Comments & Questions on: **Bristol Bay Watershed Assessment Report: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska**

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With regards to seismicity and Box 3-4, we have these comments and questions:

Overall Comments:

In the Bristol Bay Watershed Assessment, the EPA identifies earthquakes as a potential danger to dams, pipelines, and other mine facilities. Major bedrock faults have not been positively mapped in the area. A large fault (the Lake Clark Fault) runs near the proposed mine site, and may run directly through it. The hazard this fault poses is undetermined, and may be large. Given this potential threat, the EPA's concern is well founded.

Despite hundreds of millions of dollars spent on science, according to Pebble Limited Partnership (PLP)'s released statements, it has not determined the exact location or earthquake history of this fault. PLP employs flawed science to draw the optimistic conclusion that the Lake Clark Fault and other faults in the area pose no significant hazard, and fails to conduct the types of seismic risk studies that have been done for similar large projects. (See Pebble EBD Seismic Critique by Ground Truth Trekking (PDF), our general critique paper of Pebble Limited Partnership's Environment Baseline Document's seismic hazard assessment. See also Itemized Comments on the PLP EBD by Ground Truth Trekking (Excel), which lists specific problems in the EBD. Both documents are submitted in a separate Regulations.gov comment.)

We did identify some weaknesses in the Watershed Assessment's "Seismic Environment of Bristol Bay" Box 3-4. Broadly, we found this section confused the lack of evidence for seismic hazards with evidence that there is little risk of earthquakes. Very little research has been done on seismic hazards in the area, so uncertainty is high.

Additionally, we are including a preliminary field report on our ongoing research on seismic hazards in the area. In this report, we present tentative evidence for strong shaking and tectonic deformation near the Pebble Prospect (See the accompanying attachment on this Regulations.gov comment: Liquefaction & Deformation Near Lake Iliamna – Preliminary Field Report (PDF) by Bretwood Higman and Andrew Mattox).

Comment 1: **The Watershed Assessment does not describe the general seismic environment of Bristol Bay**.

In Box 3-4, the first paragraph lists off some major faults, and the second paragraph provides some information on studies of the Lake Clark Fault. What is missing is the broader geological context. The region surrounding Bristol Bay is potentially impacted by as many as four independent and actively moving blocks of crust (Haeussler 2008). The most dramatic motion in the region is likely driven by

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subduction of the Pacific Plate to the south under North America to the north. A fragment of the North America Plate called the Southern Alaska Block is sliding west along the Denali Fault and others, driving earthquakes east of Bristol Bay and its impact on the Bristol Bay Region is unknown. Finally, a section of rotating crust called the Bering Block may be shearing along the western edge of Alaska, possibly impacting Bristol Bay (Macket et al., 1997). This complex tectonic context makes it difficult to extrapolate tectonic trends from elsewhere in the state to the area.

Comment 2: **Some inaccurate characterizations and irrelevant material obscure the general status of research on seismic hazards.**

Box 3-4 states, "The western terminus of the Lake Clark Fault was originally interpreted to be near the western edge of Lake Clark, but more recent studies by USGS reinterpreted the position of the Lake Clark Fault further to the northwest, potentially bringing it as close as 16 km to the Pebble deposit (Haeussler and Saltus 2005)."

No scientific work has been done to ascertain the terminus of the Lake Clark Fault. The terminus is explicitly unknown. No evidence discovered to date has suggested or been interpreted as a terminus. Haeussler and Saltus map the fault to about 16 km short of the Pebble deposit, but their results do not suggest it terminates there. On the contrary, they show that there is about 26 km of offset on the Lake Clark Fault, similar to what is seen further northeast. This offset implies the fault must go further or transition into some other unknown fault system. Likewise, the characterization of the length of the fault as 225 km long is inaccurate. As an important distinction, the *length mapped* is 225 km.

