Potential Impacts of the Proposed Pebble Mine on Fish Habitat and Fishery Resources of Bristol Bay

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I. Abstract

The freshwater streams of the Bristol Bay drainages support important subsistence and commercial salmon fisheries and internationally-famous sport fisheries for both resident species and salmon. Northern Dynasty Mines, Inc. (NDM) has proposed to mine a metallic sulfide deposit at the headwaters of some of these streams. The project, referred to as Pebble Mine, will have a preliminary lifespan of 40 to 50 years, or even longer. Applications filed by NDM in 2006 indicate that the proposed project will leave permanent landscape features affecting some thirty square miles, including two tailings ponds that will house billions of tons of mine tailings which will include toxic materials. The project will also include a 104-mile access road, with a slurry line and a water line that will directly affect at least 12.5 square miles and a power transmission line.

The 2006 applications help identify potential impacts on the fish habitat and fisheries. Categories of these potential impacts of Pebble Mine on fish habitat and fishery resources include: direct, indirect, and cumulative effects.

Direct impacts will result from the approximately 30 square mile footprint of the mine, processing plant, and tailings ponds; more than 60 lineal miles of mainstem streams – plus the adjacent tributaries and wetlands – that will be totally or partially dewatered; the 12.5 square miles or 8,000 acres of disturbance from the access road; port facilities; and, power production and power supply lines. Siltation caused by road-building activities will smother fish food organisms and incubating eggs and alevins. Direct effects associated with the road also include fragmentation of aquatic, riparian, and terrestrial habitats.

Indirect impacts will include increased pressure on, and competition for, fish and wildlife resources, because of the increased access to the area and increased population.

Cumulative impacts will include long-term, multi-year losses of fish production and stream productivity. Over time, bridges and culverts in the access road can deteriorate and interfere with juvenile or adult fish migration between important habitats. Dust and silt from the road during the life of the project or leakage from the slurry line may smother fish food organisms and incubating fish eggs and could wash downstream to affect spawning and rearing habitat in Iliamna Lake. In addition, the weight of the roadbed and traffic can be expected to compact the soil and alter the movement of groundwater which could disrupt beach spawning by sockeye salmon in Iliamna Lake.

Although the access road and other support roads will be constructed for the proposed Pebble Mine, they will also provide access to the area by other residential, commercial, and recreational users. The human population and activities can be expected to increase, and off road, all terrain vehicle use will expand into areas not previously accessible. The impact will extend much beyond the footprint of the road itself.

Any real or perceived impact from the proposed Pebble Mine on Bristol Bay salmon populations will have the probability of destroying the high-value commercial and subsistence fisheries. In addition, it is reasonable to assume that if the proposed Pebble Mine project becomes operational, more mines will be developed and more fish populations and aquatic habitats throughout Bristol Bay may be lost. Forever.

II. <u>Introduction</u>

Northern Dynasty Mines, Inc. (NDM) has recently proposed to develop the Pebble Mine near Iliamna, Alaska in the Bristol Bay drainage for copper, gold and molybdenum (Northern Dynasty Mines 2007). The proposed mine site straddles headwaters of two highly productive Bristol Bay drainages, the Kvichak and Nushagak Rivers. A preliminary plan indicates that this mine will be among the largest in the world and that will include a 4.1 billion tonne open pit and a 3.4 billion tonne subsurface mine (Northern Dynasty Minerals Ltd. 2007b). The operational lifespan is expected to be 40 to 50 years and, it could be even longer. This mine has the potential to profoundly alter the landscape, fish habitat, fishery resources, and commercial, subsistence and recreational fisheries of Bristol Bay.

The commercial fishery in Bristol Bay is the largest sockeye salmon (*Oncorhynchus nerka*) fishery in the world, with a long-term average annual harvest of about 17 million sockeye. This harvest and that of other important commercial and subsistence salmon fisheries for Chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and pink salmon (*O. gorbuscha*) (Clark, et al. 2006; Salomone, et al. 2007) and substantial sport fisheries for both resident and anadromous fishes (Jennings, et al. 2006) depend on the high-quality habitat in the freshwater drainages of the Bristol Bay watershed for their continued survival and maintenance.

