November 18, 2011

To: Robert Shavelson
Cook Inlet Keeper
P.O Box 3269
Homer, Alaska 99603

From: Margaret A. Palmer
Professor and Director
National Socio-environmental Synthesis Center
University of Maryland

RE: Expert Comments on Denial of Unsuitable Lands Petition (ULP) by Alaska Department of Natural Resources (DNR) dated 10/24/11

I outline the science evidence that reclamation of streams and wetlands is NOT technologically feasible for the Chuitna watershed. Specifically, current and highly relevant science shows that the scientific technology and knowledge is not sufficient to reclaim salmon streams and riparian habitats post-mining in the Chuitna Watershed. Therefore if the mining proceeds, the damage done to streams and wetlands will be permanent – the damage is irreversible.

Section I. Evaluation of the reclamation examples cited by DNR

A number of projects were referenced by DNR and PacRim as evidence that it is technologically feasible to reclaim wetlands and streams in a manner suitable for the proposed mine site at Chuitna. In some cases, these projects have been referred to as restoration projects and so that term may be used in my comments since restoration is part of a reclamation process. As the Commissioner himself stressed in the decision document, it is important that competent and scientifically sound data are used in such decisions. We fully agree but further emphasize that the universally accepted method for ensuring that scientific information is sound and unbiased is the peer-review process. For this reason, it is critical that studies which have been vetted by the external scientific community be weighed more heavily than material produced without external peer review.

The basic arguments put forward by the Commissioner are that 1) there are many examples of successful stream reclamation that are analogous to what will be done on the Chuitna site, and 2) that reclamation technology has advanced significantly since the 1990 FEIS suggesting that criticisms used in that FEIS are no longer applicable. The findings from my expert evaluation of the examples provide in the DNR petition denial are that the examples are not relevant to the type of reclamation required for the Chuitna mine site, particularly for Stream 2003 and its tributaries. For each specific example, I outline below why they do not provide evidence that reclamation of stream 2003 and the broader watershed is possible. In general, the example projects cited involve streams that were only minimally impacted compared to what will occur for stream 2003, or to any other stream in the Chuitna watershed mined in the same manner as proposed for stream 2003.

Diamond Shamrock Project.

The DNR denial drew heavily on the 1987 permitting decision for this project as well as EPA's 1990 FEIS and ROD on this project. Yet this 1987 project was nothing like what is being proposed for the Chuitna site <u>and</u> the logic that was used in the DNR denial to suggest that Chuitna is technologically feasible was highly flawed for many reasons; I provide a few examples:

- Shamrock was a restoration project on a stream reach that had been diverted…not disconnected (destroyed) from the river network.
- Requiring that sediment and drainage controls (including ponds; page 51, DNR denial) be put in at a mine site does not ensure they are working effectively nor does it prove reclamation is feasible.
- There is no explanation of what '*design*' could '*prevent material damage to the hydrologic balance*' (page 52) given that the groundwater flow paths in the mined area will be fundamentally altered and there is no evidence they will recover within the time span that post-reclamation monitoring and assessment is occurring. On the contrary, there is evidence that it will take much longer and may never be sufficient to provide baseflow to created streams (Myers 2011).
- The DNR denial cites (page 17) a "conclusion" by EPA that '*wetland net productivity would be as high or highe*r' and '*therefore adverse impacts to primary wetland productivity would not be significant on a regional scale*'*. And Interruption of food webs in the immediate vicinity is not problematic because there are a large number of wetlands outside the remaining area'*. This logic is flawed for many reasons including the following:
    - 1) the goal of ecological restoration (reclamation) is **not** to increase some ecological function like productivity but to restore it to within the range of variability in pre-impact levels (Hughes et al. 2005). Having higher (or lower) productivity is not a scientifically sound goal…it is arbitrary. The reclamation goals must be based on the pre-disturbance characteristics (level of productivity) and process rates of the system (Falk et al. 2006). There is a delicate balance within ecosystems between primary productivity, secondary productivity, and decomposition. Increasing production is not always good (e.g., eutrophication is basically the result of excess productivity that has cascading effects eventually causing collapse of entire aquatic ecosystems).
    - 2) Assuming that the remaining wetland areas will function as they did pre-mining ignores the large body of science on the negative ecological impacts of fragmentation (Henry and Amoros 1995; Kondolf et al. 2006).

Valdez Creek stream reclamation

This reclamation project was completed in association with placer mining from 1983-1995 in which a stream had been mined 180-200 feet below the stream surface. This reclamation project is NOT evidence that the proposal for reclamation of Chuitna streams is technologically feasible. The Valdez Creek mining operations and impact to the stream are extremely modest in comparison to what is proposed for Chuitna Stream 2003. As the EPA Site Visit Report[1] from 1992 emphasized Valdez creek was diverted around the mine site and rejoined the natural stream after about 1 mile:

> *"Mining operations are concentrated on the lower portion of the valley, two miles upstream from the Susitna River. In this area,* ***Valdez Creek has been diverted by the mining company*** *i to access the ore beneath the active stream channel. A diversion dam has been constructed upstream of the active pit. The dam impounds* ***water,*** *which then* ***flows through the diversion channel approximately one mile until rejoining with***

---

[1] http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/placer/placer3.pdf

***the stream.** The diversion channel is lined and covered with rip-rap. **The Creek is then returned to its original channel below the mine**, before entering the Susitna River"*

Key points:

- Valdez Creek was not destroyed by mining operations from its headwaters to its confluence with downstream tributaries as is to be the case for the Chuitna 2003 streams (Figure 1).
- Water flow into the Valdez diversion channel was from the un-impacted streams above the mine or from groundwater wells.
- Fish inhabiting Valdez Creek are not salmon but instead grayling and lake trout. Further, during the normal time for migration upstream, the fish only had to be transported ~ 1 mile from a pond below the mine site to just above the diversion dam.
- Valdez biota (and ecosystem processes such as primary production) did not have to fully recover in a channel that had been constructed *de novo* over a mined area.
- Reclamation of Valdez did NOT required construction of 2 miles of stream as PacRim suggests; the stream remained intact with only a short diversion section.

