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ANCHOR QEA

Memorandum

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To: Kara Kusche, Angela Hunt, and Jim Rypkema, Alaska Department of Environmental Conservation

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cc: Bob Berto, Ethan Berto, and Tyler Rose, White Pass & Yukon Route
Ari Steinberg, SSA Marine
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Re: FINAL- Model Estimates of Water Quality Impacts During Dredging Operations Skagway Ore Terminal Remediation Project

Introduction

The remediation of marine sediments often involves the dredging of contaminated sediment followed by the placement of a clean sand cover to achieve site cleanup objectives. Both these activities inherently result in temporary water quality impacts during construction; therefore, significant effort has been made to understand and limit water quality impacts during remediation (e.g., *The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk* [U.S. Army Corps of Engineers; USACE 2008]). As a result, there is an established set of tools commonly used for analyzing water quality impacts during sediment remediation and typical approaches employed for managing those impacts.

This memorandum applies established analytical tools to assess potential water quality impacts during dredging for the Skagway Ore Terminal Remediation Project (Project) and supports future development of Project water quality monitoring procedures.

Project Description

White Pass & Yukon Route (WPYR) is proposing to conduct a remedial action to address legacy ore-related sediment contamination at the site (Figure 1). The remediation approach for the Project was developed in consultation with the Alaska Department of Environmental Conservation (DEC) based on site-specific environmental and risk assessment studies, as summarized in the *Remedial Approach Work Plan* (Work Plan; Anchor QEA 2019a). Remedial options were evaluated, and a preferred remedial action was selected in the *Remedial Action Options Analysis* (Anchor QEA 2019b), which was approved by DEC in October 2019. The *Draft Basis of Design Report* (BODR; Anchor QEA 2020), which documents the key design assumptions and criteria for implementing the remedial action, was provided to DEC in January 2020.

Remedial activities will consist of mechanically dredging approximately 7,000 cubic yards (cy) of contaminated sediment, which will be passively dewatered on a barge, stabilized to facilitate safe barge transport, and shipped to an off-site transload facility (in Washington or Oregon) for rail or truck transportation to a licensed upland disposal facility. Following sediment removal, about 700 cy of clean sand cover (i.e., a residual management cover; RMC) will be placed over the dredging footprint to address potential residual contamination. The in-water work is planned for fall or winter 2020 and is expected to take about 1 to 3 weeks to complete.

Regulatory Requirements

The Project will comply with all applicable Alaska state and federal regulations. DEC is the authorizing entity under the Clean Water Act Section 401 Certification rules. In addition, the Project will comply with the Alaska Water Quality Standards (18 Alaska Administrative Code [AAC] 70.020) and the state's antidegradation policy (18 AAC 70.015). Antidegradation Form 2G, which includes the relevant Project information for DEC to complete an antidegradation analysis for the Project, is included as Attachment A.

This memorandum provides an assessment of predicted water quality impacts during remedial dredging to help inform DEC's Section 401 Water Quality Certification and support future development of the Project water quality monitoring procedures.

Water Quality Criteria

Turbidity water quality standards are established in 18 AAC 70.020; however, these standards are more relevant for an ongoing discharge (e.g., from an outfall) than a short-term activity such as dredging. Due to the lack of an applicable standard for short-term dredging activities, and based on Anchor QEA, LLC's experience with marine dredging projects in other states (e.g., Washington, Oregon, and California) and consistent with the relevant criteria in Washington State (Washington Administrative Code [WAC] 173-201A-210(1)(e) for waters designated as "good" marine quality), a turbidity criterion of 10 Nephelometric Turbidity Units (NTU) above background—at the edge of the designated mixing zone—is proposed as a reasonable compliance criterion for the Project.

For contaminants in sediment targeted for dredging that could enter the water column due to resuspension, the acute and chronic criteria for protection of aquatic life in marine water were selected as the water quality standards for comparison purposes (*Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances* [DEC 2008]). Metals are the contaminant of concern (COC) that will be addressed through the remedial action. Alaska's marine water quality criteria for metals are expressed as the dissolved fraction and in some cases are averaged over a specific time frame (e.g., a 1-hour average for the acute criterion and a 4-day average for the chronic criterion). Applicable Alaska state water quality criteria and Skagway Harbor average ambient surface water concentrations (based on available studies) are provided in Table 1. Historical ambient surface water data for Skagway Harbor and Taiya Inlet are provided in Table 2.

Purpose of Evaluation

The purpose of the water quality analysis provided in this memorandum is as follows:

1. Determine the predicted dissolved metals concentrations that may be mobilized into the water column during dredging.
2. Help inform the selection of the numerical water quality requirements for comparison against on-site measurements at the point of compliance (i.e., the edge of the designated mixing zone) during construction.

Prior to construction, the procedures for monitoring and resultant contingency actions (i.e., procedures to follow in the case of a water quality exceedance) will be detailed for use by the water quality monitoring team and the Contractor to ensure project water quality requirements are met.

The following section describes the model used to predict dissolved metals concentrations during construction.

Water Quality Modeling

The USACE developed the DREDGE Model (Hayes and Je 2000) to help predict the impacts of dredging on contaminant concentrations within the water column. The model first estimates the mass rate at which sediments become suspended into the water column during mechanical dredging operations. Next, the model estimates the transport of the suspended solids plume from the construction area due to dispersion, transport by ambient water currents, and settlement of suspended solids. Finally, the model estimates the total and dissolved contaminant concentrations in the water column based on contaminant concentrations in suspended solids and equilibrium partitioning theory.

Description and Selection of Model Input Parameters

Table 3 presents the model input parameters selected for the analysis and the rationale for each. The DREDGE Model inputs are categorized as follows: dredging characteristics, near field model parameters (e.g., conditions at the location of dredging operations), far field model parameters (e.g., transport conditions down-gradient from dredging operations), and site characteristics. The input parameters for the model were selected based on reasonable worst-case assumptions (i.e., relatively high suspended solids in the water column relative to average conditions during dredging) to capture the expected maximum impacts due to dredging during the Project.

Two sets of Project input parameters were developed: 1-hour (acute) model run parameters and 4-day (chronic) model run parameters (Table 3). The 1-hour model run was used to approximate the worst-case conditions over a continuous single hour of dredging for comparison to acute water quality criteria. The 4-day model run was used to approximate the worst-case average conditions over 4 days where dredging occurs for comparison to chronic water quality criteria.