The Bristol Bay commercial salmon fishery contributes about 17% of the entire statewide salmon harvest; however, the ex-vessel value is nearly 32%, the greatest contribution of any commercial fishery in the state. Sockeye salmon comprise approximately 91% of the Bristol Bay salmon harvest and the Bristol Bay sockeye salmon harvest is about 56% of the statewide sockeye salmon harvest (Clark, et al. 2006). If the proposed Pebble Mine is developed, most impacts can be expected in either the Kvichak or Nushagak Drainage, or both. All species of salmon will be affected, but the entire Bristol Bay fishery will be in jeopardy; and, any impact, real or imagined, will taint this important fishery. If the entire Bristol Bay fishery is lost, each fifty-year increment - the projected lifespan of the Pebble Mine Project – a harvest of more than one billion fish, with a value of over six billion dollars will be sacrificed (Table 1).

Table 1. Twenty-year average harvest and total value of commercially-caught salmon in Naknek/Kvichak and Nushagak management districts and in Bristol Bay (from Westing, et al. 2005).

District	Sockeye	Chinook	Chum	Pink	Coho	Total
Naknek/Kvichak	8,300,000	4,200	205,900	165,000	7,300	8,600,000
Nushagak	3,800,000	49,000	40,300	393,900	38,600	4,500,000
Bristol Bay	23,600,000	69,500	971,200	593,100	132,600	25,100,000
50-year total						1,255,000,000
Value	$117,700,000	$900,000	$1,500,000	$400,000	$600,000	$120,900,000
50-year total						$6,045,000,000

The Bristol Bay salmon subsistence harvest is one of the largest in the state (Clark, et al. 2006). An average of over one thousand subsistence permits are now fished in Bristol Bay and an average of over 154,000 salmon are harvested (Table 2). This subsistence fishery would be severely impacted by any real or perceived impact from the Pebble Mine.

Table 2. Twenty-year average number of subsistence permits and harvest of subsistence-caught salmon in Naknek/Kvichak and Nushagak management districts and in Bristol Bay (from Westing, et al. 2005).

District	Permits	Sockeye	Chinook	Chum	Pink	Coho	Total
Naknek/Kvichak	497	83,900	1,400	900	700	1,200	88,100
Nushagak	490	30,900	12,300	5,200	1900	6,100	56,300
Bristol Bay	1,108	121,000	14,900	6,800	2,700	9,000	154,500

The environmental record of metallic sulfide mines, particularly where the ore body is at groundwater, as it is at the Pebble Mine site, is poor. One recent study of recently permitted large mines in the United States found that that sulfide mines are likely to develop pollution problems (Kuipers, J.R. et. al., 2006). The study found that those involving metallic sulfide deposits near groundwater have such a high risk, that water quality exceedances are near certain for acid drainage or contaminant leaching. The analysis found that 85% of these sulfide based mines polluted surface water, 93% of these mines polluted ground water, and of the mines that developed acid mine drainage 89% of the environmental documents for these mines predicted that they would not.

This report evaluates potential impacts of the proposed Pebble Mine on the fish habitat and fishery resources of these drainages.

III. Habitat Needs of Fish

All fish have the same basic habitat needs: spawning, rearing, overwintering, and migratory pathways or corridors. Each species of fish, however, is uniquely adapted to exploit available resources and to minimize competition for resources among species (Table 3).

Table 3. Freshwater habitat requirements for Bristol Bay salmonids.

Species	Spawning	Rearing	Feeding	Smolt Age	Juvenile Overwintering
Sockeye salmon	Stream and river riffle areas, beaches and areas of upwelling areas in lakes; mid-late summer to early winter	Lakes, but sometimes rivers or ponds	Zoo-plankton	Usually 1 or 2 years	Lakes; occasionally in rivers or ponds
Chinook salmon	River; deep riffles; mid-late summer	Usually in slow water along streambanks	Aquatic and terrestrial insects: salmon eggs and carcasses	Usually 1 year	Deep pools, often in spaces between rocks
Coho salmon	Usually in headwater stream areas; late summer-fall	Usually beaver ponds, sloughs, and small streams	Aquatic and terrestrial insects	Usually 2 years	Ponds and sloughs
Pink salmon	Usually lower stream reaches; shallow riffles; sometimes intertidal areas; mid-summer	Estuary	Zoo-plankton	Migrate to ocean as they emerge from the gravel	Marine
Chum salmon	Upwelling areas in streams and sloughs; mid-late summer	Estuary	Zoo-plankton	Migrate to ocean as they emerge from the gravel	Marine
Rainbow trout	Small streams; late spring-early summer	Usually in slow water along streambanks	Aquatic and terrestrial insects; salmon eggs and carcasses	Usually residents in Bristol Bay drainages	Lakes or large deep pools in rivers

Table 3. (continued)

Species	Spawning	Rearing	Feeding	Smolt Age	Juvenile Overwintering
Dolly Varden	Small streams; late summer-fall	Usually in slow water along streambanks	Aquatic and terrestrial insects; salmon eggs and carcasses	Highly variable life cycle and complex migration patterns	Usually lakes; Often anadromous

Although these seven salmonids and other fish species co-exist in the watershed, they exploit and share different niches within the habitats. In other words, the available spawning, rearing, and overwintering habitats are partitioned and shared among the fish species in time and space within a drainage to minimize competition for the available resources. Larger-bodied fish, for example, can spawn where the water is deeper and faster and the bottom materials are larger and juvenile salmonids feed on different food organisms and in different habitat niches within the watershed (Groot & Margolis 1991; Helfman, et al. 1997).