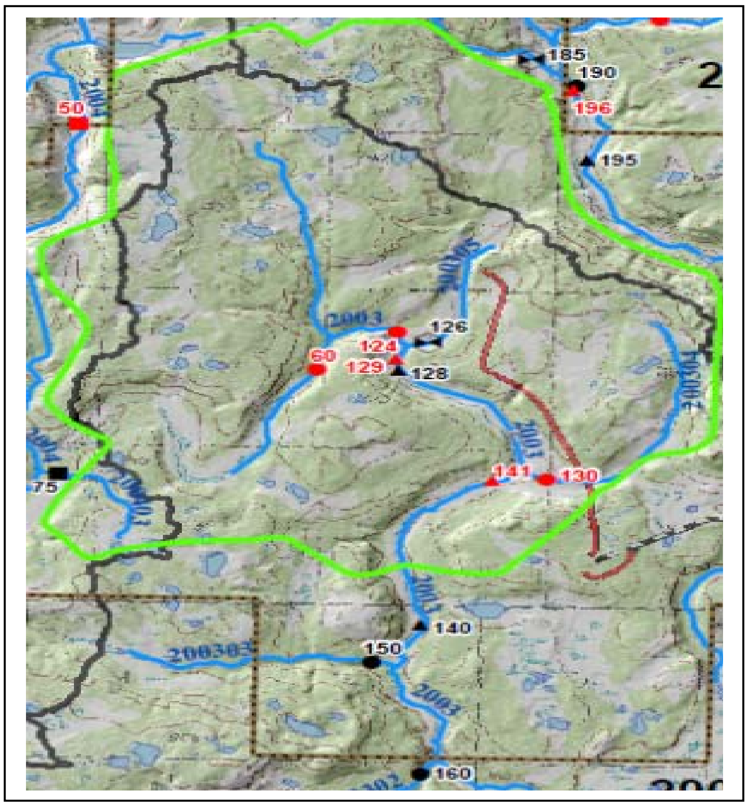

Figure 1. A portion of the Chuitna River Basin showing the proposed mining boundary in green. Note that the mining plans will result in the destruction of multiple tributaries of Stream 2003 all the way from their source (headwaters) to their junction with larger streams. Further, the flow paths to those streams will be completed changed since the entire watershed region will be mined, including major loss of wetlands that collect and store water that recharges the groundwater.

<u>Granite Ponds, near Granite Creek, AK</u>

This project focused on reducing sedimentation from gravel mining. Gravel pits were converted to ponds to act as traps for the sediment that otherwise might enter the stream. However, the stream was never impacted beyond this – it was certainly not destroyed completely or mined-through and there was never any stream creation involved. Additionally the impacts that did exist were not in headwater streams, so this project is not relevant to the type of reclamation proposed for the Chuitna Stream 2003.

<u>Resurrection Creek</u>

The impacts to this stream were modest compared to what is proposed in the Chuitna case. Small-scale hydraulic and shovel mining was done in Resurrection and tailing piles that impacted the floodplains contributed to stream straightening. These tailings did disconnect the floodplains and wetland from the stream in the lower portion of the Creek. However, the stream was not mined through to disrupt groundwater flow paths and in general, the channel itself did not undergo earth-moving activities such as filling sections, rerouting water or bull-dozing reaches. The reclamation involved two primary activities: reconnecting the floodplains to the active channel and adding meander bends to the channel (and as with all stream restoration projects, vegetation was planted after the floodplain and channel work was completed). These primary activities are nothing like what will be required for the proposed Chuitna project where the large areas of the valley will be mined through 100's of feet (thereby disrupting flow paths) and some of the headwater tributaries to stream 2003 will be completed destroyed. In the case of Resurrection case the channel and water flow paths remained intact. Further, floodplain re-grading and adding meander bends to streams like Resurrection is an extremely common practice and nothing like stream creation which I discuss later in this report. Interestingly, as I point out later (Section II), even these common practices have not been shown to lead to full ecological recovery. Restoration of channel form is not the same thing as restoration of channel process as I discussed extensively in Palmer 2009 Report on Chuitna Mine project by PacRim.

Moose Creek

This Creek had experienced some re-routing at different points in time, had portions that had been straightened and channelized (separating it from its floodplain) and the alterations also resulted in waterfalls, which prevented salmon access upstream. The restoration project consisted of "reconstructing two river reaches to bypass several waterfall barriers, 2) restoring channel connectivity to the adjacent floodplain; and, 3) re-vegetating the riparian habitat along the reconstructed reaches"[2]. In short, it was a fish passage project combined with some floodplain re-connectivity work and replanting of vegetation. The restoration did not involve the elements so critical to the proposed Chuitna project: channel creation, reclamation of major portions of the floodplain and restoration of the groundwater inputs. The impacts of the proposed mining activities are vastly more extensive including destruction of forest, wetlands, watershed-wide habitat for wildlife, headwater stream habitat for aquatic species, and the entire loss of 17.4 km of streams that support healthy populations of invertebrates and fish, including many highly valued salmon and other game fish.