Additionally, Box 3-4 includes discussion of the "Braid Scarp" feature. This is just a single ancient riverbank that, though it was investigated as a possible fault trace, is not in fact a fault. This has no implications as far as the broader tectonic behavior of the area, and has no relevance in the document.

Comment 3: **The Watershed Assessment does not make the uncertainty about seismic hazards clear.**

The most recent scientific literature (Haeussler & Waythomas 2011, Koehler & Reger 2011) on seismic hazards along the Lake Clark Fault and in Bristol Bay clearly equivocates. Little is known, the hazard is thus undetermined, and the researchers make carefully worded statements to reflect this. This is a key factor when assessing future developments in the area. Published research suggests that seismic hazard may be low, but the extent of this research is limited, and seismic hazard may be high. We found this important scientific distinction was lost in Watershed Assessment.

Perhaps the most relevant and recent paper on the subject, is Koehler and Reger, 2011. Koehler & Reger conclude that they did not find evidence for activity on the Lake Clark Fault in the Tyonek area in the recent past, paralleling the results summarized by Hauessler & Waythomas (2011). In addition, they clearly articulate the state-of-knowledge of the western end of the Lake Clark Fault, near Pebble: *"The paleoseismic history of the western part of the Lake Clark fault remains unknown."*

Koehler & Reger also clearly describe some of the limitations to knowledge of the Lake Clark Fault's activity level. For instance: *"…distributed slip on unrecognized structures and dense vegetation that might obscure tectonic features along the Lake Clark fault could limit assessment of tectonic activity."*

Together, Koehler & Reger (2011) and Haeussler & Waythomas (2011) well-characterize the overall state-of-knowledge, but this requires careful reading. There is no currently public evidence to suggest recent activity on the Lake Clark Fault, but there is also little scientific knowledge on the subject, and broad conclusions about the seismic stability or history of the area are preliminary.

Koehler & Reger 2011 is actually cited in the current version, but this is an accidental mis-reference: the paper referred to in the current version is actually Koehler 2011, which is Rich Koehler's review of the Braid Scarp.

Comment 4: **Minor technical correction on small & induced earthquakes.**

Box 3-4 states that earthquakes may occur "…outside of pre-existing faults." It would be more accurate to say such earthquakes can occur on previously unidentified, minor, or otherwise inactive faults, but it's very unusual for manmade stresses to cause the formation of new faults.

Conclusions

The Watershed Assessment appropriately considers the risks of seismic hazards to possible mine facilities. To support this, the assessment should improve its existing Box 3-4 to more accurately and completely describe the state of knowledge about seismic hazards in Bristol Bay.

P. J. Haeussler, 2008: *An Overview of the Neotectonics of Interior Alaska: Far-Field Deformation From the Yakutat Microplate Collision*; Geophysical monograph vol. 179, p. 83-108.

K. G. Mackey, K. Fujita, L. V. Gunbina, V. N. Kovalev, V. S. Imaev, B. M. Koz'min, L. P. Imaeva, 1997: *Seismicity of the Bering Strait region: Evidence for a Bering block*; Geology vol. 25, no. 11, p. 979-982.

R. D. Koehler and R. D. Reger, 2011: *Reconnaissance Evaluation of the Lake Clark Fault, Tyonek Area, Alaska*; Preliminary Interpretive Report 2011-1, State of Alaska – Department of Natural Resources, Division of Geological and Geophysical Surveys.

P.J. Haeussler, P.J. and R.W. Saltus, 2005, *26 km of offset on the Lake Clark fault since late Eocene time*, in Haeussler, P.J., and Galloway, J.P., eds., Studies by the U.S. Geological Survey in Alaska, 2004: U.S. Geological Survey Professional Paper 1709-A, 4 p.

P.J. Haeussler and C.F. Waythomas, 2011: *Review of the Origin of the Braid Scarp near the Pebble Prospect, Southwestern Alaska*; U.S. Geological Survey Open File Report 2011-1028.