Anadromous fish, of course, require freshwater for spawning, but, after the fish spawn, the decomposing carcasses of the anadromous salmon contribute immensely to raise the productivity of the entire freshwater ecosystem. Resident fish and juvenile salmon feed directly on salmon eggs that were not properly buried and the flesh of spawned fish. Decomposing salmon carcasses release nutrients that originated in marine waters to stimulate the food chain in streams, ponds, and lakes. The nutrients are transported through the watershed and into the groundwater to the benefit of riparian vegetation. A myriad of insects, birds, small and large mammals also utilize the carcasses directly and indirectly. Indeed, anadromous salmon are considered a keystone species because the entire freshwater ecosystem depends on the marine-derived nutrients that are released from the carcasses of the spawned-out salmon (Bilby, et al. 1996; Bilby, et al. 2001; Cederholm, et al. 1999; Wipfli, et al. 1998).

The distribution and habitat use of these waters by anadromous fish is documented in the Alaska Department of Fish and Game Catalog of Waters important for the Spawning, Rearing or Migration of Anadromous Fishes (Alaska Department of Fish and Game 2007). More detailed information about habitat use by anadromous and resident freshwater fish species was also provided by Alaska Department of Fish and Game (2006) and Wiedmer (2006).

IV. Components of the Pebble Mine Plan

The proposed Pebble Mine Project will include several major components: an open pit at Pebble West, underground block caving at Pebble East, at least two tailings storage ponds, and an access road, a port on Cook Inlet, and power lines. Some descriptions of these components are included in the Alaska Department of Natural Resources, Mining, Land and Water web site for Pebble Project which includes applications for surface water rights, groundwater rights, and applications for approval to construct impoundments (Alaska Department of Natural Resources 2007).

The draft estimated area of the open pit will be about 1,400 acres or 2.2 square miles (measured from Northern Dynasty Mines 2006a) and 1700 feet deep (Bradner 2005).

Two tailings ponds, with an estimated footprint of approximately 7,600 acres or 12 square miles (measured from Northern Dynasty Mines 2006a, b), are designed to contain 2.5 billion tons of mine tailings waste solids and would be as much as 700 feet deep (Alaska Department of Natural Resources, Division of Mining Land & Water 2007).

The combined, overall footprint that encompasses the open pit, the tailings pond and associated operational facilities will cover some 18,000 acres or 28 square miles (measured from Northern Dynasty Mines 2006a).

A 104-mile access road will be constructed and maintained from the mine site to a deep-water port in Cook Inlet. The road corridor will also serve as a corridor for an ore slurry pipeline and a pipeline to return recycled water to the mine site. An electrical power transmission line will be installed (Northern Dynasty Mines 2007). This line will also require a cleared corridor for installation and a support road for operational inspection and maintenance.

The upper reaches of the Upper Talarik Creek in the Kvichak drainage and the South and North Forks of the Koktuli Rivers in the Nushagak Drainage will be dewatered to process the ore and to fill the tailings ponds. The combined, totally-dewatered lengths of only the mainstem reaches will amount to approximately 14 lineal miles. The combined, partially-dewatered mainstem lengths will exceed 45 lineal miles (measured from Northern Dynasty Mines 2006c). Dewatering these streams for mining operations will simultaneously include dewatering of tributary streams and associated sloughs and wetlands that are also important for the health of the stream systems and the fish populations. Groundwater contiguous with these streams will also be pumped for mine operations and groundwater movement and recharge of the streamflow will be altered (Alaska Department of Natural Resources 2007).

Northern Dynasty Mines, Inc. forecasts that at least 200 MW of power will needed to be generated to operate the Pebble Mine (Northern Dynasty Mines 2007). This amount is greater than two times the existing production capacity of Homer Electric Association, the closest available power source. Consequently, some new energy source must be developed for the Pebble Mine to operate.