Nome Creek

This stream had been disturbed by long-ago placer mining activity within the watershed that included excessive sedimentation into the stream, some diversion of the stream through ponds (settlement ponds) or side channels. The restoration consisted of removing the ponds and side channels as well as re-grading the floodplain and re-vegetating the riparian zone[3]. Once again this is not an example relevant to the proposed Chuitna reclamation work because the channel was not mined through to great depths, there was no stream creation involved, and the longitudinal connectivity of the water course of Nome Creek remained intact.

Clear Creek

This salmon stream in California was subjected to hydraulic and dredge mining along with gravel mining disturbed the floodplain, created pits and ponds that became isolated when water levels were low and fish got stranded in these at times. Additionally piles of tailings were left along the stream channel. In 1963, a dam was built on Clear Creek that resulted in substantial decline in natural flow variability in the

---

[2] http://wildfish.montana.edu/Cases/browse_details.asp?ProjectID=73

[3] Kostohrys, John 2007 Water resources and riparian reclamation of Nome Creek, White Mtns Nat'l Rec Rea, Alaska. BLM, ALk Open File Reort 113, 49 pages (citation 360 in DNR denial)

stream – flood flows were lost entirely yet they are believed important for conditioning the stream bed and substrate for spawning sites. Restoration involved filling of the pits and re-grading floodplains so fish could not be stranded, replanting riparian vegetation, increasing releases from the dam to restore part of the historic flow variability, and adding spawning gravel to the streambed[4]. While this stream did support salmon and the project resulted in benefits to the salmon population, the project in no way resembles the Chuitna project because it was not a headwater stream, it was impacted by dams not by mining at the scale the Chuitna operation, and, it did not have its groundwater flow paths fundamentally altered in the manner that will occur in the Chuitna watershed. In short, the Clear Creek project primarily involved removal of tailing material along the channel, providing a means for fish passage, adding rock material to the streambed, and increasing flow releases from a dam to the stream. This does not resemble the type or magnitude of reclamation that would be needed for the Chuitna sites. The technologies employed for Clear Creek are not technologies that would solve the problems created by the mine impacts at Chuitna.

Silver Bow Creek

This creek was impacted by flood-delivered mine wastes and tailings (with heavy metals in them) coming from mining in the region done during the 1800's. This was declared a Superfund site and resulted in a 'reclamation project' consisting of excavating the contaminated floodplain and surrounding soils. After the excavation, the floodplain was re-graded, the channel reshaped in some places, and riparian replanting ('greening') undertaken. The heavy equipment was primarily used to remove the millions of cubic meters of contaminated soils and sediments, some habitat 'improvements' were made by adding curves to the stream and varying the channel depth.[5] It is understandable that this is a project to be proud of because of the removal of so much seriously contaminated material that had been allowed to accumulate in the floodplain and parts of the channel. But this was a Superfund clean-up and post-sculpting project, NOT a channel creation project. It is not clear why the DNR denial refers to this as the 'complete reconstruction of 10 miles of trout streams' since the channel was always in place (albeit polluted).

Reclamation examples from Illinois and Indiana:

The **Burning Star** case involved eight miles of stream that had been impacted by dragline placed mine spoil. The **Pipestone Creek** project involved "restoring" 4.6 miles of stream on reclaimed mine spoils. The **Pyramid State Park** project involved impacts to land (not streams) and the **Discovery #2 Mine** (Vingo Coal) project was a land reclamation project (again, no streams). While these projects were done on mining sites, the projects have no relevance to the reclamation to the Chuitna case for the following reasons:

- Several of these reclamation projects did not even include streams (Discovery, Pyramid)
- For those with streams, they are warm-water streams and do not support sensitive, anadromous species such as salmon (Burning Star, Pipestone)
- the watersheds do not have bogs or fens (all four sites)
- Like many of the other projects discussed above, sections of the streams were diverted around the mine during the mining process[6] but the upstream reaches were intact and the diverted reaches always connected to upstream sources and associated groundwater recharge areas.

---

[4] http://wildfish.montana.edu/Cases/methods/ClearCreek_CA.asp?ProjectID=74

[5] http://www.cfwep.org/cfinfo/agency_updates/SBC-030209.pdf

[6] http://www.techtransfer.osmre.gov/NTTMainSite/Initiatives/Geomorph/2011/Natural_Stream_Design_-_Abstracts_v4.pdf

- These streams and the catchment areas of their headwaters were not mined through as proposed for Chuitna.

Summary Section I. The results of my analysis of the reclamation examples cited by DNR and PacRim as evidence of the feasibility of reclamation at the Chuitna site clearly show that these examples <u>do not demonstrate technological feasibility for the Chuitna site</u> for a number of important reasons. The examples did not deal with situations that required anything close to the level of technology that would be needed to attempt reclamation at the Chuitna site. Many of the examples involved diverting a portion of a stream channel around a mine site such that the connectivity of the streams was not disrupted as will be the case for Chuitna. The examples did not involve complete destruction of the drainage area to entire tributaries. The examples did not involve the types of fragile wetlands present in the Chuitna site.