The dredge bucket size, cycle time, and suspended solids source strength (i.e., percent loss from the dredge bucket) were used to determine the total loading of suspended solids to the water column. These model input parameters are based on experience with similar remedial dredging projects and are considered worst-case assumptions (i.e., they result in higher concentrations than expected in the field). The dredging production rate was assumed to be 150 cy/hour for the 1-hour model run and 800 cy/day for the 4-day model run. During dredging for both scenarios, 5% of the dredged material volume was assumed to be resuspended into the water column. The DREDGE Model assumes that loading to the water column is evenly distributed throughout the water column during the raising of the dredge bucket.

Far field diffusion coefficients were established based on discussions with USACE (Schroeder 2019; Table 3). The site-specific settling rates in the model were determined based on sediment grain sizes and densities. Sediments targeted for dredging are comprised of approximately 50% fines (silt and clay) and 50% sand and gravel, based on the grain size data available for the site, and core logs from within the dredge prism (TetraTech 2008; Golder 2018). The mean settling velocity is representative of the suspended solids (i.e., fine fraction) and was therefore estimated based on the Stokes' law settling velocity of a particle size of 35 µm, representative of the median of the fine fraction of dredged material.

The ambient tidal velocities within Skagway Harbor vary; however, a speed of 0.5 meter per second (m/s) was used for modeling based on the value listed in the site *Sediment Transport Analysis* (Golder 2018, Appendix A).

Contaminant Input Parameters

Contaminant input parameters include the concentrations of core samples within the dredge prism and the partitioning coefficients for each contaminant, as presented in Table 4. The analysis included ore-related metals (the focus of the remedial action) with applicable surface water quality criteria. For the 1-hour model run, the maximum contaminant concentrations of all samples within the dredge prism were used to represent the worst-case concentrations anticipated during dredging. For the 4-day model run, the average contaminant concentrations within the dredge prism were used to represent average conditions over several days of dredging.

The contaminant partitioning coefficients (Table 4) represent the relative metals concentrations in the dissolved phase compared to the particle-bound phase in equilibrium. The partitioning coefficients were used to estimate the dissolved phase concentration from the concentrations in suspended solids in the water column (which are assumed to equal the concentration in dredged sediment). For cadmium, copper, lead, and zinc, the partitioning coefficients were calculated within the DREDGE Model assuming a pH of 8 (for marine conditions; Table 4). For arsenic, mercury, and silver, which do not have default values in the DREDGE Model, the partitioning coefficients were referenced from Table 9-2 of the *Sediment Evaluation Framework for the Pacific Northwest* (USACE et al. 2016).

Results

Table 5 presents the model results for the 1-hour model run compared against Alaska's acute water quality criteria. The DREDGE Model predicted a total suspended solids (TSS) concentration of 4.3 milligrams per liter (mg/L) at 150 feet from the work zone and 3.0 mg/L at 300 feet from the work zone. All predicted dissolved metals concentrations were below Alaska's acute water quality criteria at the modeled locations. Unlike other metals, Alaska's acute water quality criterion for copper (4.8 mg/L) is based on a 24-hour average; however, the acute criterion was not exceeded by 1-hour model predictions.

Table 6 presents the model results for the 4-day model run compared against Alaska's chronic water quality criteria. The DREDGE Model predicted a TSS concentration of 1.0 mg/L at 150 feet from the work zone and 0.7 mg/L at 300 feet from the work zone. All predicted dissolved metals concentrations were below Alaska's chronic water quality criteria at the modeled locations.

In summary, based on site-specific model inputs to the DREDGE Model, no acute or chronic water quality exceedances are predicted for metals at 150 feet or greater from the work zone during dredging activities.

Discussion

Turbidity and Total Suspended Solids

Turbidity is commonly used to measure water quality during dredging projects, with a criterion established relative to ambient background concentrations (e.g., 10 NTU above background). Turbidity measurements provide real-time information about the impacts to water quality due to dredging and therefore can provide immediate feedback to the contractor on the impacts of dredging operations. Although TSS is used in the DREDGE Model, real-time measurements of TSS during dredging are not possible (i.e., TSS requires laboratory analysis). As such, turbidity, which has a relationship to TSS, is recommended for real-time measurements of water quality during dredging.

Because turbidity is generally correlated with TSS and provides real-time feedback about water quality during dredging operations, it is commonly used as the primary tool to assess if significant resuspension is occurring due to dredging operations. Based on Anchor QEA's experience at other remedial dredging sites, the TSS to turbidity relationship ranges from approximately 2 NTU = 1 mg/L TSS to 1 NTU = 4 mg/L TSS, with 1 NTU = 2 mg/L TSS as the typical estimate.

Mixing Zone

The mixing zone requirements in 18 AAC 70.240 typically apply to permanent outfalls and discharges and are not directly applicable to short-term impacts associated with one-time dredging events. Dredging is not a continuous operation because the contractor will not work 24 hours a day (e.g., a typical workday involves 6 to 8 hours of dredging) and there is significant downtime in a typical workday for moving the dredge plant and equipment maintenance and setup. However, the concept of a mixing zone is used for this Project to assess and limit temporary water quality impacts associated with dredging, and the edge of the mixing zone is proposed as the point of compliance for the Project.

The size of the mixing zone is established as close as practicable to the work zone, considering the size of the construction equipment, amount of anticipated sediment disturbance, and safety and practicability of water quality sampling from a support vessel. Figure 2 shows an example work zone and mixing zone for the project. The work zone is the area that includes the dredging equipment that directly supports construction activities, including the derrick barge (dredge), material barge, and tug. Considering the size of the equipment, the dynamic nature of dredging, wind and weather conditions, and sampling procedure requirements, a reasonably safe distance from the work zone is about 150 feet. As described previously, the DREDGE Model results indicate that water quality is not expected to exceed acute or chronic water quality criteria for metals or TSS at this distance during typical operations. Therefore, turbidity sampling at a 150-foot early warning station (Figure 2) is proposed to provide feedback to the Contractor on any potential resuspension originating from dredging operations.