V. **Potential Impacts of the Proposed Pebble Mine on Fish Habitat and Fishery Resources**

Potential impacts of Pebble Mine on fish habitat and fishery resources can be expected from numerous sources over an unlimited timeframe. Categories of potential impacts include: direct, indirect, and cumulative impacts. Impacts and effects are synonymous (40 CFR 40 CFR 1508.8) for purposes of the National Environmental Policy Act (NEPA). NEPA regulations at 40 CFR 1508.8 provide in part:

> Effects include:
>
> (a) Direct effects, which are caused by the action and occur at <u>the same time and place</u>.
> (b) Indirect effects, which are caused by the action and are <u>later in time or farther removed in distance, but are still reasonably foreseeable</u>. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

The regulations at 40 CFR 1508.7 provide:

> Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other <u>past, recent, and reasonably foreseeable future actions</u> regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

V. a. <u>Direct Impacts.</u>

Direct physical effects of mine development will include destruction of fish habitat as the mine is developed. The project site footprint will cover nearly 30 square miles of terrestrial and aquatic habitat. At least 60 lineal miles of the mainstreams of the North and South Koktuli Rivers and the Upper Talarik Creek that will be totally or partially dewatered along with associated sloughs and wetlands, including Frying Pan Lake (measured from Northern Dynasty Mines 2006c). The mine, its pit or underground workings and any subsidence, as well as the tailings facilities will become permanent features of the land.

Spawning, rearing and overwintering habitats will be destroyed or damaged in the downstream, partially dewatered reaches where reduced discharge will affect stream productivity because the average velocity will be reduced. Consequently, the capacity of the stream to move substrate materials will be reduced and more fine materials will settle out and smother food organisms and incubating fish eggs.

These productive waters presently support spawning, rearing and overwintering sockeye, chinook, and coho salmon, Arctic grayling *Thymallus arcticus*, rainbow trout *O. mykiss*, Dolly

Varden *Salvelinus malma*, northern pike *Esox lucius*, burbot *Lota lota*, and other freshwater species (Alaska Department of Fish and Game 2007; Northern Dynasty Mines 2005). Also, the Baseline Environmental Team (2006) reported substantial numbers of juvenile coho salmon, Arctic grayling and northern pike in other waterbodies in the project area.

The environmental studies by Northern Dynasty Mines provide some data that help address the nature of likely impacts. The data also raises questions (Northern Dynasty Mines 2006d). (Table 4.)

Table 4. Salmonid abundance and population estimates in the vicinity of the Pebble Mine site, reported by (derived from Northern Dynasty Mines 2006d).

				Range of Catches		
Stream -Reach	**Date**	**Species**	**Lifestage**	**Lower**	**Upper**	**Total**
UT	2004-06	Chin	Overwinter	0	11	
UT	2004-06	Coho	Overwinter	4	21	
UT	2004-06	Sock	Overwinter	0	1	
UT	2004-06	DV	Overwinter	0	1	
UT	2004-06	RT	Overwinter	1	14	
UT – 1.0	2005	Chin	Rearing			2,024
UT – 1.0	2005	Coho	Rearing			56,654
UT – 1.0	2005	Sock	Rearing			460
UT – 1.0	2005	DV	Rearing			409
UT – 1.0	2005	RT	Rearing			530
UT	2005	Chin	Escapement	60	320	
UT	2004	Coho	Escapement	800	47,100	
UT	2005	Coho	Escapement	3,500	35,500	
UT	2004	Sock	Escapement			124,000
UT	2005	Sock	Escapement	26,000	94,000	
SFK	2004-06	Chin	Overwinter	0	23	
SFK	2004-06	Coho	Overwinter	0	18	
SFK	2004-06	Sock	Overwinter	0	120	
SFK	2004-06	Chum	Overwinter	0	5	
SFK	2004-06	DV	Overwinter	0	19	
SFK	2004-06	RT	Overwinter	0	1	

UT = Upper Talarik
SFK = South Fork Koktuli
NFK = North Fork Koktuli

Chin = Chinook salmon
Coho = Coho salmon
Sock = Sockeye salmon
RB = Rainbow trout
DV = Dolly Varden

Table 4. (continued)