<u>Section II. Scientific evidence that reclamation is not feasible</u>

The status of research evaluating the effectiveness of stream and wetland restoration/reclamation has advanced significantly in the last decade and there is now clear evidence of widespread ecological failures of restoration projects attempted on sites far less damaged than what will occur at the Chuitna site. If reclamation technology is not adequate to restore basic ecological structure and function (e.g., pre-degradation levels of water quality, biodiversity or ecological processes) in watersheds that are significantly less degraded than the Chuitna watershed post-mining, then it is certain that reclamation is not technologically feasible at Chuitna.

Demonstrating technological feasibility of a reclamation effort requires quantification of the ecological outcome. "Site walks", photos, and subjective assessments of other reclaimed areas are NOT sufficient to demonstrate that it is technologically feasible to restore biodiversity or other ecological attributes – the problems with such subjective approaches have been extensively documented (e.g., Bernhardt et al. 2005, Bernhardt et al. 2007, Jahnig et al. 2011). Further there is an extensive literature on methods for assessing the ecological effectiveness of projects.[7] This point is raised to emphasize why it is critical to use the peer-reviewed literature to address the question of technological feasibility.

---

[7] The most common metric for evaluating the ecological outcome of a stream restoration project is to sample the benthic macroinvertebrates. The communities of invertebrates are believed to provide an aggregate view of in-stream conditions because they respond to a variety of different stressors and integrate the impacts of those stressors over time (Barbour et al. 1996, Bonada et al. 2006). A number of macroinvertebrate bioassessment tools have been developed and they typically employ a suite of metrics that may include measures of richness (e.g., number of total taxa, number of EPT taxa, i.e., Ephemeroptera, Plecoptera & Trichoptera), composition (e.g., % EPT taxa, % Diptera), and/or tolerance (e.g., % dominant taxon, % tolerant taxa; Barbour et al. 1999)). Many studies have linked one or more of these metrics to land use, and more generally, stream condition (e.g., Barbour et al. 1996, Hawkins et al. 2000, Moore and Palmer 2005, Purcell et al. 2009, Stephenson and Morin 2009, Walsh et al. 2005, Walters et al. 2009). Fish bioassessments are frequently conducted because of the cultural and economic importance of these animals (Barbour et al. 1999) and such assessments are critical to evaluating the technological feasibility of restoring salmon to the Chuitna streams post-mining. Similar examples could be provided for wetland creation and I include a few references to that literature (e.g., Turner et al. 2001, ELI 2006, Kihslinger 2008).

The Commissioner's statement in the ULP denial (page 54) that: "..*petitioners fail to provide convincing evidence ….that anything has changed since DNRs 1987 Permitting Decision*…" is quite simply incorrect. In my 2009 statement (Palmer 2009 Chuitna report), I provided an extensive description of peer-reviewed journal articles documenting major ecological failures of restoration projects on streams. I will not repeat a description of the examples I provided in my 2009 statement but instead: 1) list the peer reviewed articles that describe those examples I provided, and, 2) provide brief descriptions of additional examples that have emerged since I wrote the 2009 statement.

I emphasize that the following list are of reclamation projects that have failed ecologically – these projects are NOT listed to suggest that the sites or types of degradation associated with the examples are directly similar to the Chuitna project – instead, it is the fact that **all of these projects were completed under far less technologically challenging circumstances and yet they still failed.** Thus, these peer-reviewed articles provide a very clear indication of the technologically limited state of the field of stream restoration.

Peer-reviewed articles quantifying the technological limitations of reclamation and lack of data on positive outcomes:

<u>Cited in Palmer 2009 Expert report on Chuitna</u>

- Bernhardt, E.S., M. A. Palmer, J. D. Allan, .G. Alexander, S. Brooks, J. Carr, C. Dahm, J. Follstad-Shah, D.L. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, G.M. Kondolf, S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, P. Srivastava, E. Sudduth. 2005. Restoration of U.S. Rivers: a national synthesis. Science 308:636-637. ***Summarizes database with ~38,000 stream restoration projects**
- Hilderbrand, R. H., A. C. Watts, and A. M. Randle. 2005. The myths of restoration ecology. Ecology and Society 10(1): 19. [online] URL:http://www.ecologyandsociety.org/vol10/iss1/art19.
- Kondolf, G. Mathias, M.W. Smeltzer, and S. Railsback. 2001. Design and Performance of a Channel Reconstruction Project in a Coastal California Gravel-Bed Stream. Environmental Management 28 (6): 761-76.
- Mathews, J.W. and A.G. Endress. 2008. Performance criteria, compliance success, and vegetation development in compensatory mitigation wetlands. Environmental Management 41: 130-141.
- Palmer, M. A., E. Bernhardt, J. D. Allan, and the National River Restoration Science Synthesis Working Group (2005) Standards for ecologically successful river restoration, J. Appl. Ecol., 42, 208–217.
- Palmer, M.A. 2009. Invited Odum essay: Reforming Watershed Restoration: Science in Need of Application and Applications in Need of Science. Estuaries & Coasts 32: 1-17.
- Palmer, M.A., H. Menninger, and E.S. Bernhardt. 2009. River Restoration, Habitat Heterogeneity and Biodiversity: A Failure of Theory or Practice? Freshwater Biology 55: 1 – 18. ***Evaluated 78 independent stream restoration projects.***
- Smith, S. M. and K.L. Prestegaard (2005) Hydraulic performance of a morphology-based stream channel design Water Resour. Res., Vol. 41, No. 11, W11413 10.1029/2004WR003926
- Tullos, D.D., D. Penrose, D.G. Jennings, and W.G. Cope. 2009. Analysis of functional traits in reconfigured channels. J. North Amer. Benthological Society 28:80-92. ***Evaluated 24 independent stream restoration projects**