Consistent with Anchor QEA's experience at other remedial dredging sites, 300 feet (from the work zone) is proposed as the edge of the mixing zone (i.e., the point of compliance) for the Project. Similar to the early warning station, the model results show that water quality exceedances are not expected at this distance. Turbidity sampling is proposed at the point of compliance for real-time measurement of dredging impacts. Exceedances of the water quality criterion (10 NTU above background) at the point of compliance would trigger additional communications and potential contingency actions (e.g., best management practices [BMPs] discussed in the next section).

Construction Best Management Practices

BMPs will be employed during construction to limit resuspension of dredged sediment. The BODR identified a number of potential BMPs, including the following:

- Specifications will prohibit taking multiple bites during dredging.
- The Contractor will be required to take complete dredge cuts—from the moment the bucket is closed at the mudline, the Contractor will be required to return the bucket to the surface and deposit dredge material onto the barge before returning the bucket back to the mudline.

- The Contractor will be prohibited from overfilling dredge buckets to reduce spillage back to the seabed.
- The Contractor will be prohibited from leveling the bottom surface. Instead of leveling to remove high spots, the Contractor will be required to make an additional dredging pass to remove any high spots that are identified during the post-construction survey.
- The Contractor will be prohibited from overloading the material barge beyond the top of the side rails.

Additional BMPs may be required and will be employed in the event of a water quality exceedance, such as slowing the dredge bucket cycle time or temporarily stopping work to reduce the loading of suspended sediment into the water column. These additional BMPs are listed in the project specifications as contingent BMPs in the event that water quality objectives are not met.

Silt Curtains

As discussed in the BODR and based on USACE guidance (ERDC 2008) and Anchor QEA's experience with dredging and sediment remediation projects, it is anticipated that silt curtains at this project site would be largely ineffective at containing dissolved contaminants or limiting movement of suspended sediment in Skagway Harbor due to the site's physical conditions. The combination of water depth, tidal currents, large tidal ranges, and strong weather and wind conditions (especially during the anticipated construction window) would likely render silt curtains ineffective at controlling suspended solids, and could be a hindrance to dredging operations and a potential safety concern to manage through setup, inspections, and take down. Water depth is one of the main concerns because the intent of using a silt curtain is to prevent the spread of suspended solids. At water depths of more than 40 feet (such as those at the site), there are limitations to the achievable height of a curtain due to the current forces acting on the curtain and due to the feasibility of keeping such a large curtain anchored and stationary during tidal exchange. Without the ability to use a full-length silt curtain (from the water surface to the sediment bed), suspended solids can be transported under the bottom edge of the silt curtain.

Moreover, typical silt curtains that are not fully impermeable do little to reduce the impact of dissolved contaminants, which are the basis of the water quality criteria. Fully impermeable curtains do exist, but because they are impermeable, they are more affected by tidal currents and wind and waves than permeable curtains. For these reasons, among others, silt curtains have not been proposed as a BMP to be employed during dredging.

Residuals Management Cover

The placement of clean sand on top of dredged areas is termed "residuals management cover (RMC)". The purpose of placing clean sand is to leave the final post-construction surface as clean as is feasible. RMC is a commonly used technique for addressing residuals concentrations postdredging. Following dredging, a thin layer of residuals will likely remain on the sediment surface with the same contaminant concentrations as the dredged sediment. However, dredging residuals tend to be a thin layer of unconsolidated sediment (e.g., less than 10 centimeters), and are therefore very low in contaminant mass and present a technical challenge to effectively remove (USACE 2008). By placing a layer of clean sand over the residuals, the concentration in surface sediment is immediately reduced. In addition, due to the low contaminant mass typically found in dredging residuals, RMC is expected to be effective even when the post-remediation area is exposed to vessel prop-wash forces; any potential scour forces will mix the surface RMC with the underlying subsurface sediment, resulting in lower concentrations than the residuals concentration alone.

Water Quality Impacts During RMC Placement

The placement of clean sand could result in short-term water quality impacts in the near field due to the suspension of fine material within the water column. Depending on the source of the sand, RMC placement operations can result in more turbidity in the water column than caused by dredging. However, unlike dredging, the short-term increase in turbidity associated with placement is not associated with contaminated material. For the Project, the turbidity and mixing zone criteria, as well as the monitoring proposed for dredging, are also proposed for RMC placement. However, these requirements may be reassessed with DEC based on field conditions.

Conclusions and Recommendations

Site-specific water quality modeling predicts no water quality criteria exceedances for metals or TSS due to resuspension of sediment during dredging operations. Based on these results, and considering the safety and practicability of sampling, an early warning station of 150 feet and a point of compliance of 300 feet from the work zone are recommended. Furthermore, a turbidity standard of 10 NTU above background is recommended to provide real-time feedback of water quality conditions during dredging and to provide a mechanism for corrective action(s) should resuspension become an issue. The procedures for monitoring and resultant contingency actions (i.e., procedures to follow in the case of a water quality exceedance) will be detailed for use by the water quality monitoring team that will work with the Contractor to ensure project water quality requirements are met.

References

Alaska DEC (Alaska Department of Environmental Conservation), 2008. Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances. December 2008.

Anchor QEA (Anchor QEA, LLC), 2020. *Draft Basis of Design Report*. Skagway Ore Terminal Remediation Project. January 2020.

Anchor QEA, 2019a. *Remedial Approach Work Plan*. Skagway (Nahku) Ore Terminal, Hazard ID #401. Prepared for the Alaska Department of Environmental Conservation. May 2019.

Anchor QEA, 2019b. *Remedial Action Options Analysis*. Skagway (Nahku) Ore Terminal, Hazard ID #401. Prepared for Alaska Department of Environmental Conservation on behalf of White Pass & Yukon Route. October 2019.

ERDC (U.S. Army Corps of Engineers Engineer Research and Development Center), 2008. *Technical Guidance for Environmental Dredging of Contaminated Sediments*. USACE ERDC/EL TR-08-29. September 2008.

Golder (Golder Associates), 2018. *Skagway Ore Basin Risk Assessment - Sediment Transport Analysis (Appendix A)*. Report No. 1657231-006-R-Rev0. Submitted to White Pass & Yukon Route Railway. January 25, 2018.

Hayes, D.F., and C.H. Je, 2000. *DREDGE Model User's Guide*. University of Utah, Department of Civil and Environmental Engineering. July 2000.

Schroeder, Paul (USACE), 2019. Personal communication with Greg Brunkhorst (Anchor QEA). December 3, 2019.