Stream -Reach	Date	Species	Lifestage	Range of Catches Lower	Range of Catches Upper	Total
SFK- 3/4	2004?	Chin	Rearing			0
SFK- 3/4	2004?	Coho	Rearing			65
SFK- 3/4	2004?	Sock	Rearing			0
SFK- 3/4	2004?	DV	Rearing			0
SFK- 3/4	2004?	RT	Rearing			0
SFK- 3/4	2004?	AG	Rearing			3,584
SFK	2004	Chin	Escapement	3,400	13,900	
SFK	2005	Chin	Escapement	1,700	6,000	
SFK	2004	Coho	Escapement	900	4,500	
SFK	2005	Coho	Escapement	1,700	8,100	
SFK	2004	Sock	Escapement	3,800	14,800	
SFK	2005	Sock	Escapement	2,500	10,500	
SFK	2005	Chum	Escapement	900	4,800	
NFK	2004-06	Chin	Overwinter	0	28	
NFK	2004-06	Coho	Overwinter	0	33	
NFK	2004-06	Sock	Overwinter	0	93	
NFK	2004-06	Chum	Overwinter	0	15	
NFK	2004-06	DV	Overwinter	0	25	
NFK	2004-06	RT	Overwinter			
NFK-1.190	2004?	Chin	Rearing			104
NFK	2004?	Coho	Rearing			69
NFK	2004?	Sock	Rearing			
NFK	2004?	DV	Rearing			15,446
NFK	2004?	RT	Rearing			
NFK	2004?	AG	Rearing			321
NFK	2004	Chin	Escapement	3,500	12,500	
NFK	2005	Chin	Escapement	2,900	10,800	
NFK	2004	Coho	Escapement	300	4,900	
NFK	2005	Coho	Escapement			
NFK	2004	Sock	Escapement	1,200	5,200	
NFK	2005	Sock	Escapement	1,900	9,200	
NFK	2005	Chum	Escapement	600	4,000	

UT = Upper Talarik
SFK = South Fork Koktuli
NFK = North Fork Koktuli

Chin = Chinook salmon
Coho = Coho salmon
Sock = Sockeye salmon
RB = Rainbow trout
DV = Dolly Varden

Although information that is available from NDM is classified as draft or preliminary and there is some disagreement in data presented between Northern Dynasty Mines (2005) and Baseline Environmental Team (2006), some observations are clear. All three streams are used by salmon and other fish species for spawning, rearing, and overwintering and each stream offers different habitat for different species. For example, rearing habitat is particularly important in Upper Talarik Creek for coho salmon, in South Fork Koktuli River for Arctic grayling, and North Fork Koktuli River for Dolly Varden. Escapement into Upper Talarik Creek by coho and sockeye salmon is particularly strong. Escapement into both the North and South Fork Koktuli Rivers is strong for coho, sockeye, and Chinook salmon. The South Fork Koktuli River is especially important for Chinook salmon. It is difficult to understand the accuracy of these NDM data because the numbers may be influenced by the survey method, environmental conditions (e.g., water turbidity), weather, survey timing, time of peak escapement, and other factors.

Spawning and rearing fish are well-represented in all streams, but overwintering fish are not. The authors of the NDM reports suggest several reasons why this may happen (e.g., gear avoidance or unidentified overwintering refugia) (Northern Dynasty Mines 2006d); (Northern Dynasty Mines 2005). However, NDM did report that they caught overwintering chum salmon in the North and South Forks of the Koktuli River (Northern Dynasty Mines 2006d). Chum salmon become smolt as fry and quickly migrate to estuarine waters after they emerge from their gravel and do not to overwinter in freshwater. One must wonder if these fish were correctly identified.

Salmon escapement is highly variable both between years and among the streams, however, as many as an estimated 124,000 sockeye salmon and 47,100 coho salmon escaped past the commercial and other fisheries to spawn in Upper Talarik Creek in 2004 and an estimated 13,900 chinook salmon escaped into the South Fork Koktuli in 2005 (Northern Dynasty Mines 2006d). It must be noted that any measure of escapement is probably an underestimate of the actual and that escapement estimates are made after harvests; and, therefore, are a very poor representation of the production. Although it is unclear what stream reaches were surveyed or at what stage of the individual migration the data was obtained, this magnitude of salmon escapement (and associated harvest) can be expected to be lost from production. In addition, spawning and rearing habitat for rainbow trout, Dolly Varden, Arctic grayling and northern pike will be lost as the mine is developed.

The numbers of other fish, including rainbow trout, lamprey, whitefish, sticklebacks, and northern pike, provide additional evidence that the streams are in a healthy state and support a robust fish community. Northern pike are most abundant in Frying Pan Lake, with an estimated population of 264 fish with a range of 145 to 383 (Northern Dynasty Mines 2006d). The nutrients derived from the decomposing carcasses of anadromous fish are essential to maintain the health of these fish communities and the watersheds.