<u>New or not sited (in previous Palme report) peer-reviewed articles</u>

- Albertson, L.K., B. J. Cardinale, S. C. Zeug, L.R. Harrison, H. S. Lenihan, and M. A. Wydzga. 2011. Impacts of Channel Reconstruction on Invertebrate Assemblages in a Restored River. Restoration Ecology 19:627-638.
- Baldigo, B. P., A. G. Ernst, D. R. Warren, and S. J. Miller. 2010. Variable responses of fish assemblages, habitat, and stability to natural-channel-design restoration in Catskill Mountain streams. Transactions of the American Fisheries Society 139:449–467.
- Bernhardt, E.S. and M. A. Palmer. 2011. River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation. Ecological Applications 21:6, 1926-1931
- Bernhardt, E. S., E. B. Sudduth, M. A. Palmer, J. D. Allan, J. L. Meyer, G. Alexander, J. Follastad-Shah, B. Hassett, R. Jenkinson, R. Lave, J. Rumps, and L. Pagano. 2007. Restoring rivers one reach at a time: results from a survey of US river restoration practitioners. Restoration Ecology 15:482–493.
- Filoso, S., and M. Palmer. 2011. Assessing stream restoration effectiveness at reducing nitrogen export to downstream waters. Ecological Applications 21:1989–2006.
- Fritz, K.M., S. Fulton, B.R. Johnson, *et al*. Structural and functional characteristics of natural and constructed channels draining a reclaimed mountaintop removal and valley fill coal mine 2010. *J. N. Am. Benthological Soc.* **29:** 673.
- Hart, T.M. and S.E. Davis. 2011. Wetland development in a previously mined landscape of East Texas, USA Wetlands Ecol Manage 19:317–329
- Hossler, K., V. Bouchard, M. S. Fennessy, S. D. Frey, E. Anemaet, and E. Herbert. 2011. No-net-loss not met for nutrient function in freshwater marshes: recommendations for wetland mitigation policies. Ecosphere 2(7):art82. doi:10.1890/ES11-00009.1
- Jahnig, S. C., A. W. Lorenz, and D. Hering. 2009. Restoration effort, habitat mosaics, and macroinvertebrates—does channel form determine community composition? Aquatic Conservation: Marine and Freshwater Ecosystems 19:457–169.
- Jahnig, S. C., A. W. Lorenz, D. Hering, C. Antons, A.Sundermann, E. Jedicke, and P. Haase. 2011. River restoration success: a question of perception. Ecological Applications 21:2007–2015.
- Katz, S.L, K. Barnas, R. Hicks, J. Cowen, and R. Jenkinson. 2007. Freshwater Habitat Restoration Actions in the Pacific Northwest: A Decade's Investment in Habitat Improvement. Restoration Ecology 15: 494-515
- Kondolf, G.M., S. Anderson, R. Lave, L. Paganno, A. Merenlender, and E.S. Bernhardt. 2007. Two Decades of River Restoration in California: What Can We Learn? Restoration Ecology 15: 516-523.
- Laub, B.G., D.W. Baker, B. P. Bledsoe, and M.A. Palmer. In press. Range of variability of channel complexity in urban, restored, and forested reference streams. *Freshwater Biology.*
- Louhi, P., H. Mykra¨ , R. Paavola, A. Huusko, T. Vehanen, A. Ma¨ ki-Peta¨ ys, and T. Muotka. 2011. Twenty years of stream restoration in Finland: little response by benthic macroinvertebrate communities. Ecological Applications 21:1950–1961.
- Miller, J. R., and R. C. Kochel. 2010. Assessment of channel dynamics, in-stream structures and post-project channel adjustments in North Carolina and its implications to effective stream restoration. Environmental Earth Sciences 59:1681–1692.
- Miller, S. W., P. Budy, and J. C. Schmidt. 2010. Quantifying macroinvertebrate responses to in-stream habitat restoration: applications of meta-analysis to river restoration. Restoration Ecology 18:8–19.

- Roni, P., K. Hanson, and T. Beechie. 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management 28:856–890.
- Stranko, S., M. A. Palmer, R. Hilderbrand. 2011. Fish and Benthic Macroinvertebrate Diversity of Restored Urban Streams and Reference Streams. *Restoration Ecology.* doi: 10.1111/j.1526-100X.2011.00824.x
- Sudduth, E. B., B. A. Hassett, P. Cada, and E. S. Bernhardt. 2011. Testing the Field of Dreams Hypothesis: functional responses to urbanization and restoration in stream ecosystems. Ecological Applications 21:1972–1988.
- Sundermann, A., S. Stoll, and P. Haase. 2011. River restoration success depends on the species pool of the immediate surroundings. Ecological Applications 21:1962–1971.
- Tullos, D. D., D. L. Penrose, G. D. Jennings, and W. G. Cope. 2009. Analysis of functional traits in reconfigured channels: implications for the bioassessment and disturbance of river restoration. Journal of the North American Benthological Society 28:80–92.
- Violin, C. R., P. Cada, E. B. Sudduth, B. A. Hassett, D. L. Penrose, and E. S. Bernhardt. 2011. Effects of urbanization and urban stream restoration on the physical and biological structure of stream ecosystems. Ecological Applications 21:1932–1949.
- Whiteway, S. L., P. M. Biron, A. Zimmermann, O. Venter, and J. W. A. Grant. 2010. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences 67:831–841.