TetraTech, 2008. *Evaluation of Skagway Harbor and Pullen Creek Sediments and Surface Waters*. Prepared for Alaska Department of Environmental Conservation and U.S. Environmental Protection Agency (USEPA)-Region X. February 25, 2008.

U.S. Army Corps of Engineers (USACE), 2008. *The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk*. Technical Report ERDC/EL TR-08-4. Vicksburg, MS: U.S. Army Engineer Research and Development Center. February 2008.

USACE et al. (U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration Fisheries – West Coast Region, U.S. Fish and Wildlife Service, Oregon Department of Environmental Quality, Idaho Department of Environmental Quality, Washington Department of Natural Resources, Washington Department of Ecology), 2016. *Sediment Evaluation Framework for the Pacific Northwest*. Table 9-2. July 2016.

Tables

Table 1
Alaska Ambient Concentrations and Surface Water Quality Criteria

Chemical[a]	Acute (CMC)		Chronic (CCC)		Ambient Surface Water Concentration in Skagway Harbor[b] (µg/L)
	Value (µg/L)	Time Frame	Value (µg/L)	Time Frame	
Arsenic	69	1-hour avg	36	4-day avg	--
Cadmium	40	1-hour avg	8.8	4-day avg	0.16 U
Copper	4.8	24-hour avg	3.1	4-day avg	4.34
Lead	210	1-hour avg	8.1	4-day avg	1.3
Mercury	1.8	1-hour avg	0.94	4-day avg	0.08
Silver	1.9	1-hour avg	--	--	--
Zinc	90	4-day avg	81	4-day avg	41

Notes:
Water quality criteria are from *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances* (Alaska Department of Environmental Conservation 2008) and *18 Alaska Adminsitrative Code (AAC) 70 Water Quality Standards.*
a. List of contaminants includes chemicals with water quality criteria that have been analyzed in sediment samples within the remedial footprint.
b. Ambient concentration is the average of total and dissolved surface water concentrations that have been measured in Skagway Harbor. Copper concentrations are from Tetra Tech 2009; all other data are from Tetra Tech 2008.
--: no value developed or data not available
µg/L: microgram per liter
avg: average
CCC: Criterion Chronic Concentration
CMC: Criterion Maximum Concentration
U: compound analyzed but not detected above detection limit

Table 2
Metals Concentrations in Surface Water in Skagway Harbor and Taiya Inlet

Station ID	Location	Study	Cadmium (µg/L)		Copper (µg/L)		Lead (µg/L)		Nickel (µg/L)		Mercury (µg/L)		Zinc (µg/L)	
			Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
REF	Taiya Inlet	a	0.16 U	0.16 U	2.3	5.0*	0.67 J	0.22 U	1.1 J	8.9*	0.11 J	0.055 U	54	48
REF-1	Taiya Inlet	b	--	--	2.6 U	5.3 J	--	--	--	--	--	--	--	--
REF-2	Taiya Inlet	b	--	--	2.6 U	2.6 U	--	--	--	--	--	--	--	--
SH-5	Skagway Ore Basin	b	0.16 U	0.16 U	2.6 U	2.6 U	3.2	0.22 U	1.7 J	8.6*	0.092 J	0.055 U	37	31
SH-8	Skagway Ore Basin	b	0.16 U	0.16 U	2.8	6.3*	0.76 J	0.22 U	1.2 J	8.1*	0.055 U	0.12 J	19	15
SH-9	Skagway Ore Basin	b	--	--	11.3	2.6 U	--	--	--	--	--	--	--	--
SH-10	Skagway Ore Basin	b	0.16 U	0.16 U	24	2.6 U	3.3	0.22 U	1.2 J	9.6*	0.055 U	0.055 U	67	55
SH-11	Skagway Ore Basin	b	0.16 U	0.16 U	2.8	5.6*	0.6 J	0.22 U	1.1 J	6.9*	0.059 J	0.13 J	12	12
SH-12	Skagway Ore Basin	b	0.16 U	0.16 U	4.5 J	2.6 U	5.4	0.74 J	0.99 J	9.4*	0.055 U	0.067 J	62	51
SH-14	Skagway Ore Basin	b	0.16 U	0.16 U	2.6 U	2.6 U	2.1	0.26 J	1.0 J	7.1*	0.13 J	0.14 J	48	42
SH-15	Skagway Ore Basin	b	0.16 U	0.16 U	9.1 J	2.6 U	2.4	0.6 J	0.94 J	9.7*	0.068 J	0.14 J	73	63
SH-17	Skagway Ore Basin	b	0.16 U	0.16 U	2.6 U	2.6 U	2.0	0.28 J	1.0 J	6.5*	0.055 U	0.055 U	22	19
BH-1	Small Boat Harbor	b	--	--	2.6 U	2.6 U	--	--	--	--	--	--	--	--
FD-1	Ferry Dock	b	--	--	2.6 U	2.6 U	--	--	--	--	--	--	--	--
RD-1	Railroad Dock	b	--	--	4.4 J	2.6 U	--	--	--	--	--	--	--	--
Skagway Harbor Surface Water Average[c]			0.16 U	0.16 U	5.3	3.4	2.5	0.35	1.1	8.2	0.07	0.10	43	36

Notes:

a. *Evaluation of Skagway Harbor and Pullen Creek Sediments and Surface Waters* (TetraTech 2008)

b. *Evaluation of Metals and Petroleum Derivatives in Skagway Harbor and Pullen Creek Sediments and Surface Waters* (TetraTech 2009)

c. Average includes suspect values (i.e., J and dissolved fractions*)