Direct physical effects of the access road construction with the associated slurry and water lines will begin as soon as the mine is developed. The proposed 104-mile road will connect the mine project to a deep water port in Cook Inlet (Northern Dynasty Mines 2007). The road may require as many as 120 stream crossings (Northern Dynasty Mines 2005). Streams range in size from intermittent to the Newhalen River with a peak discharge of nearly 45,000 cfs (U. S. Geological Survey 2007). Many of these streams contain anadromous fish (Alaska Department of Fish and Game 2007; Northern Dynasty Mines 2006d). About 24 of these streams have been documented to provide nearly 1200 acres of spawning habitat for up to 552,000 spawning sockeye salmon and other salmonids (Demory, et al. 1964). The Newhalen River, alone, had an escapement of over 300,000 sockeye salmon (Demory, et al. 1964). Similar and larger escapements into different streams; e.g., up to 1.5 million in the Newhalen River, were reported by Morstad (2004).

Similarly, the power transmission corridor with the support road will cross a number of streams, many, of which, are likely to support both anadromous and resident fish and fish habitat. Installation and operation of the power transmission corridor will require installation of bridges and culverts over these streams.

Despite efforts to protect stream habitat, road construction activities and bridge and culvert installation can be expected to impact streams. Fine materials, which smother food organisms and incubating fish eggs (Konduo, et al. 2001; Phillips, et al. 1975), frequently wash into streams (Harper & Quigley 2000). If the load of derelict silt is large, downstream effects may reach Iliamna Lake and reduce survival of eggs spawned by as many as one million sockeye salmon in the stream mouths and the adjacent shorelines of Knudson Bay (Demory, et al. 1964).

As the road bed is cleared and excavated, construction activities inevitably increase the surface area of the exposed rock and fragmented gravel particles which can react more rapidly chemically. Chemical decomposition and chemical pollution will depend on the source and composition of the material used for the road building, however, dust drift and pollution along the road corridor is probable (Robert Moran, pers. comm.).

All too often, culverts or bridges are improperly designed or installed and fish spawning, rearing, and migratory habitat may be lost. Each road crossing destroys stream habitat equal to the width of the roadbed as well as adjacent fringe effects. Poorly-installed culverts may be perched and under-designed stream crossings result in increased water velocity which impairs or prevents migration by juvenile or adult fish (Envirowest Environmental Consultants 1990; Harper & Quigley 2000; Wofford, et al. 2005). Many of these impacts will happen within several generations of the affected fish species.

Direct physical effects of the port facility construction will also occur during the startup process. Freshwater streams and wetlands within the footprint of the facility will be destroyed along with intertidal and upland habitats. Construction activities and vessel movements associated with construction can be expected to disturb the marine substrate and create a silt plume that will smother benthic organisms, fish and invertebrate spawn and intertidal and subtidal vegetation. The magnitude of the effects will depend on the magnitude of the disturbance and the velocity and direction of the prevailing water currents.

V. b. Indirect Impacts.

Habitat fragmentation is a probable indirect impact from the mine site footprint, the access road, and the power transmission corridor. As these structures bisect streams, wetlands and riparian areas, they will become increasingly isolated from other parts of the drainage. Migration routes between fish habitats will become more disrupted and important habitats will be marginalized (Trombulak & Frissell 2000; Jones, et al. 2000).

During the construction phase of the access road, fill materials and gravels will be required for the roadbed, surfacing, and other road-related features, such as abutments. These materials may be found locally or they must be imported, and, the location, amount, and quality of the materials, the mining and transport of these materials, and the proximity to wetlands and waterbodies will determine the degree of the other indirect effects on fish habitats.

V. c. Cumulative Impacts.

Cumulative effects on the dewatered streams within the footprint of the Pebble Mine Project include permanently lost production from the streams and tributaries that are engulfed by the mine development. In fact, these losses will be permanent. Such losses will not only affect commercial and subsistence salmon harvests, but reduced escapements will also affect downstream primary productivity from a reduction in salmon derived nutrients (Wipfli, et al. 1998). Cumulative, permanent losses will amount to a large number of fish that will be absent from the commercial, subsistence, and recreational fisheries.

Cumulative effects of the access road construction can be expected to become more severe as time passes. Culverts and bridges have a history of being under-designed or poorly installed (Flanders & Cariello 2000; Wofford, et al. 2005). High water conditions stress stream crossings and roads and, without continual and proper maintenance, road crossings, especially culverts, fail and become barriers to fish passage (Flanders & Cariello 2000; Harper & Quigley 2000; Jones, et al. 2000). Sockeye salmon and other fishes that rely on these streams for spawning will be affected. Demory, et al. (1964) documented spawning areas for sockeye salmon in the Kvichak drainage and listed twenty-one important spawning streams or ponds on the northeast shore of Iliamna Lake with up to 552,000 spawners, a beach spawning area in Knudson Bay with up to one-million spawners, and the Newhalen River with 300,000(+) spawners. Escapements to these streams can be quite variable, but similar results were reported by Morstad (2004). Some or all of these spawning populations will be at risk from failed culverts and habitat loss.