<u>Peer-reviewed article on aquatic reclamation projects on previously mined land</u>

- Jones, N.E., G.J. Scrimgeour, and W.M. Tonn. 2008. Assessing the Effectiveness of a Constructed Arctic Stream Using Multiple Biological Attributes. Environmental Management (2008) 42:1064–1076
- Scrimgeour, G.J., M. Jones. and W.M. Tonn. 2011. Benthic macroinvertebrate response to habitat restoration in a constructed Arctic stream. River Res & Applications DOI: 10.1002/rra.1602

These studies are important because the reclamation project was done on previously mined land situated in an ecoregion similar to the Chuitna site and the goal of the project was to restore fish productivity. The Jones et al. study reports on fish response while the Scrimgeour study reports on efforts to enhance food availability (macroinvertebrate productivity) for fish.

> [Excerpts from Jones et al.]
> *In 1991, diamonds were discovered in the remote region of the Northwest Territories of Canada known as the Barrenlands. In preparation for mineral extraction, two lakes and their connecting streams were drained to provide access to the diamond-bearing ore. As part of the habitat compensation agreement, a 3.4-km stream channel was blasted out of the granitic bedrock to reconnect the drainage network. Since 1997, water has been diverted around the two lakes, which became open-pit mines, through the constructed stream channel. An objective of these construction efforts was to replace the fish habitat lost during mine development. …*
>
> *We evaluated the initial success of this compensation program by comparing multiple biological attributes of the constructed stream during its first three years to those of natural reference streams in the area. The riparian zone of the constructed stream was*

> *largely devoid of vegetation throughout the period, in contrast to the densely vegetated zones of reference streams. The constructed stream also contained lower amounts of woody debris, coarse particulate organic matter (CPOM), and epilithon; had lower coverage by macrophytes and bryophytes; and processed leaf litter at a lower rate than reference streams. Species richness and densities of macroinvertebrates were consistently lower in the constructed stream compared to natural streams.*
>
> [Excerpt from Scrimgeour et al.] *"Our assessments of the performance of the constructed stream during the first 3 years after its creation have shown that it was not a good surrogate for natural reference streams. …. To enhance secondary production to levels comparable with reference streams, a suite of engineered structures were deployed in late 1998 to create riffle habitats. …. [Results:] …. reference streams supported higher densities of Simuliidae and phemeroptera compared with engineered structures and unenhanced sites within the channel. Total biomass, biomass of Chironomidae, non-chironomid Diptera and combined biomasses of (i) Nematoda, Oligochaeta and Turbellaria and (ii) Ephemeroptera, Plecoptera and Hemiptera from reference riffles exceeded those at engineered structures."*

Jones et al. and Scrimgeour et al. conclude that the reclamation effort failed to produce the desired outcomes. By three years post-reclamation adult grayling were migrating through the channel and even spawning however the young graylings produced exhibited poor growth and production of young-of-year. The additional restoration actions that involved adding engineered structures to enhance secondary production (macroinvertebrates) to support fish were unsuccessful.

The fact that the target fish population productivity in this project – arctic grayling – did not recover has important implications for the Chuitna case because the grayling requirements for growth and reproduction are not as complex and stringent as that of the Chuitna salmon (Trasky 2011, Comments on ULP denial). As Trasky outlined in his report: "Salmon dig redds into the hyporheic zone but spawning grayling do not. Grayling broadcast their eggs which drift down to the stream bottom where they develop. The eggs hatch within three weeks. It doesn't matter if these streams go anoxic, dry up or freeze to the bottom during the winter because prior to freeze up both the adults and juveniles migrate out of these systems to deep rivers and lakes to overwinter. Furthermore grayling spawn annually so the loss of an entire year class does not have long lasting consequences." If the reclamation/stream construction project on previously mined land in the NW Territories of Canada did not work for grayling who are not nearly as sensitive a salmon, it would be arbitrary scientifically to say something like this could work for salmon in Chuitna.

In short, if restoration is not possible on landscapes that have far fewer impacts to them than those proposed for the Chuitna River project, then we can say with certainty that such restoration efforts on the Chuitna post-mined land will not be possible.

Summary of Section II: These peer reviewed articles discuss major problems associated with successful restoration of streams and many provide quantitative data demonstrating ecological failures for restoration challenges that were far simpler than PacRim's plan for the Chuitna watershed. The <u>current status of the technology for stream and watershed reclamation</u> is limited to small scales (usually single reaches of streams or small parcels of land), is only useful in intact water networks

(e.g., projects may involve diverting streams but not restoring streams with no connectivity to headwaters), is not designed nor tested for situations in which the underlying soil/lithology/geology and associated groundwater flow paths are destroyed. Finally, stream creation on such parcels of degraded land has never been successfully demonstrated – indeed its feasibility has been seriously questioned (Palmer and Filoso 2009, Palmer et al. 2010, Fritz et al. 2010, Bernhardt and Palmer 2011).

References Cited

Albertson, L.K., B. J. Cardinale, S. C. Zeug, L.R. Harrison, H. S. Lenihan, and M. A. Wydzga. 2011. Impacts of Channel Reconstruction on Invertebrate Assemblages in a Restored River. Restoration Ecology 19:627-638.