*: dissolved fraction is suspect due to being in excess of the total fraction

--: no value developed or data not available

µg/L: microgram per liter

J: value is below the reporting limit, but above the detection limit

U: compound analyzed but not detected above detection limit

Table 3
Model Input Parameters

Parameter	1-Hour Model Run	4-Day Model Run	Unit	Rationale
Dredge Characteristics				
Production Rate	150 cy/hour	800 cy/day	varies	Based on dredging project experience; used to estimate the average dredging cycle time (below).
Dredge Bucket Size	4.5	4.5	cy	Equivalent to 6 cy with a 75% fill factor.
Average Dredging Cycle Time	108	486	second	108 seconds per cycle equates to 150 cy/hour representative of a productive 1-hour period of dredging; 486 seconds per cycle equates to 800 cy/day representative of a productive dredging shift averaged over 24 hours for the purpose of this analysis (i.e., 486 sec/cycle is averaged to include downtime).
In-Situ Dry Density	700	700	kg/m^3	Typical for unconsolidated sediment.
Near Field Model				
Source Strength (Percent Loss from Dredge Bucket)	5	5	percent	Based on a representative 5 percent loss from the dredge bucket; a typical percent loss for mechanical dredging.
Far Field Model				
Lateral Diffusion Coefficient	10,000	10,000	cm^2/s	Reasonable based on Personal Communication with Paul Schroeder, USACE (December 3, 2019).
Settling Velocity	0.000967	0.000967	m/s	Calculated within the DREDGE Model based on Stokes' Law and the mean particle size for the dredge footprint.
Site Characteristics - Marine Environment				
Water Depth	15.24	15.24	m	Equal to 50 feet based on the project conditions.
Ambient Water Velocity	0.5	0.5	m/s	Based on Golder 2018 (sediment transport analysis).
Mean Particle Size	35	35	µm	Mean particle size is used to calculate the settling velocity. Mean particle size fine-grained sediments.
Specific Gravity of Sediment Particles	2.65	2.65	unitless	Reasonable specific gravity for suspended particles (fines).

Notes:
Blue highlights denote changes from the 1-hour model input parameters.
Golder Associates (Golder), 2018. *Skagway Ore Basin Risk Assessment. Appendix A - Sediment Transport Analysis*
TetraTech, 2008. *Evaluation of Skagway Harbor and Pullen Creek Sediments and Surface Waters.*
µm: micrometer
cm^2: square centimeter
cy: cubic yard
kg: kilogram
m: meter
m^3: cubic meter
m/s: meter per second
USACE: U.S. Army Corps of Engineers

Table 4
Contaminant Concentrations within the Dredge Prism

Chemical	Distribution (Partitioning) Coefficient (Kd)[a] (L/kg)	Concentration (mg/kg)							
		Maximum (1-Hour Model)	Average (4-Day Model)	SED17-34		SED17-35	SED17-40		SOD-01
				4 – 5 feet	5 – 5.5 feet	5 – 5.5 feet	6 – 6.5 feet	6.5 – 8 feet	0 – 2.5 feet
Arsenic	10,000	41	19	41	13	19	23	11	10
Cadmium	354,810	105	42	105	51	30	34	16	16
Copper	229,090	1,400	534	1,400	472	436	465	185	244
Lead	4,570,880	41,900	19,100	41,900	14,400	14,100	19,500	14,700	10,000
Mercury	199,526	39	17	38.7	21	13	14	7	7
Silver	79	44	20	44	15	15	22	14	10
Zinc	776,250	73,800	28,467	73,800	33,400	19,400	21,600	10,300	12,300

Notes:

a. Kd values for cadmium, copper, lead, and zinc are based on the DREDGE Model input parameter calculation for a pH of 8 (for marine conditions). The DREDGE Model does not have input Kd values for other metals; for those chemicals, Kd values are based on the *Sediment Evaluation Framework for the Pacific Northwest, Table 9-2* (USACE et al. 2016).

Kd: distribution (partitioning) coefficient (Kd) measures the amount of chemical substance adsorbed onto sediment per amount of water.

L/kg: liter per kilogram

mg/kg: milligram per kilogram

USACE: U.S. Army Corps of Engineers

Table 5
Results for the Acute (1-Hour) Model Run

Parameter	Acute Water Quality Criteria	Distance from Work Zone			
		100 feet	150 feet	200 feet	300 feet
Total Suspended Solids (TSS) (mg/L)		5.3	4.3	3.7	3.0
Dissolved Metals (µg/L)					
Arsenic	69	0.21	0.17	0.15	0.12
Cadmium	40	0.19	0.18	0.17	0.15
Copper[a]	4.8	3.4	3.0	2.8	2.5
Lead	210	8.8	8.7	8.7	8.5
Mercury	1.8	0.10	0.09	0.08	0.07
Silver	1.9	0.23	0.19	0.16	0.13
Zinc	90	76	73	71	67

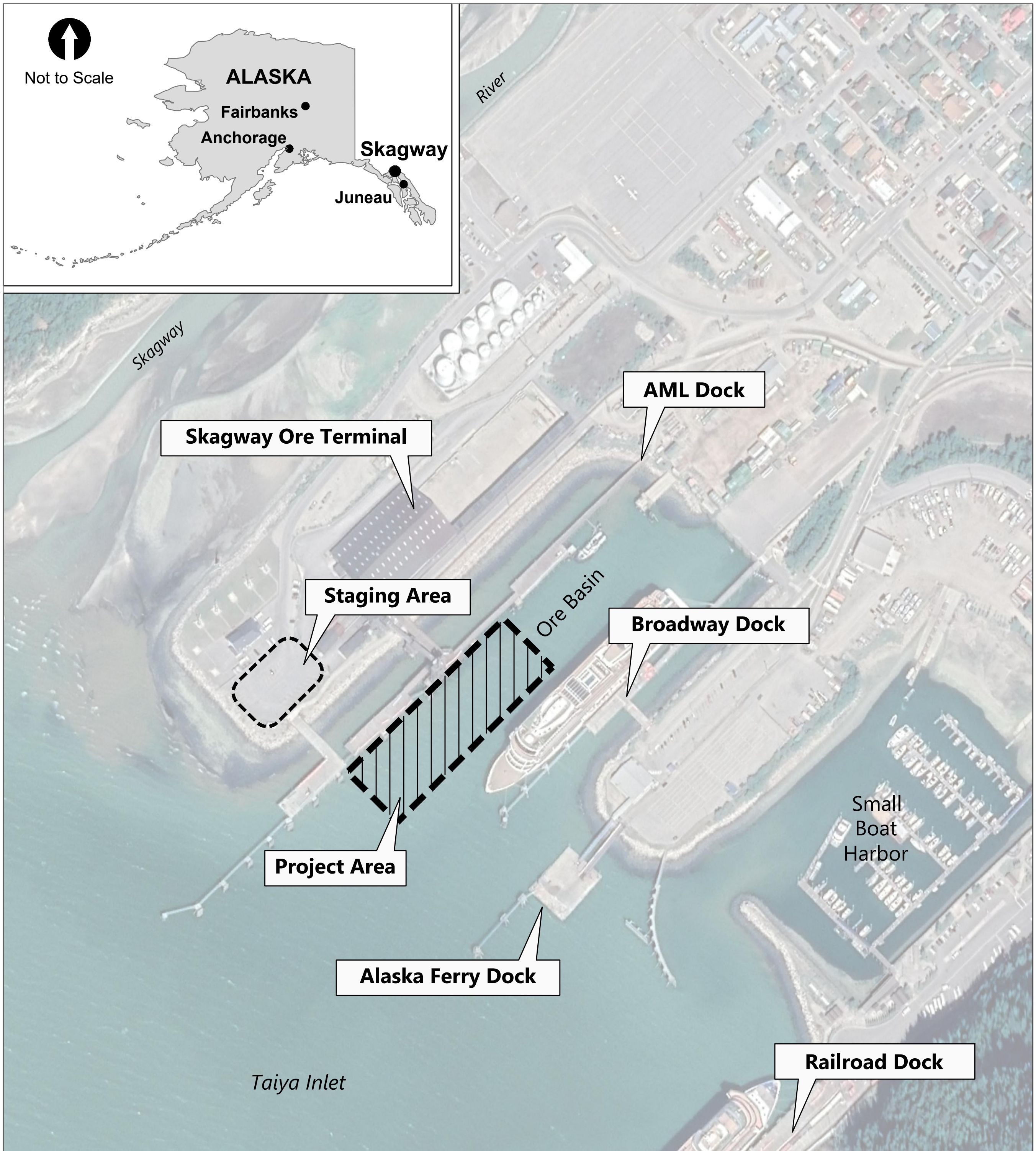
Notes:
a. The acute water quality criterion for copper is based on a 24-hour averaging time; however, the acute criterion was not exceeded by 1-hour model predictions.
µg/L: microgram per liter
mg/L: milligram per liter