It is important to recognize that the effects of access road installation and operation are not limited to the width of the roadbed. Forman (2000) and Forman and Deblinger (2000) determined that ecological road-effects zone extends to in excess of 100 meters on both sides of the road; thus, for the Pebble Mine access road, this will amount to more than 12.5 square miles or approximately 8,000 acres, including affects on streams, wetlands, and groundwater. The road will require annual maintenance, including snow plowing which will produce vehicle road wastes, road treatment chemicals, and fine materials that will eventually drain into streams and wetlands and affect aquatic food organism production and spawning habitat.

Dust production from the mine itself and the 104-mile access road will have cumulative effects. The mining activities and road usage will introduce years of continual dust drift onto the surrounding lands and waters. Off-site drift of toxic mine products, for example, has created a serious environmental problem associated with the Red Dog Mine, Alaska (Hasselbach, et al. 2004; Bluemink 2007). Potentially, large amounts of the fine material may be washed into streams, wetlands, and Iliamna Lake. Years of accumulation of fine materials cause stream substrates to become embedded and food production and fish egg hatching rates are diminished. The dust from the road and the mine itself will be ground rock which may contain toxic materials or materials which may become toxic in water.

A pipeline will transport the ore slurry from the mine to the port and another pipeline to transport reuse water from the port to the mine. After years of use, these pipelines will be increasingly susceptible to corrosion and breakage. As the access road ages, it will also become increasingly susceptible to movement, settling, and erosion which will affect the pipelines. A catastrophic break in the pipelines will have the potential to release the contents from part of the pipeline into streams and impact the aquatic habitats. If severe, outfall into Iliamna Lake may occur. Pipeline contents will include heavy metal sulfide concentrates, dissolved heavy metal ions and processing chemicals.

Cumulative effects of the port facility will include spillage, long-term slow or catastrophic failure of vessel, port and vehicular fuels and the slurry and water lines. Concentrate loading facilities in Alaska have a history of spill related contamination. The ore loading terminals in Alaska -- Greens Creek, Red Dog and Skagway -- have had spill-related contamination during their early years of operation (David Chambers, pers. comm.).

Cumulative effects of years of small or medium scale earthquakes and storm events can be expected to degrade the access road, the port facility and the tailings storage pond. Bridges, culverts, and facilities can be designed to withstand a particular-sized earthquake or a particular-sized storm event, but the cumulative effects of lesser events can cause cracks, uneven settling, or erosion. These, in turn, can accumulate and lead to stress and failure of those facilities and release of tailing pond contents, the slurry materials and petrochemicals.

The open pit and the deep shaft will create a sump where groundwater will drain and require pumping to maintain the operation. This will alter the movement of groundwater and may have profound effects on the surface flows in the streams that head in this area and share the common pool of groundwater (Northern Dynasty Mines 2006d). Never the less, Northern Dynasty Mines water rights applications and water recycling plans suggest that Northern Dynasty Mines does not expect to have any water discharge from the project.

Over time, the roadbed will compact the underlying substrate and may have profound downslope effects. Groundwater quality and movement will be altered and subsurface water drainage patterns will be changed. Downstream habitat will be altered as runoff patterns for seasonal flows are disrupted (Trombulak & Frissell 2000). For example, the effects of railroad and highway beds on subsurface drainage can be observed in the Palmer Hayflats, Girdwood, Portage Valley and the Placer River/Ingram Creek flats. The compaction has altered the natural subsurface drainage and upslope areas are more saturated while the downslope areas are drier.

Vegetative communities on opposite sides of the road are totally different from each other. Similar effects can be expected from the Pebble Mine access road.

The proposed access road alignment passes near to the sockeye salmon beach-spawning area in Knudson Bay. This spawning area, which supports up to one million spawning sockeye salmon, could be seriously affected if the roadbed prevents the movement of groundwater and the survival of incubating eggs and alevins. If the disruption of groundwater movement is severe, the groundwater supplies for Iliamna Lake beach spawning populations of sockeye salmon could be affected.