Baldigo, B. P., A. G. Ernst, D. R. Warren, and S. J. Miller. 2010. Variable responses of fish assemblages, habitat, and stability to natural-channel-design restoration in Catskill Mountain streams. Transactions of the American Fisheries Society 139:449–467.

Bonada, N., N. Prat, V.H. Resh, and B. Statzner. 2006. Developments in aquatic insect biomonitoring: a comparative analysis of recent approaches. Annual Review of Entomology 51:495-523.

Barbour, M.T., J. Gerritsen, G.E. Griffith, R. Frydenborg, E. McCarron, J.S. White, M.L. Bastian. 1996. A Framework for Biological Criteria for Florida Streams Using Benthic Macroinvertebrates. Journal of the North American Benthological Society. 15:185-211.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C. http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm

Bernhardt, E.S., M. A. Palmer, J. D. Allan, .G. Alexander, S. Brooks, J. Carr, C. Dahm, J. Follstad-Shah, D.L. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, G.M. Kondolf, S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, P. Srivastava, E. Sudduth. 2005. Restoration of U.S. Rivers: a national synthesis. Science 308:636-637.

Bernhardt, E.S. and M. A. Palmer. 2011. River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation. Ecological Applications 21:6, 1926-1931

Bernhardt, E. S., E. B. Sudduth, M. A. Palmer, J. D. Allan, J. L. Meyer, G. Alexander, J. Follastad-Shah, B. Hassett, R. Jenkinson, R. Lave, J. Rumps, and L. Pagano. 2007. Restoring rivers one reach at a time: results from a survey of US river restoration practitioners. Restoration Ecology 15:482–493

Environmental Law Institute (ELI) 2006. 2005 Status Report on Compensatory Mitigation in the United States. Environmental Law Institute, Washington, D.C.

Falk, D., M. A. Palmer, and J. B. Zedler (eds.). 2006. Foundations of Restoration Ecology. Island Press. Washington, D.C.

Filoso, S., and M. Palmer. 2011. Assessing stream restoration effectiveness at reducing nitrogen export to downstream waters. Ecological Applications 21:1989–2006

FISRWG (10/1998). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN3/PT.653. ISBN-0-934213-59-3.

Fritz, K.M., S. Fulton, B.R. Johnson, *et al*. 2010. Structural and functional characteristics of natural and constructed channels draining a reclaimed mountaintop removal and valley fill coal mine *J. N. Am. Benthological Soc.* **29:** 673.

Hart, T.M. and S.E. Davis. 2011. Wetland development in a previously mined landscape of East Texas, USA Wetlands Ecol Manage 19:317–329

Henry, C.P and C. Amoros. 1995 Restoration ecology of riverine wetlands. Environmental Management Volume 19, Number 6, 891-902, DOI: 10.1007/BF02471940

Hilderbrand, R. H., A. C. Watts, and A. M. Randle. 2005. The myths of restoration ecology. Ecology and Society 10(1): 19. [online] URL:http://www.ecologyandsociety.org/vol10/iss1/art19

Hossler, K., V. Bouchard, M. S. Fennessy, S. D. Frey, E. Anemaet, and E. Herbert. 2011. No-net-loss not met for nutrient function in freshwater marshes: recommendations for wetland mitigation policies. Ecosphere 2(7):art82. doi:10

Hughes, F.M.R., A. Colston, and J.O. Mountford. 2005. Restoring Riparian Ecosystems: The Challenge of Accommodating Variability and Designing Restoration Trajectories. Ecology and Society 10: 12. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art12/.

Jahnig, S. C., A. W. Lorenz, and D. Hering. 2009. Restoration effort, habitat mosaics, and macroinvertebrates—does channel form determine community composition? Aquatic Conservation: Marine and Freshwater Ecosystems 19:457–169.

Jahnig, S. C., A. W. Lorenz, D. Hering, C. Antons, A.Sundermann, E. Jedicke, and P. Haase. 2011. River restoration success: a question of perception. Ecological Applications 21:2007–2015.

Jones, N.E., G.J. Scrimgeour, and W.M. Tonn. 2008. Assessing the Effectiveness of a Constructed Arctic Stream Using Multiple Biological Attributes. Environmental Management. 42:1064–1076
Stephen L. Katz,[1,2] Katie Barnas,[1] Ryan Hicks,[3] Jeff Cowen,[3] and Robin Jenkinson

Katz, S.L, K. Barnas, R. Hicks, J. Cowen, and R. Jenkinson. 2007. Freshwater Habitat Restoration Actions in the Pacific Northwest: A Decade's Investment in Habitat Improvement. Restoration Ecology 15: 494-515.

Kihslinger, Rebecca L. 2008. Success of wetland mitigation projects. *National Wetlands Newsletter* 30(2): 14-16.

Kondolf, G. Mathias, M.W. Smeltzer, and S. Railsback. 2001. Design and Performance of a Channel Reconstruction Project in a Coastal California Gravel-Bed Stream. Environmental Management 28 (6): 761-76

Kondolf, G. M., A. J. Boulton, S. O'Daniel, G. C. Poole, F. J. Rahel, E. H. Stanley, E. Wohl, A. Bång, J. Carlstrom, C. Cristoni, H. Huber, S. Koljonen, P. Louhi, and K. Nakamura 2006. Process-based ecological river restoration: visualizing three-dimensional connectivity and dynamic vectors to recover lost linkages. *Ecology and Society* **11**(2): 5 http://www.ecologyandsociety.org/vol11/iss2/art5/

Kondolf, G.M., S. Anderson, R. Lave, L. Paganno, A. Merenlender, and E.S. Bernhardt. 2007. Two Decades of River Restoration in California: What Can We Learn? Restoration Ecology 15: 516-523.