Table 6
Results for the Chronic (4-Day) Model Run

Parameter	Chronic Water Quality Criteria	Distance from Work Zone			
		100 feet	150 feet	200 feet	300 feet
Total Suspended Solids (TSS) (mg/L)		1.2	1.0	0.8	0.7
Dissolved Metals (µg/L)					
Arsenic	36	0.02	0.02	0.02	0.01
Cadmium	8.8	0.04	0.03	0.03	0.02
Copper	3.1	0.5	0.4	0.4	0.3
Lead	8.1	3.5	3.4	3.3	3.2
Mercury	0.94	0.02	0.01	0.01	0.01
Silver	--	0.02	0.02	0.02	0.01
Zinc	81	18	16	14	13

Notes:
--: not available
µg/L: microgram per liter
mg/L: milligram per liter

Figures



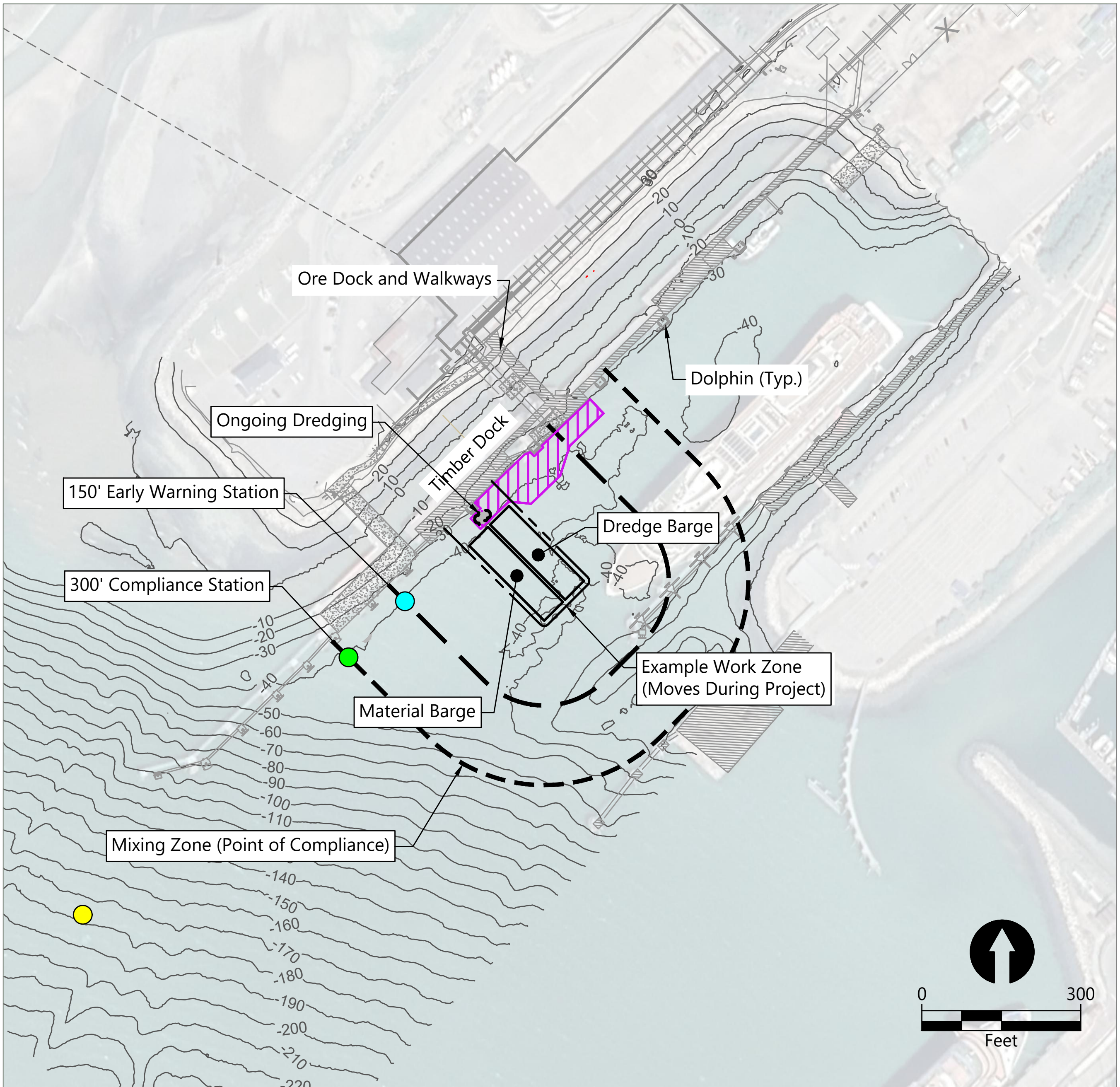
SOURCE: Google Earth Pro, 2019

Publish Date: 2020/03/09 8:52 AM | User: dholmer
Filepath: K:\Projects\0159-KPFF Consulting Engineers\Ore Terminal Remediation Support_Water Quality Monitoring Plan\0159-WQMP-001 (VICINITY).dwg Figure 1

