Fort Belknap Indian Reservation. The mines lie on a divide between the sources of tributaries of the Milk and Missouri Rivers. Between 1979 and 1996, Pegasus mined about 79 tons of gold from the two mines using the cyanide heap leach pad system to dissolve the gold out of low-grade ore.

	Tons of Rock Moved	Tons of Ore Processed	Ounces of Gold
Zortman	33,395,000	19,900,000	517,400
Landusky	186,349,863	118,367,296	2,012,244
Total		**138,267,296**	**2,529,644** (79 tons)

Outcome of Zortman and Landusky Mines 1979–1996 (Maehl 2003).

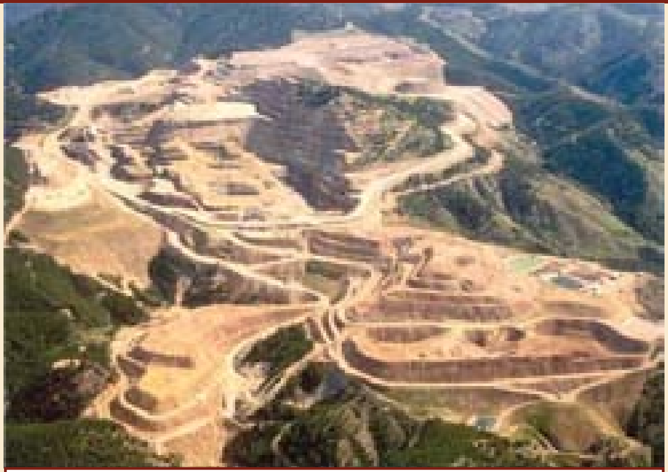
In the 1970s, Pegasus Gold Corporation was a leader in hard rock mining and the development of the cyanide heap leach process for making low-grade gold deposits profitable. Montanans in job-starved Philips County were attracted to the prospect of 300 well-paid jobs. The jobs were available for the 17-year life of the mines and served to significantly lower the unemployment rate in the county during that time (Maehl 2003). The mining company also claimed that it would not mine high-sulfide ore (Abel 1997).

Failures:

- Between 1979 and 1990, the state of Montana and the Bureau of Land Management allowed nine expansions of the mines without a supplemental Environmental Impact Statement. **None of the expansions included provisions for mining or treatment of acid-generating (sulfide) ore** (Levit and Kuipers 2000).
- It was not until 1993, when acid mine drainage entered the town of Zortman, that Pegasus was cited for violations and ordered to write a reclamation plan (Abel 1997). During this time frame, the mine also experienced 12 cyanide spills, including one that released **50,000 gallons of cyanide solution that contaminated a local water supply** (Earthworks 2011).

Impact:

- The residents of the Fort Belknap Indian Reservation, living downstream from the two mines, have resorted to litigation multiple times to try to secure safe ground and surface water.
- The Montana Department of Environmental Quality (DEQ) declared that **acid mine drainage, cyanide, selenium, and nitrates impact ground and surface waters** that are hydrologically connected to the mines and that the **impacts from acid mine drainage will continue in perpetuity.**



- The state of Montana and the Bureau of Land Management issued 9 permits for expansion of mine without a supplemental Environment Impact Statement.
- A dozen cyanide spills, including one that released 50,000 gallons of cyanide solution that contaminated a local water supply.
- Over 1 billion gallons of acid mine drainage have been treated.
- Toxic seepage, including cyanide, nitrates, and selenium, will need to be treated in perpetuity.
- Swift Gulch just below the mine has turned a bright orange with an acidic pH of 3.7, deadly to fish and aquatic life.
- Developer declared bankruptcy.
- Initial bond insufficient to cover cost of reclamation, $37 million in just the first five years.

Above: Zortman and Landusky Mines (photo by Bureau of Land Management).

- The DEQ also claimed that it is capturing and treating all ground and surface waters hydrologically connected to the mines (Mitchell 2004). However, after closure, and even with mitigation, the water in the headwaters of Swift Gulch just below the mine has turned a bright orange and become more acidic, with **pH declining from a near-neutral 7.5 to a highly acidic 3.7.** As of 2004, the groundwater sources of seepage to Swift Gulch had not even been located or diverted to treatment (Mitchell 2004).

Mitigation: After a series of lawsuits between 1993 and 1995, a Consent Decree in 1996 required Pegasus to construct water-treatment systems, pay a bond for their operation, and establish a trust for long-term operation and maintenance. In 1998, Pegasus **declared bankruptcy**, transferring the responsibility for mitigation and reclamation to state and federal taxpayers (the initial bond fund available to the state after bankruptcy was not sufficient).

The reclamation of the mine pits, waste rock dumps, and leach pads and the recontouring of the terraced hillsides helped increase the sites' resistance to erosion, covered acid-producing materials, provided drainage, and reduced random infiltration of toxic substances (Mitchell 2004). The earth-moving portion of the reclamation task was completed in 2005.

Since 1999, water-treatment plants at the mine have treated over **a billion gallons of acid mine drainage** with lime. An additional **bioreactor water-treatment plant treats the toxic seepage**, including cyanide, nitrates, and selenium, from beneath the 13 dismantled heap leach pads. The treated water is sprayed on a nearby parcel of land. Treatment is also required for **80 million gallons of precipitation collected on the heap leach pads every year**; it is hoped that with land reclamation this amount may be reduced to 10 million gallons (Maehl 2003, Mitchell 2004).

Costs:

- The company filed for bankruptcy in 1998, transferred its remaining assets to a new company, and abandoned the Zortman and Landusky Mines (Abel 1997).
- Land reclamation and recontouring have cost $9 million since 1999.
- The yearly cost of processed water management and land application is about **$1 million per year in perpetuity.** The construction of a bioreactor treatment plant to pretreat selenium cost another **$3 million**, bringing the cost of construction and the first three years of process water management and land application to **$6 million**; this amount far exceeded the predicted **$160,000 bonding amount** (Maehl 2003).
- Operating costs, labor, and lab analysis in 2000 and 2001 for the two water-treatment plants averaged **$395,000 per year**. The sureties bond for the water-treatment plants was about **$62,000 per year**—another shortfall—and the plants must be kept operating forever (Maehl 2003).
- Through 2004, Montana DEQ has spent over **$37 million for reclamation**, which includes the $33 million in bond settlement funds plus federal and state funds. The trust reserve is $11 million short of what it needs to invest (in 2001) to fund water treatment after 2017 (Mitchell 2004).

How does this compare to Pebble? Comparing the Montana situation with that in the Pebble Mine District in Alaska, reveals that **it will be impossible to capture all ground and surface waters hydrologically connected to mines in the Pebble Mine District** because the ground near Pebble is permanently saturated with ground and surface water that is inextricably linked in the frost-free season.