Louhi, P., H. Mykra¨ , R. Paavola, A. Huusko, T. Vehanen, A. Ma¨ ki-Peta¨ ys, and T. Muotka. 2011. Twenty years of stream restoration in Finland: little response by benthic macroinvertebrate communities. Ecological Applications 21:1950–1961

Mathews, J.W. and A.G. Endress. 2008. Performance criteria, compliance success, and vegetation development in compensatory mitigation wetlands. Environmental Management 41: 130 141

Miller, J. R., and R. C. Kochel. 2010. Assessment of channel dynamics, in-stream structures and post-project channel adjustments in North Carolina and its implications to effective stream restoration. Environmental Earth Sciences 59:1681–1692.

Miller, S. W., P. Budy, and J. C. Schmidt. 2010. Quantifying macroinvertebrate responses to in-stream habitat restoration: applications of meta-analysis to river restoration. Restoration Ecology 18:8–19.

Moore, A.A., and M.A. Palmer. 2005. Invertebrate biodiversity in agricultural and urban headwater streams: implications for conservation and management. Ecological Applications. 15(4):1169-1177.

Palmer, M.A. 2009. Report on Chuitna Coal Project of PacRim Coal. Submitted April 2009 to Trustees for Alaska. April 2009.

Palmer, M.A. and S. Filoso. 2009. Restoration of ecosystem services. *Science* 325: 575-576.

Palmer, M.A. 2009. Invited Odum essay: Reforming Watershed Restoration: Science in Need of Application and Applications in Need of Science. Estuaries & Coasts 32: 1-17.

Palmer, M.A., H. Menninger, and E.S. Bernhardt. 2009. River Restoration, Habitat Heterogeneity and Biodiversity: A Failure of Theory or Practice? Freshwater Biology 55: 1 – 18

Palmer, M.A. E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, E. Foufoula-Georgiou, M. S. Hendryx, A. D. Lemly, G. E. Likens, O. L. Loucks, M. E. Power, P. S. White, P. R. Wilcock. 2010. Mountaintop Mining Consequences. *Science* 327 (5962): 148-149.

Purcell, A.H., D.W. Bressler, M.J. Paul, M.T. Barbour, E.T. Rankin, J.L. Carter, and V.H. Resh. 2009. Assessment Tools for Urban Catchments: Developing Biological Indicators Based on Benthic Macroinvertebrates. Journal of the American Water Resources Association 45: 306-319.

Roni, P., K. Hanson, and T. Beechie. 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management 28:856–890.

Scrimgeour, G.J., M. Jones. and W.M. Tonn. 2011. Benthic macroinvertebrate response to habitat restoration in a constructed Arctic stream. River Res & Applications DOI: 10.1002/rra.1602

Smith, S. M. and K.L. Prestegaard (2005) Hydraulic performance of a morphology-based stream channel design Water Resour. Res., Vol. 41, No. 11, W11413 10.1029/2004WR003926

Stephenson, J.M., and A. Morin. 2009. Covariation of stream community structure and biomass of algae, invertebrates and fish with forest cover at multiple spatial scales. Freshwater Biology 54:2139-2154.

Stranko, S., M. A. Palmer, R. Hilderbrand. 2011. Fish and Benthic Macroinvertebrate Diversity of Restored Urban Streams and Reference Streams. *Restoration Ecology.* doi: 10.1111/j.1526-100X.2011.00824.x

Sudduth, E. B., B. A. Hassett, P. Cada, and E. S. Bernhardt. 2011. Testing the Field of Dreams Hypothesis: functional responses to urbanization and restoration in stream ecosystems. Ecological Applications 21:1972–1988.

Sundermann, A., S. Stoll, and P. Haase. 2011. River restoration success depends on the species pool of the immediate surroundings. Ecological Applications 21:1962–1971.

Tullos, D.D., D. Penrose, D.G. Jennings, and W.G. Cope. 2009. Analysis of functional traits in reconfigured channels. J. North Amer. Benthological Society 28:80-92

Turner, R.E., A.M. Redmond, J.B. Zedler. 2001. Count It By Acre or Function – Mitigation Adds Up to Net Loss of Wetlands. *National Wetlands Newsletter* 23(6).

Violin, C. R., P. Cada, E. B. Sudduth, B. A. Hassett, D. L. Penrose, and E. S. Bernhardt. 2011. Effects of urbanization and urban stream restoration on the physical and biological structure of stream ecosystems. Ecological Applications 21:1932–1949.

Walsh, C. J., A. H. Roy, J. W. Feminella, P. D. Cottingham, P. M. Groffman, and R.P. Morgan. 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24:706-723.

Walters, D. M., A. H. Roy, and D. S. Leigh. 2009. Environmental indicators of macroinvertebrate and fish assemblage integrity in urbanizing watersheds. Ecological Indicators 9:1222-1233

Whiteway, S. L., P. M. Biron, A. Zimmermann, O. Venter, and J. W. A. Grant. 2010. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences 67:831–841.