ANCHOR QEA

Figure 1
Project Area and Site Features

Model Estimates of Water Quality Impacts During Dredging Operations
Skagway Ore Terminal Remediation Project



SOURCES: Base CAD files provided by KPFF. Bathymetric survey by Terrasond, dated October 28, 2014. Aerial image courtesy Google Earth Pro, 2019
HORIZONTAL DATUM: Alaska State Plane Zone 1, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

NOTE:
Early warning and compliance station locations are selected to be downcurrent of the work zone and may shift depending on the tidal stage.

LEGEND:
- Existing Contours (2014, 10' Interval)
- Example Work Zone (Moves During Project)
- Dredge Footprint
- 150' Early Warning Boundary
- 300' Compliance Boundary
- Water Quality Monitoring Station
- Background Water Quality Monitoring Station (1,000 Feet from the Work Zone)

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Filepath: K:\Projects\0159-KPFF Consulting Engineers\Ore Terminal Remediation Support_Water Quality Monitoring Plan\0159-WQMP-002 (PLAN).dwg Figure 2

ANCHOR QEA

Figure 2
Conceptual Water Quality Monitoring Station Diagram

Model Estimates of Water Quality Impacts During Dredging Operations
Skagway Ore Terminal Remediation Project

Attachment A
Antidegradation Form 2G

Antidegradation Form 2G

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION (DEC)
Wastewater Discharge Authorization Program
555 Cordova Street, AK 99501
907-269-6285

Form 2G must be completed by all applicants. The applicant shall submit sufficient information for the department to complete an antidegradation analysis and make findings under 18 AAC 70.016 (b), (c), and (d). DEC may request additional information as necessary.

Antidegradation analysis is tier-specific and the department findings for Tier 1 and Tier 2 are on a parameter-by-parameter basis. Analysis and department findings for Tier 3 water are on a basis of a designated water.

The antidegradation review procedure is based on:

- The level of protection (i.e. Tier 1, 2, or 3) assigned to the pollutants of concern within the receiving water,
- The type of receiving water,
- Existing water quality of the receiving water,
- The necessity of degradation, and
- The social and economic importance of the regulated activity.

All discharges that require a permit under 18 AAC 83 Alaska Pollutant Discharge Elimination System (APDES) or an application for state certification of a federal permit under Section 401 of the Clean Water Act (CWA) are subject to antidegradation regulatory requirements under 18 AAC 70.016. [18 AAC 70.016(a)(1)(A & B)]

Submit completed form to DEC Division of Water to the address above, or via email to either of the following email addresses depending on the type of permit:

- 401 Certification for 404 CWA, or other federal permits: DEC-401Cert@alaska.gov
- APDES Permits: DEC.Water.WQPermit@alaska.gov
- Or, via other means as coordinated with DEC Division of Water.

Section 1- Facility Information [18 AAC 70.016(a)(5)(A – G)]

Facility Name: Skagway Ore Terminal Remediation Project **Permit Number**: ____________

1. Provide a list of Parameters of Concern in the discharge, the respective concentrations, persistence, and potential impacts to the receiving water.
2. Identify which Tier protection level should apply for each Parameter of Concern.

(For multiple parameters or if additional space is needed, attach separate sheet)

Receiving Waterbody or Wetland:

Skagway Harbor

Parameter of Concern:	Respective Concentrations:	Tier* Protection Level: *(*Note, complete this entry after completing the rest of the form)*
Metals contamination in sediment (see attachment)	See attachment	

Persistence:

Persistent for sediment; temporary for water quality impacts

Potential Impacts:

Approximately 7,000 cubic yards (cy) of contaminated sediment is proposed for dredging from the Skagway Ore Basin in Skagway, AK. Dredging will occur episodically over approximately 2 to 3 weeks; during that time, minimal water quality impacts are expected to occur in the vicinity of the dredging operations.

Potential water quality impacts were evaluated using a numeric model (see attached Water Quality Evaluation Memo). According to the analysis, no water quality criteria exceedances are predicted 100 feet from dredging work zone. The zone of mixing, compliance criteria, and monitoring plan will be established in coordination with DEC to minimize water quality impacts during construction.

If applicable, data is attached on the parameters that may alter the effects of the discharge to the receiving water. ☐ Yes, ☐ No, ☒ N/A

Section 2- Baseline Water Quality Provisions [18 AAC 70.016(a)(6)(A – C)]

If determined necessary and requested by the Department, submit sufficient and credible baseline water quality information for the receiving water which meets the requirements of 18 AAC 70.016(a)(6)(A – C).

Section 3- Tier 1 analysis of existing use protection [18 AAC 70.016(b)]

1. Does a discharge of any parameter identified in Section 1 occur to a Category 4 [305(b)] or Category 5 [303(d)] waterbody listed in the current approved Alaska's Integrated Water Quality Monitoring and Assessment Report?

See http://dec.alaska.gov/water/water-quality/impaired-waters.aspx for the most recently approved integrated report and category listings.

☒ Yes ☐ No

a. If yes, list parameters from Section 1 that are present in the proposed discharge that will be included in the Tier 1 analysis in the following table.

Receiving Water and Wetlands Information (if additional space is needed, attach separate sheet):

a. Name of waterbodies or wetlands to which you discharge:	**Impaired Waters**						
	b. Is the proposed discharge(s) directly to any segment of a Category 4 or 5 waterbody?		If you answered yes to b, then answer the following three questions (c, d, and e).				
			c. What parameter(s) are causing the Category 4 or 5 water degradation?	**d**. Are the parameter(s) causing the degradation present in the proposed discharge?		**e**. Is the discharge consistent with the assumptions and requirements of applicable EPA approved or established Total Maximum Daily Load (TMDL)?	
	Yes	No		Yes	No	Yes	No
Skagway Harbor	☒	☐	Petroleum Hydrocarbons	☐	☒	☒	☐
	☐	☐		☐	☐	☐	☐

Section 4- Tier 2 analysis of existing use protection [18 AAC 70.016(c)]

If not identified as requiring only Tier 1 level of protection, Tier 2 is presumed for all water as the default protection level for all parameters [18 AAC 70.016(c)(1)].