The access road and the power line support road are intended for use, year round, for logistical support of the Pebble Mine Project. It is reasonably foreseeable that the roads will be used for personal purposes by people other than by mine personnel, including home sites, recreational and subsistence hunting and fishing, access to Iliamna, Pedro Bay, and Newhalen, and commercial establishments. It is reasonable to assume that these developments will increase the number of people who work, recreate and live in this area. This will have a cumulative effect on the area including more road and trail development and for access to other areas and more stream crossings, increased human, industrial, and vehicular wastes, increased competition for fish and wildlife, and increased demand for groundwater and other resources (Trombulak & Frissell 2000). As the numbers of people and recreation and subsistence activities increase, off-road vehicle use increases and new trails expand, wetlands, streams, and fish habitat will also become increasingly fragmented and impaired wherever stream or wetland crossings are made and expanded (Wiedmer 2002).

V. d. Mitigation.

Kuipers, J.R., et al. (2006) studied a representative sample of 25 recently permitted major mines where pre-mining baseline data was available and where operational data was available. Although 100 percent of the environmental impact statements predicted that the mines would be able to comply with water quality standards, in fact:

- 76% of the mines polluted groundwater or surface water severely enough to exceed water quality standards;
- 60% of mines polluted surface water severely enough to exceed water quality standards;
- 52% of mines polluted ground water severely enough to exceed water quality standards;
- 73% of mines exceeded surface water quality standards despite predicting that mitigation would result in compliance; and,
- 77% of mines that exceeded groundwater quality incorrectly predicted that mitigation to correct problems would result in compliance.

In other words, mitigation does not work.

V. e. Tailings Dam Failure.

The fact that the tailings impoundments must last forever raises the question of whether failure of the dams is reasonable foreseeable for purposes of being a “cumulative impact.” Rather than address the foreseeability issue at this time when the designs of the dams may not be final, it is more useful to discuss the consequences of dam failure.

If one or both man-made tailing pond embankments should fail, the billions of tons of mining waste fines, including potentially toxic materials, could wash down any or all of the three streams that will have been diverted to fill the ponds. The failure could be catastrophic or chronic. The silt load alone could affect spawning habitat and stream insect production of these streams for unknown miles downstream. Water quality will be destroyed and fish populations in the Kvichak and Nushagak Rivers will be decimated and all or much of the Bristol Bay production could be tainted.

In time, natural processes, alone or in combination, may cause the embankments to breach. One large earthquake or the cumulative effects of numerous smaller earthquakes routinely stress both natural and man-made structures and, eventually, the stresses may lead to failure. Earthen dams routinely fail because water continually and insidiously erodes or dissolves at weak spots. Leaks may develop through the wall, or the margin of the dike may be eroded by wave or wind action.

If the embankment does fail, the Nushagak or Kvichak Rivers or both, will become filled with billions of tons of silt and potentially-toxic materials. The silt will smother fish food organisms and incubating fish eggs. Toxic waste will have the capability to destroy the food chain in Iliamna Lake that nourishes the juvenile sockeye salmon that rear in the lake.

The Bristol Bay sockeye salmon fisheries may become tainted: directly or indirectly; real or perceived.

VI. Conclusions

NDM has released enough information to address the nature of potential impacts from the proposed Pebble Mine. Potential impacts of Pebble Mine on fish habitat and fishery resources can be expected from numerous sources over an unlimited timeframe. Categories of potential impacts include: direct, indirect and cumulative impacts.

The footprint of the mine and tailings ponds will cover nearly 30 square miles and fully or partially dewater approximately 60 mainstem stream miles plus associated tributaries and wetlands. The access 104-mile access road will affect an estimated 12.5 square miles and cross at least 100 streams, including the Newhalen River. Culverts have a bad history of becoming barriers to migrating adult or juvenile fish. Inevitable siltation from construction activities, road traffic, erosion, and dust production will reduce fish food production and survival of fish eggs, potentially extending into Iliamna Lake.

The access roads will cause fragmentation of aquatic, riparian, and terrestrial habitats. Although the roads will be constructed for the Pebble Mine project, they will also provide access into the area by other residential, commercial, and recreational users and the human population and activities can be expected to increase. Competition for fish and game resources will increase. Off road, all terrain vehicle use will expand. The impact will expand much beyond the footprint of the road itself.

After Pebble Mine is exhausted, the abandoned pit, underground workings, waste rock, and waste impoundments will remain to become permanent features of the landscape of the Bristol Bay drainage. Unanticipated impacts may remain forever that will require innovative solutions and commitments from Alaskans and state and federal governments.

Any real or perceived impact from the proposed Pebble Mine on Bristol Bay salmon populations will have the probability of destroying the high-value commercial and subsistence fisheries. In addition, it is reasonable to assume that if the proposed Pebble Mine project becomes operational, more mines will be developed and more fish populations and aquatic habitats throughout Bristol Bay may be lost. Forever.

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