1. Is the application for a *(Check all that apply)*:

☒ New Discharge ☐ Existing Discharge ☐ Expanded Discharge

Temporary discharge during dredging

2. Does a discharge of any parameter identified in Section 1 – Facility Information require Tier 2 analysis as defined under 18 AAC 70.016(c)(2)(A) – (E)?

☐ **Yes**, proceed to **Question 3**

☒ **No**, please **explain below** and proceed to **Section 5**

Only temporary water quality impacts are anticipated during dredging.

3. For each parameter requiring a Tier 2 analysis, provide a description per discharge (e.g., parameter specific per outfall) and analysis of a range of practicable alternatives that have the potential to prevent or lessen the degradation associated with the proposed discharge [18 AAC 70.016(c)(4)] (*if additional space is needed, attach separate sheet*). Include:

A. Identification of receiving water quality and accompanying environmental impacts on the receiving water for each of the practicable alternatives;

B. Evaluation of the cost for each of the practicable alternatives, relative to the degree of water quality degradation;

C. Identification of a proposed practicable alternative that prevents or lessens water quality degradation while also considering accompanying cross-media environmental impacts. (*If the applicant has selected a non-degrading alternative, the social or economic importance analysis in Question 4 is not required.*

4. Social or Economic Importance [18 AAC 70.016(c)(5)]

Provide information that demonstrates the accommodation of important social or economic development. The applicant shall complete either a social OR economic importance analysis (or both) identifying each affected community in the area where the receiving water for the proposed discharge is located. *(if additional space is needed, attach separate sheet)*

(A) Social Importance Analysis: *(select one or more areas, and describe below)*	**(B) Economic Importance Analysis**: *(select one or more areas, and describe below)*:
☐ community services provided; ☐ public health or safety improvements; ☐ infrastructure improvements; ☐ education and training; ☐ cultural amenities; ☐ recreational opportunities	☐ employment, job availability, and salary impacts; ☐ tax base impacts; ☐ expanded leases and royalties; ☐ commercial activities; ☐ access to resources; ☐ access to a transportation network
Describe (checked items above or attach as separate document)	

Section 5- Tier 3 analysis of existing use protection [18 AAC 70.016(d)]

1. Is the discharge to a designated Tier 3 water? ☐ Yes ☐ No

(Currently, the State of Alaska has not designated any Tier 3 waters).
See http://dec.alaska.gov/water/water-quality/standards/antidegradation.aspx for Tier 3 for further information.)

Section 6. Certification Information

An Alaska Pollutant Discharge Elimination System (APDES) permit application must be signed by an individual with the appropriate authority per 18 AAC 83.385 or for 401 certification of 404 permits or other federal permits per 18 AAC 15.030.

APDES Permits	
Corporate Executive Officer 18 AAC 83.385 (a)(1)(A)	For a corporation, a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation.
Corporate Operations Manager 18 AAC 83.385 (a)(1)(B)	For a corporation, the manager of one or more manufacturing, production, or operating facilities, if (i) the manager is authorized to make management decisions that govern the operation of the regulated facility, including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental statutes and regulations; (ii) the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and (iii) authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.
Sole Proprietor or General Partner 18 AAC 83.385 (a)(2)	For a partnership or sole proprietorship, the general partner or the proprietor respectively.
Public Agency, Chief Executive Officer 18 AAC 83.385 (a)(3)(A)	For a municipality, state, or other public agency, the chief executive officer of the agency.
Public Agency, Senior Executive Officer 18 AAC 83.385 (a)(3)(B)	For a municipality, state, or other public agency, a senior executive officer having responsibility for the overall operations of a principal geographic unit or division of the agency.
401 Certifications	
Corporations 18 AAC 15.030(1)	In the case of corporations, by a principal executive officer of at least the level of vice president or his duly authorized representative, if the representative is responsible for the overall management of the project or operation.
Partnerships 18 AAC 15.030(2)	in the case of a partnership, by a general partner
Proprietorship 18 AAC 15.030(3)	in the case of a sole proprietorship, by the proprietor
Public Agency 18 AAC 15.030(4)	in the case of a municipal, state, federal or other public facility, by either a principal executive officer, ranking elected official, or other duly authorized employee.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Organization:	Name:	Title:

Phone:	Fax (optional):	Email:

Mailing Address:	Street (PO Box):		
	City:	State:	Zip:

Signature/Responsible Official

Date

Section 7. Form 2G Preparer *(Complete if Form 2G was prepared by someone other than the certifier.)*

Organization:	Name:	Title:
Anchor QEA, LLC	Julia Fitts, LG	Managing Scientist

Phone:	Fax (optional):	Email:
360-715-2708		jfitts@anchorqea.com

Mailing Address:	Street (PO Box):		
☐ Check if same as Certifiers Information	1605 Cornwall Avenue		
	City: Bellingham	State: WA	Zip: 98225

Skagway Ore Terminal Remediation Project
Antidegradation Form 2G
Section 1, Questions 1 and 2 Response

Metals Contaminant Concentrations in Modeled Surface Water 300 Feet from Work Zone

Parameters of Concern	Concentration[1] (μg/L) Acute 1-hour	Concentration[1] (μg/L) Chronic 24-hour	Persistence in Water Column	Potential Impacts to Receiving Waters	Tiered Protection Level
Total Suspended Solids (mg/L)	3.0	0.7	Negligible	None	Tier 1
Arsenic	0.12	0.01	Negligible	None	Tier 1
Cadmium	0.15	0.02	Negligible	None	Tier 1
Copper	2.5	0.3	Negligible	None	Tier 1
Lead	8.5	3.2	Negligible	None	Tier 1
Mercury	0.07	0.01	Negligible	None	Tier 1
Silver	0.13	0.01	Negligible	None	Tier 1
Zinc	67	13	Negligible	None	Tier 1

Notes
1. Concentrations are provided in micrograms per liter (μg/L) for all parameters of concern, except Total Suspended Solids, which is provided in milligrams per liter (mg/L).